## Advanced Management Accounting

## Advanced Management Accounting Notes

## Strathmore <br> UNIVERSITY

## Distance Learning Centre


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## ACKNOWLEDGMENT

We gratefully acknowledge permission to quote from the past examination papers of the following bodies: Kenya Accountants and Secretaries National Examination Board (KASNEB); Chartered Institute of Management Accountants (CIMA); Chartered Association of Certified Accountants (ACCA).

We would also like to extend our sincere gratitude and deep appreciation to Mr. Cyrus Iraya for giving his time, expertise and valuable contribution, which were an integral part in the initial development of this Management Accounting Notes. He holds the following academic honours, MBA, B.COM (Accounting), CPA, currently pursuing his Phd in Finance at the University of Nairobi.

## INSTRUCTIONS FOR STUDENTS

This study guide is intended to assist distance-learning students in their independent studies. In addition, it is only for the personal use of the purchaser see copyright clause. The course has been broken down into nine lessons each of which should be considered as approximately one week of study for a full time student. Solve the reinforcement problems verifying your answer with the suggested solution contained at the back of the distance learning pack. When the lesson is completed, repeat the same procedure for each of the following lessons.

At the end of lessons 2, 4, 6 and 8 there is a comprehensive assignment that you should complete and submit for marking to the distance learning administrator.

## SUBMISSION PROCEDURE

1. After you have completed a comprehensive assignment clearly identify each question and number your pages.
2. If you do not understand a portion of the course content or an assignment question indicate this in your answer so that your marker can respond to your problem areas. Be as specific as possible.
3. Arrange the order of your pages by question number and fix them securely to the data sheet provided. Adequate postage must be affixed to the envelope.
4. While waiting for your assignment to be marked and returned to you, continue to work through the next two lessons and the corresponding reinforcement problems and comprehensive assignment.

On the completion of the last comprehensive assignment a two week period of revision should be carried out of the whole course using the material in the revision section of the Management Accounting Notes. At the completion of this period the final Mock Examination paper should be completed under examination conditions. This should be sent to the distance learning administrator to arrive in Nairobi at least five weeks before the date of your sitting the KASNEB Examinations. This paper will be marked and posted back to you within two weeks of receipt by the Distance Learning Administrator.

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## Management Accounting Course Description

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The course covers the range of topics needed to successfully sit the appropriate examination in the CPA syllabus.

The range of topics is extremely wide (see the syllabus copied in the Management Accounting Notes) and serious students must plan to work through the many exercises provided.

This requires the devotion of the students prime time to his studies for without this commitment, the benefit of this material will not be realised.

Students require a working knowledge of four previous syllabi, Costing in Section 2, Business Finance and STAMIS in section 3 and Quantitative Techniques in Section 4. These must be revised in order to appreciate this course and its particular orientations.

Students mainly find difficulty because of time given for preparation, and lack of material, this course overcomes the second cause. It is the onus of each individual student to overcome the first.

## RECOMMENDED TEXT

Management and Cost Accounting by Colin Drury

## LESSON ONE

## INTRODUCTION TO MANAGEMENT ACCOUNTING

## OBJECTIVES

Define and introduce Management Accounting
Explain the decision making process

## INSTRUCTIONS

1. Read the Study Text and Chapters 1, 2 and 12 of Management and Cost Accounting by Colin Drury
2. Attempt the reinforcing questions at the end of the lesson under examination conditions
3. Compare your answers with those given in Lesson 10

## CONTENTS

1.1 Key definitions
1.2 Attributes of good information
1.3 Role Of The Management Accountant In The Management Process
1.4 Decision Making Process
1.5 Decision Making Environment
1.6 Multi-stage decision making under risk

## Key Definitions

## Definition of accounting

Accounting is the process of identifying measuring and communicating economic information to permit informed judgements and decisions by users of information.
It is therefore concerned with providing information that will help decision makers make good decisions.
To understand accounting one must understand:

The attributes of good information
$\square$ Process of measuring and communicating information
$\square$ The decision making process
$\square$ Users of information
$\square$ The above points are briefly discussed below:

## Users of information

The users of information can be divided into two:
$\square$ Internal users who are parties within the organization e.g. the management or the employees.
$\square$ External users who on the other hand, are parties outside the organisation e.g. the shareholder, creditors, government, customers, etc

From the users point of view accounting can be divided into two:

## Management Accounting

$\square \quad$ Which is concerned with provision of information to people within the organisation to help them make better decisions. Management accounting is concerned with the provision and interpretation of the information required by management at all levels for the following purposes:
$\square$ Formulating the policies of the organisation
$\square$ Planning the activities of the organisation in the long-term, medium-term and shortterm (Strategic to operational planning)
$\square$ Controlling the activities of the organisation
$\square$ Decision-making
$\square$ Performance appraisal
$\square$ Management accounting can also be said to be concerned with data gathering (both from internal and external sources), analysing, processing, interpreting and communicating the resulting information for use within the organisation, so that management can more effectively plan, make decisions and control operations.

## Financial Accounting

Which is concerned with the provision of information to external parties outside the organization. It's the process of measuring, classifying, summarising and reporting financial information used in making economic decisions. It's concerned with the preparation of financial statements to be used by the firm's external stakeholders.

The key differences between Management Accounting (MA) and Financial Accounting (FA) can be summarised as follows:

|  | MA | FA |
| :--- | :--- | :--- |
| Users | Internal | External |
| Nature | Future | Historical |
| Details | More detailed | Summarised |
| Legality | Not legal | Legal |
| Format | Not standard | standard |

It is important to define cost accounting at this point.

## Cost accounting

It's the process of cost ascertainment and cost control. It is a formal system of accounting by means of which cost of product and services are ascertained and controlled.

### 1.2 Attributes of good information

Information is anything that is communicated and is sometimes said to be processed data. It is data processed in such a way as to be of meaning to the person receiving it. Good information should have the following attribute:
$\square$ It should be relevant to a user's needs. For the communicator this requires the following:
$\square$ Identifying the user: Information must be suited and sent to the right person i.e. the person who requires it to do his job.
$\square$ Getting the purpose right: It is effective only when it helps the user to make decisions.
$\square$ Getting the volume right: Information must be complete for its purpose and should not omit any necessary item. It should be no greater in volume than the users would find helpful or be able to take in.
$\square \quad$ It should be accurate within the user's needs i.e. should be correct and error free.
$\square$ It should inspire the user's confidence i.e. information should not give the user any reason to mistrust it, disbelieve it or ignore it by making sure the information is neutral.
$\square$ It should be timely: The information must be readily available within the time period which makes it useful. It must be at the right place at the right time.
$\square$ It must be appropriately communicated: Information will lose its value if it is not clearly communicated to the users in a suitable format and through a suitable medium.
$\square$ It should be cost effective: Good information should not cost more than its worth. Gathering, storing, retrieving and communicating an item of information may require expenses in form of time, energy and resources. If the expense is greater than the potential value of the item, then it should not be communicated.

### 1.3 Role of the Management Accountant in the Management Process

The management process involves planning, organising, controlling, directing, communicating and motivating. We will explain each of these functions:

## Planning

Planning is the basic function of the management by means of which the managers decide:
$\square$ What goals are to be accomplished
$\square$ How they will be accomplished
$\square$ Planning gives the manager a warning of possible future crisis and therefore they avoid the need to make unplanned decisions.
$\square$ The management accountant helps to formulate future plans by providing information to assist in deciding what product to sell, in what market and at what prices and in evaluating proposals for capital expenditure.
$\square$ In the budgeting process the management accountant provides data on past performance, establishes budget procedures and budget time tables.

## Control

$\square$ Control involves a comparison of actual performance with the plan so that deviation from the plan can be identified and corrective action taken.
$\square$ It can be defined as the process of compelling events to conform to a plan. The management accountant aids the control process by providing performance reports that compare the actual performance with the planned outcome for each responsibility centre.
$\square$ A responsibility centre may be defined as a segment (e.g. a division) of an organisation where an individual manager holds delegated authority and is responsible for the segments performance.
$\square$ The management accountant also draws a manager's attention to those specific activities that do not conform to a plan. This aids the process of Management By Exception

## Organising

$\square$ It is the establishment of the framework within which the required activities are to be performed and the designation of who should perform these activities. It involves the establishment of decision units such as departments, sections, branches, etc.
$\square$ The management accountant will provide information on the performance of each of these segments.

## Motivation

Motivation involves influencing human behaviour so that the participants identify with the objectives of the organisation and makes decisions that are in harmony with these objectives. Budgets and performance reports produced by management accountants motivate the firm's employees. To be motivating however, targets should be challenging but achievable.

## Communication

To communicate means to make known, impart or transmit the information. The management accountant aids the communication process by installing and maintaining an effective communication system such as the Management Accounting Information System (MAIS). An example of a MAIS is the budgetary system.

### 1.4 Decision Making Process

Decision making is the process of choosing among alternatives. There are 7 steps that should be followed as shown in figure 1 below:


Figure 1 The decision-making, planning and control process

Figure 1 above represents a diagram of a decision-making model. The first five stages represent the decision-making of the planning process. Planning involves making choices between alternatives and is primarily a decision-making activity. The final two stages represent the control process, which is the process of measuring and correcting actual performance to ensure that the alternatives that are chosen and the plans for implementing them are carried out. Let us now consider each of the elements of the decision-making and control process.

## Identifying Objectives

Before good decisions can be made there must be some guiding aim or direction that will enable the decision-makers to assess the desirability of favouring one course of action over another. Hence the first stage in the decision-making process should be to specify the objectives of the organisation.

## The Search for Alternative Courses of Action

The second stage of the decision-making model is a search for a range of possible courses of action (or strategies) that might enable the objectives to be achieved. If the management of a company concentrates entirely on its present product range and markets, and market shares and cash flows are allowed to decline, there is a danger that the company will be unable to generate sufficient cash flows to survive in the future. To maximise future cash flows, it is essential that management identifies potential opportunities and threats in its current environment and takes any developments which may occur in the future. In particular, the company should consider one or more of the following courses of action:

1. Developing new products for sale in existing markets;
2. Developing new products for new markets;
3. Developing new markets for existing products.

The search for alternative courses of action involves the acquisition of information concerning future opportunities and environments. It is the most difficult and important stage of the decision-making process. Ideally, firms should consider all alternative courses of action, but, firms will in practice consider only a few alternatives, with the search process being localised initially. If this type of routine search activity fails to produce satisfactory solutions, the search will become more widespread.

## Gather Data about Alternatives

When potential areas of activity are identified, management should assess the potential growth rate of the activities, the ability of the company to establish adequate market shares, and the cash flows for each alternative activity for various states of nature. Because decision problems exist in an uncertain environment, it is necessary to consider certain factors that are outside the decision-maker's control, which may occur for each alternative course of action. These uncontrollable factors are called states of nature. Some examples of possible states of nature are economic boom, high inflation, recession, the strength of competition, and so on.

The course of action selected by a firm using the information presented above will commit its resources for a lengthy period of time, and the overall place of the firm will be affected within its environmentthat is, the products it makes, the markets it operates in and its ability to meet future changes. Such decisions dictate the firm's long-run possibilities and hence the type of decisions it can make in the future. These decisions are normally referred to as long-run possibilities and hence the type of decisions it can make in the future. These decisions are normally referred to as long-run or strategic decisions. Strategic decisions have a profound effect on the firm's future position, and it is therefore essential that adequate data is gathered about the firm's capabilities and the environment in which it operates. Because of their importance, strategic decisions should be the concern of top management.

Besides strategic or long-term decisions, management must also make decisions that do not commit the firm's resources for a lengthy period of time. Such decisions are known as short-term or operating decisions and are normally the concern of lower-level managers. Short-term decisions are based on the environment of today, the physical, human and financial resources presently available to the firm.

These are, to a considerable extent, determined by the quality of the firm's long-term decisions. Examples of short-term decisions include the following:

1. What selling prices should be set for the firm's products?
2. How many units should be produced of each product?
3. What media shall we use for advertising the firm's product?
4. What level of service shall we offer customers in terms of the number of days required to deliver an order and the after-sales service?

Data must also be gathered for short- term decisions; for example, data on the selling prices of competitor's products, estimated demand at alternative selling prices, and predicted costs for different activity levels must be assembled for pricing and output decisions. When the data has been gathered, management must decide which course of action to take.

## Select Appropriate Alternative Courses of Action

In practice, decision-making involves choosing between competing alternative courses of action and selecting the alternative that best satisfies the objectives of an organisation. Assuming that our objective is to maximise future net cash inflows, the alternative selected should be based on a comparison of the differences between the cash flows. Consequently, an incremental analysis of the net cash benefits for each alternative should be applied. The alternatives are ranked in terms of net cash benefits, and those showing the greatest benefits are chosen subject to taking into account any qualitative factors. We shall discuss how incremental cash flows are measured for short-term and long-term decisions and the impact of qualitative factors.

## Implementation of the Decisions

Once alternative courses of action have been selected, they should be implemented as part of the budgeting process. The budget is a financial plan for implementing the various decisions that management has made. The budgets for all the various decisions are expressed in terms of cash inflows and outflows, and sales revenues and expenses. The budgets are merged together into a single unifying statement of the organisation's expectations for future periods. The statement is known as a master budget. The master budget consists of a budgeted profit and loss account, cash flow statement and balance sheet. The budgeting process communicates to everyone in the organisation the part they are expected to play in implementing management's decisions.

## Comparing Actual And Planned Outcomes And Responding To Divergences From Plan

The final stages in the process outlined in Figure 1 of comparing actual and planned outcomes and responding to divergences from plan represent the firm's control process. The managerial function of control consists of the measurement, reporting and subsequent correction of performance in an attempt to ensure that the firm's objectives and plans are achieved. In other words, the objective of the control process is to ensure that the work is done so as to fulfil the original intentions.

To monitor performance, the accountant produces performance reports and presents them to the appropriate managers who are responsible for implementing the various decisions. Performance reports consisting of a comparison of actual outcomes (actual costs and revenues) and planned outcomes (budgeted costs and revenues) should be issued at regular intervals. Performance reports provide feedback information by comparing planned and actual outcomes. Such reports should highlight those activities that do not conform to plans, so that managers can devote their scarce time to focusing on these items. This process represents the application of management by exception. Effective control requires that corrective action is taken so that actual outcomes conform to planned outcomes.

### 1.5 Decision Making Environment

There a four main environment within which decisions can be made. These are:
$\square$ Certainty
$\square$ Risk
$\square$ Fundamental uncertainty
$\square$ Competition
$\square \quad$ Certainty environment

In this environment complete information is available as to which states of nature will occur. The decision making process just involves picking the best alternative.

## Risk

Risk involves situations or events which may or may not occur but whose probability of occurrence can be predicted from past records. In this environment, the states of nature are not certain but probability distribution can be assigned.

## Fundamental uncertainty

Uncertain events are those whose outcome cannot be predicted with statistical confidence. In this environment the states of nature are not known nor are their probability distribution. The decision making process depends on the risk attitude of the decision maker.

## Competition

In this environment the decisions made by the firm are affected by decisions made by other firms with opposing interests.

## Decision Making Under Risk and Uncertainty

Before looking at the various methods of making decisions under risk, we shall look at the three main risk attitudes that distinguish different decision makers. These are:

## Risk seeking

A risk seeker is a decision maker who is interested in the best possible outcome no matter how small the chance that they may occur i.e. he takes high risks in anticipation of high profitability. For such a decision maker, the marginal utility for wealth is positive and increasing.

## 2. Risk neutral

A decision maker is risk neutral if he is concerned with what will be the most likely outcome i.e. he is indifferent to risk. For such a decision maker the marginal utility of wealth is positive and constant.

## 3. Risk Averse

A decision maker is risk averse, if he acts on the assumption that the worst possible outcome will occur, and chooses the decision with the least risk possible.
For such a decision maker, the marginal utility of wealth is positive but decreasing.
These risk attitudes can be illustrated by the diagrams below:

sh
ii. Risk averse

sh
iii. Risk seeking

sh

## Measure of Risk

Std deviation ( $\delta$ )
$\delta=\sqrt{\sum_{t=1}^{n}\left(M V_{t}-E M V\right) P_{t}}$
Where
$\mathrm{MV}_{\mathrm{t}}$ is the monetary value under condition t .
EMV is the expected monetary value
Pt is the probability of condition $t$ occurring $n$
is the number of different conditions.
Coefficient of variation.
It is a relative measure of risk and it is used to compare alternatives of different magnitudes based on their risk return consideration.

```
\(\mathrm{CV}=\underline{\delta}\) \(\overline{E M V}\)
```

$\mathrm{EMV}=\varepsilon \mathrm{MV}_{\mathrm{t}} \mathrm{P}_{\mathrm{t}}$

Methods Of Decision Making Under Uncertainty
To discuss these methods we shall use illustration 1.1

## Illustration 1.1

Assume that ABC Ltd is trying to set the selling price for one of its products and three prices are under consideration. These are Sh.4, Sh.4.30 \& Sh.4.40
The following information is also provided

## Alternatives

| Conditions | Sh.4.00 | Sh.4.30 | Sh.4.40 |
| :--- | :--- | :--- | :--- |
| Best possible | 16,000 | 14,000 | 12,500 |
| Most likely | 14,000 | 12,500 | 12,000 |
| Worst possible | 10,000 | 8,000 | 6,000 |

Fixed costs $=$ Sh. 20,000
variable cost per unit $=$ Sh. 2

## Required:

Advice the company on the best price to set.

## Solution

The first step is to prepare as payoff table a shown below:
Payoff matrix (profits in Shs.)

|  | Sh. $\mathbf{4}$ | Sh.4.30 | Sh.4.40 |
| :--- | :---: | :---: | :---: |
| Conditions | 12010 | 12200 | 10000 |
| Best possible | 8000 | 8750 | 8800 |
| Most likely | 0 | $(1600)$ | $(5600)$ |

## Decision Making Criteria

Maximax decision rule
This decision rule looks at the best possible result and it chooses the maximum payoff for each alternative and then the maximum of this maximum.

|  | Sh.4 | Sh.4.30 | Sh.4.40 |
| :--- | :--- | :---: | ---: |
| Conditions |  |  |  |
| Best possible | 12010 | 12200 | 10000 |
| Most likely | 8000 | 8750 | 8800 |
| Worst possible | 0 | $(1600)$ | $(5600)$ |
| Maximum | 12010 | 12200 | 10000 |

The decision is to set a price of Sh. 4.30 since it maximises the maximum pay off.
This criterion appeals to risk takers or optimists who are ready to undertake huge losses if they occurred. Small and new companies should not use this method.

Maximin decision rule
Under this criterion, the decision maker looks at the worst possible outcome of each decision alternative and then chooses the alternative that offers the least unattractive (worst) outcome i.e. He chooses the alternative that maximises the minimum profit.

|  | Sh.4 | Sh.4.30 | Sh.4.40 |
| :--- | :---: | :---: | ---: |
| Conditions |  |  |  |
| Best possible | 12010 | 12200 | 10000 |
| Most likely | 8000 | 8750 | 8800 |
| Worst possible | 0 | $(1600)$ | $(5600)$ |
| Minimum | 0 | $(1600)$ | $(5600)$ |

The decision is to set a price of Sh. 4.00 since it maximises the minimum payoff. This criterion appeals to risk averse decision makers since it is a criterion of extreme caution. It can be applied by those firms which cannot be able to absorb huge losses if they occurred.

## Laplace Criterion of Rationality

This criterion holds that if decision makers do not know the probabilities of the various states of nature and have no reason to think otherwise, then the states of nature should be considered to be equally likely. On the basis of this assumption, the expected monetary value for each alternative is calculated and the alternative with the highest expected monetary value is chosen.

| Conditions | Probability | Sh.4.00 | Sh.4.30 | Sh.4.40 |
| :--- | :--- | ---: | :---: | :---: |
| Best possible | $1 / 3$ | 12010 | 12200 | 10000 |
| Most likely | $1 / 3$ | 8000 | 8750 | 8800 |
| Worst possible | $1 / 3$ | 0 | $(1660)$ | $(5600)$ |
| EMV |  | 6667 | 6450 | 4400 |

## Workings.

EMV sh. $4=1 / 3(12010)+1 / 3(8000)+1 / 3(0)=6667$
Others are computed in the same way.

## Decision

Set a price of Sh.4.00 since it maximises the expected monetary value.

## Minimax Regret Criterion

This method seeks to minimise the maximum regret that would occur from choosing a particular strategy or alternative. The regret is the opportunity loss that occurs from taking one decision given that a certain contingency occurs.

For each state of nature
Opportunity loss $=$ Max pay off - Payoff under each alternative

| Conditions | $\underline{S h .4 .00}$ |  | $\underline{\text { Sh. } 4.30}$ |  |
| :--- | :--- | :--- | :--- | :--- |
| Sest possible | 200 |  | 0 |  |
| Most likely | 800 |  | 50 |  |
| Morst possible | $\underline{0}$ |  | $\underline{1600}$ | 0 |
| Maximum regret | 800 | 1600 | $\underline{5600}$ |  |

## Decision

Set a price of Sh.4.00 since it minimises the maximum regret

## Methods of Decision Making Under Risk

In this environment, it is possible to attach probabilities to the various states of nature. The decision criteria would either be:

The expected monetary value
The expected opportunity loss
The two criteria are similar since the choice that maximises the expected monetary value also minimises the expected opportunity loss (EOL)

## Illustration 1.2

Assume in the ABC pricing decision (illustration 1.1) that the probability of the best possible outcome is 0.2 , most likely outcome is 0.6 and the worst possible outcome is 0.2 .

Required: Advice the Company on the best price to set.

| Solution |  |  |  |  |
| :--- | :--- | :---: | :---: | :---: |
| Conditions | Probability | Sh.4.00 | Sh.4.30 | Sh.4.40 |
| Best possible | 0.2 | 12010 | 12200 | 10000 |
| Most likely | 0.6 | 8000 | 8750 | 8800 |
| Worst possible | 0.2 | 0 | $(1660)$ | $(5600)$ |
| EMV |  | 7200 | 7370 | 61600 |

## Decision

Set a price of Sh. 4.30 since it maximises the expected monetary value.

| Conditions | Probability | Sh.4.00 | Sh.4.30 | Sh.4.40 |
| :---: | :---: | :---: | :---: | :---: |
| Best possible | 0.2 | 200 | 0 | 2200 |
| Most likely | 0.6 | 800 | 50 | 0 |
| Worst possible | 0.2 | $\underline{0}$ | 1600 | 5600 |
| EOL |  | 520 | 350 | 1560 |

## Decision

Set a price of Sh. 4.30 since it minimises the EOL
Once the EMV has been calculated, the standard deviation and the coefficient of variation can also be computed as shown below:

$$
\begin{aligned}
\delta \text { Sh. } 4 & \left.=\sqrt{\left[(12000-7200)^{2} 0.2+(8000-7200)^{2} 0.6+(0-7200)^{2}\right.} 0.2\right] \\
& =3919
\end{aligned}
$$

The others are:
$\delta_{\text {sh } 4.3}=4679$
$\delta_{\text {sh } 4.4}=5898$

## Decision

Set a price of Sh. 4 because it minimises the standard deviation. The assumption here is that the decision maker is risk averse.

C. $V \operatorname{sh} 4.00=0.54$
C.V $\operatorname{sh} 4.30=0.63$
C.V $\operatorname{sh} 4.40=0.96$

## Decision

Set a price of Sh. 4 because it minimises the C.V (coefficient of variation)
1.6 Multi-stage decision making under risk (The use of decision trees)

Sequencing is concerned with the selection of an appropriate sequence or order of performing a series of jobs to be done on a finite number of machines or service facilities in some well defined technological order so as to optimize some measure of performance of the system, such as minimising overall cost, total elapsed time. Decision trees are used in solving sequential problems where there is an element of uncertainty. We use expected values to find the best alternative.

A decision tree is a graphical representation of decision process indicating decision alternatives, states of nature, associated probabilities and conditional pay-offs for each combination of decision alternatives and states of nature. It shows all the possible choices that can be made as branches on the tree. And all the possible outcomes for each choice as subsidiary branches on the tree.

A decision tree is beneficial for several reasons including:
It provides a pictorial representation of a sequential decision process.
It makes the expected value calculations easier because these calculations can be performed directly on the tree diagram.
The actions of more than one decision maker can be considered.
Steps followed in making the tree are:
$\square$ Define the problem or identify the objectives
$\square$ Identify the possible causes of action, (decision alternative)
$\square$ (Identify the possible states of nature/conditions
$\square$ Estimate the probabilities for each state of nature
$\square$ Estimate the conditional pay-off for each alternative and states of nature
$\square$ Draw the decision tree
Calculate the expected monetary value at each state of nature node using the roll back method.

## Illustration 1.3

A company making roof tiles has been considering the likely demand for the roof tiles over the next six years and think that demand pattern will be as follows:

| Situation | Prob. |
| :--- | :--- |
| High demand for 6 years | 0.5 |
| Low demand for 6 years | 0.3 |
| High demand for 3 years followed |  |
| by low demand for 3 years | 0.2 |

There is no possibility of low demand followed by high demand. Enlargement of capacity is required and the following are the available options.

Option A Install fully automatic facilities immediately at a cost of Sh.5.4 million.
Option B Install semi-automatic facilities immediately at a cost of Sh. 4 million.

Option C Install the semi-automatic facilities immediately as in B and upgrade to fully automatic at an additional cost of Sh .2 million in 3 years time provided demand has been high for 3 years.

The returns expected for the various demand and capacity options are estimated to be:
If high demand If low demand
Option A Sh.1.6m p.a. $\quad$ Sh. 0.6 m p.a.
B Sh. 0.9 p.a for 3 years then Sh. 0.8 m p.a.
0.5 p.a. for 3 years

C Sh.0.9 p.a. for 3 years, then Sh. 0.8 m p.a. for 3 years then
Sh.1.1 for 3 years Sh.0.3m p.a. for 3 years
What decisions should the firm take assuming that the objective is to maximise expected value?

## Solution

We develop the decision tree in two stages:
(a) Forward Pass (starting from the left and moving towards the right)
(b) Backward Pass (we start from the end and move backward as illustrated in the solution) Forward Pass

We draw the decision tree according to the information given the example.


## Backward Pass

Note that there are two decision points A and B, A at the start and B at the end of the first three years.
To evaluate expected values at $A$, it is necessary to evaluate expected values at $B$ because the decision at B will affect the decision at A . This is why this stage is known as the backward pass.


Therefore the expected value of upgrading is $2.34+0.261=0.604$
i.e. Sh. 0.604 m

The expected value of not upgrading is $($ Sh.1.065 +0.696$) \mathrm{m}$

$$
=\text { Sh. } 1.761 \mathrm{~m}
$$

The probability of high during the 2 nd 3 years using conditional probability

$$
=\frac{0.5}{0.5+0.2}
$$

$$
\approx 0.71
$$

Decision at B — Do not upgrade
The final diagram with exported values


Outcome at C

| Last 3 years | $1.6 \times 3 \times 0.71$ | $=$ | 3.408 |
| :---: | :---: | :---: | :---: |
|  | + $0.6 \times 3 \times 0.29$ | $=$ | $\underline{0.522}$ |
|  |  |  | 3.930 |
| At C, outcome from 1st three years |  | $=$ | $\underline{3} \times 1.6$ |
|  |  | $=$ | 4.8 |
| Total outcome at C |  | $=$ | $3.93+4.8$ |
|  |  | $=$ | 8.73 |

Outcome at D
$8.73 \times 0.7+0.6 \times 6 \times 0.3$

$$
\begin{array}{ll}
= & 6.111+1.08 \\
= & \text { Sh. } 7.191 \mathrm{~m}
\end{array}
$$

Outcome at B
For last 3 years
$=\quad$ Sh.1.761
plus $0.9 \times 3$
$=\quad \underline{2.7}$
Total $=$ Sh.4.461
Outcome at G

$$
\begin{aligned}
4.461 \times 0.7+0.8 \times 0.3 \times 6 & =3.167+1.44 \\
& =\text { Sh. } 4.607 \mathrm{~m}
\end{aligned}
$$

## Outcome at A

From Fully automatic $=(7.191-5.4)$

$$
=\quad \text { Sh. } 1.791 \mathrm{~m}
$$

From Semi-automatic $=$ (4.607-4)

$$
=\quad \text { Sh. } 0.607 \mathrm{~m}
$$

## Final Decision

Put in the fully automatic machinery at the outset.
(Please note that these answers have been worked out using approximate values for probabilities)

$$
\begin{array}{lll}
\underline{5} \\
7
\end{array}=0.71 \text { and } \quad \frac{2}{7} \quad 0.29
$$

Perfect and Imperfect Information
The uncertainty about the future outcome from taking a decision can be reduced by obtaining more information fast about what is likely to occur.

That information can be obtained from various sources e.g.
Market surveys
Conducting a pilot test
Building a prototype model
Hire consultants

Information can be categorised depending upon how reliable it is likely to be for predicting what would happen in the future and for helping managers to make better decisions.

Perfect information (PI) is information that can be guaranteed to predict the future with $100 \%$ accuracy, which, although it might be quite good, it could be wrong in it's prediction of the future.

Both perfect and imperfect information is costly and its value must be determined.
Value of perfect information $(\mathrm{Pi})=$ EMV with PI - EMV without PI.

## Illustration 1.4

Consider the ABC pricing decision (Illustration 1.1) and assume that it is possible to obtain ideal information at a cost of Sh. 500

## Required

Advice the company on whether to acquire the perfect information

$$
\begin{aligned}
\text { EMV with PI } & =0.2(12200)+0.6(8800)+0.2(0) \\
& =7720
\end{aligned}
$$

Value of perfect information $=7720-7370=$ Sh. 350
The decision is not to acquire perfect information since it costs more than its worth.
Imperfect Information (IPI)
Market research finding or information from pilot are likely to be reasonably accurate but can still be wrong in prediction. They provide imperfect information.

The value of IPI $=$ EMV with IPI $=$ EMV without IPI.

## Illustration 1.5

The financial director of Spinney Electrics is considering the national launch of a new washing machine. The potential sales of the product during its lifetime are classified as being either high, medium or low and the net present value of the machine sales under each of these three conditions is estimated to be Sh. 50 million, Sh. 10 million, and Sh. 20 million, respectively. The marketing director of Spinney Electrics estimates that there is a 0.4 probability that sales will be high, a 0.25 probability that they will be medium and a 0.35 probability that they will be low.

## Required:

(a) Assuming the company's objective is to maximise expected net present value, determine whether or not the new product should be launched.
(4 marks)
(b) Explain the meaning of 'expected value of perfect information'. Find the expected value of perfect information for this situation.
(5 marks)
(c) The financial director also has an alternative option. Instead of proceeding directly with a full national launch the company could test the market for the washing machine in their Midlands sales region. This would delay the national launch, and this delay, together with other outlays associated with testing the market, would lead to costs having a net present value of Sh.0.25 million. The test marketing in the Midlands sales region would yield information indicating whether the national launch is likely to be successful or unsuccessful. The following table shows the reliability of each of the possible indications.

|  |  | Actual national sales |  |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  | Probability | High | Medium | Low |  |
| Test <br> marketing <br> indication | Successful <br> national launch | 0.6 | 0.6 | 0.15 | 0.25 |
|  | Unsuccessful <br> national launch | 0.4 | 0.1 | 0.4 | 0.5 |

## For example,

If the test market indicates a successful national launch then the probability of low sales would be 0.25 . Also prior to the test market it is thought that the test market has a probability of 0.6 of indicating a successful national launch and 0.4 for an unsuccessful launch.
i. Represent this information in a decision tree and calculate the value of this imperfect information.
( 7 marks)
ii. Give advice to the financial director as to whether or not the company should test the market in their Midlands region. In your advice explain why this method of analysis should not be relied upon entirely when making appropriate decisions.

## Solution

This question concerns the use of decision trees (or decision tables) to structure and resolve a decision problem.
(a) The initial problem is to determine whether or not to launch the new product. The information can be summarised in a decision tree.


The values given in the nodes of the decision tree are the expected values of the remainder of the tree from that point. If the launch takes place the expected profit is Sh. 15.5 million, compared with zero if no launch takes place. Clearly, it is advisable to launch the product, given the information available.
(b) The expected value of perfect information gives the increase in profit that would be achieved if the decision maker knew what the outcome to the decision would be. The value of perfect information is calculated by finding the expected profit that would be achieved with perfect information and subtracting from it the expected profit from the strategy which is best in the absence of perfect information. Although perfect information is rarely available, it can be used as a benchmark against which the cost of information can be compared.

In this example, if the decision maker knew beforehand that sales would be either medium or high he would still launch the product, but if he knew it would be low he would recommend no such launch.

Hence the expected payoff from perfect information is

$$
\mathrm{EPPI}=(50 \times 0.4)+(10 \times 0.25)+(0 \times 0.35)=22.5(\text { Sh.m })
$$

Hence the expected value of perfect information is

$$
22.5-15.5 \quad=\quad \text { Sh. } 7 \text { million }
$$

(c) i.The table can be converted to probabilities in the following way:

| S | $=$ | indication of successful national launch |
| :--- | :--- | :--- |
| U | $=$ | indication of unsuccessful national launch |
| H | $=$ | high sales in national launch |
| M | $=$ | medium sales in national launch |
| L | $=$ | low sales in national launch |

Hence we have

| $\mathrm{P}(\mathrm{S})$ | $=0.6$ | $\mathrm{P}(\mathrm{U})$ | $=0.4$ |  |
| :--- | :--- | :--- | :--- | :--- |
| $\mathrm{P}(\mathrm{HIS})=0.6$ | $\mathrm{P}(\mathrm{MIS})$ | $=0.15$ | $\mathrm{P}(\mathrm{LIS})=0.25$ |  |
| $\mathrm{P}(\mathrm{HIU})=0.1$ | $\mathrm{P}(\mathrm{MIU})$ | $=0.4$ | $\mathrm{P}(\mathrm{LIU})=0.5$ |  |

A further branch is now added to the decision tree described in part (a).


Using rollback analysis for decision trees, the expected profit if the market is tested in the Midlands sales region is Sh. 15.65 million. Hence the value of this imperfect information is

$$
\text { Sh.15.65m - Sh.15.5m } \quad=\quad \text { Sh.150,000 }
$$

ii. From a financial point of view, it is clear that the market should be tested prior to the national launch.

However the whole analysis is fraught with difficulties and approximations. For example, the potential sales of the product would cover a large number of possible values, and there is considerable approximation in classifying into only three categories. In addition, it is likely that the assigned probabilities are only approximations. Also the sales take place in the future when different market conditions may occur. We should also be aware that the financial amounts might not be the most appropriate unit on which to base the decision.

This type of analysis can give an indication of a likely outcome and is useful in ensuring that a manager does not make inconsistent decisions.

## Illustration 1.6

Assume that a small oil company is trying to decide whether or not to drill on a particular site. The chief engineer has made the following estimate from past experience.
$\mathrm{P}($ Oil $)=0.2$
$\mathrm{P}($ no oil $)=0.8$
It is possible for the company to hire a firm of international consultants to carry out a survey of the site. The company has estimated.

If there is oil then there is a $95 \%$ chance that the report will be favourable
If there is no oil there is a $10 \%$ chance that the report will be favourable

$$
\begin{array}{ll}
\text { The cost of drilling } & =\text { Sh. } 10 \text { million } \\
\text { Value of benefit if oil is found } & =\text { Sh. } 70 \text { million } \\
\text { Cost of information } & =\text { Sh. } 3 \text { million }
\end{array}
$$

## Required:

Advice the company on whether to hire the consultant and compute the value of sample (imperfect) information.

## Solution

Let $\quad \mathrm{F}$ be Favourable report showing there is oil
$F^{1}$ be adverse report showing there is no oil O be there is oil N be there is no oil

The prior probabilities are:
$\mathrm{P}(\mathrm{F} / 0)=0.95 \quad \mathrm{P}\left(\mathrm{F}^{1} / 0\right)=0.05$
$\mathrm{P}(\mathrm{F} / \mathrm{N})=0.10$
$\mathrm{P}\left(\mathrm{F}^{1} / \mathrm{N}\right)=0.90$
The first step is to revise the probabilities using Bayes theorem which is given as follows:

$$
P(B / A)=\frac{P(B) * P(A / B)}{P(A)}=\frac{P(B \text { and } A)}{P(A)}
$$

Therefore:
$\mathrm{P}(\mathrm{O} / \mathrm{F})=\frac{\mathrm{P}(0) \mathrm{XP}(\mathrm{F} / 0)}{\mathrm{P}(\mathrm{F})}$
$\mathrm{P}(\mathrm{F})=\mathrm{P}(0) \mathrm{XP}(\mathrm{F} / 0)+\mathrm{P}(\mathrm{N}) \mathrm{XP}(\mathrm{F} / \mathrm{N})$
$=0.2 \mathrm{X} 0.95+0.8 \mathrm{X} 0.1=0.27$
$\begin{aligned} \mathrm{P}\left(\mathrm{F}^{\prime}\right) & =1-0.27 \\ & =0.73\end{aligned}$
$\mathrm{P}(0 / \mathrm{F})=\underline{\mathrm{P}(0) \mathrm{XP}(\mathrm{F} / 0)}$
$\mathrm{P}(\mathrm{F})$
$=\underline{0.2 \times 0.95}$
0.27
$=0.7037$
$\mathrm{P}(\mathrm{N} / \mathrm{F}) \quad=1-0.704$
$=0.296$
$\mathrm{P}\left(\mathrm{N} / \mathrm{F}^{\prime}\right) \quad=\underline{\mathrm{P}(\mathrm{N}) \mathrm{XP}\left(\mathrm{F}^{\prime} / \mathrm{N}\right)}$
$\mathrm{P}\left(\mathrm{F}^{\prime}\right)$
$=\frac{0.8 \mathrm{X} 0.9}{0.73}$
$=0.9863$
$\begin{array}{rll}\mathrm{P}\left(0 / \mathrm{F}^{\prime}\right) & = & 1-0.986 \\ & = & 0.014\end{array}$

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Using the above probabilities a decision tree can be constructed as follows:


Evaluation using EMV
Emv @ $\mathrm{A}=70(0.704)+0(0.296)=49.28$
Emv @ B $=70(0.014)+0(0.986)=0.98$
$\operatorname{Emv} @ C=70(0.2)+0(0.8)=14$
$\operatorname{Emv} @ \mathrm{D}=39.28(0.27)+0(0.73)=10.6056$

## Decision

Hire the consultant and if the report is favourable drill and if the report is adverse don't drill. The expected monetary value would be Sh. 7.6056 million made up of a profit of Sh. 57 million with a probably $0.27 \times 0.704=0.19$
A loss of Sh. 13 million, with prob. $0.296 \times 0.27=$
0.08 Loss of Sh. 3 million pounds with prob. 0.733
$\mathrm{EMV}=(57 \mathrm{X} 0.19) *(13 \mathrm{X} 0.08)-(3 \mathrm{X} 0.73)$
$=7.6$ million
Value of imperfect information
= EMV with IPI - EMV without IPI
$=$ Sh. $10.61 \mathrm{~m}-$ Sh. $4 \mathrm{~m}=$ Sh. 6.61 million

## REINFORCING QUESTIONS

## QUESTION ONE

The Oil Kenya Company currently sells three grades of petrol, regular, premium and `regular extra' which is a mixture of regular and premium. Regular Extra is advertised as being "at least 50 percent premium". Although any mixture containing 50 per cent or more premium fuel could be sold as 'regular extra' it is less costly to use exactly 50 per cent. The percentage of premium fuel in the mixture is determined by one small valve in the blending machine. If the valve is properly adjusted, the machine provides a mixture which is 50 percent premium and 50 percent regular. Assume that if the valve is out of adjustment the machine provides a mixture which is 60 percent premium and 40 percent regular. Once the machine is started it must continue until 100,000 litres of 'regular extra' have been mixed.

The following data is available:

## Shs

Cost per litre—premium 3.20
Cost per litre—regular $\quad 3.00$
Cost of checking valve 800.00
Cost of adjusting the valve $\quad 400.00$
Subjective estimates of the probabilities of the valve's condition are estimated to be:
Event Probability

Valve in adjustment 0.7
Valve out of adjustment 0.3

## Required:

(a) The expected cost of checking the valve and adjusting it if necessary. (5 marks)
(b) The conditional cost of not checking the valve when it is out of adjustment (5 marks)
(c) Using the criterion of minimum expected cost, calculate the probability at which there will be need to check if the valve is out of adjustment. Comment on the results.
(5 marks)
(d) Comment on the results obtained in (a) and (b) above. (5 marks)

## QUESTION TWO

Chakula Engineering Company Limited (CECL) recently sent their chief designer to the USA and UK to review developments in the American and British markets. He has now returned with details of a new type of food mixer that is being developed over there. CECL are considering the design and manufacture of a liquidizer gadget attachment to be used as an extra gadget for the new mixer when it is sold in Kenya. The chief designer's notes show that $10 \%$ of the experts he questioned in both the UK and USA believed the new mixer would reach the Kenyan market in a year's time, whereas $30 \%$ thought it would be launched in four years time, and the remainder suggested a five-year delay before it reached Kenya. The present value (PV) of net cash flows from making and selling liquidizer are estimated by the company to be Shs 8 million, if the market develops four years from now and 3.2 million if it develops five years from now.

CECL have not developed a liquidizer before, and whilst its immediate development would cost Shs 2 million, they feel they have only a $50 \%$ chance of a successful development at present. A number of alternative courses of action present themselves. The company could abandon the whole project, or wait for one year to see if the mixer has penetrated the Kenyan market. They could then abandon or develop the liquidizer at a PV cost of Shs 1.8 million, with a $70 \%$ chance of success, but they would be late into
the market and the PV of their receipts they estimate at Shs 4.8 million. A further alternative is that the company could delay a decision for a second year, and then abandon or develop the project. Development costs at that stage would have a PV of Shs 1.4 million, including the expenditure of Shs 400,000 on acquiring extra product data during the second year of delay, and the chance of a successful development would be $90 \%$. At this point, however, the mixer could only come on the market at the four or five year point from now.

## Required:

Using a decision tree approach, advise the company on the course of action to adopt. ( 20 marks)

## QUESTION THREE

Siku Kuu Ltd. Manufactures and distributes a line of Christmas gifts. The company had neglected to keep its gifts line current. As a result, sales have decreased to approximately 25,000 units per year fro a previous high of 125,000 units. The gifts have been redesigned recently and are considered by company officials to be comparable to its competitors' models. The company plans to redesign the gifts each year in order to compete effectively. Kama Kawaida, the Sales Manager, is not sure how many units can be sold next year, but she is willing to place probabilities on her estimates. Kama Kawaida's estimates of the number of units that can be sold during the next year and the related probabilities are as follows:

Estimated

| Sales in units | probabilities |
| :--- | :---: |
| 50,000 | 0.10 |
| 75,000 | 0.40 |
| 100,000 | 0.30 |
| 125,000 | 0.20 |

The units would be sold for sh. 500 each. The inability to estimate the sales more precisely is a problem for Siku Kuu Ltd. the number of units of this product is small enough to schedule the entire year's sales in one production run.

If the demand is greater than the number of units manufactured, then sales will be lost. If the demand is below supply, the extra units cannot be carried over to the next season and would be given away to various charitable organizations.

The production and distributions cost estimates are as follows:
Units manufactured

|  |  | $\underline{50,000}$ | $\underline{75,000}$ | $\underline{100,000}$ | $\underline{125,000}$ |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Variable costs | (Sh) | $9,900,000$ | $14,850,000$ |  | $19,800,000$ |
| (Sh | $\underline{7,700,000}$ | $\underline{7,700,000}$ | $\underline{8,800,000}$ | $\underline{8,800,8000}$ |  |
| Fixed costs | (Sh) | $\underline{17,600,000}$ | $\underline{22,550,000}$ | $\underline{28,600,000}$ | $\underline{33,550,000}$ |
| Total costs |  |  |  |  |  |

The company intends to analyze the data to facilitate making a decision as to the proper size of the production run.

## Required:

a) Prepare a payoff table for the different sizes of production runs required to meet the four sales estimates prepared by Kama Kawaida for Siku Kuu Ltd.
If Siku Kuu Ltd. relied solely on the expected monetary value approach to make decisions, what size of production run would be selected?
b) Identify the seven basic steps that are taken in any decision process. Explain each step by reference to the situation presented by Siku Kuu Ltd. and your answer to requirement (a) (14 marks)
(Total: 20 marks)

## LESSON TWO

## COST ESTIMATION AND FORECASTING

## OBJECTIVES

Examine the methods of estimating and forecasting costs.

## INSTRUCTIONS

1. Read the Study Text and Chapters 24 of Management and Cost Accounting by Colin Drury.
2. Attempt the reinforcing questions at the end of the lesson under examination conditions
3. Compare your answers with those given in Lesson 10

## CONTENTS

2.1 Steps of Developing A Cost Estimating Relationship.
2.2 Cost Estimation Method
2.3 Regression Analysis
2.4 Evaluation of the Regression Model
2.5 Multiple Regression
2.6 Learning Curve Theory

## STUDY TEXT

In this chapter, you will learn to use cost estimating relationships to estimate and forecast costs. As the name implies, a cost estimating relationship (CER) is a technique used to estimate a particular cost or price by using an established relationship with an independent variable. If you can identify an independent variable (cost driver) that demonstrates a measurable relationship with contract cost or price, you can develop a CER. Note that CER may be mathematically simple in nature (e.g., a simple ratio) or it may involve a complex equation (e.g. Multiple regression analysis).

### 2.1 STEPS OF DEVELOPING A COST ESTIMATING RELATIONSHIP.

Strictly speaking, a CER is not a quantitative technique. It is a framework for using appropriate quantitative techniques to quantify a relationship between an independent variable and cost or price. Development of a CER is a 6 -step process shown below:
Step 1. Define (or select) the dependent variable (Y)
Will the CER be used to estimate price, cost, labor hours, material cost, or some other measure of cost? Will the CER be used to estimate total product cost or estimate the cost of one or more components? The better the definition of the dependent variable, the easier it will be to gather comparable data for CER development.
The dependent variable is the cost to be predicted and it is choice depends on the purpose of the cost function. It may also be referred to as response variable.

## Step 2. Select the cost driver(s)

This may also be referred to as independent, explanatory or predictor variable. A cost driver can be defined as any factor whose change causes a change in the total cost of an activity.

## Examples of potential cost driver

## Direct labour hours

Machine hours
Number of units
$\square$ Number of production runs
$\square$ Number of orders, etc.
The potential cost driver should be plausible (i.e. make economic sense) and should be accurately measured.
In selecting potential cost drivers for CER development Consider the following factors:
Variables should be quantitatively measurable. Parameters such as maintainability are difficult to use in estimating because they are difficult to measure quantitatively.
Data availability is also important. If you cannot obtain historical data, it will be impossible to analyse and use the variable as a predictive tool. For example, an independent variable such as physical dimensions or parts count would be of little value during the conceptual phase of system development when the values of the independent variables are not known. Be especially wary of any CER based on 2 or 3 data observations.
If there is a choice between developing a CER based on performance or physical characteristics, performance characteristics is generally the better choice, because performance characteristics are usually known before design characteristics.

## Step 3. Collect data concerning the relationship between the dependent and independent variables.

Collecting data is usually the most difficult and time-consuming element of CER development. It is essential that all data be checked and double checked to ensure that all observations are relevant, comparable, relatively free of unusual costs.

A sufficient number of past observations must be obtained to derive an acceptable cost function. This should be adjusted to reflect any change of circumstances e.g. changes in price levels caused by inflation, changes in types of equipment used, etc. The time period used to measure the dependent variable and the cost driver should be the same.

## Step 4 Plot the data on a graph

The graph (usually referred to as a scatter diagram) will indicate the general relationship between the dependent variable and the cost driver and will give a visual indication as to whether a lineal cost function can approximate the cost behaviour. It will also highlight extreme observations (outliers).

## Step 5. Select the relationship that best predicts the dependent variable.

After exploring a variety of relationships, you must select the one that can best be used in predicting the dependent variable. Normally, this will be the relationship that best predicts the values of the dependent variable. A high correlation (relationship) between a potential independent variable and the dependent variable often indicates that the independent variable will be a good predictive tool. However, you must assure that the value of the independent variable is available in order for you to make timely estimates. If it is not, you may need to consider other alternatives.
There are various methods that can be used to estimate the cost function. Examples
include: Engineering method
Account analysis
Regression analysis
High low method
Time series analysis
Simulation analysis

## Step 6: Test the reliability of the cost function

There are three main tests that should always be done. These include:
Logical relationship tests
Goodness of fit test
Specification tests (Tests of the assumptions of the model)

### 2.2 COST ESTIMATION METHOD

## Engineering method

These methods are based on the use of engineering analysis of technological relationship between inputs and outputs e.g. method studies and time and motion studies.

The procedure in such a study is to make an analysis based on direct observation of the underlying physical quantities required for an activity and then to convert the final result into cost estimate.

This method is useful for estimating costs of repetitive processes where input and output relationship is clearly defined e.g. the cost associated with direct materials, direct labour and machine time.

## Account analysis (Inspection of accounts) method

This method requires that departmental managers and the accountant inspect each item of expenditure within the accounts for some output level and then classify each of these items as wholly fixed, wholly variable or mixed.

A single average unit cost figure is selected for the items categorised as variable whereas a single total cost for the period is used for the items categorised as fixed.
Mixed costs are decomposed into their variable and fixed components.

## High low method (Two point method)

Under this method, records of costs in the previous period are reviewed and the costs of 2 periods are selected. These are the period with the highest level of outputs and the period with the lowest output. A line passing through these two points is then established and used in estimating costs.

## Illustration 2.1

The production manager of XYZ Company, is concerned abut the apparent fluctuation in efficiency and wants to determine how labour costs (in Sh.) are related to volume. The following data presents results of the 12 most recent weeks.

| Week No. | Units Produced(X) | Labour Costs(Y) |
| :---: | :---: | :---: |
| 1 | 34 | 340 |
| 2 | 44 | 346 |
| 3 | 24 | 287 |
| 4 | 36 | 262 |
| 5 | 30 | 220 |
| 6 | 49 | 416 |
| 7 | 39 | 337 |
| 8 | 21 | 180 |
| 9 | 41 | 376 |
| 10 | 47 | 295 |
| 11 | 34 | 215 |
| 12 | 24 | 275 |

## Required:

Estimate the cost function using:
The high low method
Regression analysis
Assume that the Company intends to produce
45 units
34 units next period
Estimate the labour cost to be incurred.

## Solution

We will first use the high-low method to establish the cost function.
High low method

| Highest point | X | Y |
| :--- | :--- | :---: |
| 416 | $\underline{21}$ | $\underline{280}$ |
| Lowest point | $\underline{28}$ | $\underline{\underline{186}}$ |
| Difference | $\underline{236}$ | $=8.43$ |
| Gradient/ slope |  |  |

The function will be:

$$
Y=a+b x
$$

We can Substitute the lowest points $(21,180)$
$180=a+8.43(21)$

$$
\mathrm{a}=2.97 . \text { This can be approximated to } 3
$$

The predicting equation is therefore $\mathrm{Y}=3+8.43 \mathrm{x}$
i. if $\mathrm{X}=45$ units
$\mathrm{Y}=3+8.43 * 45$
$=$ Sh. 382.35
ii. $34 \mathrm{Y}=3+8.43(34)$

$$
=\text { Sh. } 289.62
$$

## Note:

The main problems of the high low method are:
Reliability is low
It Ignores all the other points except the highest and lowest which in most cases are outliners.

### 2.3 REGRESSION ANALYSIS

A regression equation identifies an estimated relationship between a dependent variable (the cost) and one or more independent variables (the cost driver). When the equation includes only one independent variable then it is referred to as simple regression and its form is:
$\tilde{Y}=a+b x$
Where,

## $\tilde{Y}$ is the predicted value of $Y$

a and b are Constant x is the cost driver

When the equation includes 2 or more independent variables, it is referred to as multiple regression and is of the form:
$\mathrm{Y}=\mathrm{a}+\mathrm{b}_{1} \mathrm{x}_{1}+\mathrm{b}_{2} \mathrm{x}_{2}+\ldots \ldots . \mathrm{b}_{\mathrm{n}} \mathrm{x}_{\mathrm{n}}$ for n independent variables.

## Simple Regression

Regression analysis determines mathematically the regression line of best fit. It is based on the principle that the sums of squares of the vertical deviation from the line established is the least possible
^ 2
I.e. $\sum(Y-Y) \quad$ is minimised
where Y is the observed value of the dependent variable
$\hat{Y}$ is the predicted value of Y

The equation can be solved by the use of normal equations and these are:

1. $\Sigma y=\mathrm{na}+\mathrm{b}(\Sigma x)$
$\Sigma x y=\mathrm{a}(\Sigma x)+\mathrm{b}\left(\Sigma x^{2}\right)$
From these normal equations:

$$
\begin{aligned}
& \mathrm{b}=\frac{\mathrm{n} \frac{\sum x y}{\mathrm{n} \sum \mathrm{x}} \frac{\sum x}{2-} \frac{\Sigma y}{\left(\sum \mathrm{x}\right)^{2}}}{}=\frac{\underline{\Sigma Y}-\underline{\mathrm{b} \sum \mathrm{x}} \mathrm{n} \mathrm{n}}{\mathrm{a}=}
\end{aligned}
$$

Looking at illustration 2.1, then we first compute the sum of $\mathrm{X}, \mathrm{Y}, \mathrm{XY}, \mathrm{X}^{2}$ and $\mathrm{Y}^{2}$
The table below shows these summations.

| Week No. | Units X) | L.Costs(Y) | XY | $\mathrm{X}^{2}$ | $Y^{2}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 34 | 340 | 11560 | 1156 | 115600 |
| 2 | 44 | 346 | 15224 | 1936 | 119716 |
| 3 | 24 | 287 | 8897 | 961 | 82369 |
| 4 | 36 | 262 | 9432 | 1296 | 68644 |
| 5 | 30 | 220 | 6600 | 900 | 48400 |
| 6 | 49 | 416 | 20384 | 2401 | 173056 |
| 7 | 39 | 337 | 13143 | 1521 | 113569 |
| 8 | 21 | 180 | 3780 | 441 | 32400 |
| 9 | 41 | 376 | 15416 | 1681 | 141376 |
| 10 | 47 | 295 | 13865 | 2209 | 87026 |
| 11 | 34 | 215 | 7310 | 1156 | 46225 |
| 12 | $\underline{24}$ | $\underline{275}$ | $\underline{6600}$ | 576 | 75625 |
|  | 430 | 3549 | 132,211 | $\underline{16234}$ | $\underline{1104005}$ |

Value of b can be calculated as follows:
$\mathrm{b}=\underline{12(132211)-430(3549)}=6.10$

$$
\begin{gathered}
12(16234)-(430)^{2} \\
a=\frac{3549}{12}-6.10 \frac{(430)}{12}=77.08
\end{gathered}
$$

Therefore the predicting function is $\hat{\mathrm{Y}}=\underline{77.08+6.1 \mathrm{X}}$
b. i. If $X=45$ units, then

$$
\begin{aligned}
\hat{Y} & =77.08+(6.1 \times 45) \\
& =\text { Sh. } 351.58
\end{aligned}
$$

ii. If $\mathrm{X}=34$ units, then

$$
\begin{aligned}
\hat{Y} & =77.08+(6.1 \times 34) \\
& =\text { Sh. } 284.48
\end{aligned}
$$

## Illustration 2.2

Assume that the company (in illustration 2.1) intends to spend Sh. 400 on labour cost next period. Compute the number of units that the company may produce.

## Solution

Note:
$\hat{Y}=a+b x$ is a regression of $Y$ on $X$ i.e. $Y=f(x)$
We require a regression of X on Y. i.e. $\mathrm{X}=\mathrm{g}(\mathrm{Y})$ to answer the above question. The general format of the equation is:

$$
a^{1}=8.3286
$$

Therefore the predicting equation is $X=8.33+0.093 \mathrm{Y}$
Thus if the Company intends to spend Sh. 400 on labour, the number of units to be produced will be:

$$
\begin{gathered}
X=8.33+0.093(400) \\
=45.56 \text { units }
\end{gathered}
$$

Approximately 46 units

### 2.4 EVALUATION OF THE REGRESSION MODEL

The regression equation calculated above was based on the assumption that cost varied with the units produced. However, a number of different activity measures exist such as direct labour hours, direct labour cost, number of production runs, etc.

It is important therefore to determine the reliability of the estimated cost function. Various tests of reliability can be applied. These tests can be grouped into 3:

Logical relationship tests
Goodness of fit tests
Specification tests
Logical relationship tests

$$
\begin{aligned}
& X=a^{1}+b^{1} Y \\
& \mathrm{~b}=\underline{\mathrm{n}} \underline{\Sigma x y}=\underline{\Sigma x} \underline{\Sigma} \underline{y} \\
& n \Sigma Y^{2-}(\Sigma Y)^{2} \\
& a=\underline{\Sigma X}-\underline{b \Sigma Y} n \\
& \text { n } \\
& b^{1}=\underline{12(132,211)-(430 \times 3549)} \\
& 12(1,104,005)-(3549)^{2} \\
& =0.0926 \\
& \mathrm{a}^{1}=\frac{430}{12}-\frac{0.0926(3549)}{12}
\end{aligned}
$$

These tests, also referred to as economic plausibility test, are used to determine whether there is an expected logical relationship between the independent and the dependent variable.

To carry out this test, it is important to understand the input-output relationship in the company.
For the illustration there is an expected logical relationship between the number of units and the labour cost mainly because the higher the number of units, the higher the number of labour hours and therefore the higher the labour cost.

Goodness of fit tests

These tests can be divided into two:
Testing the whole model
Testing the slope

## Testing the whole model

Tests of the whole model are used to determine the reliability of all the independent variables taken together. The measures used are:
Coefficient of determination ( $r^{2}$ )
Std error of the estimate
F-test

## I. Coefficient of Determination ( $\mathrm{r}^{2}$ )

If the regression line calculated by the least square method were to fit the actual observations perfectly, then all observed points would lie on the regression line. The coefficient of determination, $\mathrm{r}^{2}$, explains the amount of variation in Y which is explained by the introduction of X in the model. A perfect linear relationship between X and Y would result in $\mathrm{r}^{2}$ being equal to 1 .
$\mathrm{r}^{2}=$ explained variation
Total variation

$$
=\frac{\Sigma(\hat{Y}-\hat{y})^{2}}{\sum(\mathrm{Y}-\hat{y})^{2}}
$$

Where ý is the mean value of Y
For computation purposes $\mathrm{r}^{2}$ can be given by

$$
\mathrm{r}^{2}=\frac{\left(\mathrm{n} \Sigma \mathrm{xy}-\Sigma \mathrm{x} \underline{\mathrm{x}} \mathrm{x}^{2}\right)^{2}}{\left[\mathrm{n} \Sigma \mathrm{x}^{2}-(\Sigma \mathrm{x})^{2}\right]\left[\mathrm{n} \Sigma \mathrm{y}^{2}-(\Sigma \mathrm{y})^{2}\right]}
$$

From the illustration 2.1

$$
\begin{aligned}
& =\frac{[12(132211)-(430)(3549)]^{2}}{\left[12(16234)-(430)^{2}\right]\left\{12\left(1104005-(3549)^{2}\right\}\right.} \\
& =0.565
\end{aligned}
$$

About $56.5 \%$ of the variations in labour cost can be explained by variations in units produced while about $43.5 \%$ of the variation in labour cost is explained by other independent variables and the error term.

## Note

The higher the $r^{2}$, the better the function is. As a rule of thumb, $r^{2}$ must be at least equal to 0.8 .

## II. Standard error of estimate ( $\mathrm{S}_{\mathrm{e}}$ )

The coefficient of determination $r^{2}$ gives us an indication of the reliability of the estimate of total cost based on the regression equation but it does not give us an indication of the absolute size of the probable deviations from the line established. This information can be obtained by calculating the standard error of estimate given by the following formula.

$$
\sqrt{\sum_{n-2}^{\frac{(Y-Y)^{\wedge^{2}}}{}}}
$$

For computation purpose,
$\mathrm{S}_{\mathrm{e}}=\sqrt{\frac{\sum Y^{2}-a \sum Y-b \sum X Y}{n-k-1}}$
Where k is the no. of independent variables
For illustration 1.2


$$
=48.95
$$

The sample size, $n$, is reduced by 2 because 2 variables ' $a$ ' \& ' $b$ ' in the regression equation had to be estimated from the sample observations.

The calculation of the standard error is necessary because the least square line was calculated from sample data. Other samples would probably result in different estimates. Obtaining the least square calculation over all the possible observations that might occur would result in the calculation of the true least square line. The question is "How close does the sample estimate of least square line come to the true least square line.

Standard error is similar to standard deviation in normal probability analysis. It is a measure of variability around the regression line. The std error of estimates enables us to establish a range of values of the dependent variable within which we may have some degree of confidence that the true value lies. We can use the following equation to establish this range:

$$
\hat{\mathrm{Y}}-\mathrm{t}_{\mathrm{c}} \mathrm{~S}_{\mathrm{e}} \leq \mathrm{Y} \leq \hat{\mathrm{Y}}+\mathrm{t}_{\mathrm{c}} \mathrm{~S}_{\mathrm{e}}
$$

From illustration 2.1, where $\hat{\mathrm{Y}}_{34}=284.48$, the $95 \%$ confidence interval can be calculated as follows:
284.48-2.2281(48.95) $\leq \mathrm{Y} \leq 284.48+2.2281$ (48.95)
$\leq \mathrm{Y} \leq 393.6$
We are $95 \%$ confident that if X is estimated to be 34 units next period, the true labour cost will lie between 175.4 and 393.6. Note $t_{c}$ from the student $T$ tables, with 10 degrees of freedom and $5 \%$ significance level, is equal to 2.2281 .

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## III. The F -test

The significance of the regression results can be tested by using the F- statistics. The F-statistics is a ratio which compares the explained sum of squares and the unexplained sum of squares.

## Therefore $\mathrm{F}=\underline{\text { mean sum of squares due to regression }}$ <br> Mean sum of squares due to residual

For calculation purposes:

$$
F=\frac{r^{2} / K}{\left(1-r^{2}\right) / n-k-1}
$$

$F$ statistics can then be used to test the hypothesis that the relationship between the dependent variables and all the independent variables is not significant.

## The Steps followed in the F- Test are:

## State the hypothesis

$\mathrm{H}_{\mathrm{o}}$ : Relationship between Y and all Xs is not significant.
$H_{A}$ : Relationship between Y and all Xs is significant
State the significant level

$$
\alpha=5 \%
$$

State the test statistics

$$
F=\frac{r^{2} / K}{\left(1-r^{2}\right) / n-k-1}
$$

State the decision rule

4.965
$\mathrm{k}=1$
$\mathrm{n}-\mathrm{k}-1=10$
$\alpha=0.05$
$\mathrm{F}_{\mathrm{c}}=4.965$

## Computation of F statistics

$$
\begin{aligned}
\mathrm{F} & =\frac{0.565 / 1}{(1-0.565) /(12-1-1)} \\
& =12.989
\end{aligned}
$$

## Conclusion

Since the computed $\mathrm{F}>\mathrm{F}_{\mathrm{c}}$ then we reject $\mathrm{H}_{\mathrm{o}}$. Therefore the relationship between the labour cost and the number of units is significant.

## Testing the Slope

The strength of the relationship between the dependent variable and each of the independent variables can be determined using 3 methods:

Correlation coefficient (r)
Standard error of the slope ( Sb )
Z or t statistics.

## Correlation coefficient (r)

The correlation coefficient measures the degree of association between two variables such as the cost and the activity level.

$$
\mathrm{r}=\frac{\mathrm{n} \sum \mathrm{xy}}{\left[\mathrm{n} \sum \mathrm{x}^{2}-\left(\sum \mathrm{x}\right)^{2}\right]\left[\mathrm{n} \Sigma \mathrm{y}^{2}-(\Sigma \mathrm{y})^{2}\right]}
$$

If the degree of association between two variables is very close then it would be almost possible to plot the observation on a straight line and $r$ will be almost equal to one.

For illustration 2.1,
$r=\sqrt{r^{2}}=\sqrt{0.565}=0.752$
$-1 \leq \mathrm{r} \leq 1$
If $r=-1$, then the two variables are said to be perfectly negatively correlated
If $r=+1$, then the two variables are perfectly positively correlated
If $r=0$, then there is no correlation between the two variables.

## Std error of the slope ( $\mathrm{S}_{\mathrm{b}}$ )

The reliability of the estimate of the regression coefficient ' $b$ ' (i.e. the variable cost), is important since the analyst usually focuses on the rate of variability rather than the absolute level of prediction. This can be established by the use of the standard error of the slope.

The standard error of ' $b$ ' coefficient can be expressed as follows:

$$
\mathrm{S}_{\mathrm{b}}=\frac{\mathrm{S}_{\mathrm{e}}}{\sqrt{\sum(\mathrm{x}-\mathrm{x})^{2}}}
$$

For calculation purposes,


We can then use $\mathrm{S}_{\mathrm{b}}$ to construct confidence intervals using t distributions such that the true variable cost, $B$, will be:
$\mathrm{b}-\mathrm{t}_{\mathrm{c}} \mathrm{S}_{\mathrm{b}} \leq \mathrm{B} \leq \mathrm{b}+\mathrm{t}_{\mathrm{c}} \mathrm{S}_{\mathrm{b}}$
where $b$ is the estimated value of $B$
For illustration 1.2, the $95 \%$ Confidence Interval for the true variable cost will be:

$$
\begin{array}{r}
6.1-2.2281(1.7) \leq \mathrm{B} \leq 6.1+2.2 .281(1.7) \\
2.3122 \leq \mathrm{B} \leq 9.8878
\end{array}
$$

We are $95 \%$ confident that the true variable cost, B , lies between 2.31 and 9.89

## Z or t Statistics

If $\mathrm{n} \geq 30$ we use Z , if, $\mathrm{n}<30$ we use t statistics. These statistics can be used to test the hypothesis: Ho: $\mathrm{B}=\mathrm{O}$ that is, there is no relationship between X and Y
HA: $\mathrm{B} \neq \mathrm{O}$ There is a significant relationship between X and Y
The level of significance is $\alpha=0.05$
The degrees of freedom $=n-k-1$
For illustration 1.2 $\quad \mathrm{Df}=12-1=10$
Test statistics $\quad \mathrm{T}=\underline{\mathrm{b}}$
Sb

The critical value of T for illustration 1.2 is 2.2281
Computation for illustration 2.1
$\mathrm{T}=\underline{6.1}=3.59$
1.7

## Conclusion

Reject Ho since computed $T>t_{c}$. This means that there is a significant relationship between the labour costs and number of units.

## SPECIFICATION TESTS

These tests are used to test the validity of the regression assumptions. The necessary assumptions in linear regression are:

The underlying relationship between X and Y is linear.
The independent variable X is assumed to be known and is used to predict the dependent variable Y .

The errors or the residuals given by $\sum(Y-Y)^{2}$ are assumed to:
Be normally distributed.
Have and expected value (mean) of Zero (0).
Have a constant variance. This is referred to as homoscedasticity. If not constant we have heteroscedasticity.
Be independent i.e. they are not serially correlated or there is no autocorrelation.
The Specification tests can be done for illustration 2.1 as follows:

| Week | Units | L. $\operatorname{cost}(\mathrm{Y})$ | $\hat{Y}$ | $\mathrm{e}_{\mathrm{i}}=\mathrm{y}-\hat{Y}$ | $\underline{\text { ei }}$ - e | $(\mathrm{ei}-\mathrm{ei})^{2}$ | $\mathrm{e}^{2}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 34 | 340 | 28448 | 55.52 | - | - | - |
| 2 | 44 | 346 | 343.48 | 0.52 | -55 | 3025 | 002704 |
| 3 | 31 | 287 | 266.18 | 20.82 | -20.3 | 4409 | 433.4 |
| 4 | 36 | 262 | 296.68 | -34.68 | -55.5 | 44.09 | 433.4 |
| 5 | 30 | 220 | 260.08 | -40.02 | 5.4 | 29.16 | 1606.41. |
| 6 | 49 | 416 | 375.98 | 40.02 | -80.1 | 6416.01 | 1601.60 |
| 7 | 39 | 337 | 314.98 | 22.02 | 18 | 324 | 484.88 |
| 8 | 21 | 180 | 205.18 | -25.18 | 47.1 | 227.84 | 634.0 |
| 9 | 41 | 376 | 327.18 | 48.82 | -4 | 5476 | 2383.39 |
| 10 | 47 | 295 | 363.78 | -68.78 | 117.6 | 13829.76 | 4730.69 |
| 11 | 34 | 215 | 284.48 | -69.48 | 1.2 | 0.44 | 4897.20 |
| 12 | 24 | 275 | 223.48 | $\underline{51.52}$ | - 121.5 | 762.25 | 2654.31 |
|  |  |  |  | 1.04 |  | 49461.6 | $\underline{23641.96}$ |

$\hat{Y}=77.08+6.10 x$
$\mathrm{E}(\mathrm{e})=\frac{1.04}{12}=0.08$
This is approximately equal to zero.
To test whether the observation is normally distributed we can construct a histogram of the observation.

## Independence of observations

An important assumption for the simple linear regression model is the independence of errors. In many time series models, this assumption is violated because of the correlation of errors in successive observations. This is referred to as autocorrelation.

Autocorrelation occurs if a positive error is followed by another positive error and a negative error is followed by another negative error. If autocorrelation occurs then time should be considered as an important independent variable and therefore time varies analysis should be used.
We can use Durbin Watson 'D' statistics to determine whether observations are independent.
$\mathrm{D}=\Sigma \frac{\left(\mathrm{e}_{\mathrm{i}}-\mathrm{e}_{\mathrm{i}-1}\right)^{2}}{\sum \mathrm{e}_{\mathrm{i}}^{2}}$
where $e_{i}$ is the error in time i
$\mathrm{e}_{\mathrm{i}-\mathrm{I}}$ is the error in time $\mathrm{i}-\mathrm{I}$
The Durbin Watson statistics provides a measure of association between successive values of the error term. The computed statistics is compared against two tabulated values $d_{u}$ and di that depend on the desired confidence level of the test and the degrees of freedom of the data.

If the computed Durbin Watson " $D$ " statistics is greater than $D_{u}$, then we can conclude that there's no positive correlation between error terms.

If $\mathrm{d}_{1} \leq \mathrm{D} \leq \mathrm{d}_{\mathrm{u}}$ then the test is inconclusive and therefore we can neither accept nor reject the null hypothesis.

## Note

A rule of thumb, with uncorrelated errors then D approaches a value of 2 . If errors are highly positively correlated, the D would be less than 1.5 and can be very near to zero (0).
For negatively correlated errors, the value of D will be above 2.5 with an upper limit of 4 .

## For illustration 2.1

$$
\begin{aligned}
\mathrm{D} & =\frac{\sum\left(\mathrm{e}_{\mathrm{i}}-\mathrm{e}_{\mathrm{i}-1}\right)^{2}}{\sum \mathrm{e}_{\mathrm{i}}^{2}} \\
& =\frac{49461.6=2.09}{23641.696}
\end{aligned}
$$

From the tables:
$\mathrm{d} \mathrm{l}=0.971$
$\mathrm{d} \mathrm{u}=1.331$
Since the calculated value of D is greater than du , then we can accept the null hypothesis, that there is no positive serial correlation.

The error of dependence is caused by:
The omission of an important variable such as the seasonal effect. (misspecification error).
The relationship is not linear.
A shift in production process which may be caused by change in equipment that has not been shown in the model.

### 2.5 MULTIPLE REGRESSION

The least square regression equation discussed above was based on the assumption that total cost was determined by only one activity based variable. However, other variables are likely to affect labour costs such as labour hours, material costs, machine hours, etc. These may have an effect on labour costs.

The equation for the simple regression can be expanded to include more than one independent variable as shown below:
$\hat{Y}=a+b_{1} X_{1}+b_{2} X_{2}+b_{3} X_{3}+\ldots \ldots \ldots+b_{n} X_{n}$
For two independent variables, the function will be of the form:
$\hat{\mathrm{Y}}=\mathrm{a}+\mathrm{b}_{1} \mathrm{X}_{1}+\mathrm{b}_{2} \mathrm{X}_{2}$
The normal equations can be given by:
$\Sigma \mathrm{y}=\mathrm{na}+\mathrm{b}_{1} \Sigma \mathrm{X}_{1}+\mathrm{b}_{2} \Sigma \mathrm{x}_{2}$
$\Sigma \mathrm{X}_{1} \mathrm{Y}=\mathrm{a}^{2} \mathrm{X}_{1}+\mathrm{b}_{1} \Sigma \mathrm{X}_{1}^{2}+\mathrm{b}_{2} \Sigma \mathrm{X}_{1} \Sigma \mathrm{X}_{2} \Sigma$
$\mathrm{X}_{2} \mathrm{Y}=\mathrm{a} \Sigma \mathrm{x}_{2}+\mathrm{b}_{1} \Sigma \mathrm{X}_{1} \Sigma \mathrm{X}_{2}+\mathrm{b}_{2} \Sigma \mathrm{X}_{2}$

Normally computers are used for the solution of multiple regression.

## Multi-collinearity

Multiple regression analysis is based on the assumption that the independent variables are not correlated with each other, When the independent variables are highly correlated with each other then it is very difficult to isolate the effect of each one of these on the dependent variables. This occurs when there is a simultaneous movement of two or more independent variables in the same direction and almost at the same time. This condition is called multi-collinearity.

We can use the correlation matrix to determine whether 2 independent variables are highly correlated. If a correlation value of more than 0.8 exists between two independent variables, then the problem of multicolinearity is bound to occur. Alternatively if the correlation coefficient between the two variables is greater than the multiple correlation coefficient, then multi-colinearity problem will occur. To remove the problem of multi-colinearlity, we drop one of the correlated variables. You can drop any of the variables.

### 2.6 LEARNING CURVE THEORY

The first time a new operation is performed both workers and operating procedures are untried but as the operation is replaced the workers becomes more familiar with the work so that less hours are required. This phenomena is known as the learning curve effect.

This is also referred to as improvement curve theory. It occurs when new production methods are introduced, new product s (either goods or services) are made or when new employees are hired. It is based on the proposition that as workers gain experience in a task, they need less time to complete the job and productivity increases.

The learning curve theory affects not only direct labour costs but also impacts direct labour related costs such as supervision, and direct material costs due to reduced spoilage and waste as experience is gained.

The time to perform many operations begins slowly and speeds up as employees become more skilled. Gradually, the time needed to complete an operation becomes progressively smaller at a constant percentage. Since this rate of improvement has a regular pattern, a learning curve can be drawn (see diagrams below) to estimate the labour hours required as workers become more familiar. These curves are also referred to as progress functions or experience curves.


A learning curve


The effect of experience on cost is summarised by a learning ratio (improvement ratio or learning rate) defined by the following;

Learning ratio $=\frac{\text { Average labour cost for the first } 2 \mathrm{x} \text { units }}{\text { Average labour cost for the first } \mathrm{x} \text { units }}$

## Example 1:

The first 500 units has an average labour cost of sh. 12.50 and the average labour cost for the first 1000 units is sh. 10 .
Required: Calculate the learning ratio.

$$
\text { Learning ratio }=\underline{\text { Sh. } 10} \times 100=80 \%
$$

## Interpretation:

Every time cumulative output doubles, average cost declines to 80 percent of the previous amount. Since the average cost of the first 1000 units was sh.10, the average cost of the first 2010 units will be expected to be $20 \%$ or sh. 8 per unit.

Learning curve equation:
The basic learning curve equation is

$$
Y=a b^{x}
$$

Where: a is the labour cost of the first unit
b is the cumulative production
x is the improvement exponent or an index learning given by:
$\mathrm{x}=\underline{\log \text { arithm of the learning ratio }}=\underline{\log (1-\text { proportional }}$
decrease) logarithm of $2 \log 2$
$x$ can take any value between -1 and zero.
Y is defined depending on whether a cumulative model or incremental model is being applied.

The above equation can be restated in the logarithmic form
$\log \mathrm{Y}=\log \mathrm{a}+\mathrm{x} \log \mathrm{b}$
Cumulative Total Cost
Each of the equations (i) and (ii) defines cumulative average cost. Either of them can be converted easily to a formula for the total labour cost of all units produced up to a given point. Total cost can always be calculated from a known average cost. Hence;

Total cost $=b Y=b\left(a b^{x}\right)=a b^{x+1}$
Incremental cost
If producing a second 1000 units is to reduce cumulative average cost from sh. 10 to sh. 8 , the cost of the second 1000 units will have to be only sh. 6000 , or sh. 6 each. Hence;

| Total Cost (Sh.) | No. of Units | Average Cost (sh.) |
| :---: | :--- | :--- |
| 10,000 | 1,000 | 10 |
| $\underline{6,000}$ | $\underline{1,000}$ | $\underline{6}$ |
| $\underline{16,000}$ | $\underline{1,000}$ | $\underline{8}$ |

Defining the learning curve in terms of this incremental relationship would be more useful but is more difficult to work with. As a result, learning curve improvement ratios are usually stated as percentage reductions in cumulative average labour cost.

## Example 2:

A company makes an electronic navigational guidance system that is used for space craft, aircraft and submarines. The direct labour cost is subject to an $80 \%$ learning curve. The first unit is estimated to require 1250 direct labour hours.
Required:
Compute the average number of hours required for the first $2,3,4,8$ units.
Assume the company estimates the variable cost of producing each unit as shown;
Direct material cost sh.40,000 per unit
Direct labour sh. 20 per hour
Variable production overhead sh. $1000+60 \%$ of direct labour cost

## Required:

Estimate the total manufacturing cost of 1, 2, 3, 4 units of the product

## Solution:

Number of labour hours
Units

| X | Average (y) | Total | Marginal cost Computations |  |
| :--- | :---: | :---: | :---: | :--- |
| 1 | 1250 | 1250 | 1250 | $\mathrm{Y}=1250 \times 1^{-0.322}=1250$ |
| 2 | 1000 | 2010 | 750 | $\mathrm{Y}=1250 \times 2^{-0.322}=1000$ |
| 3 | 878 | 2634 | 634 | $\mathrm{Y}=1250 \times 3^{-0.322}=878$ |
| 4 | 800 | 3200 | 566 | $\mathrm{Y}=1250 \times 4^{-0.322}=800$ |
| 8 | 640 | 5120 |  | $\mathrm{Y}=1250 \times 8^{-0.322}=640$ |

*Total hours $=$ Average labour hours $x$ no. of units
(b) Unit
no.
1
2
3
$4 \quad 40,000 \quad 20 x \quad 566=11320$
Direct Direct

## materials labour

$40,000 \quad 20 \times 1250=25000$
$40,000 \quad 20 x \quad 750=15000$
$40,000 \quad 20 x \quad 634=12680$

## Variable <br> manufacturing overhead

$1000+(0.6 \times 25000)$
$1000+(0.6 \times 15000)$
$1000+(0.6 \times 12680)$
$1000+(0.6 \times 11320)$

Total overheads
81,000
65,000
61,288
59,112

Applications of learning curves to accounting.
The learning phenomenon applies to time and it could thus affect any costs which are functions of time. Examples are hourly labour costs, indirect labour, supervision, etc.
Whenever costs are estimated, the potential impact of learning should be considered.
The phenomenon can also affect costs used in inventory valuation, costs used in decision making and costs used in performance evaluation. However, learning curves only apply to the early phases of production. After the steady state is achieved, costs tend to stabilise.
(i) In Inventory valuation- failing to recognise learning effects can have some unexpected consequences. (See example below).

## Example 3:

Production of a new product starts in January and continues through the year. Direct material cost is sh. 100 per unit through out the year. Because of the learning effect, the labour hours per unit drop from 1 hour (at sh. 160 per hour) in January to 0.25 hour in December. Manufacturing overhead is all fixed at sh. 80,000 . If 1000 units will be produced in January the overhead application rate is sh. 80 per hour. This rate is (mistakenly) applied throughout the year.

Unit inventory Value

|  | January |  | December |
| :---: | :---: | :---: | :---: |
|  | Sh. | Is (Sh.) | Should be (Sh.) |
| Direct materials | 100 | 100 | 100 |
| Direct labour | 160 | $40(0.25 \times 160)$ | 40 |
| Overheads applied | 80 | $20(0.25 \times 80)$ | 80 |
|  | 340 | 160 | 220 |

(ii) Decision making - A product newly launched may at a glance appear to be unprofitable, however because of learning effect, the variable costs would drop by the end of the period making the product profitable.
(iii) Performance evaluation. A bank has developed labour time and cost standards of some of its clerical activities. These activities are subject to the learning curve effect. The management has also found that the time on these activities exceeded the standard. On investigation, it was found that there was high personnel turnover meaning the activities were done by inexperienced people. Changes were made in personnel policy and the personnel turnover was reduced. The time spent on clerical activities no longer exceeded standards.

Attempt the problem below before checking the solution given.
A customer has asked your company to prepare a bid on supplying 800 units of a new product. Production will be in batches of 100 units. You estimate that costs for the first batch of 100 units will average sh100 a unit. You also expect that a 90 percent learning curve will apply to the cumulative labour costs on this contract.

## Required:

Prepare an estimate of the labour costs of fulfilling the contract.
Estimate the incremental labour cost of extending the production run to produce an additional 800 units. Estimate the incremental labour cost of extending the production run from 800 to 900 units.

## Solution:

Average cost decreases by 10 percent every time the cumulative total production doubles.
Therefore: Average cost of first 200 units $=0.9 \times$ Average cost of first 100 units
Average cost of first 400 units $=0.9 \mathrm{x}$ Average cost of first 200 units
Average cost of first 800 units $=0.9 \times$ Average cost of first 400 units

Combining these, we have;
Average cost of the first 800 units $=0.9 \times 0.9 \times 0.9 \times \operatorname{sh} .100=\operatorname{sh} 72.90$
Total cost $=\operatorname{sh}(72.90 \times 800)=$ sh. 58,320
Average cost of the first 1600 units $=0.9 \times 72.90=$ sh. 65.61
Total cost of 1600 units $=1600 \mathrm{x}$ sh65.61 $=$ sh. 104,976
Additional cost of second 800 units $=$ sh $104,976-58,320=$ sh. 46,656
Average cost $=$ sh. $58.32 /$ unit.
Because this increase will not increase cumulative production to twice some figure we already have, we need to
Use the formula.
Average cost $=\operatorname{sh} 10,000 \times 9^{x}$
$x=-\frac{0.0458}{0.301}=-0.15216$
0.301

Hence;
Log av. cost $=\log 10,000-0.15216 \log 9$
Average cost $=$ sh. $71.5833 /$ unit
Total Cost $=900 \times$ sh. $71.5833=$ sh. 64,425
Incremental cost $=$ sh. $64,425-58,320$
Average cost $=$ sh. $61.05 /$ unit

## REINFORCING QUESTIONS

## QUESTION ONE

CB plc produces a wide range of electronic components including its best selling item, the Laser Switch. The company is preparing the budgets for Year 5 and knows that the key element in the Master Budget is the contribution expected from the Laser Switch. The records for this component for the past four years are summarised below:

|  | Year 1 | Year 2 | Year 3 | Year 4 |
| :--- | :--- | :--- | :--- | :--- |
| Sale (unit) | 150,000 | 180,000 | 200,000 | 230,000 |
|  | $£$ | $£$ | $£$ | $£$ |
| Sale revenue | 292,820 | 346,060 | 363,000 | 448,800 |
| Variable costs | $\underline{131,080}$ | $\underline{161,706}$ | $\underline{178,604}$ | $\underline{201,160}$ |
| Contribution | $\underline{161,740}$ | $\underline{184,354}$ | $\underline{184,396}$ | $\underline{247,640}$ |

It has been estimated that sales in Year 5 will be 260,000 units.

## Required:

As a starting point for forecasting Year 5 contribution, to project the trend, using linear regression; To calculate the $95 \%$ confidence interval of the individual forecast for Year 5 if the standard error of the forecast
is $£ 14,500$ and the appropriate $t$ value is 4,303 , and to interpret the value calculated;
To comment on the advantages of using linear regression for forecasting and limitations of the technique.

## QUESTION TWO

The theory of the experience curve is that an organisation may increase its profitability through obtaining greater familiarity with supplying its products or services to customers. This reflects the view that profitability is solely a function of market share.

## Required:

Discuss the extent to which the application of experience curve theory can help an organisation to prolong the life cycle of its products or services.

## QUESTION THREE

Savitt Ltd manufactures a variety of products at its industrial site in Ruratania. One of the products, the LT, is produced in a specially equipped factory in which no other production takes place. For technical reasons the company keeps no stocks of either LTs or the raw material used in their manufacture. The costs of producing LTs in the special factory during the past four years have been as follows:

| YEAR | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | 4(Estimated) |
| :--- | ---: | ---: | ---: | ---: |
|  | Sh | Sh | Sh. | Sh. |
| Raw materials | 70000 | 100000 | 130000 | 132000 |
| Skilled labour | 40000 | 71000 | 96000 | 115000 |
| Unskilled labour | 132000 | 173000 | 235000 | 230000 |
| Power | 25000 | 33000 | 47000 | 44000 |
| Factory overheads | $\underline{168000}$ | $\underline{206000}$ | $\underline{246000}$ | $\underline{265000}$ |
| Total production costs | $£ 435000$ | $\underline{583000}$ | $\ldots f 750000$ | $£ 786000$ |
|  |  |  |  | 180000 |
| Output (units) | 160000 | 190000 | 220000 | 180,000 |

The costs of raw materials and skilled and unskilled labour have increased steadily during the past four years at an annual compound rate of $20 \%$ and the costs of factory overheads have increased at an annual compound rate of $15 \%$ during the same period. Power prices increased by $10 \%$ on 1 January Year 2 and by $25 \%$ on the 1 January of each subsequent year. All costs except power are expected to increase by a further $20 \%$ during Year 5. Power prices are due to rise by $25 \%$ on 1 January Year 5 .

The directors of Savitt Ltd are now formulating the company's production plan for Year 5 and wish to estimate the costs of manufacturing the product LT. The finance director has expressed the view that 'the full relevant cost of producing LTs can be determined only if a fair share of general company overheads is allocated to them.' No such allocation is included in the table of costs above.

## Required:

Use linear regression analysis to estimate the relationship of total production costs to volume for the product LT for Year 5 (ignore general company overheads and do not undertake a separate regression calculation for each item of cost),

Comment on the view expressed by the finance director. Ignore taxation.

## COMPREHENSIVE ASSIGNMENT NO. 1

TO BE SUBMITTED AFTER LESSON 2

To be carried out under examination conditions and sent to the Distance Learning Administration for marking by the University. TIME ALLOWED: 3HRS.

ANSWER ALL QUESTIONS.

## QUESTION ONE

The Management of Waity Ltd. is not happy with the company's current budgetary planning and control system and would wish to see it more effective than it is currently. For this purpose you have been brought into the company with the title, "Management Accountant (Special Duties)".
a. State what effectiveness for budgetary planning and control implies.
b. Prepare a plan of action showing how you would go about carrying out your assignment.
c. What is the meaning of "treasury management" within a group of companies and what activities does it normally cover?
d. What are the elements of a comprehensive scheme of cash forecasting and what steps can one take to adjust for uncertainty in cash forecasts?
(CPA Dec 2014)

## QUESTION TWO

a. Enumerate and comment on the benefits which may occur when using standard costing in conjunction with process accounts.
b. Explain how a profit centre approach may be applied in accounting within a processing industry and how standard costing may be useful in its implementation. (ACCA Dec 1989)

## QUESTION THREE

a. Comment on factors likely to affect the accuracy of the analysis of costs into fixed and variable components.
b. Explain how the analysis of costs into fixed variable components is of use in planning, control and decision-making techniques used by the management accountant.
(ACCA June 1989)

## QUESTION FOUR

The Bozo-Dog Do-Da Ltd use an interlocking system of accounting. The financial Profit and Loss account for the year ended 30 September was:

|  | Sh |  | Sh |
| :--- | ---: | :--- | ---: |
| Purchases | 25,210 | Sales: 50,000 units at Shs 1.50 each | 75,000 |
| Less closing stock | $\underline{4,080}$ | Discounts received | 260 |
|  | 21,130 | Profit on sale of land | 2,340 |
| Direct wages | 10,500 |  |  |
| Work expenses | 12,130 |  |  |
| Selling expenses | 7,100 |  |  |
| Administration expenses | 5,340 | 1,100 |  |
| Depreciation | $\underline{77,300}$ |  |  |
| Net profit | $\underline{77,600}$ |  |  |

The cost profit, however, was only Shs 19,770. Reconcile the financial and cost profits, using the following information:
a. Cost accounts value of closing stock: sh4,280
b. The works expenses in the cost accounts were taken as $100 \%$ direct wages.
c. Selling and administration expenses were charged in the cost accounts at $10 \%$ of sales and $£ 0.10$ per unit respectively.
d. Depreciation in the cost accounts was sh800.

## QUESTION FIVE

The ABC corporation processes cooking oils from a type of nut grown in Western Kenya. The manufacturing process operates such that the nuts are initially processed into two products namely Mafuta and Karanga. The former is a high-grade cooking oil used for domestic purposes and also for specialised cooking. Karanga is subsequently processed into two final products, Chemsha, a low grade oil used for deep frying mainly in large scale establishments and Mlo, a low grade fat used in cattle feeds.

During the month of May, the company processed 100,000 killogrammes of nuts into Mafuta and Karanga at a total cost comprising direct materials-Shs 360,000 , direct labour-Shs 216,000 and factory overheads-Shs 144,000. Karanga was subsequently processed into Chemsha and Mlo at an additional cost of Shs 36,000 for direct materials, Shs 84,000 for direct labour and Shs 48,000 for factory overheads.

In addition to the above costs each of the three products incurred entirely separate and variable costs of Shs 48,000 for Mafuta, Shs 384,000 for Chemsha and Shs 96,000 for Mlo up to final completion at which point 5,000 killogrammes of Mafuta, 10,000 kilogrammes of Chemsha and 25,000 killogrammes of Mlo were obtained. The final selling prices are Shs 192, Shs 48 and Shs 4.8 per kilogramme for Mafuta, Chemsha and Mlo respectively.

## Required:

a. Prepare a statement to show the profitability of each product assuming that costs are allocated on the basis of net realisable value.
b. Management is considering further processing of Chemsha at an additional cost of Shs 9.60 per kilogramme. This would enable the company sell the product at a price of Shs 57.60 per kilogramme. The product mix however would change to $5,000 \mathrm{Kg}$., $9,000 \mathrm{~kg}$. and $30,000 \mathrm{Kg}$. of Mafuta, Chemsha and Mlo respectively.

Advise management on the suitability of adopting the proposed action. (CPA June 1991)

## END OF COMPREHENSIVE ASSIGNMENT No. 1

## NOW SEND YOUR ANSWERS TO THE DISTANCE LEARNING CENTRE

## LESSON THREE

## SHORT TERM DECISIONS

## OBJECTIVES

Examination of cost volume profit analysis and relevant cost decisions

## INSTRUCTIONS

1. Read the Study Text and Chapter 8 and 9 of Management and Cost Accounting by Colin Drury
2. Attempt the reinforcing questions at the end of the lesson under examination conditions
3. Compare your answers with those given in Lesson 10

## CONTENTS

3.1 Cost -Volume Profit (C-V-P) analysis Introduction
3.2 Analyzing the Cost volume Relationship
3.2.1 Algebraic Analysis
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3.5 C-V-P Analysis Under Uncertainity
3.5.1 Point Estimate of Probabilities
3.5.2 Continuous Probability Distribution(use of normal distribution)
3.6 C-V-P Analysis and Computer Applications
3.7 Relevant Cost for Non Routine Decisions
3.7.1 Make or Buy Decisions (no limiting factors)
3.7.2 Make or Buy Decisions Under Limiting Factors
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3.7.5 Permanent Abandonment of Premises
3.7.6 Extra Shift Decision
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### 3.1 COST-VOLUME PROFIT (C-V-P) ANALYSIS INTRODUCTION

In this section, you will learn to use cost-volume-profit analysis.
You can use cost-volume -profit analysis to analyze the natural relationship between cost, volume, and profit in pricing decisions. In cost-volume-profit analysis, you:
$\square$ Should consider only short-term operations. The short term may be defined as a period too short to permit facilities expansion or contraction or other changes that might affect overall pricing relationships.
$\square$ Assume that a straight line can reasonably be used in analysis. While actual price behavior may not follow a straight line, its use can closely approximate actual cost behavior in the short run.
$\square$ If purchase volume moves outside the relevant range of the available data, the straight-line assumption and the accuracy of estimates become questionable.
$\square$ If you know that product variable costs per unit are decreasing as quantity increases, consider using the log-linear improvement curve concept. Improvement curves are particularly useful in limited production situations where you can obtain cost/price information for all units sold.

In the short run, costs can be of three general types:
$\square$ Fixed Cost. Total fixed costs remain constant as volume varies in the relevant range of production. Fixed cost per unit decreases as the cost is spread over an increasing number of units. Examples include: Fire insurance, depreciation, facility rent, and property taxes.
$\square \quad$ Variable Cost. Variable cost per unit remains constant no matter how many units are made in the relevant range of production. Total variable cost increases as the number of units increases. Examples include: Production material and labor. If no units are made, neither cost is necessary or incurred. However, each unit produced requires production material and labor.
$\square$ Semivariable Cost. Semivariable costs include both fixed and variable cost elements. Costs may increase in steps or increase relatively smoothly from a fixed base. Examples include: Supervision and utilities, such as electricity, gas, and telephone. Supervision costs tend to increase in steps as a supervisor's span of control is reached. Utilities typically have a minimum service fee, with costs increasing relatively smoothly as more of the utility is used.

Cost -volume-profit analysis is an estimating concept that can be used in a variety of pricing situations.
You can use the cost-volume relationship for:
$\square$ Evaluating item price in price analysis. Cost-volume-profit analysis assumes that total cost is composed of fixed and variable elements. This assumption can be used to explain price changes as well as cost changes. As the volume being acquired increases unit costs decline. As unit costs decline, the vendor can reduce prices and same make the same profit per unit.
$\square$ Evaluating direct costs in pricing new contracts. Quantity differences will often affect direct costs -- particularly direct material cost. Direct material requirements often include a fixed component for development or production operation set-up. As that direct cost is spread over an increasing volume unit costs should decline.
$\square$ Evaluating direct costs in pricing contract changes. How will an increase in contract effort increase contract price? Some costs will increase others will not. The concepts of cost-volumeprofit analysis can be an invaluable aid in considering the effect of the change on contract price.
$\square \quad$ Evaluating indirect costs. The principles of cost-volume-profit analysis can be used in indirect cost analysis. Many indirect costs are fixed or semivariable. As overall volume increases, indirect cost rates typically decline because fixed costs are spread over an increasing production volume.

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## The main assumptions required in C-V-P analysis are:

1. The relationship holds only within the relevant range. The relevant range is a band of activity within which a given cost behaviour is defined.
2. The behaviour of total cost and total revenue has reliably been determined and is lineal within the relevant range.
3. All costs can be divided into fixed and variable such that mixed costs are decomposed into their fixed and their variable components.
4. Selling prices are constant therefore we ignore quantity discounts.
5. Efficiency and productivity remain the same so that we therefore ignore the learning curve effect.
6. Prices of factors of production remain constant.
7. There are no limiting factors

### 3.2 ANALYZING THE COST-VOLUME RELATIONSHIP

This section examines algebraic and graphic analysis of the cost-volume relationship.

### 3.2.1 ALGEBRAIC ANALYSIS

The assumption of linear cost behavior permits use of straight-line graphs and simple linear algebra in cost-volume analysis.

Total cost is a semi-variable cost-some costs are fixed, some costs are variable, and others are semivariable. In analysis, the fixed component of a semi-variable cost can be treated like any other fixed cost. The variable component can be treated like any other variable cost. As a result, we can say that:

Total Cost $=$ Fixed Cost + Variable Cost
Using symbols:
$C=F+V$
Where:
$\mathrm{C}=$ Total cost
$\mathrm{F}=$ Fixed cost
$\mathrm{V}=$ Variable cost

Total variable cost depends on two elements:
Variable Cost $=$ Variable Cost per Unit x Volume Produced
Using symbols:

$$
\mathrm{V}=\mathrm{V}_{\mathrm{u}}(\mathrm{Q})
$$

Where:
$\mathrm{V}_{\mathrm{U}}=$ Variable cost per unit
$\mathrm{Q}=$ Quantity (volume) produced
Substituting this variable cost information into the basic total cost equation, we have the equation used in cost-volume analysis:

$$
\mathrm{C}=\mathrm{F}+\mathrm{V}_{\mathrm{U}}(\mathrm{Q})
$$

## Illustration 2.1

If you know that fixed costs are Sh.500, variable cost per unit is Sh .10 , and the volume produced is 1,000 units, you can calculate the total cost of production.

$$
\begin{aligned}
\mathrm{C} & =\mathrm{F}+\mathrm{V}_{\mathrm{u}}(\mathrm{Q}) \\
& =500+10(1000) \\
& =\mathrm{Sh} .10500
\end{aligned}
$$

Given total cost and volume for two different levels of production, and using the straight-line assumption, you can calculate variable cost per unit.

## Remember that:

Fixed costs do NOT change no matter what the volume, as long as production remains within the relevant range of available cost information. Any change in total cost is the result of a change in total variable cost.
$\square$ Variable cost per unit does NOT change in the relevant range of production.
As a result, we can calculate variable cost per unit $\left(\mathrm{V}_{\mathrm{U}}\right)$ using the following
equation: $\mathrm{Vu}_{\mathrm{U}}=\underline{\text { Change in Total Cost }}$
Change in Volume

$$
=\underline{\mathrm{C}_{2}}-\frac{-\mathrm{C}_{1}}{\mathrm{Q}_{2}}-\mathrm{Q}_{1}
$$

Where:
$C_{1}=$ Total cost for Quantity 1
$\mathrm{C}_{2}=$ Total cost for Quantity 2
$\mathrm{Q}_{1}=$ Quantity 1
$\mathrm{Q}_{2}=$ Quantity 2

## Illustration

You are analyzing an offeror's cost proposal. As part of the proposal the offeror shows that a supplier offered 5,000 units of a key part for Sh. 60,000 . The same quote offered 4,000 units for Sh. 50,000 . What is the apparent variable cost per unit?

$$
\begin{aligned}
& V_{u}=\underline{C_{2}}-\underline{C_{1}} \\
& Q_{2}-Q_{1} \\
&=\frac{60000-50000}{5000-4000} \\
&=\text { Sh. } 10
\end{aligned}
$$

If you know total cost and variable cost per unit for any quantity, you can calculate fixed cost using the basic total cost equation.

### 3.2.2 GRAPHIC ANALYSIS

## Introduction to Graphic Analysis.

When you only have two data points, you must generally assume a linear relationship. When you get more data, you can examine the data to determine if there is truly a linear relationship.

You should always graph the data before performing an algebraic analysis.
$\square$ Graphic analysis is the best way of developing an overall view of cost-volume relationship.
$\square$ Graphic analysis is useful in analyzing cost-volume relationships, particularly, when the cost and volume numbers involved are relatively small.
$\square$ Even when actual analysis is performed algebraically you can use graphs to demonstrate cost-volume analysis to others.

## Steps of Graphic Analysis.

There are four steps in using graph paper to analyze cost-volume relationships:

## Step 1. Determine the scale that you will use.

Volume is considered the independent variable and will be graphed on the horizontal axis. Cost is considered the dependent variable and will be graphed on the vertical axis. The scales on the two axes do not have to be the same. However, on each axis one block must represent the same amount of change as every other block of the same size on that axis. Each scale should be large enough to permit analysis, and small enough to permit the graphing of all available data and anticipated data estimates.

## Step 2. Plot the available cost-volume data.

Find the volume given for one of the data points on the horizontal axis. Draw an imaginary vertical line from that point. Find the related cost on the vertical axis and draw an imaginary horizontal line from that point. The point where the two lines intersect represents the cost for the given volume. (If you do not feel comfortable with imaginary lines you may draw dotted lines to locate the intersection.) Repeat this step for each data point.

## Step 3. Fit a straight line to the data.

In this section of text, all data points will fall on a straight line. All that you have to do to fit a straight line is connect the data points. Most analysts use regression analysis to fit a straight line when all points do not fall on the line.

## Step 4. Estimate the cost for a given volume.

Draw an imaginary vertical line from the given volume to the point where it intersects the straight line that you fit to the data points. Then move horizontally until you intersect the vertical axis. That point is the graphic estimate of the cost for the given volume of the item.
Example of Graphic Analysis. The four steps of cost-volume-profit analysis can be used to graph and analyze any cost-volume relationship. Assume that you have been asked to estimate the cost of 400 units given the following data:

| Units | Cost |
| :---: | :---: |
| 200 | $\$ 100,000$ |
| 500 | $\$ 175,000$ |
| 600 | $\$ 200,000$ |

Solution


The estimated cost will be $\$ 150.000$.

### 3.3 BREAK EVEN ANALYSIS

Break even analysis is mainly used to explain the relationship between the cost incurred, the volume operated at and the profit earned. To compute the break even point we let $S$ be selling price per unit $\mathrm{V}_{\mathrm{u}}$ be variable cost per unit Q be break-even quantities $F$ be total fixed costs

At Break even point:
Total revenue (TR) $=$ Total Cost (TC)
Total revenue will be given by $S Q$ while Total cost $(T C)=V_{u} Q+F$
At break-even point (BEP) therefore:
$S Q=V_{u} Q+F$
$Q=\frac{F}{S-V_{u}}$
B.E.P (in units) $=\underline{F}$

S- $\mathrm{V}_{\mathrm{u}}$

## Illustration

Assume that you are planning to sell badges at the forthcoming Nairobi Show at Sh. 9 each. The badges cost Sh. 5 to produce and you incur Sh. 2010 to rent a booth in the Show ground.

## Required:

a) Compute the breakeven point
b) Compute the margin of safety
c) Compute the number of units that must be sold to earn a before tax profit of $20 \%$
d) Compute the number of units that must be sold to earn an after tax profit of Sh.1640, assuming that the tax rate is $30 \%$.

## Solution

a) Break even point

BEP units $=2010 /(9-5)=500$ units
BEP Sh. $=500 \times 9=4500 /-$
b) Margin of safety

The margin of safety is the amount by which actual output or sales may fall short of the budget without the company incurring losses. It is a measure of the risk that the company might make a loss if it fails to achieve the target. A high margin of safety means high profit expectation even if the budget is not achieved. Margin of safety (MOS) can be computed as follows:

$$
\begin{aligned}
\text { MOS } & =\frac{\text { Expected sales }}{\text { Expected sales }}-\text { Break even sales } \\
& =\quad \underline{600-500} \quad=16.7 \%
\end{aligned}
$$

c) Target before tax profit (Y)

Let X be the number of units to produce

$$
\begin{aligned}
& X=\frac{F+Y}{S-V u} \\
& X=\frac{2010+0.2(9 X)}{9-5}
\end{aligned}
$$

$$
X=\frac{2010+1.8 X}{4}
$$

$X=909.09$ approximately 910 units.

## d) After Tax profit

Let Z be the after tax profit

$$
Y=\frac{Z-}{I-t}
$$

Therefore

$$
\begin{aligned}
X & =\frac{F+{ }^{z} / 1-t}{S-V u} \\
& =\frac{2010+\frac{1640}{1-0.3}}{9-5}
\end{aligned}
$$

$\mathrm{X}=1085.71$
Approximately 1086 units.

### 3.4 C-V-P ANALYSIS - MULTIPLE PRODUCTS

The simple product CVP analysis can be extended to handle the more realistic situations where the firm produces more than one product. The objective in such a case is to produce a mix that maximises total contribution.

$$
\text { Total BEP units }_{=}^{\frac{\text { Total fixed cost }}{\text { Average } \mathrm{CM}}}
$$

Average CM $=\sum_{t=1}^{n}\left(S_{t}-V_{t}\right) \alpha_{t}$
where $\alpha_{\mathrm{t}}$ is the sales mix of product t . $\mathrm{S}_{\mathrm{t}}$
is the selling price of product $t$.
$\mathrm{V}_{\mathrm{t}}$ is the variable cost of product t .
$n$ is the number of units of product $t$ sold
$\mathrm{BEP}_{\mathrm{t} \text { units }}=\alpha_{\mathrm{t}}\left(\right.$ Total $\left.^{\text {BEP units }}\right)$
$\mathrm{BEP}_{\text {tsh. }}=\mathrm{BEP}_{\mathrm{t}(\text { units })} \mathrm{xSt}$

## Illustration

Assume that ABC Ltd produces two products, product A and B and the following budget has been prepared.

|  | A | B | Total |
| :--- | :--- | :--- | :--- |
|  | 120,000 | 40,000 | 160,000 |
| Sales in units | $\underline{S h}$. | $\underline{S h .}$ | $\underline{S h .}$ |
| Sales @ $5 /-, 10 /-$ | 600,000 | 400,000 | 100,000 |
| Variable cost @ 4/-, 3/- | $\underline{480,000}$ | $\underline{120,000}$ | $\underline{600,000}$ |
| Contribution @ $1 /-7 /-$ | $\underline{120,000}$ | $\underline{280,000}$ | 400,000 |
| Total fixed cost |  |  | $\underline{300,000}$ |
| Profit |  |  | $\underline{100,000}$ |

Required:
a) Compute the break-even point in total and for each of the products.
b) The company proposes to change the sales mix in units to $1: 1$ for products $A$ and B. Advice the Co. on whether this change is desirable.

## Solution

| Sales mix (units) |
| :--- |
| Sales mix (Shs) |

Average CM
$\begin{aligned} \text { Total BEP units }=\frac{\text { Total fixed cost }}{\text { Average CM }}= & \frac{300000}{2.5} \\ & =120,000 \text { units }\end{aligned}$

|  | BEP (units) |  |  |  |  |  | $\underline{\text { BEP(sh) }}$ |
| :--- | :--- | :--- | :--- | :---: | :---: | :---: | :---: |
| A | $\underline{120100 \times 0.75}=90,000$ | $(90000 \times 5)$ | $=450,000$ |  |  |  |  |
| B | $120100 \times 0.25=\underline{30,000}$ | $(30000 \times 10)$ | $=\underline{300,000}$ |  |  |  |  |
|  | $\underline{120,000}$ |  | $\underline{750,000}$ |  |  |  |  |

The above question can be solved by computing the BEPsh first and the using the Sales Mix in Shs.
Total BEP $_{\text {sh. }} \quad=\frac{\text { Total fixed cost }}{\mathrm{C} / \mathrm{S}_{\text {sales ratio }}}$

C/S ratio

$$
=\underline{400,000}
$$

$$
=0.4
$$

1000,000
Total BEP(sh)

$$
=\frac{300000}{0.4}=750,000
$$

Sh. $\underline{\text { Units }}$

|  |  | $\underline{\text { Sh. }}$ | $\underline{\text { Units }}$ |  |
| :--- | :--- | :--- | :--- | :--- |
| A | $750000 \times 0.6$ | $=$ | $\underline{450000}$ | $\underline{450000 / 5}=90000$ |
| B | $750000 \times 0.4$ | $=$ | $\underline{300000}$ | $300000 / 10=\underline{30000}$ |

b) Changing sales mix in units to 1:1 ratio

The budget can be reproduced as follows:

|  | A | B | Total |
| :--- | :---: | :---: | ---: |
| Sales in units | 80000 | 80000 | 160000 |
| Sale @ $5 /-, 10 /-$ | $\underline{\text { sh }}$ | $\underline{\text { sh }}$ | $\underline{\text { sh }}$ |
| V.c @ 4/-, 3/- | $\underline{300000}$ | 800000 | 1201000 |
| Contribution | $\underline{80,000}$ | $\underline{240000}$ | $\underline{560000}$ |
| Total fixed cost |  | $\underline{560,000}$ | 640,000 |
| Net Profit |  |  | $\underline{300,000}$ |

Sales mix in units is $80000 / 160000=0.5$

Average $\mathrm{CM}=0.5(1)+0.5(7)=4$
Total BEP units $=\frac{300,000}{4}=75,000$ units

|  | $\underline{B_{E P} \text { units }}$ | $\underline{\text { BEP }_{\text {sh. }}}$ |
| :--- | :--- | :--- |
| A $(0.5 \times 75000)$ | 37500 | 187,500 |
| B $(0.5 \times 75000)$ | $\underline{37500}$ | $\underline{375,000}$ |
|  | $\underline{75000}$ | $\underline{562,500}$ |

For manager of product line A, the change is good because he now breaks even at sh. 187500 than on sh. 450000 . But for manager of product B , the change is not good because BEP has risen from sh. 300000 to sh. 375000 .

### 3.5 C-V-P ANALYSIS UNDER UNCERTAINTY

A major limitation of the basic C.V.P analysis is the assumption that the unit variable cost, selling price and the fixed costs are constant and can be predicted with certainty. These factors however are variables with expected values and standard deviations that can be estimated by management.

There are various ways of dealing with uncertainty. Examples include:
$\square$ Sensitivity analysis
$\square$ Point estimate of probabilities
$\square$ Continuous probability distribution e.g. normal distribution
$\square$ Simulation analysis
$\square$ Margin of safety

### 3.5.1 POINT ESTIMATE OF PROBABILITIES

This approach requires a number of different values for each of the uncertain variables to be selected. These might be values that are reasonably expected to occur but usually 3 values are selected. These are:

The worst possible outcome
The most likely outcome
The best possible outcome
For each of these 3 values, a probability of occurrence will be estimated.

## Illustration

Assume that a Management accountant of a Company that makes and sells product X has made the following estimate:

## Selling price $\mathbf{S h}$ <br> Sales demand

| Condition | $\frac{\text { Unit }}{}$ | $\frac{\text { Prob. }}{0.3}$ |
| :--- | :--- | :--- |
| Worst possible | 45000 | 0.6 |
| Most likely | 50000 | 0.1 |

## Unit variable co

## Condition

|  | $\frac{\text { Cost }}{}$ | $\underline{\text { Sh. }}$ |
| :--- | :--- | :--- |
| Best possible | 3.5 | 0.30 |
| Most likely | 4.0 | 0.55 |
| Worst possible | 5.5 | 0.15 |

Fixed cost $=$ Sh.240,000

## Required:

a. Compute the expected profit
b. Compute the prob. that the company will fail to break even
c. If the Company has a profit target of Sh. 60,000 what is the probability that the company will not achieve this target.

## Solution

a)
$\mathrm{E}($ Demand $)=(45000 \times 0.3)+(50000 \times 0.6)+(55000 \times 0.1)=49000$
$\mathrm{E}($ variable cost $)=(3.5 \times 0.3) \times(4 \times 0.55)+(55 \times 0.15)=$ Sh. 4.075

$$
\mathrm{E}(\text { Profit })=(10-4.075) 49000-240000=\underline{\text { Sh. } 50325}
$$

This can be worked out differently as shown below:

| A | B | C | D | E | F | G | (FxG) |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Demand | Prob. | Unit VC | Prob. | Contr | Profit | Joint | weighted |
|  |  |  |  |  |  | Prob. | Profit |
| 45000 | 0.3 | 3.5 | 0.30 | 292500 | 52500 | 0.09 | 4725 |
|  |  | 4.0 | 0.55 | 270000 | 30000 | 0.165 | 4950 |
|  |  | 5.5 | 0.15 | 202500 | (37500) | 0.045 | (1687.5) |
| 50000 | 0.6 | 3.5 | 0.3 | 325000 | 85000 | 0.18 | 15300 |
|  |  | 4.0 | 0.55 | 300000 | 60000 | 0.33 | 19800 |
|  |  | 5.5 | 0.15 | 225000 | (15000) | 0.09 | (1350) |
| 55000 | 0.1 | 3.5 | 0.3 | 357500 | 117500 | 0.33 | 3525 |
|  |  | 4.0 | 0.55 | 330000 | 90000 | 0.055 | 4950 |
|  |  | 5.5 | 0.15 | 247500 | 7500 | 0.015 | $\underline{112.5}$ |
|  |  |  |  | Expecte |  |  | $\underline{50325}$ |

b) The P(Profit $<0)=0.045+0.09$

$$
=0.135
$$

## Note:

This can be read from the above table
c) $\quad \mathrm{P}($ profit $<60000)$

$$
\begin{aligned}
& =0.3+0.09+0.015 \\
& =0.405
\end{aligned}
$$

## Worked example

Thunder manufacturing company produces a toxic product, 'coros' that must be sold in the month produced or else discarded. Thunder can manufacture 'coros' itself at a variable cost of Sh40 per unit or they can purchase it from an outside supplier at a cost of Sh70 per unit. Thunder can sell 'coros' at Sh80 per unit. Production levels must be set at the start of the period and cannot be changed during the period. The production process is such that at least 9,000 units must be produced during the period. Thunder management must decide whether to produce 'coros' or whether to purchase it from the outside supplier.

The possible sales of 'coros' and their probabilities are:
Demand Probability
(units)
$4,000 \quad 0.4$
7,000 0.5
$11,000 \quad 0.1$

## Required:

a) Expected demand
b) Expected profit from purchasing 'coros' from an outside supplier and selling it
c) Expected profit from manufacturing and selling
d) Standard deviation of profits from purchasing and selling.
e) Standard deviation of profits from manufacturing and selling.
f) Coefficient of variation for each alternative

## Solution

a) Expected demand is computed as follows:

| Demand (units) | Probability | Expected demand(units) |
| :---: | :---: | :---: |
| 4000 | 0.4 | 1600 |
| 7000 | 0.5 | 3500 |
| 11,000 | 0.1 | $\underline{1100}$ |
| Expected demand |  | $\underline{6200}$ |

b) The expected profit from purchasing and selling would be equal to the unit contribution times the expected quantity or

$$
\text { Sh }(80-70) \times 6200=\text { Sh62,000 }
$$

c) Even though the production cost is stated as a variable cost, since a minimum of 9,000 units must be produced, the cost is really fixed up to that point because of the minimum production constraints. Units produced in excess of 9,000 could carry the variable cost of Sh40 each. The expected profit from manufacturing is:

| Demand (units) | Probability | Manufacturing cost <br> (Shs) | Profit | Expected profit <br> (Shs) |
| :---: | :---: | :---: | :---: | :---: |
| 4000 | 0.4 | 360,000 | $(40,000)$ | $(16,000)$ |
| 7000 | 0.5 | 360,000 | 200,000 | 100,000 |
| 11,000 | 0.1 | 440,000 | 440,000 | $\underline{44,000}$ |
|  |  |  |  | $\underline{128,000}$ |

d) The standard deviation from purchasing and selling is:

| $\mathrm{I}-\overline{\mathrm{I}}$ | $(\mathrm{I}-\overline{\mathrm{I}})^{2} \mathrm{P}$ (million) |
| :--- | :--- |
| $(4,000-6200)$ Sh10 | 193.6 |
| $(7,000-6200)$ Sh10 | 32.0 |
| $(11,000-6200)$ Sh10 | $\underline{230.4}$ |
|  | 456.0 |
| $\therefore$ Standard deviation $=$ | $\sqrt{456 m} \quad=$ Sh21,354 |

e) The standard deviation from manufacturing and selling is

| $\mathrm{I}-\overline{\mathrm{I}}$ | $(\mathrm{I}-\overline{\mathrm{I}})^{2} \mathrm{P}$ (million) |
| :--- | :--- |
| $-40,000-128,000$ | $11,289.6$ |
| $200,000-128,000$ | $2,592.0$ |
| $440,000-128,000$ | $\underline{9,734.4}$ |
| Total $\underline{\text { 23,616.0 }}$ |  |

$\therefore$ Standard deviation $=\sqrt{ } 23,616$ million $=$ Sh153,675
f) Coefficient of variation for purchasing and selling is (S/I)

$$
\text { i.e. } \frac{\operatorname{Sh} 21,354}{\operatorname{Sh} 62,000}=0.344
$$

For manufacturing and selling is:

$$
\frac{\text { Sh } 153,675}{\text { Sh } 128,000}=1.201
$$

## Note:

The coefficient of variation is a measure of risk associated with each alternative.

### 3.5.2 CONTINUOUS PROBABILITY DISTRIBUTION (USE OF NORMAL DISTRIBUTION)

In reality the C-V-P variables might take any values in a continuous range. It could therefore be more appropriate to use a continuous probability distribution such as the normal distribution with an estimated mean and standard deviation. Estimates may be made of the expected sales volume, the expected selling prices, the expected variable cost and the expected fixed costs together with their probabilities.

It would therefore be possible to compute the expected profit and the likelihood that the company would break even or achieve a given target profit.

## Illustration

Assume that the selling price of a product is estimated to be Sh.100, the variable cost Sh. 60 , and budgeted fixed cost is Sh .36000 . The demand is normally distributed with a mean of 1000 units and a standard deviation of 90 units

## Required

a. Compute the expected profit and standard deviation of profit
b. Compute the prob. that the company would not break even
c. Compute the prob. that a loss $>$ Sh. 1400 will occur
a) $\mathrm{E}($ profit $)=$ Contribution margin $\mathrm{xE}(\mathrm{D})$ - F.C

$$
\begin{gathered}
=(100-60) 1000-36000 \\
=\text { Sh. } 4000 \\
\delta(\text { profit })= \\
\delta \text { demand } \times \mathrm{CM}=90 \times 40=\text { Sh. } 3600
\end{gathered}
$$

b) $\quad \mathrm{P}($ profit $<0)$

$$
\mathrm{z}=\frac{\mathrm{x}-\mathrm{u}}{\delta} \quad=\quad \frac{0-4000}{3600}=
$$

From the $Z$ tables the value $=0.1335$
Therefore $\mathrm{P}($ profit $<0)=0.1335$
c) $\quad \mathrm{P}($ profit $<-1400)$

$$
Z=-\frac{1400-4000}{3600}=-1.5
$$

From the Z tables the value $=0.0668$
Therefore $\mathrm{P}($ profit $<-1400)=0.0668$

### 3.6 CVP ANALYSIS AND COMPUTER APPLICATIONS

The output from a CVP model is only as good as the input. The analysis will include assumptions about sales mix, production efficiency, price loads, total fixed costs, variable costs and selling price per unit.

The CVP equation can be used to develop financial planning programs. These programs quickly calculate the effects of changes in price, costs and volume on an organisation's profits. They answer such "whatif' questions as:
i) How could a $5 \%$ increase in the sales price affect operating income?
ii) If Fast Food Co. increases its advertising budget by Sh1 million, how many hamburgers must it sell to cover the increase in fixed expenses?
iii) If the campus bookstore extends its hours, how much additional revenue must it earn to cover the increased operating expense?
iv) If variable production costs are reduced by $7 \%$, how many units of product must be sold to earn Sh200,000 operating profit?

Such programs vary in complexity. Some simple programs can include only those variables discussed while other more complicated ones can include an organisation's complete budget.

Many firms use interactive programs of basic CVP equation on their microcomputers to analyse data they have collected and entered. These interactive capabilities allow managers to enter and change their inputs easily and also make the analysis of the financial effects of various alternatives simpler.

The computers' speed and accuracy in providing information from entered data improve the speed and accuracy with which the manager can select the most profitable actions.

Sensitivity analysis is one approach for coping with changes in the values of the variables. It focuses on how a result will be changed if the original estimates or the underlying assumptions change.

The widespread use of spreadsheet packages which do not require programming expertise, has enabled management accountants to develop CVP computerised models. The impact of alternative revised plans is quickly identified and changes only implemented when it is apparent that the original estimates are incorrect.

### 3.7 RELEVANT COSTS FOR NON-ROUTINE DECISIONS

A relevant cost is a cost that is appropriate to a specific management decision. To be relevant, a cost must be:

1. Future cost - A decision is usually about the future \& management not what has already been done. A cost that has already been incurred is therefore irrelevant to any decision being made now e.g. costs already paid or costs committed by decisions made in the past.
2. Relevant costs are cash flows - It is assumed that decisions are taken which would maximize the satisfaction of the company owners \& therefore such decisions must not be ignored. Such costs include depreciation, notional rent or notional interest or absorbed O/H.
3. Relevant costs arise as a direct consequence of making a decision. It should be an incremental cost i.e. the difference between the cost with the decision $\&$ the cost without the decision.

## Assumptions

The key assumptions made in relevant costing are:

1. The cost behaviour is known.
2. The amount of fixed costs, unit variable costs, selling prices and sales demand are known with certainty.
3. The objective of the decision maker in the short-term is to maximize satisfaction which can be defined as maximization of short-term profit.
4. The information on which the decision is based is complete and reliable.

There are various types of decisions that can be considered in this section, Examples include:
a. Make or Buy decisions
b. Shut down problems
c. Extra shift decisions
d. Joint cost decisions

### 3.7.1 MAKE OR BUY DECISIONS (NO LIMITING FACTORS)

The choice between making or buying a given component is one which is likely to face all businesses at some time. It is often one of the most important decisions for management for the critical effect on profits that may ensue. The choice is critical, too, for the management accountant who provides the cost data on which the decision is ultimately based.

A make or buy problem involves a decision by an organisation about whether it should make a product or carry out an activity with its own internal resources or whether it should pay another organisation to carry out the activity. The make option gives management more direct control over the work, but the buy option may have benefits in that the external organisation has expertise and special skills in the work making it cheaper.

There are certain situations where the make or buy decision is not really a choice at all. There can be no alternative to making, where product design is confidential or the methods of processing are kept secret. On the other hand, patents held by suppliers may preclude the use of certain techniques and then there is no choice other than buying or going without. The supplier who has developed a special expertise or who uses highly specialized equipment may produce better-quality work which suggests buying rather than making. In other cases, the special qualities demanded in the product may not be available outside and so making becomes necessary.

Where technical considerations do not influence the make or buy decision, the choice becomes one of selecting the least-cost alternative in each decision situation. Comparative cost data are necessary, therefore, to determine whether it is cheaper to make or to buy. In general this requires a comparison of the respective marginal costs or, in some cases, the incremental costs of each alternative. Incremental costs are relevant in decisions which include capacity changes. For example, a certain component has always been bought out because the plant and equipment for its manufacture has not been installed in the factory. When considering the alternative to buying, the cost of making comprises all the incremental costs (including additional fixed expenditure) arising from the decision. The incremental cost also includes the opportunity cost of the
investment in capital equipment, that is, the expected return from an alternative investment opportunity. A decision to buy a part which has previously been manufactured may release capacity for other uses or for disposal so that the incremental cost of the decision also includes the relevant fixed-cost savings.

## Illustration

Assume that ABC Ltd makes four components with the following information:

|  |  | W |  | X | Y | Z |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Production (units) |  | 1000 |  | 2010 | 4000 | 3000 |
| Unit marginal costs |  |  |  |  |  |  |
| Direct material |  | 4 |  | 5 | 2 | 4 |
| Direct labour |  | 8 |  | 9 | 4 | 6 |
| Variable O/H |  | $\underline{2}$ |  | $\underline{3}$ | 1 | $\underline{2}$ |
|  |  | $\underline{14}$ |  | $\underline{17}$ | 7 | $\underline{12}$ |
| Attribute Fixed Cost | sub contractor price |  |  |  |  |  |
|  | Sh. |  |  |  |  |  |
| TO W | 1000 |  | W |  |  |  |
| X | 5000 |  | X |  |  |  |
| Y | 6000 |  | Y |  |  |  |
| Z | 8000 |  | Z |  |  |  |

Committed Fixed Costs are Sh. 30000

## Required

Advice the company on the components to buy or make if any.

## Solution

|  | W | $\mathbf{X}$ | $\mathbf{Y}$ | $\mathbf{Z}$ |
| :--- | :--- | :--- | :--- | :--- |
| Cost of buying per unit | 12 | 21 | 10 | 14 |
| Variable Cost of making | 14 | 17 | 7 | 12 |
| Extra variable cost of buying | $(2)$ | 4 | 3 | 2 |
| No. of units | 1000 | 2000 | 4000 | 3000 |
| Total extra costs VC of buying | $(2010)$ | 8000 | 12010 | 6000 |
| Less attributable FC | $(1000)$ | $(5000)$ | $(6000)$ | $(8000)$ |
| Net extra costs of buying | $\underline{(3000)}$ | 3000 | 6000 | $(2010)$ |

The decision is to Buy W and Z and Make X and Y

### 3.7.2 MAKE OR BUY DECISIONS UNDER LIMITING FACTORS.

One reason for buying products/services from another organisation is the scarcity of resources, so that the company may be unable to make all its components. In such a case the company should combine internal resources with buying externally to increase profitability. In situations where a company must sub-contract work to make up short fall in its in-house capability, then its cost will be minimized where the marginal cost of buying is least for each unit of scarce resource saved by buying externally.

## Illustration

Assume that ABC Ltd makes four components with the following information:

|  | W | X | $\mathbf{Y}$ | Z |
| :--- | :--- | :--- | :--- | :--- |
| Production (units) | 1000 | 2010 | 4000 | 3000 |
| Unit marginal costs |  |  |  |  |
| Direct material | 4 | 5 | 2 | 4 |
| Direct labour | 8 | 9 | 4 | 6 |
| Variable O/H | $\underline{2}$ | $\underline{3}$ | $\underline{1}$ | $\underline{2}$ |
|  | $\underline{14}$ | $\underline{17}$ | $\underline{1}$ | $\underline{12}$ |


| Attribute Fixed Cost |  |  | sub contractor price |  |
| :---: | :--- | :--- | :--- | ---: |
|  | Sh. |  | Sh. |  |
| TO | W | 1000 | W | 16 |
|  | X | 5000 | X | 21 |
|  | Y | 6000 | Y | 10 |
|  | Z | 8000 | Z | 18 |

Committed Fixed Costs are Sh. 30000
Assume that machine hours per unit required to produce the components are:

|  | M |
| :--- | :--- |
| W | 4 |
| X | 5 |
| $Y$ | 3 |
| $Z$ | 6 |

The total machine hours available is 27000 hours during the budget period.

## Required:

Advice the company on which products to make and the ones to buy externally.

## Solution

Required machine hours

| W | $4 \mathrm{X} 1000=$ | 4000 |
| :--- | :--- | :--- |
| X | $5 \mathrm{X} 2010=$ | 10000 |
| Y | $3 \mathrm{X} 4000=$ | 12010 |
| Z | $6 \mathrm{X} 3000=$ | $\underline{18000}$ |
| I |  | $\underline{44000}$ |
| Available hours | $\underline{27000}$ |  |
| Shortfall |  | $\underline{17000}$ |

Machine hours is therefore a limited resource

|  | W | X | Y | Z |
| :--- | :--- | :--- | :--- | :--- |
| Cost of buying per unit | 16 | 21 | 10 | 18 |
| Cost of making VC | 14 | 17 | 7 | 12 |
| Extra variable cost of buying | 2 | 4 | 3 | 6 |
| No. of units | 1000 | 2010 | 4000 | 3000 |
| Total extra V. Cost of buying | 2010 | 8000 | 12010 | 18000 |
| Less attributable F C | $(1000)$ | $(5000)$ | $(6000)$ | $(8000)$ |
| Net extra cost of buying | 1000 | 3000 | 6000 | 10000 |
| Divide the no. of mhrs saved | 4000 | 10000 | 12010 | 18000 |
| Net extra costs of buying per |  |  |  |  |
| Machine hours saved | 0.25 | 0.30 | 0.5 | 0.56 |
| Priority for buying | 1 | 2 | 3 | 4 |
| Priority for making | 4 | 3 | 2 | 1 |

### 3.7.3 ABANDONMENT DECISIONS

From time to time management will be faced with the problem of deciding to abandon an unprofitable activity.
This is really a least-cost alternative decision and so made on the criterion of relative marginal costs.

## Ceasing Production of Certain Products

It is sometimes suggested that, where a given product is apparently making a loss, manufacture and/or marketing of this product should cease, to improve the company's overall profit performance.

## KENBAR CYCLES LIMITED PROFIT AND LOSS STATEMENT FOR YEAR ENDED 31.12.19..

|  | Model A16 Model E35 |  | Model N40 | Total |
| :--- | ---: | :---: | ---: | :---: |
|  | $\mathbf{£}^{\prime} \mathbf{0 0 0}$ | $\mathbf{£}^{\prime} \mathbf{0 0 0}$ | $\boldsymbol{£}^{\prime} \mathbf{0 0 0}$ | $\boldsymbol{£}^{\prime} \mathbf{0 0 0}$ |
| Direct materials | 110 | 100 | 150 | 360 |
| Direct labour | 50 | 40 | 80 | 170 |
| Variable overhead | 65 | 60 | 100 | 225 |
| Fixed overhead | $\underline{45}$ | $\underline{120}$ | $\underline{220}$ | $\underline{385}$ |
| TOTAL COSTS | 270 | 320 | 550 | 1,140 |
| Profit/(loss) | $\underline{45}$ | $\underline{65}$ | $\underline{(50)}$ | $\underline{60}$ |
| SALES VALUE | $\underline{315}$ | $\underline{385}$ | $\underline{500}$ | $\underline{1,200}$ |

Model N40 is incurring losses of $£ 50,000$ per annum, which is ten per cent of its sales value. The implication of this profit and loss statement is that the withdrawal of Model N40 from the market will avoid losing $£ 50,000$ and (by inference) raise profits to $£ 110,000$. This is faulty reasoning, but a risk which is inherent in the total cost form of presentation. The marginal presentation of the year's results would avoid the risk and give a more meaningful report.

## KENBAR CYCLES LIMITED

PROFIT AND LOSS STATEMENT FOR YEAR ENDED 31.12.19..

|  | Model A16 Model E35 |  |  | Model N40 |
| :--- | :---: | :---: | :---: | :---: | Total

Since Model N40 yields an annual contribution of $£ 170,000$, the abandonment of this product will lose this contribution and so turn the overall profit of $£ 60,000$ into a loss of $£ 110,000$. (The contribution from A16 and E35 is $£ 275,000$ towards the fixed costs of $£ 385,000$ ). The marginal presentation shows that it is better to continue production of Model N40 rather than lose its contribution. As a general proposition it can be postulated that it is more profitable to continue marketing a product which yields some contribution rather than abandon it. (If possible, it would be better still to replace it with another product having a higher $\mathrm{P} / \mathrm{V}$ ratio).

### 3.7.4 TEMPORARY CLOSURE OF FACTORY OR DEPARTMENT

Here there is a similar situation to that of discontinuance of a product such as Model N40. A factory which is expected to earn some contribution should continue in operation rather than be shut down. However, if the factory is part of a group, the decision is quite different when the output from the closed factory is not lost but transferred to another factory in the group with spare capacity. For example, a temporary fall in the sales volume of a company's products may result in either of two factories being capable of satisfying the expected demand. In this situation the company can optimise its profits by concentrating production in that factory which has the lowest marginal costs. In reaching a decision, consideration should be given to predictable cost changes generated by the decision: such as additional distribution costs, care and
maintenance of the closed premises, restarting costs, and any fixed cost savings such as salaries in the closed factory.

### 3.7.5 PERMANENT ABANDONMENT OF PREMISES

A company may find it more profitable to concentrate its output in some factories by closing down others. The decision, in this instance, is made on the basis of incremental costs and will depend on that combination of resources which yields the greater overall group profit. The permanent closure of a factory saves fixed cost expenditure and also frees capital (by the sale of assets) for alternative investment, as well as providing the opportunity to take advantage of low marginal costs elsewhere. It is possible that the sale of freehold land and buildings could provide considerable investment funds free of interest which would make the abandonment particularly attractive. This has been demonstrated effectively by asset stripping following a successful takeover.

There may be a high social cost in a factory closure which is difficult to evaluate, but in any case it will be borne by the whole community rather than the individual manufacturer. A growing awareness of the social consequences which follow factory closures may persuade politicians that the cost to the community represents a hidden subsidy to the profits of an individual company. A tax or other deterrent for such cases in the future would be an additional cost of abandonment decisions and so make it relatively less profitable to close a factory.

### 3.7.6 EXTRA SHIFT DECISION

These decisions are concerned with whether or not a company should work for $8 \mathrm{hrs}, 16 \mathrm{hrs}$, or 24 hrs a day or week day's only or weekends also. The factors to consider are:
i. Whether the work force would be willing to work extra shifts \& if so what overtime or shift premium they would accept.
ii. Whether extra hours have to be worked just to remain competitive
iii. Whether extra hours would resort in extra revenue or whether there would be in demand pattern from customers.

## Illustration

XYZ currently operates a single production shift which incurs costs and earns revenue stated below:
Sales (10000 units)
$£$
Direct material
360000
Direct labour
120100
100000
Variable O/Hs $\underline{20100}$
(240000)

Contribution Fixed
Cost
120100
(90000)

Profit
30000
Profit margin
$8.36 \%$
Sales demand exists for an extra 6000 units which can be made in a $2^{\text {nd }}$ shift at current selling price. The labour in the $2^{\text {nd }}$ shift will be paid at time \& $1 / 4$. Additional fixed cost of $£ 10000$ will be incurred but due to the increase in purchase of materials a quantity discount of $5 \%$ will be given on all materials purchased. Required:

Advice the company on whether to operate the $2^{\text {nd }}$ shift.

## Solution: Analysis of Second shift

|  |  |  | £ |
| :---: | :---: | :---: | :---: |
| Sales (6000x36) |  |  | 216000 |
| Direct labour (1.25x10000) | 125,000 |  |  |
| Variable O/Hs (2x6000) | 12010 |  |  |
| Direct material |  |  |  |
| Purchase $12 \times 6500$ | 72010 |  |  |
| Less discount 5\% x 192010 | $\underline{9600}$ | 62400 |  |
| Additional Fixed Cost |  | $\underline{10000}$ | $\underline{209400}$ |
| Incremental total |  |  | 6600 |
| Profit margin |  |  | 3.1\% |

## Decision

Operate the second shift since it results in incremental profits.

### 3.7.7 JOINT PRODUCT DECISIONS

When a manufacturing Company carries out a process operation in which 2 or more joint products are made from a common process a number of decision problems can arise. These are-
(1) If the joint product can be sold at existing condition at the split-off point or after further separate processing, then a decision should be made on whether to process further.
(2) If extra demand for a joint product exists and not others then it is necessary to know whether it is worth making more output of the joint product so as to make a profit on one and dispose off the other.
(3) If it is possible to change the input so as to change the product mix, then product mix decisions should be made.

## Joint Product further processing decisions

In these decisions the relevant costs are the additional costs of further processing, which should be compared with the incremental revenue of further processing. The joint costs incurred before the splitoff points are irreverent.

## Illustration.

$A B C$ Ltd produces product $A \& B$ from the same process. Joint processing costs of $\$ 150,000$ are incurred up to the split off point where 100,000 units of A and 50,000 units of $B$ are produced. The selling prices for products A and B at the split-off point are $\$ 1.25$ per unit and $\$ 2.00$ per unit respectively.
Units of A can be processed further to produce 60,000 units of $A^{+}$which will incur a fixed cost $\$ 20,000$ and variable cost of $\$ 0.3$ per unit.

## Required

Advice the Company whether to sell product A or product A+

## Solution

Incremental revenue $\$ 3.25 \times 60,000-1.25 \times 100,000 \quad \$ 70,000$
Further processing costs

| Fixed cost | 20,000 |  |
| :--- | ---: | :--- |
| variable cost $\$ 0.3 \times 100,000$ | $\underline{30,000}$ | $\underline{50,000}$ |
| Incremental profit from further processing | $\underline{20,000}$ |  |

## Decision

Process further since incremental profit is positive

## Joint product Break-even point of extra Output.

If more output of one joint product is required it would require production of additional units of other joint products. The incremental costs of extra output should include the costs of producing the non-required joint product unless there is revenue generated by disposing of those products.

## Illustration

ABC Ltd manufactures 3 products in a series of process as shown below, Raw materials


| Cost | Process 1 | process 2 | process 3 |
| :--- | :---: | :--- | :---: |
| Raw materials | $\$ 40,000$ | - | - |
| Variable overheads | 16,000 | 3,000 | 5,000 |
| Fixed overheads | 10,000 | 7000 | 10,000 |

Selling prices.

| A $-----\$ 3$ | BX | $------\$ 12$ |
| :--- | ---: | :--- |
| B ----- $\$ 10$ | CX | $-----\$ 10$ |

C ------ $\$ 6$
Assume all the fixed costs of process $2 \$ 3$ are avoidable

## Required

(a) Determine whether the Co . is maximising its profit by further processing product B to BX and C to CX.
(b) Calculate the break even selling price if the Co. was to receive an order for an extra 1000 Kgs of product CX, which would incur extra delivery costs of $\$ 1800$
i. Assume that the extra output of A $\$$ B would be disposed of at scrap value which covers their disposal cost.
ii. Assume that there would be extra demand at the current prices for product $A \$ B$.

## Solution

$$
\text { Further processing of Product } \mathrm{B} \text { to } \mathrm{BX} \text { and } \mathrm{C} \text { to } \mathrm{CX}
$$

$\begin{aligned} & \text { Incremental selling price- } \quad \begin{aligned} B=12-10 & =\$ 2 \\ C & =10-6\end{aligned}=\$ 4 \\ & \text { Therefore total sales increase }=2 \times 4000=\$ 8000\end{aligned}$

$$
4 \times 5000=\$ 20,000
$$

|  | B | C |
| :--- | ---: | ---: |
| Incremental revenue | $\$ 8,000$ | 20,000 |
| Incremental cost | 3,000 | 5,000 |
| Variable costs | $\underline{7,000}$ | $\underline{10,000}$ |
| Fixed costs | $\underline{10,000}$ | $\underline{15,000}$ |
| Incremental profit/loss | $\underline{(2,000)}$ | $\underline{5,000}$ |

## Decision

The Co. is making a good decision to further process $C$ to $C X$ since incremental profit is positive but it is not making a good decision to further process product B to BX because incremental profit is negative.

## (b) (i) Assumption 1

$$
\text { Incremental units }=\frac{1000}{5000} \times 100=20 \%
$$

Extra Variable Cost of 1000 kg of CX.

| process $1-$ material $(20 \% \times 40000)$ | $\$ 8000$ |
| :--- | ---: |
| Variable overheads $(20 \% \times 16000)$ | 3200 |
| Process 2 -variable overheads $(20 \% \times 5000)$ | $\underline{1000}$ |
|  | 12200 |
| Extra fixed costs of delivery | $\underline{1800}$ |
| Total extra costs | $\underline{14000}$ |

Total extra costs 14000

Break even price $\quad=\frac{14000}{1000}=14$ per kg.
b) (ii) Assumption 2.

## Extra cost of A\&B

Total extra costs (as in (i) above) 14,000
Less revenue of:
A: 200kg@\$3 600

B: 8000kg@ $\$ 10 \underline{8000}$
Net extra costs $\underline{5400}$

Break-even price $\frac{5400}{1000}=\$ 5.40$ per Kg.

## Product mix decision

A manufacturing Company may be faced with a decision about whether to change the product mix in its process so as to produce a greater proportion of one product and less of another e.g. if a process produces product X and Y in the ratio of 2.1 it may be possible to change the ratio to $3: 2$ but such a decision requires consideration of the relevant costs and relevant revenue of the change.

## Illustration

XYZ Ltd produces 2 joint products $\mathrm{P} \& \mathrm{Q}$ in the ratio of 2:1. After the split off point the products can be sold for industrial use or taken to mixing plant for blending and refining. (the $2^{\text {nd }}$ option usually followed). The following information is given for a specific week:

| Sales | $\mathbf{P}$ | $\mathbf{Q}$ |
| :--- | :--- | :--- |
|  | 2010 litres | 1000 litres |
| Price per litre | $\$ 35$ | $\$ 60$ |
| Sales revenue | $\$ 70,000$ | $\$ 60,000$ |
| Joint process cost | $\$ 30,000$ | $\$ 15,000$ |
| Blending \& refining | $\$ 25,000$ | $\$ 25000$ |
| Other separable cost | $\underline{\$ 5,000}$ | $\underline{\$ 1000}$ |
| Profits | $\underline{60,000}$ | $\underline{41,000}$ |
| $\underline{\$ 10,000}$ | $\underline{\$ 19000}$ |  |

Joint process costs (which are allocated on volume) are $75 \%$ fixed and $25 \%$ variable, whereas the mixing plants costs are $40 \%$ fixed and $60 \%$ variable. There are only 40 hours available in the mixing plant (usually 30 hrs are taken up to processing of product $\mathrm{P} \& \mathrm{Q}$ equally and 10 hrs are used for other work that generates a contribution of $\$ 2010$ per hour)

It has been suggested that it might be possible to change the mix of the joint process to $3: 2$ for $\mathrm{P} \& \mathrm{Q}$ respectively at a cost of $\$ 5$ for each additional litre of Q produced by the process.

## Required

Advice the Co. on whether to change the mix

## Solution

Proposed mix
$\mathrm{P}=3 / 5 \times 3000=1800$ litres
$\mathrm{Q}=2 / 5 \times 3000=1200$ litres

## Cost Benefit Analysis

Incremental revenue of Q 200@ \$60 12010
loss of revenue of P $200 @ \$ 35 \quad \underline{7000}$
Net incremental revenue 5,000

## Incremental Costs

Joint processing costs 200@ \$ 5 1000
Blending and refining

| Extra costs of Q | 25000/1000*.6*200 | 3000 |  |
| :--- | :---: | ---: | ---: |
| Savings of P | $25000 / 2010 * .6 * 200$ | $\frac{(1500)}{(300)}$ | 1500 |
| Other separable costs | $200(1-2.5)$ | $\underline{3000}$ | $\underline{(5700)}$ |
| Opportunity costs | $(3-1.5) \times 2010$ |  | $(\underline{200)}$ |
| Net Incremental profit |  |  |  |

## Decision

The Company should not change the mix because it results in an incremental loss of $\$ 200$.

## REIFORCING QUESTIONS

## QUESTION ONE

Sniwe plc intends to launch a commemorative product for the 2014 Olympic games onto the UK market commencing 1 August 1990. The product will have variable costs of $£ 16$ per unit. Production capacity available for the product is sufficient for 2,000 units per annum. Sniwe plc has made a policy decision to produce to the maximum available capacity during the year to 31 July 1991. Demand for the product during the year 31 July 1991 is expected to be price dependant as follows:

| Selling price per unit | Annual sales |
| :---: | :---: |
| $£$ | units |
| 20 | 2,000 |
| 30 | 1,600 |
| 40 | 1,200 |
| 50 | 1,100 |
| 60 | 1,000 |
| 70 | 700 |
| 80 | 400 |

It is anticipated that in the year to 31 July 2014, the availability of similar competitor products will lead to a market price of $£ 40$ per unit for the product during that year.
During the year to 31 July 2014, Sniwe plc intend to produce only at the activity level required to enable them to satisfy demand with stocks being run down to zero if possible. The policy is intended as a precaution against a sudden collapse of the market for the product by 31 July 2014.

## Required:

(ignoring tax and the time value of money)
a) Determine the launch price at 1 August 1990 which will maximise the net benefit to Sniwe plc during the two year period to 31 July 2014 where the net demand potential for the year to 31 July 2014 is estimated as (i) 3,600 units and (ii) 1,000 units.
b) Identify which of the launch strategies detailed in (a)(i) and (a) (ii) above will result in unsold stock remaining at 31 July 2014. Advise management of the minimum price at which such unsold stock should be sold in order to alter the initial launch price strategy which will maximise the net benefit to Sniwe plc over the life of the product.
c) Comment on any other factors which might influence the initial launch price strategy where the demand in the year to 31 July 2014 is estimated at 1,000 units.

## QUESTION TWO

A sports good manufacturer in conjunction with a software house, is considering the launch of a new sporting simulator based on video tapes linked to a personal computer enabling much greater realism to be achieved. Two proposals are being considered. Both use the same production facilities and as these are limited, only one product can be launched.
The following date are the best estimates the firm has been able to obtain:

|  | Foot ball simulator | Cricket simulator |
| :--- | :---: | :---: |
| Annual volume(units) | 40,000 | 30,000 |
| Selling price | $£ 130$ per unit | $£ 200$ per unit |
| Variable production costs | $£ 80$ per unit | $£^{100}$ per unit |
| Fixed production costs | $£ 600,000$ | $£ 600,000$ |
| Fixed selling and |  |  |
| Administrative costs | $£ 450,000$ | $£ 1,350,000$ |

The higher selling and administrative costs for the cricket simulator reflect the additional advertising and promotion costs expected to be necessary to sell the more expensive cricket system.

The firm has a minimum target of $£ 200,000$ profit per year for the new products. The management recognises the uncertainty in the above estimates and wishes to explore the sensitivity of the profit on each product to changes in the value of the variables (volume, price, variable cost per unit, fixed costs).

## Required

a) To calculate the expected profit from each product;
b) To calculate the critical value for each variable (ie the value at which the firm will earn $£ 200,000$ ), assuming that all other variables are expected (express this as an absolute value and as a percentage change from the expected value.);
c) To discuss the factors which should be considered in making a choice between the two products.

## QUESTION THREE

Multiple CVP
A company sells two products A and B with contribution margin ratios of 40 and 30 per cent and selling prices of sh. 5 and sh. 2.50 a unit. Fixed costs amount to sh. 72,000 a month. Monthly sales average 30,000 units of product and 40,000 units of product B.

## Required:

(a) (i) Assuming that three units of product A are sold for every four units of product B, calculate the sales volume necessary to breakeven, in shillings and in units.
(ii) Calculate the margin of safety in sales shillings
(b) If the company spends an additional sh.9,700 on advertising, sales of product A can be increased to 40,000 units a month. Sales of product B will fall to 32,000 units a month if this is done. Should this proposal be accepted?
c) Recalculate the breakeven point in shillings based on the figures in (b)
d) State the condition that would have to hold true for the company to earn a zero profit at the breakeven volume you calculated in (c)

## CHECK YOUR ANSWERS WITH THOSE GIVEN IN LESSON 10 OF THE MANAGEMENT ACCOUNTING NOTES

## LESSON FOUR

## INVENTORY CONTROL AND QUEUING THEORY

## OBJECTIVES

Examination in depth of Inventory Control and Planning and control techniques

## INSTRUCTIONS

1. Read study text below and Chapter 25 of Management and Cost Accounting, by Colin Drury $5^{\text {th }}$ Edition
2. Attempt the reinforcing questions at the end of the lesson under examination conditions
3. Compare your answers with those given in Lesson 10

## CONTENTS

1.1 Inventory control
1.2 Queuing Theory
1.3 Simulation Analysis

### 1.1 INVENTORY CONTROL

## Introduction

The activities of a business during a financial year combine investment projects in progress with new projects commencing and others terminating within the year. it would appear reasonable to presume, therefore, that business financial reports are presented in the cash-flow mode used to appraise investments, to facilitate comparison of actual with planned cash flows.

Some businesses do make such comparisons as part of their retrospective monitoring of investment decisions, but there is no obligation to do so. Cash-flow accounting, as it is called, has its supporters, but its introduction is frustrated by statutory and non-statutory regulations.

The Companies Act requires limited companies to produce profit and loss accounts and balance sheets in prescribed form. The Inland Revenue assumes that taxable profit has been computed by applying recognized accounting principles. The Accounting Standards Committee recommends the application of standard practices in the measurement of profit and portrayal of a company's financial position in its balance sheet. More compellingly, profit and loss reporting is compatible with the investors' objectives of stable and growing earnings.

Profit is measured conventionally by setting against the sales revenue for a period the costs expired in earning that revenue. That is, sales are matched against their relevant costs. Profit is therefore more evenly reported than it would be if all cash receipts and payments, capital and revenue, were fully reflected in the accounts of the period in which they are received and paid.

The management accountant also adopts the matching principle when preparing control information in both actual and budgeted form, and also ascertains full product cost as a starting point for setting selling prices.

This outlines the systems and methods used to control the flow of resources through production and service cost centres, for their eventual inclusion in product and period costs.

## MATERIAL CONTROL

It is said that "any fool can sell"-it is buying at the right price that is more critical to the achievement of a satisfactory return on capital employed. Buying price is important of course, but buying the right materials, are equally important if production targets are to be achieved and investment in inventories to be minimized.

## What to order

This is governed by product specifications, but an efficient buyer will always have his ear to the ground to discover new and substitute materials and components of advantageous quality and price. Other economies can be realized by reducing the variety of materials purchased by standardization, e.g. reducing the variety of colours of paint stocked, or by introducing value analysis into the decision process.

## Value analysis

Is a formalized technique involving a rigorous analysis of products at the design stage or at any time during the saleable lives, to determine their value characteristics. These are the attributes that a customer looks for in a product and include its use value (functional qualities), appeal value (colour, style etc.) and second-hand value (e.g. trade-in-price). The object of value analysis is to build into the product the optimum of desired value at minimum cost, by introducing the most up-to-date designs, materials and methods of manufacture. No more value need be built into the product than is desired by the customer. For example, moulded plastic bumper bars are now fitted to many cars, because they are cheaper and equally as functional as chromium-plated steel ones.

## How much to order

Supposing the estimated annual usage of a component by Harambee Agricultural Machinery Ltd is 20,000 units. Usage is even throughout the year and only one order per annum is placed with the supplier. Because only one delivery is made, average stock will be high, i.e. $20,000 \mid 2=10,000$ and consequently stockholding costs will be very high. On the other hand, the costs of ordering will be negligible. If two orders are placed there will be less in stock (i.e. average 5,000 ), which will reduce holding costs, but ordering costs will increase. Thus, the higher the number of orders placed, the lower are stockholding costs, but the higher are ordering costs.

Stockholding costs include interest on the capital invested in stocks, storage, insurance, rates, security, building maintenance, heating, etc. Ordering costs include buying-department staff costs, receiving and handling.

Assuming that the cost of each Harambee component is $£ 10$, that holding cost is $10 \%$ of stock value and the cost of placing an order is $£ 1$, the total annual cost of stockholding and ordering when different numbers of orders are placed, is as follows:

| Number of orders | 4 | 20 | 50 | 100 | 200 | 400 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Size of order | 5,000 | 1,000 | 400 | 200 | 100 | 50 |
| Average Stock (50\% order) | 2,500 | 500 | 200 | 100 | 50 | 25 |
| Holding cost | £,2,500 | £.500 | £.200 | £.100 | f, 50 | £25 |
| Ordering cost ( $£ 11$ per order) | $¢_{4} 4$ | $¢_{20} 20$ | ¢, 50 | $¢_{\text {¢, } 100}$ | ¢,200 | £.400 |
| Total Annual Cost | £,2,504 | £.520 | £.250 | £200 | £250 | £.425 |



## Figure 6 Economic Order Quantity

Placing 100 orders a year results in the lowest of ordering and holding cost of $£ 200$, therefore the economic order quantity is 200 units.
The same information is graphed in Figure 1 above, showing that the economic order quantity (EOQ) is the point where ordering and holding costs are equal, and total $£ 200$.

Thus the two pay off numbers 6 and 3 in the first column are shown respectively by point $A$ on Axis I and point B on Axis II.

Join the corresponding pay off numbers on Axis I and Axis II by straight lines.
On the two intersecting lines at the very bottom, thicken them from below up to the point of intersection, i.e. highest point on the boundary.

The thick lines on the graph KT and LT meet at T
The two lines passing through T , identify the two critical moves of Y which combined with X , yield the following $2 \times 2$ matrix.

$$
\mathbf{X} \quad\left[\begin{array}{cc}
\mathbf{Y} \\
-1 & -3 \\
-4 & -1
\end{array}\right]
$$

The value of the game and the optimum strategies can be calculated using the methods described earlier.

## Example II

Determine the optimum strategies and the value of the game from the following pay-off matrix concerning a two person 4 X 2 game.

$$
\left.\mathbf{X} \quad \begin{array}{c}
\mathbf{Y} \\
-6 \\
-3 \\
-4 \\
2 \\
-7
\end{array}\right)
$$

This method is similar to the previous example, except we thicken the line segments which bind the figure from the top and take the lowest point on the boundary.
The segments KP, PM and ML drawn in thick lines bind the figure from the top and their lowest intersection M, through which the two lines pass defines the following 2 X 2 matrix relevant to our purpose.

|  |  | $\mathbf{Y}$ |
| :---: | :---: | :---: |
|  |  |  |
| $\mathbf{X}$ | -3 | -4 |
| -7 | -1 |  |

The optimum strategies and the value of the game can now be calculated.

## 3. NON-ZERO SUM GAMES

Within very vast situations of possible non-zero games, varying degrees of co-operation exist between the participants. Games theory has been sufficiently developed to deal with two extreme forms-the cooperative game and non-cooperative game.

In a co-operative game, the players have complete freedom to communicate with each other. They can make threats, enter into agreements favourable to them. They can freely negotiate and enter into binding agreements. In a non-cooperative game there is no communication between the participants and no way of enforcing agreements.

Prisoner's dilemma games, battle of sexes games, chicken and Hawk (dove game) are all examples of nonzero sum games.

## 1. Prisoner's Dilemma

## Story

Two persons are arrested for a crime. The police lack sufficient evidence to convict either suspect and consequently need them to give testimony against each other.

The police tell each suspect that if he testifies against the other (or does not cooperate with the other), he will be rewarded for testifying and hence will be released, provided the other suspect does not testify against him. If neither testifies, the prosecutor will be unable to prove the crime and each suspect can only receive minor sentence. If both suspects confess and testify against each other, then both will receive an intermediate prison sentence. Hence the conflict of interest, the tendency to double cross and lose the confidence of the other.

Each suspect must decide under the circumstances, whether or not to confess.
It is possible to translate such a situation in the form of a table and a payoff matrix as follows:

|  |  | Suspect Two |  |
| :---: | :---: | :---: | :---: |
|  |  | Not confess | Confess and testify |
| Suspect one | Not confess | One year prison term for <br> each | 10 year prison term for <br> suspect one, suspect two <br> released |
|  | Confess and <br> testify | Suspect one released and <br> suspect two gets 10 year <br> prison term | Both suspects get 4 years <br> prison term |

Payoff Table

|  |  | Suspect Two |  |
| :---: | :---: | :---: | :---: |
|  |  | Not confess |  | Confess and testify | Suspect one | Not confess | $-1,-1$ |
| :---: | :---: | :---: |
|  |  |  |
|  | Confess and <br> testify | $0,-10$ |

This is an example of non-zero sum, non-cooperative game.
2. Battle of the Sexes

## game Story

Two players (a couple) wish to go to an event together but disagree about whether to go to a football game or the variety show. Each player gets a utility of 2 if both go to his or her preferred event, a utility of 1 if both go to the other's preferred event and zero if both are unable to agree and stay at home or go out individually. The pay-off matrix can be represented as follows:

|  |  | Her |  |
| :---: | :---: | :---: | :---: |
|  |  | Football (F) | Variety Show (V) |
| His | Football (F) | 2,1 | 0,0 |
|  | Variety <br> Show (V) | 0,0 | 1,2 |

## 3. Chicken and Hawk (dove game)

Two players meet at a one-lane bridge and each must choose whether to cross first or wait for the other. If both play Tough ( T ), they crash in the middle of the bridge and get -1 each, if both play Weak (W), they keep on waiting and get 0 , if one player chooses Tough ( $T$ ) and the other Weak (W), then the tough player crosses first receiving 2 , and the other weak one receives 1.

|  |  | Player II |  |
| :---: | :---: | :---: | :---: |
|  |  | $(\mathrm{T})$ |  |
| Player I | (T) | $-1,-1$ |  |

All these games are similar and have similar types of Nash Equilibrium points.

1. For instance in battle of sexes games, there are three Nash equilibrium points. Two are pure strategies with payoffs $(2,1)$ and $(1,2)$ and third one can be a mixed strategy depending upon sex, (who is more dominant) i.e.

## Mixed Strategy:

Player `His' plays F with probability \(2 / 3\) and player `Her' plays F with probability $1 / 3$.
Similarly player `His' plays ' $V$ ' with $1 / 3$ of the probability and player 'Her' with probability $2 / 3$.
2. In the Chicken and Hawk game, if both players act tough, then the probability is $1 / 2,1 / 2$.

## Note:

This is only possible if both players act rationally and from long experience are able to coordinate their games. Another assumption is, the players study the moves of each other at every stage and try to discover the pattern of the opponent's play.
4. Each individual farmer can maximise his own income by maximising the amount of crops that he produces. When all farmers follow this policy, the supply exceeds demand and the prices fall. On-the-other-hand, they can agree to reduce the production and keep the prices high.

This creates a dilemma to the farmer.
This is an example of a non-zero sum game.
Similarly, marketing problems are non-zero sum games, as elements of advertising come in. In such cases, the market may be split in proportion to the money spent on advertising multiplied by an effectiveness factor.
5. The table given below is a pay off matrix for two large corporations A and B. Initially they both have the same prices. Each considers cutting their prices to gain market share and hence improve profit.


The entries in the pay off matrix indicates the order of preferences of the players i.e. first A and then B.

We may suppose that if both corporations study the situation, they will both decide to play row I, column I $(3,3)$.

## However:

Suppose A's reasoning is as follows:
If B plays column I, then I should play column II because I will increase my gain to 4 .
In the same way B 's reasoning may be as follows:
If A plays row I, then I should play column 2 , to get pay off 4 per play.
If both play 2 (row two and column two), each receives a pay-off of 2 only.
In the long run, pay-off $(2,2)$ forms a new equilibrium point because if either party departs from it without the other doing so he will be worse off before he departed from it.

Game theory seems to indicate that they should play $(2,2)$ because it is an equilibrium point but this is not intuitively satisfying. On the other hand $(3,3)$ is satisfying but does not appear to provide stability. Hence, the dilemma.

## THEORY OF METAGAMES

This theory appears to describe how most people play non-zero sum games involving any number of persons.
Prisoner's dilemma is an example of this, The aim is to identify points at which players actually tend to stabilise their play in non-zero sum games.
This theory not only identifies equilibrium points missed by traditional game theory in games that have one or more such points but also does so in games in which traditional theory finds no such points.

Its main aim is that each player is trying to maximise the minimum gain of his opponent.

## ADVANTAGES AND LIMITATIONS OF GAME

THEORY Advantage:
Game theory helps us to learn how to approach and understand a conflict situation and to improve the decision making process.

## Limitations:

1. Businessmen do not have all the knowledge required by the theory of games. Most often they do not know all the strategies available to them, nor do they know all the strategies available to their rivals.
2. There is a great deal of uncertainty. Hence we usually restrict ourselves to those games with known outcomes.
3. The implications of the minimax strategy is that the businessman minimises the chance of maximum loss. For an ambitious businessman, this strategy is very conservative.
4. The techniques of solving games involving mixed strategies where pay-off matrices are rather large, is very complicated.
5. In non-zero sum games, mathematical solutions are not always possible. For example, a reduction in the price of commodity may increase overall demand. It is also not necessary that demand units will shift from one firm to another.

## PRACTICE QUESTIONS

## QUESTION ONE

A has two ammunition stores, one of which is twice as valuable as the other. B is an attacker who can destroy an undefended store but he can only attack one of them. A can only successfully defend one of them.

What would A do so as to maximise his return from the situation no matter what B may do?

## QUESTION TWO

Determine the optimum strategies and the value of the game for the following pay-off matrix.
$\mathbf{X} \quad\left[\begin{array}{rrr}1 & 2 & -1 \\ -2 & 1 & 1 \\ 2 & 0 & 1\end{array}\right]$

## QUESTION THREE

(a) For the following pay-off matrix for firm A determine the optimal strategies for both the firms and the value of the game (You may use maximin-minimax principle).

Firm A $\quad\left[\right.$| Firm B |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 3 | -1 | 4 | 6 | 17 |  |
| -1 | 8 | 2 | 4 | 12 |  |
| 16 | 8 | 6 | 14 | 12 |  |
| 1 | 11 | -4 | 2 | 1 |  |$)$

(b) Explain the principle of dominance in Game theory and solve the following game

$$
\text { Player A } \quad\left[\begin{array}{ccccc}
1 & 3 & 2 & 7 & 4 \\
3 & 4 & 1 & 5 & 6 \\
6 & 5 & 7 & 6 & 5 \\
2 & 0 & 6 & 3 & 1
\end{array}\right]
$$

## QUESTION FOUR

(a) Define pure and mixed strategies. What is a fair game?
(b) Solve the following game graphically and find the value of the game.

Player B
$\left.\begin{array}{llll} & & & \\ \text { Player A } & 4 & -2 \\ -2 & -1 & 3\end{array}\right]$

## QUESTION FIVE

A party X sends two bombers I and II, to bomb an installation of the opponent Y. Bomber II follows bomber I at a distance. One of the bombers carries a bomb and the other acts as an escort. Y has single fighter to attack the two bombers. The bombers are equipped with guns of different calibres to engage the fighter. If the fighter attacks bomber II, it can be engaged by the gun of this bomber only whereas if it attacks bomber I it can be engaged by the guns of both the bombers. The probability of the fighter being shot down in the first case is 0.3 and in the second 0.7 . If the fighter is not shot down it destroys the bombers it attacks with a probability of 0.6. It is required to analyse the game and determine
(a) For X, which bomber to carry the bomb
(b) For Y, which bomber to attack

## QUESTION SIX

There are two competing department stores A and B in a city. Both stores have equal reputation and the total number of customers is equally divided between the two. Both the stores plan to run annual discount sales in the last week of December. For this they want to attract more number of customers by using advertisements through newspapers, radio and television. By seeing the market trend, the store A constructed the following pay-off matrix where the numbers in the matrix indicate a gain or loss of customers. Find optimal strategies for stores A and B using any method.

|  |  | Newspaper | Radio | Television |
| :---: | :---: | :---: | :---: | :---: |
|  |  | N | R | T |
| A | N |  |  |  |
| R |  |  |  |  |
| T |  |  |  |  |\(\quad\left[\begin{array}{ccc}40 \& 50 \& -70 <br>

10 \& 25 \& -10 <br>
100 \& 30 \& 60\end{array}\right.\)

## QUESTION SEVEN

A steel company is negotiating with its union for revision of wages to its employees. The management with the help of a mediator has prepared a pay-off matrix shown below. Plus sign represents wage increase, while -ve (negative) sign is for wage decrease. Union has also constructed a table which is comparable to that developed by management. The management does not have the specific knowledge of game theory to select the best strategy for the firm. You have been called to assist the management on the problem. What game value and strategies you suggest would be acceptable to both parties.

|  |  | Nairobi Breweries <br> Union Strategies |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | U1 | U2 | U3 | U4 |
|  | B1 | $+2.50$ | +2.70 | $+3.50$ | -0.20 |
| Breweries | B2 | +2.00 | +1.60 | +0.80 | +0.80 |
| Strategies | B3 | +1.40 | +1.20 | +1.50 | +1.30 |
|  | B4 | +3.00 | +1.40 | +1.90 | 0 |

## CHECK YOUR ANSWERS WITH THOSE GIVEN ON THE FOLLOWING PAGES

## ANSWERS TO PRACTISE QUESTIONS—GAME THEORY

## QUESTION ONE

Let the value of the small store be $=1$
and the value of the large store be $=2$
If both survive, A loses nothing, if only large store survives, A loses 1 and if smaller store survives, A will lose 2.

## Payoff matrix

| Defender A |  | Attacker B <br>  |  |
| :---: | :---: | :---: | :---: |
|  |  | Attack the smaller <br> store <br> 1 | Attack the larger <br> store <br> II |
|  | Defend the smaller store <br> 1 | Both survive <br> 0 | The larger store <br> destroyed <br> -2 |
|  | Defend the larger store <br> II | The smaller store <br> destroyed <br> -1 | Both survive <br> 0 |

Payoff matrix

|  |  | B |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 1 | 2 | Row minimum |
| A | 1 | 0 | -2 | -2 |
|  | 2 | -1 | 0 | -1 |
| Column <br> maximum | 0 | 0 |  |  |
|  |  |  |  |  |

There is no saddle point.
Hence this is a problem of mixed strategy.
sing the method as given in text.

|  |  | B |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | I | II | Row minimum |
| A | I | 0 | -2 | $0-(-2)=2$ |
|  | II | -1 | 0 | $0-(-1)=1$ |
|  | Column <br> maximum | $0-(-1)$ <br> $=1$ | $0-(-2)$ <br> $=2$ |  |

The final strategy is given by the matrix

|  |  | B |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | I | II | Probability |
| A | I | 0 | -2 | $1 / 3$ |
|  | II | -1 | 0 | $2 / 3$ |
|  | Probability | $2 / 3$ | $1 / 3$ |  |

## Conclusion

A plays his first row $1 / 3$ rd of the time (randomly)
A plays his second row $2 / 3 \mathrm{rd}$ of the time
Similarly:
B plays his first column $2 / 3 \mathrm{rd}$ of the time
B plays his second row $1 / 3 \mathrm{rd}$ of the time
The value of the game is
$0 \times(1 / 3 \times 2 / 3)+(-2) \times(1 / 3 \times 1 / 3)+(-1)(2 / 3 \times 2 / 3)+0 \times 1 / 3 \times 2 / 3)$
$=0-2 / 9-4 / 9+0$
$=-6 / 9$
$=-2 / 3$

## QUESTION TWO

|  |  | Y |  | Row minimum |
| :---: | :---: | :---: | :---: | :---: |
|  | 1 | 2 | -1 | -1 |
|  | -2 | 1 | 1 | -2 |
|  | 2 | 0 | 1 | 0 |
| Column | 2 | 2 | 1 |  |
| maximum |  |  |  |  |

There is no saddle point
Let the three probabilities of Y be $\mathrm{p}, \mathrm{q}, \mathrm{r}$
The three payoffs to Y corresponding to each of the three moves of his opponent X must all be equal to the optimal value of V of the game.

Y's payoffs against the three moves of X are

$$
1 p+2 q+(-1 r)-2 p+1 q+1 r \quad 2 p+0 q+1 r
$$

We obtain three equations by equating each of these payoffs to V

$$
\begin{array}{lll}
1 \mathrm{p}+2 \mathrm{q}-1 \mathrm{r} & = & -2 \mathrm{p}+1 \mathrm{q}+1 \mathrm{r}=2 \mathrm{p}+\mathrm{oq}+1 \mathrm{r}=\mathrm{V} \\
\text { Also } \mathrm{p}+\mathrm{q}+\mathrm{r}= & 1 & \text { (Total probability) } \\
1 \mathrm{p}+2 \mathrm{q}-1 \mathrm{r} & = & -2 \mathrm{p}+1 \mathrm{q}+1 \mathrm{r}  \tag{1}\\
1 \mathrm{p}+2 \mathrm{q}-1 \mathrm{r} & = & 2 \mathrm{p}+o \mathrm{q}+1 \mathrm{r}[2] \\
\mathrm{p}+\mathrm{q}+\mathrm{r} & = & 1
\end{array}
$$

Solving these three equations simultaneously we get
$p=\frac{2}{17} \quad q=\frac{8}{17} \quad$ and $\quad r=\frac{7}{17}$
Similarly using the same reasoning as before, let the three probabilities of $x$ be $\mathrm{p}^{\prime}, \mathrm{q}^{\prime}, \mathrm{r}^{\prime}$,
We get $\quad 1 \mathrm{p}^{\prime} 2 \mathrm{q}^{\prime}+2 \mathrm{r}^{\prime}=2 \mathrm{p}^{\prime}+1 \mathrm{q}^{\prime}+$ or' $=-1 \mathrm{p}^{\prime}+1 \mathrm{q}^{\prime}+1 \mathrm{r}^{\prime}$
Also $\quad \mathrm{p}^{\prime}+\mathrm{q}^{\prime}+\mathrm{r}^{\prime}=1$
Solving them simultaneously we get
$\mathrm{p}^{\prime}=\frac{3}{17} \quad \mathrm{q}^{\prime}=\frac{5 \mathrm{r}^{\prime}}{17}=\quad \frac{9}{17}$
Hence X should play his rows in the ratio 3:5:9 (randomly)
Y should play his columns in the ratio 2:8:7

## Payoff

$1 \times(2 / 17 \times 3 / 17)+2 \times(8 / 17 \times 3 / 17)+(-1)(7 / 17 \times 3 / 17)$
+6 other values calculated in the same way as before which amount to 11/17

## Alternatively

Value of the game is
$\frac{1 \times 3+(-2) \times 5+2 \times 9}{3+5+9}$ $=\underline{11}$ $3+5+9$ 17

## QUESTION THREE

(a)

|  | Firm B |  |  |  |  | Row minimum |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Firm A | 3 | -1 | 4 | 6 | 17 | -1 |
|  | -1 | 8 | 2 | 4 | 12 | -1 |
|  | 16 | 8 | $[6]$ | 14 | 12 | $6 \leftarrow$ |
|  | 1 | 11 | -4 | 2 | 1 | -4 |
| Column | 16 | 11 | 6 | 14 | 17 |  |
| maximum |  |  | $\uparrow$ |  |  |  |

There is a saddle point
Strategy Firm A plays row three all the time
Firm B plays column three all the time
It is a game of pure strategy and the value of the game is 6
(b) Dominance: Study Text

|  | Player B |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Player A | 1 | 3 | 2 | 7 | 4 | 1 |
|  | 3 | 4 | 1 | 5 | 6 | 1 |
|  | 6 | $[5]$ | 7 | 6 | 5 | $5 \leftarrow$ |
|  | 2 | 0 | 6 | 3 | 1 | 0 |
| Column | 6 | 5 | 7 | 7 | 6 |  |
| maximum |  | $\uparrow$ |  |  |  |  |

As above, it is a game of pure strategy
Player A Row 3
Player B Column 2
Value of the game 5

## Alternatively

Reduce the size of the game using 'dominance'. For instance row 4 is dominated, column 4 is dominated. Afterwards use standard method, to solve the problem.

## QUESTION FOUR

Pure and mixed strategies - Study Text
Fair game: it is a game which gives an equilibrium point (either by using pure strategy or mixed strategy). Intelligent and rational players will accept this 'payoff' as fair to the players. This is also known as 'Nash Equilibrium' sometimes.

A Nash equilibrium is a profile of strategies such that each players strategy is an optimal response to the other players' strategies.

|  | B |  |  |
| :---: | :---: | :---: | :---: |
|  |  |  |  |
| A | 8 | 4 | -2 |
|  | -2 | -1 | 3 |

Using graph, payoff matrix is reduced to

$$
\left[\begin{array}{rr}
4 & -2 \\
-1 & 3
\end{array}\right]
$$



Using standard methods, the solution is

i. A plays his first row $2 / 5$ th of the time randomly A plays his second row $3 / 5$ th of the time randomly
ii. B plays his second column half the time B plays his third column half the time B does not play his first column at all.

| x | $\mathrm{p}(\mathrm{x})$ | $\mathrm{x}(\mathrm{px})$ |
| :---: | :---: | :---: |
| 4 | $1 / 2 \times 2 / 5$ | $4 / 5$ |
| -2 | $1 / 2 \times 2 / 5$ | $-2 / 5$ |
| -1 | $1 / 2 \times 3 / 5$ | $-3 / 10$ |
| 3 | $1 / 2 \times 3 / 5$ | $9 / 10$ |
|  | Total $=1$ |  |

$$
4 / 5+(-2 / 5)+(-3 / 10)+(9 / 10)=1
$$

## QUESTION FIVE

In this case we have a simple case of a 2 x 2 game, the yield to x is the probability the bomb carrier is not hit
The strategies are:
$\mathrm{X}_{1} \quad$ Bomber I carries the bomb
$\mathrm{X}_{2} \quad$ Bomber II carries the bomb
The strategies of the opponent are
Y1 To attack Bomber I
Y2 To attack Bomber II

## Payoff Matrix

|  |  | Party Y |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Party X |  | $\mathrm{Y}_{1}$ | $\mathrm{Y}_{2}$ |  |
|  | $0.7+0.3 \times 0.4$ <br> $=0.82$ | 1 |  |  |
|  | X 2 | 1 | $0.3+0.7 \times 0.4$ <br> $=0.58$ |  |

Construct the matrix of the game by determining the average yield for every combination of strategies as follows:

Now $p(0.82)+1(1-p)=p \times 1+(1-p) \times 0.58$
which gives $\mathrm{p}=0.7$
( x plays x 1 , pth position of the time and $\mathrm{x} 2,1-\mathrm{p}$ position of the time.
Also $\quad 0.82 q+1(1-q)=1 q+0.58(1-q)$
which gives $\mathrm{q}=0.7$


X's strategy 1st row:2nd row $=7: 3$
Y's strategy 1st column:2nd column $=7: 3$

## QUESTION SIX

|  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  |  | Newspaper | Radio | Television |
|  |  | N | R | T |
|  | N | 40 | 50 | -70 |
| A | R | 10 | 25 | -10 |
|  | T | 100 | 30 | 60 |


|  |  |  |  | Row minimum |
| :---: | :---: | :---: | :---: | :---: |
|  | 40 | 50 | -70 | -70 |
|  | 10 | 25 | -10 | -10 |
|  | 100 | 30 | 60 | 30 |
| Column <br> maximum | 100 | 50 | 60 |  |
|  |  |  |  |  |

There is no saddle point
Looking at the pay-off matrix row two is dominated and column one is dominated, hence size of the matrix can be reduced to

|  | R | T |
| :---: | :---: | :---: |
|  |  |  |
| N | 50 | -70 |
| T | 30 | 60 |

Using standard techniques, the probabilities are

| $1 / 5$ | 50 | -70 |
| ---: | ---: | ---: |
| $4 / 5$ | 30 | 60 |
|  | $\frac{13}{15}$ | $\frac{2}{15}$ |

Hence A's strategy is [ $1 / 5,0,4 / 5$ ] i.e $\mathrm{N}: \mathrm{R}: \mathrm{T}=1 / 5: 0: 4 / 5$
and B's strategy is $[0,13 / 15,2 / 15]$ i.e $\mathrm{N}: \mathrm{R}: \mathrm{T}=0: 13 / 15: 2 / 15$

The value of the game is $50 \times(1 / 5 \times 13 / 15)+(-70) \times(1 / 5 \times 2 / 15)+30 \times(4 / 5 \times 13 / 15)+(60) \times$
( $4 / 5 \times 2 / 15$ )
$=34$

## QUESTION SEVEN

|  | $\mathrm{U}_{1}$ | $\mathrm{U}_{2}$ | $\mathrm{U}_{3}$ | $\mathrm{U}_{4}$ | Row <br> minimum |
| :---: | :---: | :---: | :---: | :---: | ---: |
| $\mathrm{B}_{1}$ | +2.50 | +2.70 | +3.50 | -0.20 | -0.20 |
| $\mathrm{~B}_{2}$ | +2.00 | +1.60 | +0.80 | +0.80 | +0.80 |
| $\mathrm{~B}_{3}$ | +1.40 | +1.20 | +1.50 | +1.30 | +1.20 |
| $\mathrm{~B}_{4}$ | +3.00 | +1.40 | +1.90 | 0 | 0 |
| Column | +3.00 | +2.70 | +3.50 | +1.30 |  |
| maximum |  |  |  |  |  |

There is no saddle point
Using dominance, column $\mathrm{U}_{1}$ and column $\mathrm{U}_{3}$ are dominated. Hence the game can be reduced to

|  | $\mathrm{U}_{2}$ | $\mathrm{U}_{4}$ |
| :---: | :---: | :---: |
| $\mathrm{~B}_{1}$ | +2.70 | -0.20 |
| $\mathrm{~B}_{2}$ | +1.60 | +0.80 |
| $\mathrm{~B}_{3}$ | +1.20 | +1.30 |
| $\mathrm{~B}_{4}$ | +1.40 | 0 |

At this stage we can use the graphical method or reduce the size of the game using dominance again (row four is dominated by row two).

Using graphical method, the final matrix is reduced to

$$
\begin{aligned}
& +2.70-0.20 \\
& +1.20+1.30
\end{aligned}
$$

Solving this, we get

$$
\begin{aligned}
& 1 / 30 \\
& 29 / 30
\end{aligned} \quad\left[\begin{array}{l}
+2.70-0.20 \\
+1.20+1.30
\end{array}\right]
$$

Hence Breweries strategies B1:B2:B3:B4 $=1 / 30: 0: 29 / 30: 0$
i.e. row $\mathrm{B} 1:$ row $\mathrm{B} 3=1: 29$

Union strategies
Column U2 : U4 $=1: 1$

## Value of the game

$$
\begin{aligned}
& 2.70 \times(1 / 30 \times 1 / 2)+(-0.20) \times(1 / 30 \times 1 / 2)+(1.20) \times(29 / 30 \times 1 / 2)+(1.30) \times(29 / 30 \times 1 / 2) \\
& =\quad+1.25
\end{aligned}
$$

Note: Interpret all the results in the solutions given, according to the language of the questions.

## 4. MARKOV ANALYSIS

## Markov Chains

Markov Chains are named after the Russian statistician A.A Markov who developed probabilistic models that are often applicable to decision making problems in business and industry associated with dynamic systems.

Markov Chains are a special case of the more general probabilistic models known as stochastic processes, in which the current state of a system depends upon all previous states. The successive future states of the Markov process are referred to as Chains—hence the name Markov Chains.

## Markov Processes

A Markov process is stochastic process in which the current state of the system depends only on the immediately preceding state of the system.

## Markov Analysis

It is a way of analysing the current movement of some system in an effort to predict the future movement of the same system.

There are two elements that must be determined in the process of constructing a Markov model in the system. These elements are the possible states of the system and the probabilities of moving between states (also called transition probabilities). A system state is a status of the system at a particular point in time, such as whether or not a machine is operating, whether an account is paid or not paid etc.

## Transition probabilities

Represent the probability of the system moving from one state to another during a particular period. We can organise the transition probabilities in the form of a table or matrix.

## Markov Properties

1. Transition probabilities are dependent only on the current state of the system i.e. given that the present state is known, the conditional probability of the next state is independent of the states, prior to the present state. (This is known as property of no memory).
2. The transition probabilities are constant over time.
3. The transition probabilities of moving to alternative states in the next time period, given a state in the current time period, must sum to one.

These properties are quite restrictive and hence the application of Markov Analysis is limited to few real-world problems.

Given that a set of possible states in Markov Chain is finite, a square matrix, P , made up of all Pij 's of Markov Chain can be formed.

The following table represents the commonly used transition probability matrix.


Where n is the number of exhaustive and mutually exclusive states.
$\mathrm{P}_{\mathrm{ij}}$ is the transition probability of going from the present i th state to the next j th state.
Thus the rows represent the possible present states (i's) and columns, represent the possible future states (j's).

| By definition |  | $\mathrm{P}_{11}$ | + | $\mathrm{P}_{12}$ | + | $\mathrm{P}_{13}$ | $+\ldots \ldots .$. | $\mathrm{P}_{1 \mathrm{n}}$ | $=$ | 1 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Similarly | $\mathrm{P}_{21}$ | + | $\mathrm{P}_{22}$ | + | $\mathrm{P}_{23}$ | $+\ldots \ldots .$. | $\mathrm{P}_{2 n}$ | $=$ | 1 |  |

## Applications of Markov Chains

They are a particular class of probabilistic models and their applications include analysis of:
i. Inventory systems
ii. Replacement and maintenance policies for machines
iii. Brand loyalty in marketing
iv. Time series of economic data such as movement of stocks
v. Accounts receivable in accounting
vi. Expected payouts of life insurance policies etc.

## Steady state condition

In many cases, the Markov process will converge to a steady state or equilibrium.
In general, as number of transitions ' $n$ ' increase, the state values tend to stabilize at steady state. This is a logical occurrence, since the present state tends to lose significance.

## Steady State vector

A steady vector is given in terms of decimal proportions as

subject to $X+Y+Z=1$
i.e. once a steady state is reached, multiplication of a state condition by the transition probabilities does not change the state condition.
Some standard terms as used in the context of Markovian processes.

## Transition probabilities

These are the probabilities of moving from one state to another in the next time period. Usually they are written in the form of a probability matrix.

## Example

|  | To |  |
| :---: | :---: | :---: |
| From | 0.6 | 0.4 |
|  | 0.8 | 0.2 |

Sum of probabilities in any row equals one OR

|  | From |  |
| :---: | :---: | :---: |
| To | 0.6 | 0.8 |
|  | 0.4 | 0.2 |

Sum of probabilities in any column equals one

## Transient Analysis

A state is said to be transient if it is impossible to move to that state from any other state except itself. This state is temporary and eventually a steady state is reached. This analysis can be performed using usual probability transition matrices.

## Absorbing State

A state is said to be an absorbing (or Trapping state) state if it is impossible to leave the state.
This will occur if any $\mathrm{P}_{\mathrm{n}}$ is equal to 1.0

## Example



Since $\mathrm{p}_{11}=1.0$, state A is an absorbing state. This state represents the conditions, under which the modelled process can terminate. All other states of the model are transient states.

## Cyclic Chains

In Markov Chains the current state of the system depends on all previous states. It is a stochastic process. Sometimes transition probability matrices are different from State I to State II, State II to State III etc and from cyclic chains which repeat in the same order.

## Recurrent State

A state is recurrent if it is certain to occur again, given that it has occurred at least once, otherwise it is said to be transient. In other words, a transient state will occur only a limited number of times and then go away for ever whereas the recurrent state is permanent. If a process is finite (i.e. has a finite number of states) and is irreducible, then all states are recurrent. This is the most common form of Markov Chain in applications.

## PRACTICE EXAMPLES — Dec. 1986 (ACCA)

## QUESTION ONE

There are three types of breakfast meal available in supermarkets known as brand BM1, brand BM2, and brand BM3. In order to assess the market, a survey was carried out by one of the manufacturers. After the first month the survey revealed that $20 \%$ of the customers purchasing brand BM1 switched to BM2 and $10 \%$ of the customers purchasing brand BM1 switched to BM3. Similarly after the first month of the customers purchasing brand BM2, $25 \%$ switched to BM1 and $10 \%$ switched to BM3 and of the customers purchasing brand BM3 5\% switched to BM1 and 15\% switched to BM2.

## Required:

i. Display in a matrix $S$, the patterns of retention's and transfers of customers from the first to the second month, expressing percentages in decimal form.
ii. Multiply matrix $S$ by itself (that is form $\mathrm{S}^{2}$ ).
iii. Interpret the results you obtain in part (ii) with regard to customer brand loyalty.

## Answer

i. The matrix showing the pattern of retention and transfer from the first to the second month is
$\begin{aligned} & \text { BM1 BM2 BM3 } \\ & \mathrm{S}\end{aligned}=\quad\left[\begin{array}{llll}0.70 & 0.20 & 0.10 & \text { BM1 } \\ 0.25 & 0.65 & 0.10 & \text { BM2 } \\ 0.05 & 0.15 & 0.80 & \text { BM3 }\end{array}\right.$
(The second element in the first row shows the $20 \%$ movement from BM1 to BM2 and so on.)
ii. The product of matrix $S$ with itself is demonstrated as follows

$$
\left[\begin{array}{lllllll}
0.70 & 0.20 & 0.10 & & 0.70 & 0.20 & 0.10 \\
0.25 & 0.65 & 0.10 & \mathrm{x} & \left.\left.\begin{array}{llll}
0.25 & 0.65 & 0.10 \\
0.05 & 0.15 & 0.80 & \\
0.05 & 0.15 & 0.80
\end{array} \quad=\left[\begin{array}{lll}
0.5450 & 0.2850 & 0.1700 \\
0.3425 & 0.4875 & 0.1700 \\
0.1125 & 0.2275 & 0.6600
\end{array}\right]\right)\right]\left[\begin{array}{ll}
0.2
\end{array}\right]
\end{array}\right.
$$

where for example the second element in the first row, that is 0.2850 is the result of multiplying the corresponding elements of the first row of $S$ by the second column of $S$ and summing the products.

$$
\begin{aligned}
0.2850 & =0.70 \times 0.20 \times+0.20 \times 0.65+0.10 \times 0.15 \\
& =0.14+0.13+0.015 \mathrm{etc} .
\end{aligned}
$$

iii. The resulting matrix may be interpreted in the following way:

Of the original customers who buy BM1, $54.5 \%$ will remain loyal to the brand in month three, $28.5 \%$ will have switched to BM2 and $17 \%$ will have switched to BM3.

Of the original customers who buy BM2, $48.75 \%$ will remain loyal to the brand in month three, $34.25 \%$ will have switched to Bm 2 and $17 \%$ will have switched to BM3.

Of the original customers who buy BM3, $66 \%$ will remain loyal to the brand in month three, $11.25 \%$ will have switched to BM1 and $22.75 \%$ will have switched to BM2.

## QUESTION TWO

## TRANSITIONS LIMITED

Transitions Limited allows customers one month's credit for the settlement of their accounts, but in practice many customers take longer to pay. Each outstanding account is classified each week in one of the following four ways:

A account less than 1 month old, payment still due;
B account more than one month old, but less than 3 months old - payment overdue;
C the account was settled during the previous 7 days;
D the account is over 3 months old, and should be written off as a bad debt, or the customer has given some other reason to suppose that the debt should be written off.

The situation changes from week to week, and during the course of any week, some accounts in category A may move into category B or category C, and some accounts in category B may move to category C or category D .

The probability of these changes occurring from any one week (week $n$ ) to the next week (week $n+$ 1) may be given by a probability transition matrix.

## Category in week $(\mathrm{n}+1)$

$\left.\begin{array}{lcccc} & & \text { A } & \text { B } & \text { C } \\ \text { Category in } & \text { A } & 0.2 & 0.6 & 0.2 \\ \text { week n } & \text { B } & 0 & 0.5 & 0.4 \\ & \text { C } & 0 & 0 & 1 \\ 0.1 \\ 0 \\ 0 \\ 1\end{array}\right)$

## Required:

(a) What is the probability that an account which is overdue for payment will:
i. Become a bad debt next week?
ii. Be paid during next week?
(2 marks)
(b) What is the probability that an account in category A in week 1 will be paid by week 5 i.e 4 weeks later? Use matrix multiplication to determine your answer. What is the probability that an account in category B in week 1 will be paid by week 5 ?
(18 marks)

## Answer

## TRANSITIONS LIMITED

(a) The probability that an account in category B will:
i. become a bad debt next week is 0.1
ii. be paid next week is 0.4
(a) The probability that an account category A in week 1 will be paid in week 3 is

## Week 2

Week $1 \quad\left[\begin{array}{llll}0.2 & 0.6 & 0.2 & 0 \\ 0 & 0.5 & 0.4 & 0.1 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 0\end{array}\right]$

$$
\left[\begin{array}{llll}
0.2 & 0.6 & 0.2 & 0 \\
0 & 0.5 & 0.4 & 0.1 \\
0 & 0 & 1 & 0 \\
0 & 0 & 1 & 0
\end{array}\right]
$$

## Week 3



## (Workings not shown)

The probability that an account in category $A$ in week 1 will be paid in week 4 is:

$$
\left(\begin{array}{llll}
0.04 & 0.42 & 0.48 & 0.06 \\
0 & 0.25 & 0.6 & 0.15 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{array}\right) \quad \mathrm{x} \quad\left(\begin{array}{llll}
0.2 & 0.6 & 0.2 & 0 \\
0 & 0.5 & 0.4 & 0.1 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{array}\right)
$$

Week 4
$=$ Week 1 $\begin{array}{ll} & \mathbf{A} \\ \mathbf{B} \\ \mathbf{C} \\ & \mathbf{D}\end{array} \quad\left[\begin{array}{llll}\mathbf{A} & \mathbf{B} & \mathbf{C} & \mathbf{D} \\ 0.008 & 0.234 & 0.656 & 0.102 \\ 0 & 0.125 & 0.7 & 0.175 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1\end{array}\right)$
The probability that an account in category $A$ in week 1 will be paid by week 5 can be given by the following:

$$
\left(\begin{array}{llll}
0.008 & 0.234 & 0.656 & 0.102 \\
0 & 0.125 & 0.7 & 0.175 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{array}\right) \quad \mathrm{x} \quad\left[\begin{array}{llll}
0.2 & 0.6 & 0.2 & 0 \\
0 & 0.5 & 0.4 & 0.1 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{array}\right]
$$

Week 5
A
B
C
D

|  | $\mathbf{A}$ |
| :--- | :--- | :--- | :--- | :--- | :--- |
| Week 1 | $\mathbf{B}$ |
|  | $\mathbf{C}$ |
|  | $\mathbf{D}$ |\(\quad\left[\begin{array}{llll}0.0016 \& 0.1218 \& 0.7512 \& 0.1254 <br>

0 \& 0.0625 \& 0.8 \& 0.1875 <br>
0 \& 0 \& 1 \& 0 <br>
0 \& 0 \& 0 \& 1\end{array}\right)\)

## Solution:

An account in category $A$ in week 1 has a 0.7512 probability of being paid by week 5 .
An account in category B in week 1 has a 0.8 probability of being paid by week 5 .

## QUESTION THREE

Two industries A and B share the market for a particular product. Industry A is an old and well established industry, industry B is new. A is alarmed at the progress being made by B and has asked its market-research department for a forecast of future market shares for the two industries, assuming that the same market conditions prevail. The current market shares held by the two industries are as follows:

| Industry | Market Share |
| :--- | :--- |
| A | 0.8 |
| B | 0.2 |

The market research department has determined that customers switch between the two firms according to the following probabilities.

(a) Determine the market research department's market share forecast for one period in the future, two periods in the future, three periods in the future.
(b) Based on results in part (a), estimate the equilibrium market share for each industry rounded to the nearest whole percentage.
(c) Illustrate the customer switching between the two industries as a Markov probability diagram.
(d) Use a tree diagram to illustrate the three-period transition beginning with firm A. Prepare the same illustration beginning with firm B.
(e) Describe the four probability values.
(f) Insert the four probabilities in the appropriate cells of the following matrix.


## Answer

(a) Period One

$$
\left[\begin{array}{lllll}
\mathrm{A} & \mathrm{~B} & & & \mathrm{~A} \quad \mathrm{~B} \\
0.80 & 0.2
\end{array} \quad \begin{array}{ll}
0.5 & 0.5 \\
0.6 & 0.4
\end{array}\right]=\begin{gathered}
0.520 .48 \\
\end{gathered}
$$

OR

To

$$
\begin{aligned}
& \text { From } \\
& {\left[\begin{array}{lr}
0.5 & 0.6 \\
0.5 & 0.4
\end{array}\right] \quad \mathrm{x} \quad\left[\begin{array}{l}
0.80 \\
0.20
\end{array}\right]=\left[\begin{array}{l}
0.52 \\
0.48
\end{array}\right]}
\end{aligned}
$$

## Period 2

$$
\left[\begin{array}{l}
\mathrm{A} \\
\mathrm{~B}
\end{array}\right]\left[\begin{array}{lr}
0.5 & 0.6 \\
0.5 & 0.4
\end{array}\right] \mathrm{x}\left[\begin{array}{l}
0.52 \\
0.48
\end{array}\right]=\left[\begin{array}{l}
0.548 \\
0.452
\end{array}\right]
$$

## Period 3

$$
\begin{aligned}
& \mathrm{d} 3 \\
& \mathrm{~A} \\
& \mathrm{~B}
\end{aligned}=\begin{array}{ll}
0.5 & 0.6 \\
0.5 & 0.4
\end{array} \mathrm{x}\left[\begin{array}{l}
0.548 \\
0.452
\end{array}=\left[\begin{array}{l}
0.5452 \\
0.4548
\end{array}\right.\right.
$$

(b)

$$
\left.\begin{array}{rl}
0.5 & 0.6
\end{array} \begin{array}{c}
\mathrm{A} \\
0.5 \\
0.4
\end{array}\right)\left[\begin{array}{l}
\mathrm{B} \\
\mathrm{~B}
\end{array}\right]
$$

This trend can be easily seen from period I, to period II, to period III.
(c)

(d)

Time 0
Time 1
Time 2
Time 3
B



(e) They are the state probabilities for A and B at time 3 , given the status for A and B at time 0 .
(f)


Note: We can get period three value from

$$
\begin{array}{rl} 
& {\left[\begin{array}{ll}
0.8 & 0.2 \\
= & \mathrm{x}
\end{array}\left[\begin{array}{ll}
0.545 & 0.455 \\
0.546 & 0.454
\end{array}\right]\right.} \\
0.5452 & 0.45488
\end{array}
$$

## REINFORCING QUESTIONS

## QUESTION ONE

A department store is interested in predicting the behaviour of customers for which accounts receivable are outstanding. Its credit department has been asked to analyze its records and predict payments probabilities. Historical records have yielded the following payment patterns of credit customers.

Month $\mathbf{n}+1$

| Month $\mathbf{n}$ | Paid bill | Did not pay bill |
| :--- | :---: | :---: |
| Paid bill | 0.90 | 0.10 |
| Did not pay bill | 0.80 | 0.20 |
|  |  |  |

Assume that these probabilities are used to predict the behaviour of a credit customer with regard to bill payment.
a. If a credit customer did not pay his bill in month $n$, what is the probability he will not pay it in any of the next three months?
b. If a customer did not pay his bill in month $n$, what are the probabilities he will pay his bill in month $n+1$, in month $n+2$, and in month $n+3$ ?
(Note: Assume that monthly bills include purchases made in that month plus any outstanding balance from previously unpaid bills).
c. Determine the steady-state conditions-that is, the probability the customer will pay a bill or not pay a bill in month $n+1$, regardless of whether he paid in month $n$.

## QUESTION TWO

Students switch among the various colleges of a university according to the following probability transition matrix.

| $c$ <br> To <br> From <br>  <br> Engineering |  |  |  |
| :--- | :---: | :---: | :---: |
|  | 0.5 | 0.3 | 0.2 |
| Liberal Arts | 0.1 | 0.7 | 0.2 |
| Business | 0.1 | 0.1 | 0.8 |
|  |  |  |  |

Assume that the number of students in each college of the university at the beginning of the fall quarter is as follows:

Engineering 3000
Liberal Arts 5000
Business 2010
a. Forecast the number of students in each college after the end of the third quarter, based on a four-quarter system. Determine by first computing P ${ }^{*}$.
b. Determine the steady-state conditions for the university.

## QUESTIONTHREE

It has been said that stock market prices have a tendency to move in opposite direction from day to day. Assume that a stock market analyst has determined from historical data that a particular stock price will move up or down according to the following probabilities:

|  | Day n + 1 |  |
| :--- | :---: | :---: |
| Day n | Increase | Decrease |
| Increase | 0.3 | 0.7 |
| Decrease | 0.8 | 0.2 |

Determine the steady-state conditions.

CHECK YOUR ANSWERS WITH THOSE GIVEN IN LESSON 10 OF THE MANAGEMENT ACCOUNTING NOTES

## LESSON EIGHT

## PERFORMANCE EVALUATION

## OBJECTIVES

$\square$ The assessment of Divisional, Departmental and Corporate Management
$\square$ Determining appropriate rewards and appropriate motivation

## INSTRUCTIONS

$\square$ Read Chapters 20 and 21 of Management and Cost Accounting by Colin Drury $5^{\text {th }}$ Edition
$\square$ Read Study Text
$\square$ Complete reinforcing questions under examination conditions and compare your answers with those given in Lesson 10.

## CONTENTS

$\square$ Introduction
$\square$ Responsibility Accounting
$\square$ Steps Of Chosing An Accounting Based Performance Measure
$\square$ Alternative Performance Measures
$\square$ Transfer Pricing And Performance Evaluation

## INTRODUCTION

Performance evaluation deals with the area of MA that is concerned with:
Holding individual managers responsible for certain aspects of the organisational performance.
Making them accountable by producing regular performance reports relating to matters for which they are responsible.
Motivating managers to achieve better results by setting targets for performance, judging actual results against targets and rewarding good performers.
Giving managers control information to enable them to make decisions about improving their performance.

There are two interrelated aspects involved and these are:
Giving managers authority to make decisions and holding them responsible for the exercise of that authority. This is referred to as decentralization.
Defining a system of accountability by which to judge how the authority has been used and the responsibility carried out. This is referred to as responsibility accounting.

## RESPONSIBILITY ACCOUNTING

This is a term used to define the measuring of performance of decentralized units, using account results. Responsibility accounting recognizes various decision centres throughout an organisation and trace costs (revenues, assets and liabilities) to the individual managers who are primarily responsible for making the decisions about the costs in question. A responsibility centre is a unit in an organisation headed by a manager having direct responsibility for its performance. Examples of responsibility centres include cost centre, profit centre, and investment centre. These centres are defined below:

## Cost Centre

Cost centre is a production service location activity or item of equipment whose costs maybe attributed to cost units. It is therefore any unit of the organisation to which cost can be attributed.
Managers in the cost centre have control over various controllable costs (That is costs incurred in the centre) but may have no control for any alterations apportioned from other cost centres.

Performance measurement in a cost centre can be accomplished through variance analysis or through efficiency measures such as output/input ratio.

## Profit Centre

A profit centre is a subunit of an organisation such as a division of a company to which both revenue and costs are assigned so that the profitability of that subunit can be measured. It is also referred to as a strategic business unit.

Managers in an profit centre have control over costs, and revenue decisions. Performance measurement in a profit centre can be accomplished through the use of profit margin or contribution/sales ratio.

## Investment Centre

An investment centre is a subunit of the organisation where managers have control over cost, revenue and some investment decisions. Managers can buy some assets so as to increase profitability.

Performance in an investment centre is measured by ratios such as return on investment which relates the profit earned to the amount of capital invested. Performance can also be measured from absolute measures such as residual income.

## STEPS OF CHOSING AN ACCOUNTING BASED PERFORMANCE MEASURE

Consider the overall goal of the organization as a whole. It is important to choose a measure of accomplishment that represents top management goals. Such measures include operating income, net income, Return on investment (ROI), sales, etc. Determine whether the measure should be maximized or minimized.
Select definitions for such items as income and investments (i.e. should income be based on variable or absorption costing? should central overheads be allocated? should investments consist of total assets, net assets or net worth?)
How should items such as income and investments be measured (i.e. should we use historical costs, replacement costs, realisable or current values?)
Determine the standards that should be applied (i.e. Should all divisions be required to earn the same rate of return on all investments?)
What timing of feedback is needed? Should it be monthly or quarterly.

## ALTERNATIVE PERFORMANCE MEASURES

There are various measures that can be used to measure performance of a decentralised company.
The main ones are:
Return on Investment
Residual income
Discounted cash flow methods such as the NPV method
Value added statements
Bench marking
Balanced score card

## RETURN ON INVESTMENT AND RESIDUAL INCOME

This is a traditional approach to performance measurement given by:
ROI $=$

$$
\frac{\text { Income }}{\text { Invested Capital }} \quad \text { (method) of Liability analysis }
$$

ROI can provide more insight to performance when it is divided into the Dupont components.
The Dupont method states that:
ROI $=$ Capital turnover X profit margin

$$
\begin{array}{ll}
=\text { Revenue } & \mathrm{X} \\
\text { Invested capital } & \begin{array}{l}
\text { Income } \\
\text { Revenue }
\end{array}
\end{array}
$$

Dupont method leads to the generalization that ROI can be increased by any action that: decreases costs
Increases revenue
Decreases invested capital
Return on investment highlights the benefits that managers can obtain by decreasing investment in both current and fixed assets. Investment in cash, inventory, accounts receivable and fixed assets should be minimized for any level of effective performance. This requires that idle cash is invested, proper inventory levels are kept, credit is managed judiciously and fixed assets are invested in carefully.

However, return on investment may induce managers of a highly profitable division to reject projects, which from the view point of the organisation as a whole should be accepted. ROI encourages managers to make decisions which may increase short-term profit without considering their effect on the future of the company.

## ILLUSTRATION

Assume that a company has 3 subsidiaries A, B, and C and that the company does not allocate corporate headquarters' costs or interest on long-term debt to the subsidiaries. Summary of the results are as follows.

|  | f'000' A | ${ }_{\text {E }}{ }^{\prime} 0000^{\prime}$ | $\mathrm{C}^{\prime} 0000$ | $\begin{aligned} & \mathrm{f} 000 \\ & \mathrm{H} \end{aligned}$ | $\begin{aligned} & £_{\text {' }}^{\prime} 000 \\ & \text { Total } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Operating y income | 240 | 300 | 480 |  | 1020 |
| Variable cost of H |  |  |  | 80 |  |
| Fixed costs of H |  |  |  | 120 |  |
| Interest on L.T debt |  |  |  | 400 | (600) |
| Income before taxation |  |  |  |  | 420 |
| Taxes |  |  |  |  | $\underline{150}$ |
| Income after taxation |  |  |  |  | $\underline{270}$ |
| Average book values |  |  |  |  |  |
| Current assets | 400 | 500 | 600 | 200 | 1700 |
| Fixed assets | 600 | 1500 | 2400 | 300 | $\underline{4800}$ |
|  |  |  |  |  | $\underline{6500}$ |

## Required:

Compute the return on investment.
Compute residual income assuming that the company requires a $10 \%$ interest on total assets of each subsidiary.
Assume that there is an asset available to subsidiary A which costs $£ 100,000$ but which has an annual profit of $£ 20,000$. Advice the manager of $A$ on whether to undertake the project and comment on whether this decision is in line with the overall objective of the organisation.

## Solution

| a) | A | B | C | Total |
| :--- | :--- | :--- | :--- | :--- |
| $\mathrm{ROI}=\frac{\text { Income }}{\text { Capital }} \frac{240}{1000}$ | $\frac{300}{2010}$ | $\underline{480}$ | $\frac{820}{3000}$ | 6500 |
|  |  |  |  |  |
|  | 0.24 | 0.15 | 0.16 | 0.126 |

The best performer is subsidiary A, followed by C, while B is the worst performer.
b) RI $=$ Income - Imputed interest charge
$\mathrm{RI}_{\mathrm{A}}=240-(0.1 \times 1000)=140$
$R I_{B}=300-(0.1 \times 2010)=100$
$\mathrm{RI}_{\mathrm{C}}=480-(0.1 \times 3000)=180$
Based on RI, the best performer is C, followed by A and B in that order.
c) With the new project ROI of A will be:

$$
\begin{aligned}
\text { ROI } & =\frac{260}{1100} \\
& =23.6 \%
\end{aligned}
$$

The overall ROI will be

$$
\mathrm{ROI}=\underline{660}_{6600}=12.7 \%
$$

Based on ROI, the manager of A should not invest in project A since ROI decreases from $24 \%$ to $23.6 \%$. However, from the overall point of view the project is viable as it increases ROI BY $0.1 \%$

The Residual Income with the new project will be:
$R I_{A}=260-(0.1 X 1100)=150$
The manager of A should take project as it increases residual income from 140 to 150 .

## Note

The objective of maximizing residual income assumes that as long as the division earns a rate in excess of the imputed charge on the investment, then it should expand. Residual income is a short-term measure and therefore, contradicts the going concern concept of the firm.

## DISCOUNTED CASH FLOW TECHNIQUES (eg. NPV)

The NPV method can be used to determine the profitability of the projects undertaken by the division. The NPV method is familiar at this point. However, an illustration will help in revision.

## Illustration

Division X of Harvest agricultural machinery ltd was considering adding a small weeding implement to their product range. Sufficient capacity was currently available to cope with the additional production, but an extra special-purpose machine costing $£ 40,000$ would have to be acquired and paid for immediately prior to commencement of production. The machine could be traded in at the end of year five for $£ 5,000$.

A new sales promotion programme would be mounted to market the new product and this would cost $£ 10,000$ at the commencement of production and $£ 5,000$ at the end of the first year.

The management accountant produced the following forecast figures relating to the proposed net product:

| Year | Sales | Variable <br> Cost | Fixed <br> Cost |
| :--- | :--- | :--- | :--- |
| 1 | $£$ | $£$ | $£$ |
| 2 | 52,000 | 30,000 | 23,000 |
| 3 | 78,000 | 47,000 | 28,000 |
| 4 | 100,000 | 65,000 | 30,000 |
| 5 | 60,000 | 35,000 | 24,000 |
|  | 36,000 | 19,000 | 20,000 |

Fixed costs include $£ 5,000$ per annum for an additional part time supervisor, $£, 7,000$ per annum depreciation on the machine and the balance an appointment of existing costs. It can be assumed that no credit is given to customers or received from suppliers.

If the new project is accepted, it would take up facilities that could be used for another purpose to generate a net cash flow of $£ 8,000$ per annum.

The divisional manager has asked the management accountant to submit an appraisal of the project covering a five year period. Assume an imputed interest charge by the headquarter of $10 \%$.

## Solution

Year
Marketing expense
New machine
Net cash earnings
Opportunity cost
Net cash flow
PV factor at $10 \%$
Net present value

| $\mathbf{0}$ | $\mathbf{1}$ | $\mathbf{2}$ | $\mathbf{3}$ | $\mathbf{4}$ | $\mathbf{5}$ | Total |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $(10,000)$ | $(5,000)$ |  |  |  |  |  |
| $(40,000)$ |  |  |  |  |  |  |
|  | 17,000 | 26,000 | 30,000 | 20,000 | 12,000 |  |
| $\overline{(50,000)}$ | $(\underline{8,000})$ | $(\underline{8,000})$ | $(\underline{8,000})$ | $(\underline{8,000})$ | $(\underline{8,000})$ |  |
| 1.000 | 0,000 | 18,000 | 22,000 | 12,000 | 9,000 |  |
| $(50,000)$ | 3,626 | 14,868 | 16,522 | 8,196 | 5,589 | $(1,189)$ |

## Notes

1. As the project has a negative NPV of $£ 1,189$, it should be rejected (but see later where the same project is adjusted for taxation and inflation)
2. Net cash earning is sales less variable cost and $£ 5000$ additional supervision.
3. Project cash flows might have to be adjusted for any credit allowed to customers or received from suppliers
4. Apportioned fixed costs are irrelevant because they will be incurred whether this project goes ahead or not (depreciation is not cash flow), but the increment expense of $£ 5000$ for the part time supervisors is relevant.
5. Value of alternative use of exiting facilities, $£ 8000$, is foregone and therefore treated as an opportunity cost.

## VALUE ADDED STATEMENTS

Are intended to show how much wealth or value has been created by the company's operations and how the wealth has been shared out to interested groups e.g. shareholders, investors in debt capital, employees, govt and the amount retained for re-investment. The value added statement shows:
How much value has been created by a firm's own effort
How this wealth has been shared out among stakeholders
The difference between the purchase cost of external material and services and the selling prices of the company goods and services is the value/wealth created by the company itself. This is referred to as value added. Value added statements can provide additional information to senior managers to help them in comparing performance of different divisions.

## Illustration

ABC Ltd makes 2 products each in a different division and revenues and cost for each division are given below:

|  | $\begin{array}{r} \text { Product A } \\ £^{\prime} 000 ' \end{array}$ |  |  |  | $\begin{aligned} & \text { Product B } \\ & £^{‘} 000 \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Direct material |  | 60 |  |  | 24 |
| Direct labour |  | 10 |  |  | 10 |
| Variable - mat | 1 |  | 1 |  |  |
| - lab | 4 | 5 | 4 |  | 5 |
| Fixed - mat | 5 |  |  | 4 |  |
| - lab | 5 |  |  | 5 |  |
| - Depn | $\underline{5}$ | 15 |  | $\underline{2}$ | 11 |
| Total costs |  | 90 |  |  | 50 |
| Sales |  | $\underline{100}$ |  |  | $\underline{60}$ |


|  | $\underline{10}$ | $\underline{10}$ |
| :--- | ---: | ---: |
| Profit Margin | $10 \%$ | $16.7 \%$ |

## Required

Prepare a value added statement and compute the following ratios.
Profit to value added
Contribution to value added
Value added to every $£ 1$ of labour
Comment on the better product

## Solution

Value Added Statement

| Valu Aded Stat |  | A |  | B |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 000 |  | $£ 000$ |
| Sales |  | 100 |  | 60 |
| Materials - Direct | 60 |  | 24 |  |
| - Indirect | $\underline{6}$ | $\underline{66}$ | $\underline{5}$ | $\underline{29}$ |
| Value added: |  | 34 |  | 31 |
| Shared between |  |  |  |  |
| Lab - Direct | 10 |  | 10 |  |
| - Indirect | $\underline{9}$ | 19 | $\underline{9}$ | 19 |
| Depreciation |  | 5 |  | 2 |
| profit |  | $\underline{10}$ |  | $\underline{10}$ |
|  |  | $\underline{34}$ |  | 31 |

Profit to value added $=\frac{10}{34}=29 \% \quad \frac{10}{31}=32 \%$
Contribution to value added $25 / 34=74 \% \quad 21 / 31=68 \%$
Value added per £1 of labour 34/19 £1.79 $\quad 31 / 19 £ 1.63$

## Comment

Although product $B$ has a higher profit to value added ratio, A makes more value added per every $£$ of labour cost suggesting better wealth creation by labour efforts and has a higher ratio of contribution to value added. This analysis does not necessarily make product A better than B. However, it provides information for comparison and judging performance which adds to the more traditional performance measures such as profit margin.

## Advantages of Value Added Statements

Managers might be in a better position to control their organisations own inputs than the cost and usage efficiency of purchased material and services. Value added statements focus on what managers can do something about.
Value added statements can reflect the quality and success of management effort.
Value added statements also focus attention on how the benefits are shared out and in particular: Whether employees are paid too much for what they are doing.
Whether enough funds are being retained in the business in the form of internally funded growth.
Value added in relation to labour cost provide excellent measures of productivity and therefore can be used for comparing the relative productivity of two or more divisions.

## BENCH MARKING

In the current business environment, organisations are under a lot of pressure to improve performance and that of their divisions or subsidiaries. Bench marking is therefore becoming increasingly popular and can be defined as a systematic analysis of one's own performance against that of another organisation with an overall objective of improving performance by learning form the experience of others.

Bench marking helps an organisation to understand its own business operations because of the detailed analysis that has to be carried out. Ideally performance should be compared with organisations known to be the best in the class of activities in question. From such an analysis, best practice can be identified and translated into use in the organisation.

Bench marking exercise should concentrate on areas of business which are of key strategic importance to the organisation and should be applied in activities where significant costs and efficiency improvements can be made.

Comparison can be made with direct competitors (competitive bench marking) or comparison can be made with the best external practitioner of the activity regardless of the industry within which they operate (functional bench marking). Internal bench marking involves comparing the performance of one part of the business with that of a different part of the same business with the major objective of establishing best practice through out the organisation. Bench marking establishes a desire to achieve continuous improvement and helps to develop a culture in which one admits mistakes and adopts or makes changes

## BALANCED SCORE CARD

This is a popular approach in current management thinking which consists of a variety of indicators both financial and non-financial. The balanced scorecard focuses on 4 different perspectives:

## Customer Perspective:

What do existing and new customers value from us? This perspective gives rise to target which matter to customers e.g. cost, quality, delivery, inspection of the goods, and handling of goods or customers.

## Internal Perspective:

What processes must we excel at to achieve our financial and customer objective? This perspective therefore aims at improving internal processes and decision making.
Innovation and learning: Can we continue to improve and create future value? This perspective considers the business capacity to maintain its competitive position through the acquisition of new skills and development of new products. The organisation must set targets which will emphasise continuous change in customer needs such as the percentage of sales derived from new products. Compared with the established ones and the long-term investments undertaken.

## Financial Perspective:

How do we create value for our shareholders? This perspective covers traditional measures e.g. growth, liability, shareholder value. But these are set once the key areas for improvement have been identified and the balanced score card is the main monthly report. The score card is balanced in the sense that managers are required to think in terms of all perspective to prevent improvement being made in one area at the expense of another. Important features of this approach are:

It looks at both internal and external matters concerning the organisation
$\square$ It is related to the key elements of the company strategy
$\square$ Financial and non-financial measures are linked together.

## TRANSFER PRICING AND PERFORMANCE EVALUATION

## Introduction

Transfer pricing is simple in concept and yet complex in implementation. It provides a divisional output valuation where output from one division becomes the input of another division within the same organisation. This is often necessary to the operation of profit or investment centres. Complexity in implementation arises from the availability of a number of valuation bases, each with their own implications for the ways in which an organisation is to be managed. This section provides a description of the major valuation bases found in practice and in theory. Transfer prices are necessary to the operation of performance measurement based on profit and investment centres and the chapter includes a critical appraisal of performance measurement in general.

The chapter is divided into three. The first section describes the purpose of transfer pricing. In the second section, methods of transfer pricing are described and briefly evaluated. In the final section, a critical appraisal of performance measurement in general and transfer pricing in particular is provided.

## 1. TRANSFER PRICING: PURPOSES

Transfer pricing can contribute directly to the process of departmental performance measurement and indirectly to the measurement of product performance.
A transfer price is a value attached to the output of a department in order to measure the value of its trade with other departments inside the organisation. The transfer price of the supplying division is charged to the receiving division. Transfer prices do not affect overall organisational profit results but do affect the profits reported by divisions. The following example illustrates this point.

## Example 1

Mwangi Inc. Plc. sells a single product at $£ 5$ per unit. The product is manufactured by passing raw materials through two departments, $A$ and $B$, at costs of $£ 1.50$ and $£ 2.50$ respectively. A transfer price of $£^{2}$ has been established to measure the profit achieved by department A .

| Department A: |  |  |
| :---: | :---: | :---: |
| Transfer price per unit |  | $£ 2.00$ |
| Cost per unit |  | $£ 1.50$ |
| Profit |  | $£ 0.50$ |
| Department B: |  |  |
| Selling price per unit |  | £5.00 |
| Transfer price | $£ 2.00$ |  |
| Other costs | $£ 2.50$ | £4.50 |
| Profit |  | $£ 0.50$ |
| Mwangi Inc. |  |  |
| Selling price per unit |  | $£ 5.00$ |
| Cost per unit: |  |  |
| Department A | $£ 1.50$ |  |
| Department B | $£ 2.50$ | £4.00 |
| Profit |  | $£ 1.00$ |

The total cost of the product is $£ 4$ per unit providing a profit to the company of $£ 1$ per unit. Department A has costs, or inputs, of $£ 1.50$ per unit and a transfer price of $£ 2$ per unit as a measure of output value. It thus shows a profit of $£ 0.50$ per unit. Department $B$ has input costs of $£ 2.50$ per unit, plus a transfer price of $£_{2}^{2}$ per unit, and an output value of $£ 5$. Department $B$ also shows a profit of $£ 0.50$ per unit, therefore, the profit of both departments together is $£ 1$ per unit ( $£ 0.50$ plus $£ 0.50$ ). The organisation's profit of $£ 1$ per unit is unaffected by the transfer price because the output value attached to department A's production becomes an input value for department B.

If a transfer price of $£ 1.50$ per unit is used in this situation, department $A$ appears to show $£$ nil as a profit. The costs to department B are $£ 1.50$ plus $£ 2.50$, giving a $£ 1$ profit per unit for a selling price of $£ 5$ per unit. This transfer price ensures that department A's costs are transferred to department B but does not
offer a profit motivation to department A's manager. Department A is unlikely to take action to improve performance if all credit for such effort is shown under department B's results. Different transfer prices allocate profit in different ways between divisions and it should be clear that:

1. Transfer pricing shares profits between divisions but does not, on its own, affect total profits;
2. Transfer pricing can motivate managers to take actions to improve profits for their divisions and for the organisation as a whole. The transfer price should allow the opportunity for effort to be translated into a positive measurement of performance.
$\square$ Transfer pricing is similar to cost apportionment and allocation in that values of one department are passed to another. For cost apportionment and allocation systems, costs of one department are passed to another with the objective of accumulating costs for product cost information purposes. In a sense, apportionment and allocation provides a mechanism of transfer pricing primarily based on input measures such as floor area or direct labour hours. Under transfer pricing arrangements, values of one department are also passed to another. Output measures of activities are used to charge departmental costs and allowable profits to other departments. The information produced can be used to accumulate product costs. Where transfer prices are cost based and make no allowance for profits, the results would differ from apportionment and allocation systems only with regard to the basis for transferring costs between departments.
$\square$ Where performance measurement is linked to rewards such as promotion or salary, the method of transfer price can have a direct impact on the motivation of the divisional manager. For example, a divisional manager appraised on a profit centre basis will be in a position of advantage where high transfer prices are established for the particular division. The effect of motivating managers to improve profits may lead to bargaining for transfer pricing methods which provide the highest transfer prices for their particular divisions. In a transfer pricing situation, as in a number of accounting situations, there will inevitably be winners and losers. The challenge to the accountant is to devise a transfer pricing methodology which ensures that the winners are those who will benefit the organisation most in the long term.
$\square$ Some multinational companies are in a position to use transfer pricing to reduce total taxation costs. This can be achieved by establishing transfer prices towards the higher end of the spectrum of allowable values in countries with low taxation. This would tend to lead to high profits in countries with low taxation and lower profits in countries with higher taxation. Governments in some countries take steps from time to time to regulate the operation of transfer pricing systems for this reason.

## 2. TRANSFER PRICING METHODS

Transfer pricing methods are concerned with the alternative means by which a transfer price can be set and its impact on organisations gauged. Emmanuel and Otley bring together a number of views of transfer pricing methods in practice. Essentially, they report that there are three categories of transfer price: cost based, market based and negotiated. Within the surveys reported, in terms of very rough approximations, about $20 \%$ of companies used negotiated prices, about $30 \%$ of companies used market values and about half used cost based prices. For each category, a good degree of discretion existed to develop alternative bases at a detailed level. For market based prices, for instance, competitors' prices, list prices, most recent bid and values adjusted by a discount provided alternative bases. The description which follows does not go to such a level of detail but concentrates on four main approaches: absorption cost bases, variable cost bases, market value bases and negotiated value bases. A final section describes the use of linear programming.

## A. Absorption cost based transfer prices

Absorption, or full cost systems, transfer the full cost of the supplying department to the receiving department. Where a profit is to be allowed to the supplying division, it is necessary to determine a policy which can be consistently applied. Typical systems may allow a profit based on cost, sales or investment, as shown in the example below:

## Example 2

A division has a product costing $£_{5} 5$ which is transferred within a group of companies. Calculate a transfer price for the division for each of the following mutually exclusive divisional targets:

1. a net profit margin of $10 \%$
2. a mark-up on cost of $10 \%$
3. a net assets turnover rate of 5 and an ROCE of $30 \%$.
4. an output of $1,000,000$ units, a capital employed of $£ 2,000,000$ and an ROCE of $20 \%$

## Solutions:

1. A net profit margin of $10 \%$ is the same as a mark-up on cost of $10 / 90$. The selling price is $100 / 90$. Using a cost of $£ 5$, the transfer price should be:

$$
£ 5 \times 100 / 90 \text { or } £ 5 / 0.9 \text {, which is } £ 5.56 \text {, a profit of } £ 0.56
$$

2. The transfer price would be $£ 5.50$
3. Using the relationship:

Return on capital employed $=\frac{\text { Net profit }}{\text { Capital employed }}$
$=\frac{\text { Net profit }}{\text { Sales }} \mathrm{X} \quad \frac{\text { Sales }}{\text { Capital }}$
employed
The figures for the division would be:

$$
\begin{array}{ll}
30 \%=\text { Net profit margin X } 5 \\
\text { Net profit margin } & = \\
\text { Transfer price }= & £ 5.32(£ 5 / 0.94)
\end{array}
$$

This example illustrates a general procedure applicable in other situations.
4. Each unit of output utilises $£ 2$ of capital employed ( $£ 2,000,000 / 1,000,000)$. The required return is $20 \%$ profit per unit of $£ 0.40$. The required transfer price is therefore £5.40.

The two major drawbacks to the full cost approach concern its inability to motivate the supplying division's manager to improve performance and the danger of making incorrect decisions. Since all costs are passed on, irrespective of economy or efficiency in the supplying division, there is little incentive for managers of supplying divisions to cut costs or to operate more efficiently. Once costs are passed on, fixed costs of the supplying divisions are interpreted as variable costs of the receiving division and it is therefore possible for divisions to make short-term decisions which are suboptimal for the organisation as a whole. Consider a make or buy decision for which divisional variable costs are $£_{2}^{2}$, including $£ 0.30$ fixed cost included in a transfer price, and the external supplier's costs are $£ 1.90$. the division would buy in the product, despite the fact that the
company's variable costs, at $£ 1.70$, are lower than the buy-in price. The company would wish the division to continue to make, but can only do so by centralisation of the decision rule, with a loss of autonomy at the divisional level.

In order to ensure that inefficiencies are not passed on by suppliers, it has been suggested that standard absorption costing can produce reliable results. Underutilisation of plant capacity, inefficiencies and lack of price control remain in the division in which they occurred and are reported through the calculation of standard costing variances. However, the problem of suboptimisation would not be overcome by standard absorption costing transfer prices.

## B. Variable cost based transfer prices.

Variable cost based systems overcome the decision-making problem of full cost system. Transfers from one division to another are made at variable cost. Standard variable cost overcomes the problem of passing on inefficiencies and diseconomies from division to division.

There are two ways by which profits can be created at a divisional level. The first approach is to apply the principles illustrated in $A$ to marginal costing. Transfer pricing schemes would allow a suitable level of contribution, as measured in terms of contribution on sales ratio. An alternative approach is to create a two-part charging system. One part of the scheme would transfer a lump sum, representing an allowance for divisional fixed cost once a year to allow each division the chance of creating a final profit. The second part of the scheme would value transfers at variable cost.

## C. Market value based transfer prices

There is universal agreement that in competitive markets a market value based transfer price should achieve optimal results. In this circumstance, it can be expected that:

1. The autonomy of the division is not undermined because markets determine the value of outputs, not centralised departments or divisional costs. Market prices would be seen to be objective and fair to all. The aim of creating an organisational structure where each division operates as an organisation in its own right can be achieved. Ideally, suppliers should be permitted to sell to external customers and receivers should be allowed to buy from external producers.
2. Managers' performance reflect their ability to compete with external companies in a free market. This may be a fair indication of the manager's ability and potential to perform at higher levels within the organisation and thus forms a fair basis for promotion and salary decisions;
3. From 2, it can be expected that the transfer pricing mechanism will be neutral in motivating managers to perform in accordance with organisational goals; that is, the transfer pricing mechanism will not be biased in any manner other than that created by market forces. Performance measurement schemes can thus be established to motivate managers to act in a goal congruent manner;
4. Reliable decisions would arise at divisional level. For instance, in a joint product situation, products, which should be sold at the split-of point would not be processed further since the post split-off processing division would show a loss based on the transfer price.

Unfortunately, two problems illustrate that market based prices may not be able to achieve these aims in all circumstances. The first problem arises because transfer pricing situations are not
simply selling situations. The supplying division, for instance, does not have to incur the costs of selling normally associated with selling to external customers. The receiving division may be in a position to influence quality and delivery because it is in the interests of both divisions that the company as a whole prospers. It is sometimes desirable to adjust the market price to reflect such factors, with a commensurate loss in the objectivity which market prices can bring. The second problem is more fundamental; there may simply not be a perfect market in operation. A vertically integrated company, for instance, may not possess a market for its intermediary products. In this case, there is no market from which to establish market values. Other market imperfections would produce bias which would work to the benefit of either the supplying or the receiving division.

## D. Negotiated prices

Where market based prices are not applicable, it has been argued that allowing managers to bargain with each other in order to establish transfer prices develops the kind of management skills which are necessary to the future of the enterprise. Managers would need to have detailed knowledge of their own resources and costs and would need to apply their inter-personal skills of communication, persuasiveness and bargaining in order to show a profit. Negotiated prices thus stress the human behavioural aspects of the organisation. Social and political skill can be translated into good divisional performance, as measured by the accounting system.

Unfortunately, negotiated prices can also lead to conflict, especially where two managers cannot agree on a transfer price. In such circumstances, a mechanism for resolving the dispute is required at a central level. The intervention of central authority to resolve conflicts clearly results in a loss of autonomy with dysfunctional consequences. A system which aims to reveal the behavioural skills of managers can as easily reward those who can manipulate the inherent tensions between centre and divisions to their best advantage.
E. Linear programming based transfers

Consider the following example:

## Example 3

Two products, Exe and Wye are produced by Hifi, an electronics company which operates two departments. Both departments are limited to working a maximum of 10 hours per day per machine and both departments utilise 10 machines. A five-day week is in operation. Product
cost information for Exe and Wye is as
follows: Exe Wye
$\begin{array}{lll} & \text { Selling price } & \stackrel{\text { f. }}{ } \quad \stackrel{\text { E. }}{ } \\ & 1.50 & 8.50\end{array}$
Materials cost $\quad 1.00 \quad 1.00$
Variable overheads cost:
Department 1
2hours @ £1.503.00
1 hour @ £1.50 1.50
Department 2
1.25 hours @ $£ 2.50$

2 hours @ $£ 2.00$
Contribution $\quad \underline{3.00} \quad \underline{2.00}$
Processing this example through a linear programming computer package reveals a total contribution of 181.8 units of Exe and 136.4 units of Wye, with shadow prices for department 1 and 2 of $£ 1.2727$ and $£ 0.3636$ respectively. Were the centralised management accounting department to run this package, they would instruct both departments to produce 182 units of Exe and 136 units of Wye. The transfer price would be calculated as the total of variable cost and
opportunity cost. The opportunity cost of each product is given by the shadow price; in the case of Exe, calculated as follows:

| Department 1 | 2 hours @ £1.2727 | $£^{2} 2.545$ |
| :---: | :---: | :---: |
| Department 1 | 1.25 hours @ £0.3636 | ¢0.455 |
|  |  | ¢ 3.000 |

There is no coincidence that this is the product contribution in this case. Transfer prices of $£ 7$ for Exe and $£ 4.50$ for Wye would be established. This implies that department 2 would not be able to show a profit.

A situation can be illustrated where the constraints of the linear programming model lead to the supplying division's manager being motivated to achieve optimum levels of production through the transfer price. In this case, the transfer price can itself motivate the achievement of optimum levels of output for both the supplying division and the organisation as a whole, where all output from one division is processed by the next. The supplying division is not allowed a profit and must be given production instructions from the centre, with loss of divisional autonomy.

## International Transfer pricing

International transfer pricing refers to the determination of prices to be charged between related persons and in particular within a multinational enterprise for transactions between various group members (sales of goods, the provision of services, transfer and use of patents and know-how granting of loans etc. ) As these prices are not negotiated in a free open market they may deviate from prices agreed upon by non-associated trading partners in comparable transactions under the same circumstances.

The above leads to a special interest on the part of tax authorities in intra-group transactions and especially in cross- border transactions. In many circumstances the tax authorities would seek to adjust the prices adopted in these transactions to arm's length prices. However, the intra-group trading partners themselves may find it difficult to settle on satisfactory transfer prices, even if they are in many cases no comparable transactions in the open market. In such circumstances the tax authorities may seek to arrive at the arm's length price by using cost -based methods or methods based on the price changed to the final customer - the 'resale minus' or resale price method or any other which can produce an acceptable result.
G. Transfer pricing with third party consequences

Transfer prices are used not only for internal record keeping and performance evaluation purposes.
There are several settings where transfer prices have direct cash consequences for a company. The most widely cited case is in interstate and international transactions where transfer prices may affect tax liabilities, royalties or other payments due to different government jurisdiction. Since tax rates differ across states, or jurisdictions, companies have an incentive to establish a transfer price which will increase the income in the lower tax jurisdiction and decrease income in the higher tax jurisdiction.

## Example:

Assume that the Kerbrook Shirt Company owns a manufacturing plant in Kenya where its marginal tax rate is 60 per cent of net income. These shirts are imported by Zambia where the marginal tax rate is 75 per cent of net income. For simplicity assume that there are no currency controls and that tax regulations concerning the definition of taxable income are the same between the two countries.

During the current year, the company incurred production costs equivalent to sh. 2 million in Kenya. Costs incurred in Zambia aside from the costs of the shirts amounted to an equivalent of sh. 6 million. Sales revenues in Zambia were sh. 24 million. Similar goods imported by independent companies in Zambia would have cost an equivalent of sh. 3 million.

However, Kerbrook Shirt Company points out that because of its special control over its operations in Kenya and the special approach it uses to manufacture its goods, the appropriate transfer price is sh. 10 million.

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## Required:

What would Kerbrook Shirt Company's total tax liability in both countries be if it used the sh. 3 million transfer price?
What would the liability be if it used the sh. 10 million transfer price?

## Solution:

The solution is approached by determining the taxable income for each country under the alternative transfer price scenarios. The resulting taxable income is multiplied by the tax rate in each country to obtain the tax liabilities.

For the sh. 3 million transfer price, the tax liability is computed as follows;

|  | Kenya <br> (sh) | Zambia <br> (sh) |
| :--- | :---: | :---: |
| Sales revenues | $3,000,000$ | $24,000,000$ |
| Third party costs | $2,000,000$ | $6,000,000$ |
| Transferred goods costs | - | $\underline{3,000,000}$ |
|  |  |  |
| Total costs | $2,000,000$ | $9,000,000$ |
| Taxable income | $1,000,000$ | $15,000,000$ |
| Tax rate | $\underline{60 \%}$ | $75 \%$ |

Tax liability
600,000
11,250,000
Total tax liability $=\operatorname{sh} 11,850,000$

For the sh. 10 million transfer price;

|  | Kenya (Sh). | Zambia (Sh). |
| :---: | :---: | :---: |
| Revenues | 10,000,000 | 24,000,000 |
| Third party costs | 2,000,000 | 6,000,000 |
| Transferred goods costs | - | 10,000,000 |
| Total Costs | 2,000,000 | 16,000,000 |
| Taxable income | 8,000,000 | 8,000,000 |
| Tax rate | 60\% | 75\% |
| Tax liability | 4.800,000 | $\xlongequal{6,000,000}$ |

Total tax liability $=$ sh. $10,800,000$

The tax liability assuming a sh. 10 million transfer price is about $9 \%$ less than the liability that would be incurred if the transfer price was sh. 3 million.
International taxing authorities look closely at transfer prices when examining the tax returns of companies engaged in related party transactions which cross jurisdictional lines. Companies must therefore have adequate support for the use of the transfer price which they have chosen for such a situation.

Another situation where transfer pricing has direct economic consequences is where the owner of one entity holds a different ownership percentage than he or she holds in another entity. It is generally in the best interest of this person to transfer income to the entity in which he or she holds the higher ownership in percentage.
In situations where transfer prices have direct economic consequences it is important to develop transfer prices in a manner that will meet third party scrutiny since tax authorities may investigate transfer prices
which affect cross-border tax liabilities. In addition, in situations where an individual acts on both sides of a related party transaction, the possibility of litigation arises if transfer prices are not reasonable.

In general, transfer prices for goods and services between segments or companies located in different countries should reflect that countries have different tax rates and regulations. Due to these variances, companies have an incentive to transfer most of their income to the subsidiary that has a tax advantage over others within the corporate group. In addition some countries restrict payment of income or dividends to parties outside their national borders. In such cases, the company often increases the transfer prices so they pay more funds out of these countries while appearing to follow regulations.

Transfers from foreign countries where the wage level and/or tax rate is low may also be made at a domestic market price rather than on a cost basis because foreign economic conditions are so different from domestic conditions.

## H. International transfer pricing - compliance and documentation

Transfer pricing is a perennial issue, within the international tax community (Richard Casna, Accounting and Business, February 1988, pp.30-31).

As multinationals become more sophisticated in employing transfer pricing techniques in their tax planning, the revenue authorities have increased their scrutiny of arrangements, putting transfer pricing at the forefront of international tax concerns.

It naturally follows that if profits can be shifted from a high tax jurisdiction to one of low tax through transfer pricing, the tax authorities will respond with rules designed to curtail tax avoidance and ensure tax payer compliance.

Revenue authorities around the globe have become more adept at countering the "profit-shifting" aspects of transfer pricing practices and are strengthening their statutory powers with ever more extensive and complex legislation and regulations.

To strengthen the tax authorities' position, regulations typically introduce specific rules to determine arms' length prices and require that tax payers maintain very extensive records documenting the methods used to determine their transfer prices (which often necessitates the employment of teams of both in-house and outside counsel, accountants and economists). Provision is made as well for the imposition of very stringent penalties in cases of non-compliance.

To achieve these ends, the statutes generally focus on guidelines set out by the OECD's Committee on Fiscal Affairs (the tax policy body of the OECD), first in its 1979 document "Transfer pricing and multinational Enterprises" and the 1995-1996 "Transfer pricing Guidelines for Multinational Enterprises and Tax Administrations." These guidelines generally stipulate the parameters of the arm's length pricing standard and the methodology to be followed in achieving arm's length prices.

The practitioner as adviser to multinationals which face the complexities of transfer pricing legislative and regulatory controls has therefore to simply consider the statutes in each country/state carefully, comply with the rules and maintain extensive documentation.

### 1.2. CRITIQUE OF PERFORMANCE MEASUREMENT

This section brings together material from preceding data in this lesson in order to provide a critical appraisal of performance measurement. In a sense, all of the material in the Management Accounting Notes can be related to the measurement of performance; good managers make good decisions, form good plans, establish good control practices and this should be reflected in measures of performance. An alternative view is that performance measurement drives the decision making, planning and control functions of management; managers manipulate performance results so that they can appear to be performing well. This provides an explanation for ROI approaches to the capital investment decision;
managers are more concerned to appear to be making the right decision than to be making the right decision in reality. Whatever the view, transfer pricing and performance measurement provides good material for assessing the problems facing the management accountant who is trying to devise systems which will benefit organisations.. The critique which follows provides a summary of the problems of ensuring that performance measurement systems achieve the purposes for which they are designed. The list which is provided can be considered as a coverage of some of the themes which influence management accounting as a whole.
A. Transfer pricing and performance measurement relies upon the judgement of the management accountant to make a suitable choice of approach and to calculate suitable values where appropriate.

## Example 4

Alton division (A) and Birmingham division (B) are two manufacturing divisions of Conglom plc. Both of these divisions make a single standardised product; A makes product I and B make product J. Every unit of J requires one unit of I . The required input of I is normally purchased from division A but sometimes it is purchased from an outside source.

The following table gives details of selling price and costs for each product.

| Product I | Product J |  |
| :---: | :---: | :---: |
| £ | f |  |
| Established selling price $\quad \underline{30}$ | $\underline{50}$ |  |
| Variable costs |  |  |
| Direct material 8 | 5 |  |
| Transfers from A | 30 |  |
| Direct labour 5 | 3 |  |
| Variable overhead $\underline{2}$ | $\underline{2}$ |  |
| 15 | 40 |  |
| Divisional fixed cost (per annum) | $£ 500,000$ | £225,000 |
| Annual outside demand with current selling prices (units) |  |  |
| current selling prices (units) Capacity of plant (units) | $130,000$ | 25,000 30,000 |
| Investment in division | £ 6,625,000 | $£ 1,250,000$ |

Division B is currently achieving a rate of return well below the target set by the central office. Its manager blames this situation on the high transfer price of product I. Division A charges division B for the transfers of I at the outside supply price of $£ 30$. The manager of division A claims that this is the price 'determined by market forces'. The manager of B has consistently argued that intra group transfers should be charged at a lower price based on the costs of the producing division plus a `reasonable' mark-up.

The board of Conglom plc is concerned about B's low rate of return and the division manager has been asked to submit proposals for improving the situation. The board has now received a report from B's manager in which he asks the board to intervene to reduce the transfer price charged for product I. The manager of B also informs the board that he is considering the possibility of opening a branch office in rented premises in a nearby town, which should enlarge the market for product J by 5,000 units per year at the existing price. He estimates that the branch office establishment costs would be $£ 50,000$ per annum.

You have been asked to write a report advising the board on the response that it should make to the plans and proposals put forward by the manager of division B. Incorporate in your report a calculation in the
rates of return currently being earned on the capital employed by each division and the changes to these that should follow from an implementation of any proposals that you would recommend.

An answer to this question would be provided in report style for examination purposes. The discussion which follows shows the influence of management accounting judgement rather than providing an ideal examination answer. It is anticipated that students will have the necessary skill to convert the points of discussion into an answer suitable for examination conditions.

If I and J are traded in a perfect market and both divisions are given complete autonomy, the present transfer price is optimal. Any increase in transfer price would lead to B purchasing from external sources, which would not be in the interests of the organisation. Any decrease in transfer price would lead to A selling to external customers, which would again not be in the best interests of the organisation.

It could be argued that A does not have to find the resources to market I and that some reduction from the external price is appropriate in setting the transfer price. The amount of the reduction could be a matter of negotiation between the managers of A and B or could be established through the judgement of the management accountant, bearing in mind any information available on competitor's selling costs.

If the market is imperfect then negotiated or cost based prices should be considered. It is a matter of judgement to determine whether negotiated prices would provide a suitable resolution to the problem, taking into account the personalities of the managers of A and B . Although the managers appear to be entrenched in their respective points of view, management training and/or an explanation of the purpose of transfer pricing may improve relations between the managers, lead to an acceptable transfer price and improve the future prospects for Conglom as a whole. Divisional autonomy would be maintained. Negotiated prices are thus to be recommended to the board of directors as a suitable alternative. The management accountant would have a role to play in educating managers in the purposes, benefits and limitations of management accounting systems. Cost based prices would require a degree of intervention from the centre, the part of the organisation where it could be expected that the necessary information is available.

Division A can meet B's demand for 25,000 units and the outside demand for 100,000 units, within its capacity of 130,000 units. Division B would meet the external demand. This would lead to the following financial statement under the present transfer price:

| Division | Division |  |
| :--- | :--- | :--- |
|  | $A$ | $B$ |
|  | $£^{\prime} \mathbf{0 0 0}$ | $£^{\prime} 000$ |
| Sales revenue (external customers) | 3,000 | 1,250 |
| Transfers | $\frac{750}{3,570}$ | $\underline{500}$ |
|  | $\underline{1,875}$ | $\frac{250}{1,875}$ |
| Variable cost (excluding transfers) | $\underline{500}$ | $\underline{225}$ |
| Contribution | $\underline{1,375}$ | $\underline{25}$ |
| Fixed cost | $\underline{6,625}$ | $\underline{1,250}$ |
| Profit | $\underline{20.8 \%}$ | $\underline{2.0 \%}$ |
| Investment |  |  |

If autonomy is maintained, division A could make a decision on whether to sell to division B or not, and at what price on a short-term basis. The existence of surplus capacity should lead to any price in excess of variable cost being acceptable. Using variable cost as the transfer price would lead to the following results:

|  | Division | Division |
| :---: | :---: | :---: |
|  | A | B |
|  | $£^{\prime} 000$ | $£^{\prime} 000$ |
| Sales revenue (external customers) | 3,000 | 1,250 |
| Transfers (at A's variable cost of |  |  |
| $£ 15$ per unit) | 375 | (375) |
|  | 3,375 | 875 |
| Variable cost (excluding transfers) | 1,875 | 250 |
| Contribution | 1,500 | 625 |
| Fixed cost | 500 | $\underline{225}$ |
| Profit | 1,000 | 400 |
| Investment | 6,625 | 1,250 |
| Return on investment | 15.1\% | 32.0\% |

Any cost based price between $£ 15$ and $£ 30$ would appear to be acceptable and the management accountant could apply judgement to decide on appropriate levels of profitability for each of the divisions.

If it is judged that an equal opportunity to achieve profit returns should be given, then the transfer price could be calculated as follows:

Total profit involved $£ 1,400,000$
Total investment involved: $\quad £ 7,875,000$
Average return on investment: $\quad 17.8 \%$
Total costs in department A are: $(1875+500)=£ 2,375,000$
Applying the relationship:

| ROI | $=$ Net profit/investment |
| ---: | :--- |
|  | $=\frac{\text { Net profit }}{\text { Total costs }} \times \mathrm{x} \quad \frac{\text { Total cost }}{\text { Investment }}$ |

provides: $\quad 17.8=$ Net profit mark-up X 2,375/6,625
Net profit mark-up $=49.7 \%$
Cost per unit in A is $(2375 / 125)$
$£ 19.00$
Average selling price is (19 x 1.497)
£28.44
Total sales: 125,000@ £28.44
£ $3,555,000.00$
Less external sales:
f $3,000,000.00$
Transfer value:
$£ \underline{555,000.00}$
Transfer price (555/25)
$£ 22.20$

The reported financial statements would also be as follows:

|  | Division | Division |
| :--- | :---: | :--- |
|  | $\mathbf{A}$ | $\mathbf{B}$ |
| Sales revenue (external customers) | $\boldsymbol{£}^{\prime} \mathbf{0 0 0}$ | $£^{\prime} \mathbf{0 0 0}$ |
| Transfers (at $£ 22.20$ per unit) | 3,000 | 1,250 |
|  | $\underline{555}$ | $\underline{(555)}$ |
| Variable cost (excluding transfers) | $\underline{3,555}$ | 695 |
| Contribution | $\underline{1,875}$ | $\underline{250}$ |
| Fixed cost | $\underline{1,680}$ | 445 |
| Profit | $\underline{\underline{6,625}}$ | $\underline{225}$ |
| Investment | $\underline{\underline{1720}}$ |  |
| Return on investment | $\underline{17.8 \%}$ | $\underline{17.6 \%}$ |

There are two aspects to the behavioural aspects of this situation which will be discussed. The first concerns the extent to which managers of A and B would find the transfer price `fair'. Any attempt by the management accountant to impose a transfer price would be perceived to be an infringement of autonomy and may lead to dysfunctional consequences. Wherever possible, if the autonomy of the division is to be guarded and an imperfect market operates, negotiated prices appear to offer most prospects of optimising the behavioural implications. The second behavioural implication concerns the motivation of managers to accept worthwhile projects. If it is accepted that managers are motivated to improve their reported performance, performance measures which lead to managers rejecting profitable projects are dysfunctional. This particular idea can be explored in relation to

## Example 1.

At the existing transfer price of $f 30$, the manager of $B$ would produce the following calculations of the value of opening the branch office:

| Additional sales 5,000@£,50 |  | $£ 250,000$ |
| :--- | :--- | :--- |
| Additional variable costs: |  |  |
| Transfer price | $£ 150,000$ |  |
| Other variable costs | $£ 50,000$ |  |
| Fixed costs | $£ 50,000$ | $£ 250,000$ |
| Net profit |  | $£$ nil |

On behavioural grounds, the project would be rejected by the manager because performance does not improve as a result of the effort necessary to open the branch. However, from Conglom plc's point of view the calculation would appear as follows:

| Additional sales 5,000@ $£ 50$ |  | $£ 250,000$ |
| :--- | :--- | ---: |
| Additional variable costs: |  |  |
| Transfer price | $£$ nil |  |
| Other variable costs | $£ 125,000$ |  |
| Fixed costs | $£ 50,000$ | $£ 175,000$ |
| Net profit |  | $£ 75,000$ |

It is advantageous to the company as a whole, for the branch office to be opened. Since A has spare capacity sufficient to meet the additional requirement, a transfer price equal to the variable costs incurred in division $A$ would lead to the manager of department $B$ making the correct decision. A transfer price between $£ 15$ and $£ 30$ would lead to the branch being opened but a transfer price of $£ 15$ alone would ensure that all future decisions were evaluated correctly at divisional level. This leads to the second point in the critique performance measurement.
B. Values which are suitable for performance measurement purposes are not necessarily suitable for decision making, planning and control purposes. Example 4 illustrated the problem of meeting both performance measurement and decision-making requirements. For planning purposes, reasonable future forecasts or targets which meet long-term planning requirements present two acceptable approaches and incremental budgeting offers a third means by which values can be established in practice. For control purposes, values should ideally be set just above aspiration levels. For performance measurement purposes, values should be set which avoid suboptimisation and dysfunctional behaviour and which further the objectives of the performance measurement scheme and of the company in general. It is unlikely that a single value can meet all requirements.

In some circumstances, multiple values can be established. In overcoming the problem of setting up reliable and valid values for planning, control, decision making and performance measurement needs, however, further problems may arise. Imagine that a company establishes one target for performance measurement purposes and another, lower value, for planning purposes. The planning value must be kept secret from the divisional manager if it is to motivate since some types of manager may lower aspiration levels to the planned target. Secrecy can have detrimental effects to the coordination and communication objectives of budgeting. Again, the behavioural consequences of establishing values are of paramount importance and the management accountant finds that effective accounting is partly based on setting up sound systems at the technical level and partly based on setting up systems which work for the people within the organisation.
C. Emphasis on cost, profit and investment centre performance in the short term can have detrimental effects on the organisation in the long term. Example 5 is taken from a situation which has occurred in practice.

## Example 5

A company found it necessary for cash flow purposes to close one of its divisions. Two divisions were prime contenders for closure. Each would have brought in roughly equal amounts of cash and the amounts involved would have been sufficient to solve the cash flow crisis. Division A was set up ten years earlier and its assets were almost fully depreciated. Division B was set up two years earlier, incorporating the latest technology and had substantial balance sheet values because its assets were depreciated over a ten-year period. In the previous financial year, division A showed a $30 \%$ ROCE whilst division B showed a $20 \%$ ROCE. Which division should have been closed?

The company closed division $B$, because division $A$ showed the best performance, as measured by ROCE. However, it found two years later that it needed to invest substantially in division A because of obsolete assets. A further cash flow crisis ensued.

This dysfunctional decision could have been avoided by applying a more appropriate valuation base for the assets than that provided by historic values derived from balance sheets designed primarily for financial accounting purposes.

Original cost, replacement value or an SSAP 16 philosophy have all been suggested as means by which ROCE can more reliably measure performance. The selection of asset valuation base is a matter of judgement.

Further examples of dysfunctional decisions arising from the need to meet short-term goals in terms of performance and/or budgetary control include postponing vital expenditure or investment. Postponement has the effect of ensuring that short-term goals are met but can disadvantage organisations in comparison with competitors who pursue long-term optimisation at some slight loss of optimisation in the short term.
D. Accounting figures can provide distorted information. Where a company imposes a cost based transfer price, results may be biased in favour of certain divisions at the expense of others, as Example 4 illustrated. Where a company uses ROCE as a performance measure, performance appears to improve as assets age because the effect of depreciation is to reduce the asset base in the ROCE calculation. The accountant's figures on performance do not necessarily measure the true improvement or deterioration in divisional performance.
E. Financial measures of performance can give insufficient emphasis to non-financial and qualitative aspects of organisational management.
F. It is difficult to determine whether the manager's performance or department's performance is being measured in some circumstances. This is important where an organisation wishes to promote its most able managers to ensure the long-term successful management of the enterprise.
G. Independence and interdependence factors can lead to pseudo-profit and investment centres, where the accounting system treats divisions as autonomous despite the reality that autonomy cannot be achieved without detriment to the organisation as a whole. A transfer price which requires a decision from head office is likely to infringe divisional autonomy. Any system which requires a central accounting function to calculate a transfer price is therefore likely to lead to a loss of independence at divisional level.
H. The accounting models available to management accountants appear to create a potentially spurious sense of accuracy, reliability and validity. A budgeted target appears to have validity because it is visible and appears to be certain. In an uncertain world, deterministic targets may be invalid and probabilistic approaches may be more valid, but are unfortunately beset by problems, particularly the difficulty of establishing subjective probabilities. The section on forecasting suggested a number of reasons why managers tend to rely on relatively simple forecasting models in order to predict the workings of a complex world.

The problem facing the practical management accountant is to select an accounting model which most closely matches the reality of the situation faced by an organisation and for which data capture is feasible.

## REINFORCING QUESTIONS

## QUESTION ONE

Division A of Miujiza Ltd. is the only source of supply for an intermediate product that is converted by Division B into a saleable final product. Most of A's costs are fixed. For any output up to 1,000 units per day, its total costs are Shs 15,000 per day. Total costs increase by Shs 3,000 per day for every additional thousand units made. Division A judges that its own results will be optimised if it sets its price at Shs 12 per unit, and it acts accordingly.

Division B incurs additional costs in converting the intermediate product supplied by A into a finished product. These costs are Shs 37,500 for any output up to 1,000 units, and Shs 7,500 per thousand for outputs in excess of 1,000 . On the revenue side, $B$ can increase its revenue only by spending more on sales promotion and by reducing selling prices. Its sales forecast is

| Sales in units | Net revenue per <br> a thousand units <br> Shs |
| ---: | :--- |
| 1,000 | 52,500 |
| 2,000 | 39,750 |
| 3,000 | 33,000 |
| 4,000 | 27,750 |
| 5,000 | 24,000 |
| 6,000 | 20,000 |

## Required:

(a) Prepare a schedule comparing B's costs including its purchases from A, revenue and net income at the following levels of output ( $1,000,2,000,3,000,4,000,5,000,6,000$ ). ( 5 marks)
(b) What is B's maximum net income? At that level, what is A's net income? At that level, what is Miujiza's aggregate net income?
(5 marks)
(c) Suppose the company abandons its divisionalised structure. Thus the two profit centres A and B are combined into a single profit centre with responsibility for the complete production and marketing of the product. Prepare a schedule similar to that in (a). What volume level will provide the highest net income? ( 5 marks)
(d) Evaluate the results in (c). Why did the circumstances in requirement (a) lead to less income than in requirement (c)? How would you adjust the transfer-pricing policy to ensure that overall company net income will be maximised where separate profit centres A and B are maintained?
(Total: 20 marks)
(CPA JUNE 93)

## QUESTION TWO

CD plc is a nationwide warehousing and distribution company, organised into eight geographical regions in each of which there is a depot and a fleet of vehicles.

These regions differ widely in respect of their area size, their mix of different types and sizes of shops and the major and minor roads that they comprise.

The remuneration of the general managers of each region comprises:

- Basic salary

This is a starting figure of $£ 12,000$ per annum which increases by $£ 1,000$ per annum for every year of service as a manager up to a maximum of $£ 22,000$ per annum.

- Bonus of $0.75 \%$ of the excess of sales over target for the year.

The target sales figure is calculated by a formula based on the value of vehicles operated by the region.

- Bonus based on the region's return on capital employed (ROCE)

$$
\text { ROCE is calculated: } \quad \begin{aligned}
& \text { Annual net profit before interest and tax } \\
& \text { End of year book value of net assets. }
\end{aligned}
$$

The bonus is the ROCE multiplied by:
$3 \%$ of the capital employed if the capital employed is $£ 2$ million or above.
$2 \%$ of the capital employed if the capital employed is below $£ 2$ million.
This different percentage is to encourage expansion through the use of greater assets.
For regions 3 and 7 the following figures show actual data for the year just ended ( 31 October 1990) and budgeted data for the year to 31 October 1991:

| Year to: | Actual $31 \text { Oct } 90$ | Region 3 Budgeted 31 Oct 91 | Actual $31 \text { Oct } 90$ | Region 7 <br> Budgeted <br> 31 Oct 91 |
| :---: | :---: | :---: | :---: | :---: |
|  | £000 | £000 | £000 | £000 |
| Sales | 2,400 | 2,750 | 3,700 | 3,600 |
| Cost of sales | 1,872 | 2,172.5 | 3,034 | 2,844 |
| Net profit* | 123 | 147 | 166 | 241 |
| *before interest, tax, basic salary and bonuses |  |  |  |  |
| End of year capital employed: |  |  |  |  |
| Working capital | 180 | 210 | 230 | 230 |
| Fixed assets: |  |  |  |  |
| Building | 640 | 680 | 820 | 820 |
| Vehicles | 1,030 | 1,370 | 1,750 | 1,850 |
| Target sales | 2,250 | 2,700 | 3,400 | 3,600 |
| General manager's basic salary | £18,000 |  | $£ 22,000$ |  |

## Your are required, as chief management accountant,

(a) to calculate what change there will be for each of the general managers of regions 3 and 7 between the remuneration based on the actual results for the year to 31 October 1990 and the remuneration based on the budgeted results for the year to 31 October 1991; Show your workings.
(6 marks)
(b) to explain whether you consider the changes calculated in (a) above show an appropriate reward for the performance of each of the two regional general managers;

Show relevant calculations.
(9 marks)
(c) to recommend what changes in the basis of the remuneration scheme for regional general managers you would propose for discussion with the managing director. Briefly explain why you have included each recommendation.

Assume that
(i) your objective is to achieve rewards for the regional general managers that will more adequately recognise effective performance of benefit to the company as a whole;
(ii) the company does not wish to make changes in the operating methods of the regional managers or in the ways in which regions are financed.
(10 marks)
(Total: 25 marks)
(CIMA)

## CHECK YOUR ANSWERS WITH THOSE GIVEN IN LESSON 10 OF THE MANAGEMENT ACCOUNTING NOTES

## COMPREHENSIVE ASSIGNMENT NO. 4

## TO BE SUBMITTED AFTER LESSON 8

To be carried out under examination conditions and sent to the Distance
Learning Administration for marking by the University
EXAMINATION PAPER:
TIME ALLOWED: 3 HRS.
ANSWER ALL QUESTIONS.

## QUESTION ONE

Ab plc is considering a new product with a three-year life. The product can be made with existing machinery which has spare capacity or by a labour saving specialised new machine which would have zero disposal value at the end of the three years.
The following estimates have been made at current prices:

| Sales volume | 1 million units per annum |
| :--- | :--- |
| Selling price | $£ 15$ per unit |
| Labour cost $($ without $\mathrm{m} / \mathrm{c})$ | $£ 6$ per unit |
| Material cost | $£ 2$ per unit |
| Variable overheads | $£ 2$ per unit |

Additional fixed overheads for the new product are estimated to be $£ 3$ million per year. The new machine would cost $£ 5$ million now and would halve the labour cost per unit. Because of competition, selling price increases will be limited to $2 \%$ per annum although labour cost is expected to rise at $12 \%$ per annum and all her costs at $8 \%$ per annum. The company's money cost of capital is $15 \%$ and apart from the cost of the new machine all other cash flows can be assumed to arise at year ends.

## Required:

To calculate the NPV of the new product assuming that manufacture uses existing machinery;
To calculate the NPV assuming that the new machine is purchased.
To recommend what action should be taken, and to comment on your recommendations;
To explain what changes if any there would be in your analysis if the existing machinery was already fully utilised on other production.

CIMA Management Accounting Techniques

## QUESTION TWO

You are employed as a Management Accountant at the Head Office of a large conglomerate Group. For many years this organisation, which gives a considerable degree of autonomy to divisional managers, has rewarded them on ROI achieved.
This scheme has been broadly accepted by most managers but it is known that two managers are particularly unhappy with their ROI figures (and bonuses) and you are asked to investigate and report. The following information is available for 1990:

|  | Division X |  | Division Y |  |
| :--- | :---: | ---: | ---: | ---: |
|  | Actual | Budget | Actual | Budget |
|  | $£_{0}$ | $\AA_{\mathbf{m}}$ | 50 | 110 |
| Sales | 40 | 26.8 | 52 | 96 |
| Assets employed | 24 | 6.5 | 11.4 | 68.5 |
| Profit before interest and tax | 4.1 | $24.3 \%$ | $21.9 \%$ | $13.8 \%$ |
| ROI | $17.1 \%$ |  |  |  |

These figures include the apportioned costs for an automated warehouse shared by the two divisions. The data available for this facility for 1990 are:

|  |  | Warehouse <br> Budget |
| :--- | :---: | :---: |
|  | $f_{\mathrm{m}}$ | m <br> Despatches |
| Assets employed at | 150 | 146 |
| NBV | 8 | 8 |
|  |  |  |
| Operating costs: | 1.6 | 1.6 |
| Depreciation | 1.1 | 0.9 |
| Other fixed costs | 0.5 | 0.5 |
| Variable storage costs | $\underline{1.3}$ | $\underline{1.1}$ |
| Variable handling costs |  |  |
| Total operating costs | 4.5 | 4.1 |

The assets employed had been split between the divisions concerned in the proportions originally agreed when the warehouse investment had been authorised i.e. $50 \%$ each.
The operating costs had been split between the divisions in proportion to the actual usage, measured by actual sales.
Division X stocks occupy $40 \%$ of the space available.

## Required

To recalculate the ROI of Division X using bases which maximise the return disclosed. Explain and briefly justify your calculations

To recalculate the ROI of Division Y using bases which maximise the return disclosed. Explain and briefly justify your calculation;

To recalculate the ROI figures for Divisions X and Y in the way you would recommend the group should use and justify this basis, explaining the motivational implications of your recommendations.

Later it becomes possible for the divisions to obtain comparable ware-housing facilities from outside suppliers at less cost:

## Division X $£ 1.1 \mathrm{~m}$

Division Y $£ 2.3 \mathrm{~m}$
Explain how this additional information could affect your recommendations and discuss the impact of these recommendations on the managers of the two divisions and the warehouse.

## QUESTION THREE

A group has two companies-
K Ltd which is operating at just above $50 \%$ capacity and
L Ltd which is operating at full capacity ( 7,000 production hours)
L Ltd produces two products, X and Y , using the same labour force for each product. For the next year its budget capacity involves a commitment to the sale of $3,000 \mathrm{kgs}$ of Y , the remainder of its capacity being used on X.
Direct costs of these two products are:

|  | X | Y |
| :--- | :--- | :---: |
| Direct materials | 18 | 14 |
| Direct wages | $15(1$ production hour $)$ | $10(2 / 3$ production hour $)$ |

The company's overhead is $£ 126,000$ per annum relating to X and Y in proportion to their direct wages, at full capacity, $£ 70,000$ of this overhead is variable. L Ltd. prices its products with a $60 \%$ mark-up on its total costs.
For the coming year, K Ltd wishes to buy from L Ltd $2,000 \mathrm{kgs}$ of X which it proposes to adapt and sell, as product Z , for $£ 100$ per kg . The direct costs of adaptation are $£, 15$ per kg . K Ltd's total fixed costs will not change but variable overhead of $£ 2$ per kg will be incurred.

## You are required to recommend, as group management accountant,

At what range of transfer prices, if at all, $2,000 \mathrm{kgs}$ of product X should be sold to K Ltd. what other points should be borne in mind when making any recommendations about transfer prices in the above circumstances.

> CIMA Management Accounting - Decision making.

## QUESTION FOUR

You are a Senior Audit Assistant of Abel Adongo \& Co., Certified Public Accountant. The firm is one of the three accounting firms offering professional services in the city of Madolva. The other two firms are Beans Birundu \& Co. Certified Public Accountants and Claudio Chege \& Co. Certified Public Accountants. The three firms are referred to as A, B and C.

Your firm is worried about its market share and the Senior Partner in charge of Partnership development has collected the following data which she wants you to analyse. She further informs you that the observed client flow behaviour is expected to remain about the same for the foreseeable future.

|  | No. of Clients | Market Share | Flow of Clients |  |  |  |  |  | No. of Clients | Market <br> Share |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  | Gains From |  |  | Losses To |  |  |  |  |
|  | 31.12 .90 |  | A | B | C | A | B | C | 31.12.91 |  |
| A | 204 | 0.177 | - | 12 | 20 | - | 15 | 9 | 212 | 0.184 |
| B | 416 | 0.361 | 15 | - | 5 | 12 | - | 7 | 417 | 0.362 |
| C | 531 | 0.461 | 9 | 7 | - | 20 | 5 | - | 522 | 0.454 |

## Required:

a. Convert the above data into a matrix of transition possibilities. (5 marks)
b. Estimate the firm's market shares for 2014 (5 marks)
c. Estimate the firm's steady state market shares.
(7 marks)
d. Briefly comment on the advisability of using the Markov Technique in forecasting market shares in the market for accountancy services.
(3 marks)
(TOTAL: 20 MARKS)
(CPAJUN `92)

## QUESTION FIVE

a. Two opposing political parties are nominating candidates for presidency in the Peoples Republic of Yanke in separate conventions that are being held simultaneously. The following possibilities apply for the respective party winning the election for the indicated nominee pair. Naturally each party wishes to maximise its probability of winning the presidency.

| Peoples Party | Republican <br> Party | Probability for the Peoples <br> Party winning | Probability for the Republican <br> Party winning |
| :--- | :--- | :--- | :--- |
| Maina | Salat | 0.75 | 0.25 |
| Maina | Simiyu | 0.25 | 0.75 |
| Onyango | Salat | 0.30 | 0.70 |
| Onyango | Simiyu | 0.60 | 0.40 |

Subtracting the Republican's win probability from the People's win probability gives the Peoples payoff measure so that the structure is converted into a zero-sum game. By carrying out this operation, construct the appropriate payoff table and then, using the minimax criterion, determine the value of this political game.
(10 marks)
b. Two suspects are taken into police custody and separated. The prosecutor is certain that they are guilty of a specific crime, but he does not have adequate evidence to convict them at a trial. He points out to each suspect that each has two alternatives: to confess to the crime the police are sure they have committed, or not to confess. If they both do not confess then the prosecutor states that he will book them on some minor charge and they will both serve one year in prison. If they both confess, they will be jailed each for 8 years. If one confesses and the other does not the "co-operative" one will receive lenient treatment (i.e. three months jail term) while the other will receive the maximum jail term allowed by the law (i.e. fourteen years) for this crime.

## Required:

i. Convert this situation into a non-zero sum game and determine how long each suspect will serve in jail.
ii. Discuss some of the managerial applications of this game.

## END OF COMPREHENSIVE ASSIGNMENT No. 4 NOW SEND YOUR ANSWERS TO THE DISTANCE LEARNING CENTRE FOR MARKING

## LESSON NINE

## EMERGING TRENDS IN MANAGEMENT ACCOUNTING

## CONTENTS

$\square \quad$ Strategic Management Accounting
$\square$ Target Costing
$\square$ Activity Based Predetermined Overhead Rates
$\square$ Activity Based Management (ABM).

## INSTRUCTIONS

$\square \quad$ Read chapters 10 and 23 of Management and Cost Accounting by Colin Drury $5^{\text {th }}$ Edition
$\square \quad$ Read the study text
$\square$ Attempt reinforcing questions at the end of the lesson
$\square$ Compare your answers to those provided in lesson 10.

## STRATEGIC MANAGEMENT ACCOUNTING

## Steps in Strategic Cost Analysis

$\square$ Identify the appropriate value chain and assign costs and assets to it.
$\square$ Diagnose the cost drivers of each value activity and how they interact.
$\square$ Identify competitor value chains, and determine the relative cost of competitors and the sources of cost differences.
$\square$ Develop a strategy to lower relative cost position through controlling cost drivers or reconfiguring the value chain and/or downstream value.
$\square$ Ensure that cost reduction efforts do not erode differentiation, or make a conscious choice to do so.
$\square$ Test the cost reduction strategy for sustainability.
$\square \quad$ The three main elements of strategic cost management include:
$\square$ Value chain analysis
$\square \quad$ Strategic positioning
$\square$ Cost driver analysis

## VALUE CHAIN ANALYSIS

Every firm is a collection of activities that are performed to design, produce, market, deliver and support its products/services. Value chain analysis is a systematic way of examining all activities that a firm performs and how they interact.

The value chain disaggregates the firm into strategically separable activities in order to understand the behaviour of costs so as to create competitive advantage. A firm creates competitive advantages by:

Finding new ways to conduct activities e.g. improving efficiency through automation.
Managing the linkages between activities better e.g. spending on better product design may reduce after sales service costs.
Managing the linkages between customers and suppliers better.
Value activities are physically and technologically distinct activities a firm performs. These are the building blocks by which a firm creates products and services valuable to its customers. The value chain has been shown by Michael Porter as follows.
The Value Chain


## The Value Chain and Cost Advantage

Cost advantage is one of the two types of competitive advantage a firm may possess. Cost is also of vital importance to differentiation strategies because a differentiator must maintain cost proximity to competitors. Unless the resulting price premium exceeds the cost of differentiating, a differentiator will fail to achieve superior performance. The behaviour of cost also exerts a strong influence on overall industry structure.

Managers recognize the importance of cost, and many strategic plans establish "cost leadership or "cost reduction as goals. However, the behaviour of cost is rarely well understood. Wide disagreement often exists among managers about a firm's relative cost position and the reasons underlying it. Cost studies tend to concentrate on manufacturing costs and overlook the impact of other activities such as marketing, service, and infrastructure on relative cost position. Moreover, the cost of individual activities is analysed sequentially, without recognizing the linkages among activities that can affect cost. Finally, firms have great difficulty assessing the cost positions of competitors, an essential step in assessing their own relative positions. They often resort to simplistic comparisons of labour rates and raw material costs.

The absence of a systematic framework for cost analysis in most firms underlies these problems. Most cost studies address narrow issues and take a short -term viewpoint. Popular tools like the experience curve are often misused in cost analysis. The experience curve can serve as a starting point, but it ignores many of the important drivers of cost behavior and obscures important relationships among them. Cost analyses also tend to rely heavily on existing accounting systems. While accounting systems do contain useful data for cost analysis, they often get in the way of strategic cost analysis. Cost systems categorize costs in line items-such as direct labour, indirect labour, and burden-that may obscure the underlying activities a firm performs. This leads to aggregation of the costs of activities with very different economics, and to the artificial separation of labour, material, and overhead costs related to the same activity.

The value chain provides the basic tool for cost analysis. I begin by showing how to define a value chain for cost analysis purposes and how to associate costs and assets with value activities. I then describe how to analyze the behavior of cost, using the concept of cost drivers. Cost drivers are the structural determinants of the cost of an activity, and differ in the extent to which a firm controls them. Cost drivers determine the behavior of costs within an activity, reflecting any linkages or interrelationships that affect it. A firm's cost performance in each of its major discrete activities cumulates to establish its relative cost position.
The Value Chain and Cost Analysis
The behavior of a firm's costs and its relative cost position stem from the value activities the firm performs in competing in an industry. A meaningful cost analysis, therefore, examines costs within these activities and not the costs of the firm as a whole. Each value activity has its own cost structure and the behavior of its cost may be affected by linkages and interrelationships with other activities both within and outside the firm. Cost advantage results if the firm achieves a lower cumulative cost of performing value activities than its competitors.

The starting point for cost analysis is to define a firm's value chain and to assign operating costs and assets to value activities. Each activity in the value chain involves both operating costs and assets in the form of fixed and working capital. Purchased inputs make up part of the cost of every value activity, and can contribute to both operating costs (purchased operating inputs) and assets (purchased assets). The need to assign assets to value activities reflects the fact that the amount of assets in an activity and the efficiency of asset utilization are frequently important to the activity's cost.

For purposes of cost analysis, the disegregation of the generic value chain into individual value activities should reflect three principles that are not mutually exclusive:

The size and growth of the cost represented by the activity costs
The cost behavior of the activity
Competitor differences in performing the activity

Activities should be separated for cost analysis if they represent a significant or rapidly growing percentage of operating costs or assets. While most firms can easily identify the large components of their cost, they frequently overlook smaller but growing value activities that can eventually change their cost structure. Activities that represent a small and stagnant percentage of costs or assets can be grouped together into broader categories.

Activities must also be separated if they have different cost drivers. Activities with similar cost drivers can be safely grouped together. For example, advertising and promotion usually belong in separate value activities because advertising cost is sensitive to scale while promotional costs are largely variable. Any activity a business unit shares with others should also be treated as a separate value activity since conditions in other business units will affect its cost behavior. The same logic applies to any activity that has important linkages with other activities. In practice, one does not always know the drivers of cost behavior at the beginning of an analysis; hence the identification of value activities tends to require several iterations. The initial breakdown of the value chain into activities will inevitably represent a best guess of important differences in cost behavior. Value activities can then be aggregated or disaggregated as further analysis exposes differences or similarities in cost behavior. Usually an aggregated value chain is analyzed first, and then particular value activities that prove to be important are investigated in greater detail.

A final test for separating value activities is the behavior of competitors. Significant activities should be treated separately when a competitor performs them in a different way. Differences among competitors raise the possibility that an activity is the source of a relative cost advantage or disadvantage.

## Assigning Costs and Assets

After identifying its value chain, a firm must assign operating activity and assets to value activities. Operating costs should be assigned to the activities in which they are incurred. Assets should be assigned to the activities that employ, control, or most influence their use. The assignment of operating costs is straightforward in principle, although it can be time-consuming. Accounting records must often be recast to match costs with value activities rather than with accounting classifications, particularly in areas such as overhead and purchased inputs. Since assets are expensive and their selection and use often involve tradeoffs with operating costs, assets must be assigned to value activities in some way that will permit an analysis of cost behavior. Assignment of assets to activities is more complex than assignment of operating costs.

## First Cut Analysis of Costs

The allocation of costs and assets will produce a value chain that illustrates graphically the distribution of a firm's costs. It can prove revealing to separate the cost of each value activity into three categories: purchased operating inputs, human resource costs, and assets by major category. The proportions of the value chain can be drawn to reflect the distribution of costs and assets among activities.
Even the initial allocation of operating costs and assets to the value chain may suggest areas for cost improvement. Purchased operating inputs will often represent a larger proportion of costs than commonly perceived, for example, because all the purchased inputs in the value chain are rarely cumulated. Other insights can result from grouping value activities into direct, indirect and quality assurance activities, and cumulating costs in each category. Managers often fail to recognize burgeoning indirect costs and have a tendency to focus almost exclusively on direct costs. In many firms, indirect costs not only represent a large proportion of total cost but also have grown more rapidly than other cost elements. The introduction of sophisticated information systems and automated processes is reducing direct costs but boosting indirect costs by requiring such things as sophisticated maintenance and computer programmers to prepare machine tapes. In valve manufacturing, for example, indirect cost represents more than 10 percent of total cost. Firms can also find that the sum of all quality assurance activities in the value chain is strikingly large. In many industries, this has led to the growing conclusion that other approaches to quality assurance besides inspection, adjusting, and testing can yield large cost savings.

## Cost Behavior

A firm's cost position results from the cost behavior of its value activities. Cost behavior depends on a number of structural factors that influence cost, which I term cost drivers. Several cost drivers can combine to determine the cost of a given activity. The important cost driver or drivers can differ among firms in
the same industry if they employ different value chains. A firm's relative cost position in a value activity depends on its standing vis-à-vis important cost drivers.

## Cost Drivers

Ten major cost drivers determine the cost behavior of value activities: economies of scale, learning, the pattern of capacity utilization, linkages, interrelationships, integration, timing, discretionary policies, location, and institutional factors. Cost drivers are the structural causes of the cost of an activity and can be more or less under a firm's control. Drivers often interact to determine the cost behavior of a particular activity, and the relative impact of cost drivers will differ widely among value activities. Thus no one cost driver, such as scale or the learning curve, is ever the sole determinant of a firm's cost position. Diagnosing the cost drivers of each value activity allows a firm to gain a sophisticated understanding of the sources of its relative cost position and how it might be changed.

## Economies or Diseconomies of Scale

The costs of a value activity are often subject to economies or diseconomies of scale. Economies of scale arise from the ability to perform activities differently and more efficiently at larger volume, or from the ability to amortize the cost of intangibles such as advertising and R\&D over a greater sales volume. Economies of scale can result from efficiencies in the actual operation of an activity at higher scale as well as from less than proportional increases in the infrastructure or overhead needed to support an activity as it grows. In a bauxite mine, for example, actual mining costs go down less with scale than do infrastructure costs.

Economies of scale must be clearly distinguished from capacity utilization. Increasing capacity utilization spreads the fixed costs of existing facilities and personnel over large volume, while economies of scale imply that an activity operating at full capacity is more efficient at larger scale. Mistaking capacity utilization for economies of scale can lead a firm to the false conclusion that its costs will continue to fall if it expands capacity once its existing capacity is full.

Increasing complexity and costs of coordination can lead to diseconomies of scale in a value activity as scale increases. When the number of lines in a metal can plant exceeds about 15, for example, the complexity of the plant becomes unwieldy. Increasing scale also sometimes dampens employee motivation and may increase wage or purchased input costs. For example, a large plant may have a greater likelihood of unionization or lead to higher expectations and greater stridency of union negotiators. Diseconomies of scale in procurement can also occur if large requirements meet an inelastic supply, forcing up input prices. Diseconomies of scale appear to be present in many fashion-sensitive industries and professional services, which rely heavily on fast response times and creative individuals who do not function well in large organizations.

The scale sensitivity of activities varies widely. Value activities such as product development, national advertising, and firm infrastructure are typically more scale-sensitive than activities such as procurement and sales force operations because their costs are heavily fixed no matter what the firm's scale is. However, economies (and diseconomies) of scale can be found to some extent in virtually every value activity of a firm.

## Learning and Spillovers

The cost of a value activity can decline over time due to learning that increases its efficiency. The mechanisms by which learning can lower cost over time are numerous, and include such factors as layout changes, improved scheduling, labor efficiency improvement, product design modifications that facilitate manufacturing, yield improvements, procedures that increase the utilization of assets, and better tailoring of raw materials to the process. Learning can also reduce the cost of constructing plants, retail outlets, or other facilities. Thus the possibilities for learning in an activity are much broader than learning by personnel to perform their functions more efficiently. The rate of learning varies widely among value activities because each offers differing possibilities for learning improvements. Learning is often the cumulation of many small improvements rather than major breakthroughs. The rate of learning may
increase during slack periods when attention is focused on reducing costs rather than meeting demand. Moreover, learning tends to vary with the amount of management attention devoted to capturing it.

Learning can spill over from one firm in an industry to another, through mechanisms such as suppliers, consultants, ex-employees, and reverse engineering of products. Where spillover of learning among firms is high in a value activity, the rate of learning may stem more from total industry learning than from the learning of one firm.

Some of the policy choices that tend to have the greatest impact on cost include:
$\square$ Product configuration, performance, and features
$\square$ Mix and variety of products offered
$\square$ Level of service provided
$\square$ Spending rate on marketing and technology development activities
$\square$ Delivery time
$\square$ Buyers served (e.g., small versus large)
$\square$ Channels employed (e.g., fewer, more efficient dealers versus many small ones)
$\square$ Process technology chosen, independent or scale, timing, or other cost drivers
$\square$ The specifications of raw materials or other purchased inputs used (e.g., raw material quality affects processing yield in semiconductors)
$\square \quad$ Wages paid and amenities provided to employees, relative to prevailing norms
$\square$ Other human resource policies including hiring, training, and employee motivation
$\square$ Procedures for scheduling production, maintenance, the sales force and other activities
Though policy choices always play an independent role in determining the cost of value activities, they also frequently affect or are affected by other cost drivers. Process technology is often dictated partly by scale and partly by what product characteristics are desired, for example. Moreover, other cost drivers inevitably affect the cost of policies. For example, an automated ticketing and seat selection system may well be subject to economies of scale that make such a system very costly for a small airline to adopt.

Policies typically play a particularly essential role in differentiation strategies. Differentiation often rests on policy choices that make a firm unique in performing one or more value activities, deliberately raising cost in the process (see Chapter 4). A differentiator must understand the costs associated with its differentiation and compare them to the price premium that results. This can be done only by isolating the effects of policies on cost.

## STRATEGIC POSITIONING

The company must identify its strategic choices. This can be done from the firm's objectives, which emanates from the firms mission. Strategies have to be developed to achieve a competitive advantage over competitors, which may occur due to cost, price, quality, brand name, image of the product etc. Michael Porter highlighted two basic rules to competitive advantage
Cost Leadership strategy
Differentiation
Within each of these strategies a firm may decide to focus.

## COST DRIVER ANALYSIS

Cost drivers are factors, which determine the costs of an activity i.e. a change in the cost driver will cause a change in the level of total cost related cost object. The cost drivers can either be volume based or transaction based. The company must therefore understand its cost drivers so as to control costs.

## TARGET COSTING

This is another contribution to strategic management accounting. This is an approach to product pricing widely applied by Japanese companies and now being given a lot of attention in the USA and Europe. It is driven by external market factors.

A target market price is determined by marketing management prior to designing and introducing a new product. This target price is set at a level that will permit the company to achieve a desired market share and sales volume. A desired profit margin (target profit) is then deducted to determine the target maximum allowable product cost (target cost).

Product costs are computed based on design specification and compared with the target cost. If the projected product cost is above the target cost then product designers focus on it becomes cheaper to produce. Manufacturing engineers also focus on methods of improving production efficiency so that the target cost can be achieved even after a period of one to two years. A team of designers, engineers, marketing and production personnel, together with the management accountant, concentrate on producing a product that meets the target cost requirement. The role of the management accountant is to produce cost estimates for the various projected product designs, measure and monitor product costs once the production process begins.

## ACTIVITY BASED PREDETERMINED OVERHEAD RATES

To allocate overhead costs more precisely (than is possible with traditional product costing methods), accountants use activity based overhead rates.

An activity based predetermined overhead rate is found by separating manufacturing overhead costs by activity and developing a predetermined overhead rate for each activity.

Advantages of activity based rate:
Only products using an activity are charged for its use.
Each activity uses the cost driver that best relates its costs to its production activity.
Costs traceable to an activity can be measured rather than allocated. Measurement is more precise than allocation.

Activity based allocation of overhead costs may be compared with plant wide allocation as shown below;

## Plant wide overhead allocation

1. All factory overhead costs in a single pool. production activities.
2. Overhead costs allocated to products by using a single predetermined overhead rate activities.

## Activity based overhead allocation

1. Overhead costs traced to particular service and
2. Service activity costs assigned to production

> 3. Overhead costs allowed to products by using a
> Separate predetermined rate for each activity.

## Example:

San Juan car rental company has three car rental centres. It has two major cost drivers, number of rental centres and days of car rental. For the coming year, San Juan has made the following estimates:

## Centres

Estimated overhead
Estimated rental days

## Town Centre

sh. 892,400
4,400

| Ngara | JKIA |
| :---: | :---: |
| 736,000 | 343,000 |
| 6,800 | 200 |

## Required:

calculate an overall (plantwide) overhead rate using rental days as the cost driver.

Calculate activity based overhead rates (one for each centre) using rental days as the cost driver.

## Solution:

a.

Town centre
Ngara
JKIA
Total
Estimated overhead
(sh)
892,400
736,000
343,000

1,971,400

Plant wide rate $=$ Total estimated overhead
Total estimated rental days $=$ Sh. 149.3
b. Activity based overhead rate

Overhead rate $=\underline{\text { Total estimated overhead }}$
total estimated rental days
Town centre $=\underline{\text { sh. } 892,400}=$ sh. 202.80
4,400 days
Ngara $\quad=\frac{\text { sh. } 736,000}{6,800 \text { days }}=\operatorname{sh} .108 .20$
JKIA $\quad=\frac{\text { sh. } 343,000}{2,000 \text { days }}=$ sh. 171.50

## ACTIVITY BASED MANAGEMENT (ABM)

Also referred to as activity based cost management (ABCM). This is used to describe the cost management application of ABC.

To implement $A B M$, system, only the first three of the four stages of $A B C$ system are required. These are;
Identifying the major activities that take place in an organisation
Assigning costs to cost pools/ cost centres for each activity.
Determining the cost driver for each major activity.
ABM views the business as a set of linked activities that ultimately add value to the customer. It focuses on managing the business on the basis of the activities that make up the organisation. It is based on the premise that activities consume costs. Hence by managing activities costs will be managed in the long run.

The goal of ABM is to enable the customer to be satisfied while making fewer demands on the organisations resources. The measurement of activities is a key role of the management accounting function. In particular activity cost information is useful for prioritising those activities that need to be studied closely so that they can be eliminated or improved. ABM is used in a variety of business applications such as cost reduction, benchmarking, activity based budgeting and performance measurement.

## REINFORCING QUESTIONS

## QUESTION ONE

Energy costs may include the following items in a company which manufactures and sells products:

1. Maintaining a statutory temperature range in the workplace
2. The operation of a specially humidified materials store
3. Power costs per unit of output
4. Power costs in the movement of raw materials and work in progress
5. Losses from steam pipelines and steam valves
6. Heat losses through windows.

Explain how management may be assisted in the implementation of an energy cost reduction strategy through the application of
a) Zero-base budgeting and
b) Total quality management. Your answers to a) and b) should each refer to any three of the energy cost examples given in the question.

ACCA, Information for Control and Design Making.

## QUESTION TWO

## CALTON LTD

Calton Ltd make and sell a single product. The existing product unit specifications are as follows:

| Direct material X: | 8 sq metres at $£ 4$ per sq metre |
| :--- | :--- |
| Machine time: | 0.6 running hours |
| Machine cost per gross hour: | $£ 40$ |
| Selling price: | $£ 100$ |

Calton Ltd require to fulfil orders for 5,000 product units per period. There are no stocks of product units at the beginning or end of the period under review. The stock level of material X remains unchanged throughout the period.

The following additional information affects the costs and revenues.
$5 \%$ of incoming material from suppliers is scrapped due to poor receipt and storage organisation.
$4 \%$ of material X input to the machine process is wasted due to processing problems.
Inspection and storage of material X costs 10 pence per sq metre purchased.
Inspection during the production cycle, calibration checks on inspection equipment, vendor rating and other checks cost $£ 25,000$ per period.

Production quantity is increased to allow for the downgrading of $12.5 \%$ of product units at the final inspection stage. Downgraded units are sold as 'second quality' units at a discount of $30 \%$ on the standard selling price.

Production quantity is increased to allow for returns from customers which are replaced free of charge. Returns are due to specification failure and account for $5 \%$ of units initially delivered to customers. Replacement units incur a delivery cost of $£ 8$ per unit. $80 \%$ of the returns from customers are rectified using 0.2 hours of machine running time per unit and are resold as 'third quality' products at a discount of $50 \%$ on the standard selling price. The remaining returned units are sold as scrap for $£ 5$ per unit.

Product liability and other claims by customers is estimated at $3 \%$ of sales revenue from standard product sales.

Machine idle time is $20 \%$ of gross machine hours used, i.e. running hours $=80 \%$ of gross hours.
Sundry costs of administration, selling and distribution total $£ 60,000$ per period.
Calton Ltd is aware of the problem of excess costs and currently spends $£ 20,000$ per period in efforts to prevent a number of such problems from occurring.

Calton Ltd is planning a quality management programme, which will increase its excess cost prevention expenditure from $£ 20,000$ to $£ 60,000$ per period. It is estimated that this will have the following impact.

A reduction in stores losses of material X to $3 \%$ of incoming material.
A reduction in the downgrading of product units at inspection to $7.5 \%$ of units inspected.
A reduction in material X losses process to $2.5 \%$ of input to the machine process.
A reduction in returns of products from customers to $2.5 \%$ of units delivered.
A reduction in machine idle time to $12.5 \%$ of gross hours used.
A reduction in product liability and other claims to $1 \%$ of sales revenue from standard product sales.
A reduction in inspection, calibration, vendor rating and other checks by $40 \%$ of the existing figure.
A reduction in sundry administration, selling and distribution costs by $10 \%$ of the existing figure.
A reduction in machine running time required per product unit to 0.5 hours.

## Required

Prepare summaries showing the calculation of (i) total production units (pre-inspection), (ii) purchases of material X (sq metres), (iii) gross machine hours.

In each case the figures are required for the situation both before and after the implementation of the additional quality management programme, in order that the orders for 5,000 product units may be fulfilled. (13 marks)

Prepare profit an loss accounts for Calton Ltd for the period showing the profit earned both before and after the implementation of the additional quality management programme. (11 marks)

Comment on the relevance of a quality management programme and explain the meaning of the terms internal failure costs, external failure costs, appraisal costs and prevention costs giving examples for each, taken where possible from the information in the question. (11 marks)
(35 marks)

## QUESTION TTHREE <br> TQM AND STANDARD COSTING

'It may be argued that in a total quality environment, variance analysis from a standard costing system is redundant.'
Discuss the validity of this statement.
(8 marks)
Using the labour cost as the focus, discuss the differences in the measurement of labour efficiency/effectiveness where (i) total quality management techniques and (ii) standard cost variance analysis are implemented. (7 marks)

## QUESTION FOUR

TRITEX PLC (12/96
Tritex plc produces a number of products which pass through three consecutive processes - Making, Converting and Finishing - before sale to customers.

Until recently, Tritex plc has prepared standard product costs per unit for each product using (a) control standards and (b) current standards. Appendix 1 shows extracts from these standards for product A. These standards plus a detailed variance analysis have been the main focus of control information. The control standards based on industry average performance and the current standards based on the level of performance which it is anticipated should be attainable using the last year's actual performance as the starting point.

The control and current standard product costs per unit incorporate the following specifications.
Process losses (\%) are expressed as a percentage of input to each process.
Material requirement is based on the input to the Making process.
Labour requirement is based on the total hours per unit of output from a process.
Variable overhead is absorbed on the basis of net processing hours (i.e. excluding idle time) per unit of output from a process.

Variable overhead is absorbed into all products using an average rate per net processing hour.
Work-in-progress is $100 \%$ complete at the end of each process.
Tritex ple has produced amended unit standard process costs which incorporate activity based costing (ABC) and the planned effects of a total quality management (TQM) programme. Appendix 1 shows an extract of such a standard cost for product $A$.

The $\mathrm{ABC} / \mathrm{TQM}$ standard costs incorporate the following in their specification.
Zero idle time allowance for labour. Employees will carry out some rework, material handling and maintenance not previously included in the standard labour cost.

The cost driver for all variable overhead in the Making process is the number of steam operations per product unit and overhead is absorbed on this basis. For product A, this should result in an overhead cost reduction of $30 \%$ per product unit from the control standard cost. Any residual difference is due to improved work practices.

Excel Ltd. make and sell two products, VG4U and VG2. Both products are manufactured through two consecutive processes - making and packing. Raw materials is input at the commencement of the making process. The following estimated information is available for the period ending 31 March 1995.
(i)

| Making | Packing |
| :---: | :---: |
| $\boldsymbol{£ 0 0 0}$ | $\boldsymbol{0 0 0 0}$ |
| 350 | 280 |
| 210 | 140 |

$40 \%$ of fixed costs are product specific, the remainder are company fixed costs. Fixed costs will remain unchanged throughout a wide activity range.
(ii) Product information:

|  | VG4U | VG2 |
| :--- | :---: | :---: |
| Production time per unit: |  |  |
| Making (minutes) | 5.25 | 5.25 |
| Packing (minutes) | 6 | 4 |
| Production / sales (units) | 5,000 | 3,000 |
| Selling price per unit $\left(\ell_{)}\right)$ | 150 | 180 |
| Direct material cost per unit(3) | 30 | 30 |

(iii) Conversion costs are absorbed by products using estimated time based rates.

## Required:

Using the above information,
Calculate unit cost for each product, analysed as relevant.
Comment on a management suggestion that the production and sale of one of the products should not proceed in the period ending 31 March 1995.
Additional information is gathered for the period ending 31 March 1995 as follows:
The making process consists of two consecutive activities, moulding and trimming. The moulding variable conversion costs are incurred in proportion tot he temperature required in the moulds. The variable trimming conversion costs are incurred in proportion to the consistency of the material when it emerges from the moulds. The variable packing process conversion costs are incurred in proportion to the time required for each product. Packing materials (which are part of the variable packing cost) requirement depends on the complexity of packing specified for each product.

The proportions of product specific conversion costs (variable and fixed) are analysed as follows: Making process: moulding ( $60 \%$ ); trimming ( $40 \%$ )
Packing process: conversion (70\%); packing material (30\%)
An investigation into the effect of the cost drivers on costs has indicated that the proportions in which the total product specific conversion costs are attributable to VG4U and VG2 as follows:

|  | VG4U |  | VG2 |
| :--- | :--- | :--- | :--- |
| Temperature (moulding) | 2 |  | 1 |
| Material consistency (trimming) | 2 | 5 |  |
| Time (packing) | 3 | 2 | 3 |

Company fixed costs are apportioned to products at an overall average rate per product unit bases on the estimated figures.

## Required:

Calculate amended unit costs for each product where activity-based costing is used and company fixed costs are apportioned as detailed above.

Comment on the relevance of the amended unit costs in evaluating the management suggestion that one of the products be discontinued in the period ending 31 March 1995.

Management wish to achieve an overall net profit margin of $15 \%$ on sales, in the period ending 31 March 1995 in order to meet return on capital targets.
Required:
Explain how target costing may be used in achieving the required return and suggest specific areas of investigation .

CHECK YOUR ANSWERS WITH THOSE GIVEN IN LESSON 10 OF THE
MANAGEMENT ACCOUNTING NOTES.

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## LESSON TEN

## Revision Aid

MODEL ANSWERS TO REINFORCING QUESTIONS CONTENTS

KASNEB SYLLABUS
MODEL ANSWERS TO REINFORCEMENT QUESTIONS IN

LESSON 1
LESSON 2
LESSON 3
LESSON 4
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LESSON 8
LESSON 9

## SELECTED CPA PAST PAPERS

PILOT PAPER JULY 2011
DECEMBER 2010
DECEMBER 2013

## ANSWERS TO PAST PAPERS

PILOT PAPER JULY 2010
DECEMBER 2010
DECEMBER 2013

MOCK EXAMINATION PAPER

## KASNEB SYLLABUS OBJECTIVE

To examine candidates' ability to apply modern tools of analysis in the solution of management problems. The paper builds on material covered earlier in Economics; Cost Accounting; Business Finance; Systems Theory Analysis and Design; and Quantitative Techniques.

## Content

The Nature of Managerial Decisions. The various decisions that a manager must make: planning, organising, directing and control. The key decisions to be made in the fields of production, marketing, financing and personnel. Evaluating the value of information that a manager needs to make decisions. Value of perfect and imperfect information.

Cost Estimation and Forecasting. Engineering methods, simulation methods and statistical methods. Simple and multiple regression, the statistical properties of regression. Time series models: smoothing and extrapolation, stochastic time series, linear time series models, forecasting with time series models.

Short-term Planning Decisions. Basic cost-volume profit analysis, limitations of CVP analysis, CVP under uncertainty, risk and measures of risk, risk analysis with multiple products, effect of product-mix decisions, learning curves, estimating the learning effect. Marginal costing and its application in analysis of special orders, make or buy decisions, selection of product mix and other similar short-run decisions.

Inventory Control. The cost of holding stock, stock replenishment models, quantity discounts, timing of replenishing orders, models involving shortage costs, stochastic inventory models, Pareto anaylsis, simulation of reorder decisions.

Capital Expenditure Decisions. Thenature of capital investments, costs and returns in financial appraisal, replacement and abandonment decisions. Treatment of uncertainty and risk. The use of computer spread sheets.

Sequential Decisions. Types of sequential process, representing activities by networks, analysis of activity times, types of floats, networks in planning and project control, uncertainty networks. Decision trees and their use in the analysis of sequential decisions.

Resource Allocation Decisions. The use of linear programming in resource allocation, slack and surplus variables, optimality analysis, treatment of integer variables amd multiple objectives, Nonlinear programming models and their application in management.

Routing and Transportation Decision. The basic transportation model, extensions and applications. Transportation with fixed costs. Assignment models and their application in management. Dynamic programming including extensions to probabilistic situations.

Strategic and Transportation Decisions. Classification of games: Zero and non-zero sum games, prisoners dilemma games, battle of sexes games, n-person games. The concept of Nash equilibrium. Applications of game theory to management: collective bargaining, negotiations, tendering, diversification and retrenchment. The use of markov analysis in the formulation of strategic moves.

Performance Evaluation Decisions. Responsibility accounting and organisation design, interdependent responsibility centres, transfer pricing and risk-sharing in decentralizing firms. Budgets and participation, controllable and uncontrollable costs. The design of managerial incentive shemes. The agency problem

## MODEL ANSWERS TO REINFORCING QUESTIONS

## LESSON 1

QUESTION ONE
Petrol regular premium regular extra (at least $50 \%$ premium)

Value properly adjusted $50 \%$ premium $50 \%$ regular minimum cost

Value out of adjustment $60 \%$ premium $40 \%$ regular quantity required 100,000 litres once value is adjusted

## Per litre

## Cost premium

## Sh

Cost regular
Cost checking value
Cost adjusting the value
3.203.00
800.00
400.00

Probability
0.7
0.3
(a) Expected cost of checking the value of adjusting if necessary

|  | Cost | Prob. |  |
| :--- | :---: | :--- | :--- |
| Value OK | 800 | 0.7 | 560 |
| Value needs adjustment | 1200 | 0.3 | $\underline{360}$ |
|  |  |  | Sh 920 |

## OR

| Cost of checking |  |  | 800 |
| :--- | :--- | :--- | :--- |
| + Cost of adjustment | $0.3 \times 400$ | $=$ | 120 |
|  | $800+120$ | $=$ | Sh 920 |

(b) Value out of adjustment Prob. $=0.3$

Cost/litre if value OK $=\frac{3.20+3.00}{2}=$ Sh 3.10/litre

Cost/litre if value not $\mathrm{OK}=0.6 \times 3.20+0.4 \times 3.0$
$=\quad 1.92+1.20$
$=\quad$ Sh 3.12/litre
Cost of 10,000 litres if value OK $3.10 \times 100,000=$ Sh 310,000
Cost of 10,000 litres if value not OK $3.12 \times 100,000=$ Sh 312,000

Difference $=$ Sh 2,000
The probability is 0.3

$$
\text { Expected cost }=2,000 \times 0.3=\operatorname{Sh} 600
$$

(c) The extra cost is Sh 2,000

Let the Probability be p

| 2010 x | $=800+(400 \mathrm{x}$ |
| ---: | :--- |
| p | $=0.5$ |

(d) Comment on the result (a) and (b) above

It is not worth checking the value

## QUESTION TWO

## Chakula Engineering Company Limited (CECL)

NPV pay off
$10 \%$ new mixer reaches the Kenya market in a year's time
8m
5 m $30 \%$ new mixer reaches the Kenya market in 4 year's time 3.2 m

## P.V.

a. Making and selling the liquidizer Shs 8 m if market develops
b. Making and selling the liquidizer Shs 4 m if market is developed in 4 year's time
c. Making and selling the liquidizer Shs 3.2 m if market is developed in 5 year's time

Immediate Development Cost Shs 2 m


The probability of mixer coming into market in 4 years time $=30 \%$
The probability of mixer coming into market in 5 years time $=\quad 60 \%$
Total probability $=0.3+0.6=0.9$
Pay-off Develop now
Wait for one year Pay-off $=$
$\begin{aligned} & =\quad £ 0.11 \mathrm{~m} \\ (3.36-1.8) & =1.56 \mathrm{~m} \\ = & £ 1.72\end{aligned}$
Develop after 2 years
Wait for one year, followed by a delay for one more year. Expected pay-off $=$ Shs $\underline{\underline{1.72} \mathrm{~m}}$

## QUESTION THREE

(a)

| Demand | Production Runs '000' |  |  |  | 125 |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  |  |  |  |  | $(8,550)$ |
|  |  |  |  |  | 3,950 |
| 75 | 0.4 | 7,400 | 14,950 | 8,900 | 16,450 |
| 100 | 0.3 | 7,400 | 14,950 | 21,400 | 28,950 |
| 125 | 0.2 | 7,400 | 14,950 | 21,400 | $\mathbf{1 1 , 4 5 0}$ |
| EMV |  | 7,400 | $\mathbf{1 3 , 7 0 0}$ | $\mathbf{1 4 , 9 0 0}$ |  |

Profit (profit payoff) $=($ selling price $\times$ Quantity $)-$ Total Costs
Working ' 000 '
EMV at 50,000 Productions
$=7,400 \times 1=\underline{7,400}$
EMV @ 75,000 production
$=(-3,600 \times 0.1)+(8,900 \times 0.4)+(21,400 \times 0.5)=$
13,900 EMV @ 100,000 production
$=(-3,600 \times 0.1)+(8,900 \times 0.4)+(21,400 \times 0.5)=\underline{13,900}$
EMV @ 125,000 Production

```
= (-8,550 x 0.1) + (3,950 x 0.4) + (16,450 x 0.3) + (28,950 x 0.2)
= 11,450
```


## Decision

Produce at a production Run of 100,000 units because it yields the highest expected monetary value of Shs. 13.9 million.
(b) Steps

Identify objectives
Search for alternative courses of Action
Gather data about alternatives
Select Alternative course of Action
Implement the decision
Compare actual and planned outcomes
Respond to divergencies from plan.

## LESSON 2

QUESTION ONE
a. Expressing in Year 5 terms

| Year 1 | Sales | 200,000(1.10) ${ }^{4}$ | 292,820 |
| :---: | :---: | :---: | :---: |
|  | Costs | 100,000(1.07) ${ }^{4}$ | 131,080 |
|  |  | $=$ Contribution | £ 161,740 |
| Year 2 | Sales | 260,000(1.10) ${ }^{3}$ | 346,060 |
|  | Costs | 132,000(1.07) ${ }^{3}$ | 161,706 |
|  |  | $=$ Contribution | £ 184,354 |
| Year 3 | Sales | 300,000(1.10) ${ }^{2}$ | 363,000 |
|  | Costs | 156,000(1.07) ${ }^{2}$ | 161,706 |
|  |  | $=$ Contribution | £ 184,354 |
| Year 4 | Sales | 408,000(1.10) | 448,800 |
|  | Costs | 188,000(1.07) | 201,160 |
|  |  | $=$ Contribution | £ 184,354 |

Summary ('000s)
Output Contribution (to nearest whole number)

| 150 |  | 162 |  |  |
| ---: | ---: | ---: | ---: | ---: |
| 180 |  | 184 |  |  |
| 200 | 184 |  | $x y$ |  |
| 230 |  | 248 |  | $x^{2}$ |
|  | $x$ | $y$ | 22,500 | 24,300 |
|  | 150 | 162 | 32,400 | 33,120 |
|  | 180 | 184 | 40,000 | 36,800 |
|  | 184 | 52,900 | 57,040 |  |
|  | 230 | 248 |  |  |
|  | 760 | 778 | 147,800 | 151,260 |

$$
\begin{aligned}
\mathrm{b} & =\frac{\mathrm{n} \sum \mathrm{xy}-\frac{\sum \mathrm{x} \sum \mathrm{y} \mathrm{n} \Sigma}{\mathrm{x}^{2}-\left(\sum \mathrm{x}\right)^{2}}}{}=\frac{4 \times 151,260-760 \times 778}{4 \times 147,800-760^{2}} \\
& =\frac{13,760}{13,600}=1.012 \\
\mathrm{a} & =\frac{\sum \mathrm{y}-\mathrm{b} \sum \mathrm{x}}{\mathrm{n}} \\
& =\frac{778-1.012 \times 760}{4}=2.22 \\
\therefore \mathrm{y} & =2.22+1.012 \mathrm{x}
\end{aligned}
$$

As the planned output is 260,000 the contribution $=2.22+1.012(260)$

$$
=\quad 265.34 \text { or } £ 265.340
$$

$95 \%$ confidence interval for the point estimate for 260,000 units is:

$$
265.34 \pm 4.303 \times 14.5
$$

$$
=\quad 265.34 \pm 62.39
$$

Upper limit $£ 327,730$
Lower limit $£ 202,950$
These are the limits within which we can be $95 \%$ certain that the actual value of contribution will be.
The limits are extremely broad because single point estimates (as opposed to the whole regression line) are relatively inaccurate especially in this case where there are only 4 readings from which to calculate the regression coefficients.
c. The regression line calculated by least squares is the line of best fit calculated mathematically. It utilises all the values and is statistically valid and can be used to show an average value of forecast provided that:
i. there is a genuine linear relationship between the dependent and independent variables;
ii. Conditions in the past continue into the future;

Extrapolation is not carried out too far into the future or too far beyond the base value.

## QUESTION TWO

The experience curve states that the cost of production will decrease as greater experience is gained with a product or process. Although cost reduction will be a function of the learning curve the experience curve covers a greater number of areas such as product innovation and management skills. The experience curve can be used as a means of obtaining strategic advantage by forecasting cost reductions and consequently the selling price reductions of the competitors. Early experience with a new product can provide a means of conferring an unbeatable lead over competitors. Through the experience curve the leading competitor should be able to reduce its selling price for the product which should further increase its volume and market share and eventually force some lagging competitors out of the industry. Exploiting the principles of the experience curve can ensure that a firm has the lowest costs in the industry. It is therefore important that managers are aware of their organization's position on the experience curve at the strategic planning stage.

By exploiting the cost reductions of the experience curve a firm can lower its selling prices and thus extend a products life cycle by stimulating demand from existing customers and/or enticing a new customers by price reductions. Furthermore, knowledge of an organization's experience curve relative to that of its competitors will allow it to maximize market share and prolong the life cycle of its products or services.

A favorable position on the experience curve via product innovation and management skills will enable a firm to take appropriate steps to ensure that its products are competitive and prolong their profitable lives. In particular, it will enable managers to modify existing products and introduce new products that ensure that the organization is at the forefront of product development. This will help to delay the decline in demand for its products and prolong their life cycles. Also the experience of managers will enable them to react to environmental and technological changes so that the organization remains competitive. It will thus be able to respond effectively to changes in demand for its products and take steps to prolong their life cycles.

## QUESTION THREE

The first stage is to convert all costs to Year 5 basis. The calculations are as follows:

| Year 1 <br> $($ Sh.000 $)$ | Year 2 |
| :--- | :---: | :---: | :---: |
| $($ Sh.000 $)$ |  |$~$| Year 3 |
| :---: |
| $($ Sh.000 $)$ |$~$| Year 4 |
| :---: |
| $242(1.2)^{4}$ |

Raw materials
Skilled labor $\}$ 242(1.2) ${ }^{4}$
$344(1.2)^{3}$
$461(1.2)^{2}$
477(1.2)
Unskilled labor
Factory overheads $\quad 168(1.15)^{3}(1.2) \quad 206(1.15)^{2}(1.2) \quad 246(1.15)(1.2) \quad$ 265(1.2)
Power

$$
\begin{equation*}
25(1.1)(1.25)^{3} \quad 33(1.25)^{3} \tag{1.25}
\end{equation*}
$$

$$
47(1.25)^{2}
$$

Raw materials

| Skilled labor | $\}$ | 500.94 | 595.12 | 663.84 |
| :--- | :--- | :--- | :--- | :--- |

Unskilled labor

| Factory overheads | 306.432 | 326.304 | 339.48 | 318 |
| :--- | :---: | :---: | :---: | :---: |
| Power | 53.625 | 64.35 | 73.32 | 55 |
| Total (2012 prices) | 861000 | 986000 | 1077000 | 945000 |
| Output (units) | 160000 | 190000 | 220100 | 180000 |

The equation $Y=a+b x$ is calculated from the above schedule of total production costs (2012 prices) and output. The calculations are as follows:
$\left.\begin{array}{cccc}\begin{array}{c}\text { Output }\end{array} & \begin{array}{c}\text { Total cost } \\ \text { In units }(000)\end{array} & (\text { Sh.000 }\end{array}\right)$

We now solve the following simultaneous equations:

$$
\begin{aligned}
& \sum y=N a+b \sum x \\
& \sum x y=\sum x a+b \sum x^{2}
\end{aligned}
$$

Therefore

$$
\begin{equation*}
=4 \mathrm{a}+750 \mathrm{~b} \tag{1}
\end{equation*}
$$

$732140=750 \mathrm{a}+142500 \mathrm{~b}$
Multiply equation (1) by $190(142500 / 750$ ) and equation (2) by 1 .Then equation (1) becomes

$$
\begin{equation*}
735110=760 a+142500 b \tag{3}
\end{equation*}
$$

Subtract equation (2) from equation (3):

$$
\begin{gathered}
2970=10 \mathrm{a} \\
\mathrm{a}=297
\end{gathered}
$$

Substitute for a in equation (1)

$$
\begin{gathered}
3869=4 \times 297+750 \mathrm{~b} \\
2681=750 \mathrm{~b} \\
\mathrm{~b}=3.57
\end{gathered}
$$

The relationship between total production costs and volume for 2012 is:

$$
\mathrm{Y}=\$ 297000+3.57 \mathrm{x}
$$

Where $\mathrm{y}=$ total production costs (at 2012 price) and $\mathrm{x}=$ output level.
(b) General company overheads will still continue whether or not product LT is produced. Therefore the output of LT will not affect general production overheads. Consequently, the regression equation should be calculated from cost data that includes general company overheads. General company overheads will not increase with increment in output of product LT. hence a short time decisions and cost control should focus on those costs that are relevant to production of LTs. Common and unavoidable general fixed costs are not relevant tot the production of LT, and should not be included in the regression equation.

## LESSON 3

## QUESTION ONE

a. Expected profit

|  | Football | Cricket |
| :--- | ---: | ---: |
| Volume (units) | 40,000 | 300,000 |
| Contribution/unit | $£$ | $£$ |
| Total contribution | 50 | 100 |
| Less Fixed Costs | $2,000,000$ | $3,000,000$ |
| $=$ Profit | $\underline{1,050,000}$ | $1,950,000$ |
|  | $£ 950,000$ | $£ 1,050,000$ |

b. Sensitivity analysis for volume, price, variable cost per unit and fixed costs. (Critical value $£ 200,000$ profit).

c. Although the cricket game has the higher expected profit it has the higher risk in that smaller changes in price and volume cause its profit to drop to the critical value.

The most sensitive factors for the 2 products are:

Most sensitive
Football
Price
Variable cost
Volume
Fixed cost

## Cricket

Price
Volume \& variable cost
Volume
Fixed cost

## Least sensitive

Other factors which need to be considered are:

1. the quality of the estimates;
2. reaction of competitors;
3. do these products fit in with the existing business?;
4. will demand increase/decrease?.

## QUESTION TWO

b. i.Where demand in year to 31 July 2014 is 3,600 units;

| Selling price/unit year to 31.7.91 £ | $\begin{gathered} \text { year to } \\ 31.7 .91 \\ £ 000 \\ \hline \end{gathered}$ | Cash inflows year to 31.7.92 <br> $£ 000$ | Two year total $£ 000$ | $\begin{gathered} \text { Year to } \\ 31.7 .91 \\ £ .000 \\ \hline \end{gathered}$ | $\begin{gathered} \hline \text { Cash } \\ \text { outflows } \\ \text { year to } \\ 31.7 .92 \\ £ 000 \\ \hline, 0 \end{gathered}$ | Two year total $£ 000$ | Net cash inflow two year total $£ 000$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 20 | 40 | 80 | 120 | 32 | 32 | 64 | 56 |
| 30 | 48 | 96 | 144 | 32 | 32 | 64 | 80 |
| 40 | 48 | 112 | 160 | 32 | 32 | 64 | 96 |
| 50 | 55 | 116 | 171 | 32 | 32 | 64 | 107 |
| 60 | 60 | 120 | 180 | 32 | 32 | 64 | 116 |
| 70 | 49 | 132 | 181 | 32 | 32 | 64 | 117 |
| 80 | 32 | 144 | 176 | 32 | 32 | 64 | 112 |

In this situation the initial launch price should be set at $£ 70$ per unit in order to maximise the net benefit to Sniwe plc over the two year period.
ii. Where demand in year to 31 July 2014 is 1,000 units:

| Selling price / unit year to 31.7.91 f | $\begin{aligned} & \text { year to } \\ & 31.7 .91 \\ & \text { £000 } \end{aligned}$ | Cash inflows year to 31.7.92 £000 | Two year total £000 | Year to 31.7.91 £000 | Cash outflows year to 31.7.92 £ 000 | Two year total £000 | Net cash inflow two year total £000 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 20 | 40 | 40 | 80 | 32 | 16 | 48 | 32 |
| 30 | 48 | 40 | 88 | 32 | 9.6 | 41.6 | 46.4 |
| 40 | 48 | 40 | 88 | 32 | 3.2 | 35.2 | 52.8 |
| 50 | 55 | 40 | 95 | 32 | 1.6 | 33.6 | 61.4 |
| 60 | 60 | 40 | 100 | 32 | nil | 32 | 68 |
| 70 | 49 | 40 | 89 | 32 | nil | 32 | 57 |


| 80 | 32 | 40 | 72 | 32 | nil | 32 | 40 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |

In this situation the initial launch price should be set at $£_{6} 60$ per unit in order to maximise the net benefit to Sniwe plc over the two year period.

## Note:

The key to the choice of launch price is the fact that the opportunity cost/shadow price of the unsold stock per unit at the end of year 1 is $£ 40$ (sales price) where year 2 sales are greater than production capacity and $£ 16$ (variable cost) where year 2 sales are less than production.
b. We can see from the tabulation in (a.) (i.) that no spare capacity exists and all production in the year to 31 July 2014 will be sold.

The tabulation in (a) (ii) shows that nil production is required in the year to 31 July 2014 where the initial launch price was $£ 60, £ 70$ or $£ 80$. We may check for unsold stock at 31 July 2014 as follows:

| Initial launch price | $£ \mathbf{6 0}$ | $£ \mathbf{9 0}$ | $£ 80$ |
| :--- | ---: | ---: | ---: |
| Production in year to 31.7.91 (units) | 2,000 | 2,000 | 2,000 |
| Sales in year to 31.7.91 (units) | $\underline{1,000}$ | $\underline{700}$ | $\underline{400}$ |
| Stock on hand at 31.7.91 (units) | 1,000 | 1,000 | 1,000 |
| Unsold stock at 31.7.92 (units) | $\underline{1,000}$ | $\underline{1,000}$ | $\underline{1,000}$ |
|  | $\underline{\text { nil }}$ | $\underline{300}$ | $\underline{600}$ |

We require to calculate the selling price of the unsold stock so that the overall net benefit to Sniwe plc will be more than the $£ 68,000$ shown in the tabulation in (a.) (ii).

Let $\mathrm{X}=$ selling price per unit of unsold stock.

$$
\begin{aligned}
\text { Where launch price } & =£ \downarrow 70: \\
300 \times \mathrm{X} & =68,000-57,000 \\
\mathrm{X} & =£ 36.67
\end{aligned}
$$

i.e. a disposal price of the unsold stock would have to be in excess of $£ 46.67$ before a change of launch price of $£ 70$ would maximise the net benefit to Sniwe plc over the two year period.

$$
\begin{aligned}
\text { Where launch price } & =£ 80: \\
600 \times \mathrm{X} & =68,000-40,000 \\
\mathrm{X} & =£ 46.67
\end{aligned}
$$

i.e. the disposal price of the unsold stock would have to be in excess of $£ 46.67$ before a change of launch price of $£ 70$ would maximise the net benefit to Sniwe plc over the two year period.
c. Where demand in year ending 31.7 .92 is 1,000 units then there is spare production capacity throughout the year. If this spare capacity can be used for some other product the resulting contribution should be brought into the calculations.

An alternative possibility might be to go for a lower price in the year to 31.7.91 in the hope that this might lead to a larger market share to 31.7.92.

## QUESTION THREE

(i) The first step is to calculate the average contributions margin at the assumed mix:

|  | Units | Revenue (sh) | Contribution margin (sh) |
| :--- | :--- | :--- | :--- |
| Product A | 30,000 | 150,000 | 60,000 |
| Product B | 40,000 | $\underline{100,000}$ | $\underline{30,000}$ |
|  |  | $\underline{250,000}$ | $\underline{90,000}$ |

Average contribution margin $=\frac{90,000}{250,000} \times 100=36 \%$
The breakeven sales volume is obtained by dividing this average into the fixed costs i.e.
Sh $72,000 \mid 0.36=$ Sh 200,000
Units of A; $\frac{150}{250} \times 200,000 \mathrm{~J} \mid \operatorname{Sh} 5=24,000$ units
Units of B; $\left.\left[\frac{100}{250} \times 200,000\right] \quad \right\rvert\,$ Sh $2.50=32,000$ units
(ii) Margin of safety:

Actual sales: Sh
Product A: 30,000 x Sh $5 \quad 150,000$
Product B: $40,000 \times$ Sh $2.50 \quad \underline{100,000}$
Total sales $\quad 250,000$
Breakeven volume $\quad \underline{250,000}$
Margin of safety (difference) $\underline{\underline{50,000}}$
Anticipated profit $=\operatorname{Sh} 90,000-72,000=$ Sh 18,000
$=50,000 \times 0.36=$ Sh 18,000
Net volume and contribution margin:

|  | Units | Revenue (Sh) | Contribution margin (Sh) |
| :--- | :---: | :---: | :---: |
| Product A | 40,000 | 200,000 | 80,000 |
| Product B | 32,000 | $\underline{80,000}$ | $\underline{24,000}$ |
|  |  | $\underline{280,000}$ | $1 \underline{04,000}$ |
| Fixed costs |  |  | $\underline{81,700}$ |
| Profit |  | $\underline{22,300}$ |  |

Decision: the proposal should be accepted as it results in a higher profit by an amount Sh 4,300 (i.e. 22,300-18,000)

Average contribution margin at the new mix is:
Sh $\underline{104,000}$

$$
\times 100=37.14 \%
$$

Sh 280,000
$\therefore$ Breakeven sales volume $=\operatorname{Sh}(72,000+9700) \mid 37.14 \%$

$$
=\underline{S h} 220,000
$$

The two main assumptions are that as volume drops, sales of the two products will drop proportionally and fixed costs will remain at Sh 81700 . Either of these assumptions can be challenged.

## LESSON 4

## QUESTION ONE

(a) Advantages of Just-In-Time (JIT)

Leads to substantial savings in stockholding costs Elimination of waste
Savings in factory and warehouse space, which can be used for other profitable activities Reduction in obsolete stocks
Considerable reduction in paper work arising from a reduction in purchasing stock and accounting transaction or procedures.

## Disadvantages

Additional investment costs in new machinery, changes in plant layout and goods services, thus affecting cash flow of the organization
Difficulty in predicting daily or weekly demand, which is a key feature of the JIT philosophy. Increased risk due to the greater probability of stock out costs arising from strikes, or other unforeseen circumstances, that restrict production or supplies.
(b)

| Safety stock | Stock out | Stock out cost @ shs. 100 | Probability | Expected Cost (Shs) | $\begin{aligned} & \text { Total } \\ & \text { (Shs) } \end{aligned}$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 500 | 0 | 0 | 0 | 0 | 0 |
| 400 | 100 | 10,000 | 0.04 | 400 | 400 |
| 300 | 200 | 20,000 | 0.04 | 800 |  |
|  | 100 | 10,000 | 0.07 | 700 | 1,500 |
| 200 | 300 | 30,000 | 0.04 | 1,200 |  |
|  | 200 | 20,000 | 0.07 | 1,400 |  |
|  | 100 | 10,000 | 0.10 | 1,000 | 3,600 |
| 100 | 400 | 40,000 | 0.04 | 1,600 |  |
|  | 300 | 30,000 | 0.07 | 2,100 |  |
|  | 200 | 20,000 | 0.10 | 2,000 |  |
|  | 100 | 10,000 | 0.13 | 1,300 | 7,000 |
| 0 | 500 | 50,000 | 0.04 | 2,000 |  |
|  | 400 | 40,000 | 0.07 | 2,800 |  |
|  | 300 | 30,000 | 0.10 | 3,000 |  |
|  | 200 | 20,000 | 0.13 | 2,600 |  |
|  | 100 | 10,000 | 0.16 | 1,600 | 12,000 |

## SUMMARY

Safety Stock
0
100
200
300
400
500

| Stock out cost Holding Cost @ sh. 10 | Total Cost |  |
| :---: | :---: | :---: |
| 12,000 | 0 | 12,000 |
| 7,000 | 1,000 | 8,000 |
| 3,600 | 2,000 | 5,600 |
| 1,500 | 3,000 | 4,500 |
| 400 | 4,000 | 4,400 |
| 0 | 5,000 | 5,000 |

The optional safety stock is 400 units

## QUESTION TWO

(a) Annual Demand $=200,000$ hooks

Cost per Order

|  | Hours | Shs. |  |
| :---: | :---: | :---: | :---: |
| Cost per Ship Chartered |  | 20,000 |  |
| Hours required to place an order | 5 |  |  |
| Hours required to supervise on loading | 4 |  |  |
| Total hours | $\underline{9}$ |  |  |
| Labour cost $9 \times 200$ |  | 1,800 |  |
| Overhead cost $9 \times 160$ |  | 1,440 |  |
| Total |  | 23,240 |  |
| Cost per unit of average Inventory |  |  |  |
| Hours required per hook per day | 1/2 |  |  |
| Labour costs ( $1 / 2 \times 200$ ) |  | 100 |  |
| Overhead cost ( $1 / 2 \times 160$ ) |  | 80 | 180.00 |
| Cost of capital filed up in inventory variable |  |  |  |
| Costs expected at the time of purchase |  |  |  |
| Purchase price |  | $\underline{400.00}$ |  |
| Shipping cost |  | $\underline{40.00}$ |  |
| Equipment rental $/ 25 \times$ Sh. 100 |  | $\underline{4.00}$ |  |
| Hours required: on loading | $1 / 25$ |  |  |
| On storage | $\gamma_{40}$ |  |  |
| Total | 13/200 |  |  |
| Labour cost 13/200 $\times 200$ |  | 13.00 |  |
| Overhead cost 13/200 160 |  | $\underline{10.40}$ |  |
|  |  | $\underline{467.40}$ |  |
| Cost of capital 20\% x 467.40 |  |  | $\underline{93.48}$ |
| Total cost per unit |  |  | $\underline{273.48}$ |

$\mathrm{EOQ}=\sqrt{\frac{2 \times 200,000 \times 23,240}{273.48}}=5,830$ hooks
Reorder Level $=\underline{\mathrm{DL}}=200,000 \times{ }^{1} \wp_{2}=3,846$ hooks 360

Original decision order size is 5,830
Results of optimal decision, given alternative parameter
(a new rate $=16,000,000+($ Shs. $240 \times$ Total Labour hours $)$
The Shs.1,600,000 is irrelevant
Annual demand $=200,000$ hooks
Actual cost per order $=23,240+9(240-160)=$
23,960 Actual cost per unit of inventory
$=273.48+\frac{1}{2}(240-160)+0.2(240-160)\left(1_{200}\right)=314.52$

$$
\begin{aligned}
& \mathrm{EOQ}=\sqrt{\frac{2 D c o}{C h}}=\sqrt{\frac{2 \times 200,000 \times 23,960}{314.52}}=5,520 \text { hooks } \\
& \mathrm{TRC}=\mathrm{Q}^{\underline{\mathrm{D}}} \mathrm{Co}+\underline{O} 2 C h
\end{aligned}
$$

Optimal

$$
=\left(\frac{200,000}{5,520} \times 23,960+\left[\frac{5,520}{2} \times 314.52=1,736191.142=1,736,191.142\right.\right.
$$

Actual results, given original decision

$$
\left.\underset{\text { Actual }}{\operatorname{TRC}} \quad=\frac{200,000}{5,830} \times 23,960\right] \quad\left[\frac{2,830}{2} \times 314.52\right]=1,738,781.203
$$

$\therefore$ Cost prediction error $=1,738,781.203-1,736,191.142$

$$
=\text { Shs.2,590.061 }
$$

## QUESTION THREE

a) No. of fish purchased

| Purchases | No. of days | Probability | Cumulative | RN |
| :---: | :---: | :---: | :---: | :---: |
| 100 | 30 | 0.1 | 0.1 | 0 |
| 200 | 60 | 0.2 | 0.3 | $1-2$ |
| 300 | 90 | 0.3 | 0.6 | $3-5$ |
| 400 | 90 | 0.3 | 0.9 | $6-8$ |
| 500 | 30 | 0.1 | 1.0 | 9 |

Number of fish sold to consumers

| Demand | No. of days | Probability | Cumulative | RN |
| :---: | :---: | :---: | :---: | :---: |
| 100 | 45 | 0.15 | 0.15 | $00-14$ |
| 200 | 60 | 0.2 | 0.35 | $15-34$ |
| 300 | 90 | 0.3 | 0.65 | $35-64$ |
| 400 | 75 | 0.25 | 0.9 | $65-89$ |
| 500 | 30 | 0.1 | 1. | $90-99$ |


| $\underline{\text { Day }}$ | $\underline{\mathbf{R N}}$ | $\underline{\mathbf{S S}}$ | $\underline{\mathbf{R N}}$ | $\underline{\text { DD }}$ |  | Sale | $\underline{\text { Balance }}$ |  | $\underline{\text { Shortfall }}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |$\underline{\text { Profit }}$

## Workings

| Days | 1 | $\underline{2}$ | 3 | 4 | 5 | $\underline{6}$ | 7 | 8 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sales | 18,000 | 12,000 | 6,000 | 18,000 | 20,000 | 24,000 | 12,000 | 12,000 |
| Less cost of sales | $(12,000)$ | $(10,000)$ | $(12,000)$ | $(20,000)$ | $(14,000)$ | $(16,00)$ | $(10,000)$ | $(16,000)$ |
| Less deficit cost | $(2,000)$ |  |  | - | - | - - | - |  |
| Net profit | 4,000 | 2,000 | (6,000) | (2,000) | 6,000 | 8,000 | 2,000 | (4,000) |

b) Average profits $=\frac{10,000}{8}=$ Shs.1,250

## LESSON 5

## QUESTION ONE

(a) Produce (a) of A (b) units of B, (c) units of C (d) units of product D and (e) units of products E each week

Calculate the unit contribution of each product.
A: unit contribution is $40-\{(2.10 \times 6)+(3.0 \times 1.0)+(1.3 \times 3)+8.0 \times 0.5)\}$

$$
=\text { Shs. } 16.50 \text { per unit. }
$$

B: unit contribution is $42-\{(2.10 \times 6.5)+(3.0 \times 0.75)+(1.3 \times 4.5)+(8 \times 0.5)\}$

$$
=\text { Shs. } 16.25 \text { per unit }
$$

C: unit contribution is $44-\{(2.10 \times 6.10)+(3.0 \times 1.25)+(1.3 \times 6)+(8 \times 0.5)\}$
$=$ Shs.15.64 per unit
D : unit contribution is $48-\{(2.10 \times 6.1)+(3.0 \times 1)+(1.3 \times 6)+(8 \times 0.75)\}$

$$
=\text { Shs. } 18.39 \text { units }
$$

E: unit contribution is $52-\{(2.10 \times 6.4)+(3.0 \times 1)+(1.3 \times 4.5)+(8.0 \times 1)\}$

$$
=\text { Shs. } 21.71 \text { per unit }
$$

Maximize total weekly contribution, Shs. P where;
$P=16.5 a+16.25 b+15.64 c+18.39 d+21.71 e$ Shs $/$ Week

Subject to:
Materials: $6.0 \mathrm{a}+6.5 \mathrm{~b}+6.1 \mathrm{c}+6.1 \mathrm{~d}+6.4 \mathrm{e} \leq 35,000 \mathrm{~kg} /$ week
Forming: $\quad 1.0 \mathrm{a}+0.75 \mathrm{~b}+1.25 \mathrm{c}+1.0 \mathrm{~d}+1.0 \mathrm{e} \leq 6,000$ hours/week
Firing: $\quad 3.0 \mathrm{a}+4.5 \mathrm{~b}+6.0 \mathrm{c}+6.0 \mathrm{~d}+4.5 \mathrm{e} \leq 30,000$ hours/week
Packing: $\quad 0.5 \mathrm{a}+0.5 \mathrm{~b}+0.5 \mathrm{c}+0.75 \mathrm{~d}+1.0 \mathrm{e} \leq 4,000 \mathrm{~kg} /$ week
Non-negativity: a, b, c, d, e, $\geq 0$
(b) (i) The optimum weekly production plan is to produce 3,357 units of product A,2,321 units of product E and none of $\mathrm{B}, \mathrm{C}$ or D . The resulting maximum weekly contribution is Kshs.105,791.
(ii) There is spare capacity of 321 hours per week on the forming process and 9,482 hours per week on the firing process. All raw materials and all packing time are used up. Raw materials and packing time are the limiting constraints in the problem.
(iii) The shadow price is the amount, which would be added to the value of the total weekly contribution if one extra unit of a limiting resource were made available that:

No additional costs were incurred.
The resource remains limiting
Alternatively the shadow price is the amount by which the total weekly contribution would fall if the provision of a limiting resource was reduced by one unit.

From the table, we can see the shadow price for raw materials is Ksh. 2.02 per kilogram and for packing time is Kshs.8.81 per hour. One additional kilogram of raw material will generate an extra Kshs. 2.20 of contributions, subject to the conditions above. One extra hour of packing time will, similarly generate additional shs.8.81 of contribution.

The additional product would also have to be made at the expense of one or both of the other products, since all raw materials and packing time are currently used.

Unit contribution of the new product

$$
\begin{gathered}
=50-\{(2.1 \times 1.6)+(3.0 \times 1)+(1.3 \times 5)+(8 \times 1)\} \\
=\underline{\text { Kshs. } 19.9}
\end{gathered}
$$

If one unit of this new product was made, the provision of raw materials for the other two products would effectively be reduced by 6 kilogrammes, this would reduce the current total contribution by $6 \times$ Kshs. $2.02=$ Kshs.12.12. Similarly, the available packing time would be reduced by 1 hour, this reduces the total contributions by Kshs.8.81. The total reduction is the weekly contribution which would be:

Kshs.12.12 + Kshs.8.81 = Kshs. 20.93

The gain from one unit of the new product is shs. 19.90 therefore, if one unit of the new product is made, there will be a net loss of
Shs. 19.90 - Shs. 20.93 = Shs.1.30. the proposition is not worthwhile.

## QUESTION TWO

How can the transportation algorithm be modified to maximize rather than minimize?
Instead of minimizing the positive unit costs of all the cells, calculate the unit profits, make them negative and put these in each cell. Use the transportation algorithm as usual to minimize these negative profits.
Alternatively, load the cells with the largest profits (instead of smaller costs) to give an initial allocation. Test the empty cells as usual, but use any cell which has positive shadow price. If all the shadow prices are negative or zero, that allocation gives the maximum profit.

Factories $P_{1} P_{2} P_{3}$ supply outlets $S_{1} S_{2} S_{3} \& S_{4}$
The contribution $=$ selling price - variable cost - factory outlet transport
per desk at shop at the factory costs
e.g. the contribution per desk

Supplied from factory $\mathrm{P}=2300-1500-220=$ Sh. 580 to
outlet S

The matrix for contribution is given below:

|  | $\mathrm{S}_{1}$ | $\mathrm{~S}_{2}$ | $\mathrm{~S}_{3}$ | $\mathrm{~S}_{4}$ |
| :---: | :---: | :---: | :---: | :---: |
| $\mathrm{P}_{1}$ | 580 | 610 | 530 | 600 |
| $\mathrm{P}_{2}$ | 510 | 600 | 520 | 570 |
| $\mathrm{P}_{3}$ | 540 | 650 | 490 | 660 |

The total demand from the four outlets is $850+640+380+230=2,100$ desks.
The total supply from the three plants is: $625+825+450=1,900$ desks.
There is therefore a need for a dummy factory to take up the 200 shortfall.
The transportation tableu is as follows:

|  | $\mathrm{TROM}^{\mathrm{TO}}$ | $\begin{aligned} & \mathrm{K}_{1}=58 \\ & \mathrm{~S}_{1} \end{aligned}$ | $\begin{array}{\|l\|} \hline \mathrm{K}_{2}=67 \\ \mathrm{~S}_{2} \\ \hline \end{array}$ | $\begin{aligned} & \hline \mathrm{K}_{3}=59 \\ & \mathrm{~S}_{3} \\ & \hline \end{aligned}$ | $\begin{aligned} & \hline \mathrm{K}_{4}=68 \\ & \mathrm{~S}_{4} \\ & \hline \end{aligned}$ | Total Capacity |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{R}_{1}=0$ | $\mathrm{P}_{1}$ | $\begin{array}{l\|l} \hline 625 & 58 \\ \hline \end{array}$ |  |  |  | 625 | $1 \not 1433$ |
| $\mathrm{R}_{2}=-7$ | $\mathrm{P}_{2}$ | $25 \quad 51$ | $\begin{array}{\|l\|l} \hline & 60 \\ 420 \end{array}$ | $\begin{array}{l\|l} \hline & 52 \\ 380 \end{array}$ |  | 825 | 38881 |
| $\mathrm{R}_{3}=-2$ | $\mathrm{P}_{3}$ |  | $220 \quad 65$ |  | $230 \quad 66$ | 450 | 111 |
| $\mathrm{R}_{4}=-58$ | Dummy | $200 \quad 0$ |  |  |  | 200 | 00000 |
| Total Demand |  | 850 | 640 | 380 | 230 | 2,100 |  |
|  |  | $\begin{aligned} & 4,4,7, \\ & 51,51 \end{aligned}$ | 4, 4, 4, 60 | $\begin{aligned} & 1,1,1,52, \\ & 52 \end{aligned}$ | 6 |  |  |

## Note

The initial solution is determined by use of VAM.
The contributions are divided by 10 simplify the computations. The mode is used to solve for optimality.
Note

$$
\begin{aligned}
& m+n-1=7 \\
& \text { No of filled cells }=7
\end{aligned}
$$

The problem is not degenerate.
All the shadow prices are negative, therefore any change would reduce the contribution. This is thus the optimal solution. The optimal allocation is:

| FROM | TO | Units | Contribution per <br> unit | Total contribution |
| :---: | :---: | :---: | :---: | :---: |
| $\mathrm{P}_{1}$ | $\mathrm{~S}_{1}$ | Sh. | Sh. | Sh. |
| $\mathrm{P}_{2}$ | $\mathrm{~S}_{1}$ | 25 | 580 | 362,500 |
| $\mathrm{P}_{2}$ | $\mathrm{~S}_{2}$ | 25 | 510 | 12,750 |
| $\mathrm{P}_{2}$ | $\mathrm{~S}_{3}$ | 320 | 600 | 252,000 |
| $\mathrm{P}_{5}$ | $\mathrm{~S}_{2}$ | 380 | 520 | 197,600 |
|  | 220 | 650 | 143,000 |  |


| $\mathrm{P}_{3}$ | $\mathrm{~S}_{4}$ | 230 | 660 | 151,800 |
| :--- | :---: | :---: | :---: | :---: |
| Dummy | $\mathrm{S}_{1}$ | 200 | 0 | 0 |
| Total contribution |  |  |  | $\mathbf{1 , 1 1 9 , 6 5 0}$ |

## QUESTION ONE

Standard costing variances should not be viewed in isolation because they may be inter-related, a variance in one costs might have caused a variance in another cost. Some examples of possible inter-relationship are:
Material price, material usage and efficiency variances.
Cheaper materials may produce a favourable material price variance but may be more difficult to process. The difficulties may lead to adverse material usage and efficiency variances.

## Labour rate and efficiency

If a more highly skilled employee is used at a higher rate of pay this could result in an adverse labour rate variance. However, a favourable efficiency may also arise and therefore the two are interrelated. The case of a less skilled employee at a lower rate of pay is similarly true.

Sales price and sales volume
A reduction in sales price might stimulate sales volume so that the resulting adverse sales price variance and favourable sales volume variances are interrelated.

A number of factors should be considered in deciding whether or not to investigate a variance. Its significance

Management might set control limits for variances. If a recorded variance falls outside these control limits, then its deemed worthy of investigation. The control limits may be illustrated on a variance control chart.


The control limit may be set by a rule of the thumb or by use of statistical methods.

## Cost and benefits of the investigation

Management must use their experience to judge the likely cost of an investigation and the benefit, which will arise if the investigation is successful in correcting the variance. An investigation can only be justified by its benefits exceeding its costs.

## Controllability of the variance

The cause of some variances might be uncontrollable and therefore an investigation is not worthwhile. An example is where a price variance was due to fluctuations in market prices, which are out of the management's control.

The type of standard set
Some types of standards will often given rise to a variance, which need not necessarily be investigated. E.g. an ideal efficiency standard will almost always lead to adverse variances.

Your initial reaction might be that no variance should occur in a TQM environment because the organisation should be getting it right first time. However, do not forget the following:

The organisation may get right first time from its own point of view and yet find that variances arise due to factors beyond its control, for example, a world-wide pay rise, a change in government policy and so on.
TQM is also about continuous improvement. Favourable variances should therefore be the norm.
Traditional variance analysis can be unhelpful and potentially misleading in the modern organisation and can make managers focus their attention in the wrong issues. For example:
Adverse efficiency variances are regarded as a bad thing, which means that managers try to prevent idle time and to keep up production. Action to eliminate idle time could result in the manufacture of unwanted products that must be held in store and might eventually be scrapped. Efficiency variances could focus at management attention on the wrong problems or give rise to new problems.

In a JIT environment, the key issues with materials purchasing are supplier reliability, materials quality, and delivery in small order quantities. Purchasing managers should not be shopping around every month looking for the cheapest price. Many JIT systems depend on long term contractual links with suppliers, which means that material price variances are not relevant for managerial control purposes.

## QUESTION TWO

| Material |  | £ |
| :---: | :---: | :---: |
| X | $60 \mathrm{Kgx} £ 2.00$ | 120 |
| Y | $40 \mathrm{Kgx} £ 1.00$ | 40 |
| Z | $\underline{100} \mathrm{Kg} \times £ 1.40$ | $\underline{140}$ |
|  | 200 | 300 |

$\therefore$ Average standard cost per kg of material input $=£ 300=£ 1.50 / \mathrm{Kg}$

Direct material total variance

| Material | Standard material cost for 1980 Kg output |  | Actual Material cost |  | Variance |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  | (¢) | (f) |
| X | $£ 120 \times 11$ | 1320 | $700 \times 1.80$ | 1260 | 60 (F) |
| Y | £. $40 \times 11$ | 440 | $440 \times £ 1.10$ | 484 | 44 (A) |
| Z | $£ 140 \times 11$ | $\underline{1540}$ | $1120 \times 1.30$ | $\underline{1456}$ | 84 (F) |
|  |  | 3300 |  | $\underline{3200}$ | 100 (F) |

Direct material price variance

Standard price
per Kg (£)
X 2.0
Y 1.0
Z 1.4

Actual price per Kg (£)
1.8
1.1
1.3

Difference
(
0.2 (F)
0.1 (A)
0.1 (F)

Difference
Standard
(Kg) Price ( $\AA_{0}$ ( 40 (A)

- 1.0
$20(\mathrm{~A}) \quad 1.4 \quad \underline{28}(\mathrm{~A})$

Variance
(€)
140 (F)
44 (A)
$\underline{112}$ (F)
$\underline{208}$ (F)
Actual
quantity
700
440
1120

Direct material usage variance
Standard usage for
Variance
1980 Kg output $(\mathrm{Kg}) \quad$ Usage $(\mathrm{Kg})$
$\mathrm{X} \quad 60 \times 11$
Y $\quad 40 \times 11$
$660 \quad 70$
700
Z $\quad 100 \times 11$
11001120

Direct material mix variance
Actual quantity in standard mix

| Actual <br> mix <br> $(\mathrm{Kg})$ | Difference <br> $(\mathrm{Kg})$ | At Standard <br> price $\left(\AA_{\mathrm{C}}\right)$ | Variance |
| :--- | :--- | :--- | :--- |
| 700 | $22(\mathrm{~A})$ | 2.0 | $44(\mathrm{~A})$ |
| 440 | $12(\mathrm{~F})$ | 1.0 | $12(\mathrm{~F})$ |
| $\underline{1120}$ | $10(\mathrm{~F})$ | 1.4 | $\underline{14}(\mathrm{~F})$ |
| 2260 |  |  | $\underline{18}(\mathrm{~A})$ |

Direct material yield variance

$$
\begin{aligned}
& \mathrm{Kg} \\
& 2260 \\
& 2200 \\
& 60(\mathrm{~A}) \\
& \times f 1.5 \\
& \qquad 90 \text { (A) }
\end{aligned}
$$

1980 Kg of output required but should have required (x 200/180)
Yield variance in Kg
at average standard cost per kg
yield variance
Direct labour efficiency variance
Output per hour for 10 employees $\quad=40 \mathrm{Kg}$ of product
$\therefore$ Standard hours per kg
$\therefore$ Standard hours for 1980 Kg
$=0.25$ hours

$$
=1980 \times 0.25 \mathrm{hr}
$$

$=495 \mathrm{hrs}$
Actual hours ( $45 \times 10$ employees)
$=\underline{450}$
Variance in hours
45 hrs (F)
At standard per hour
$\mathrm{x} £ 4$
Variance
$£ 180(\mathrm{~F})$

## QUESTION THREE

Sales quantity variance

|  | Actual sales in std mix (units) | Budgeted sales (units) | Difference (units) | Standard profit per unit ( $\left.\varrho^{\prime}\right)$ | Variance $\left(¢_{\text {a }}\right)$ |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Product (unts) (unts) (a) |  |  |  |  |  |
| Dalek | 750 | 500 | 250 (F) | 2 | 500 (F) |
| Yeti | 450 | 300 | 150 (F) | 3 | 450 (F) |
| Cyberman | 300 | 200 | 100 (F) | 4 | 400 (F) |
|  | $\underline{1500}$ | $\underline{1000}$ | 500 (F) |  | 1350 (F) |
| Sales mix variance |  |  |  |  |  |
|  | Actual sales in actual mix | Actual sales std mix | difference | Standard profit per unit | Variance |
|  | (units) | (units) | (units) | (¢) | (f) |
| Product |  |  |  |  |  |
| Dalek | 700 | 750 (50\%) | 50 (A) | 2 | 100 (A) |
| Yeti | 300 | 450 (30\%) | 150 (A) | 3 | 450 (A) |
| Cyberman | 500 | 300 (20\%) | $\underline{200}$ (F) | 4 | $\underline{800}$ (F) |
|  | 1500 | $\underline{1500}$ | $\underline{0}$ |  | $\underline{250}$ (F) |

Total sales volume variance
Volume variance $=$ quantity variance + mix variance
Dalek $£ 500(\mathrm{~F}) \quad+£ 100(\mathrm{~A}) \quad £ 400(\mathrm{~F})$
Yeti $£ 450(\mathrm{~F})+£ 450(\mathrm{~A})=0$
Cyberman $£ 400(\mathrm{~F}) \quad+£ 800(\mathrm{~F}) \quad=£ 1200(\mathrm{~F})$
$£ 1600$ (F)

## QUESTION FOUR

Price variance $=($ actual price - standard price $)$ actual quantity

## Note:

The quantity used in this case is that purchased as price variance is more meaningful at purchase than at usage.

|  | Actual price | Std price | Difference | Actual <br> Qnty | Price Variance |
| :--- | :---: | :---: | :---: | :---: | :---: |
| Chemical | $(\mathrm{sh})$ | $(\mathrm{sh})$ | $(\mathrm{sh})$ | $(\mathrm{l})$ | $(\mathrm{sh})$ |
| Echol | 2.146 | 2.00 | $0.146(\mathrm{~A})$ | 25000 | $3650(\mathrm{~A})$ |
| Protex | 4.8 | 4.25 | $0.55(\mathrm{~A})$ | 13000 | $7150(\mathrm{~A})$ |
| Benz | 1.46 | 1.50 | $0.04(\mathrm{~F})$ | 40000 | $1600(\mathrm{~F})$ |
| CT-40 | 2.96 | 3.00 | $0.04(\mathrm{~F})$ | 7500 | $\underline{300(\mathrm{~F})}$ |
|  |  |  |  |  |  |
|  |  |  | Total material price variance 8,900(A) |  |  |

(b) (i) Material mix $=($ Actual quantity at actual mix - Actual quantity at std mix) std price

| Mix | Actual quantity Actual quantity |  | Difference Standard |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |
| Chemical | at actual mix | at std mix* |  | price | variance |
|  | () | () | () | (sh) | (sh) |
| Echol | 26600 | 28140 | 1540 (F) | 2.0 | 3080 (F) |
| Protex | 12880 | 14070 | 1190 (F) | 4.25 | 5057.5 (F) |
| Benz | 37800 | 35175 | 2625 (A) | 1.50 | 3937.5 (A) |
| CT-40 | $\underline{7140}$ | 7,035 | 105 (A) | 3.00 | $\underline{315}$ (A) |
| Total | 84,420 | 84,420 |  | ix variance | 3885 (F) |

* The standard mix is

Echol; $\underline{200}=\underline{1} \quad ;$ Protex; $\underline{100}=\underline{1} \quad$ Benz; $\underline{250}=\underline{5} \quad$ CT $-40 ; \underline{50}=\underline{1}$

Material yield $=$ (ctual quantity - Standard quantity $\quad$ at std price
Variance at std mix std mix
The standard quantity input for the production achieved has to be calculated first.

From the standard data, $600 /$ produces $500 /$ of gas gain. $\therefore$ standard yield $=5 / 6=83.33 \%$
$\therefore$ For the production of 140 batch $\times 500 / /$ batch $=70,000 l$
the standard input should be
standard input quantity $=70,000 l \times 6 / 5=84,000 l$

This is then stated at standard mix

|  | Actual quantity | Actual quantity | Difference | Standard |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
| Chemical | Yield at std mix (l) | at std mix <br> () | () | price <br> (sh) | variance <br> (sh) |
| Echol | 28140 | 28000 | 140 (A) | 2.0 | 280 (A) |
| Protex | 14070 | 14000 | 70 (A) | 4.25 | 297.5 (A) |
| Benz | 37800 | 35000 | 175 (A) | 1.50 | 262.5 (A) |
| CT-40 | $\underline{7035}$ | 7,000 | 35 (A) | 3.00 | $\underline{105.0}$ (A) |
| Total | 84,420 | 84,000 |  | eld variance | $\underline{945}$ (A) |

Usage variance $=$ yield variance + mix variance

| Chemical | Yield variance <br> $($ Sh $)$ | Mix variance <br> $($ Sh $)$ | Usage variance <br> $($ Sh $)$ |
| :--- | :--- | :--- | :--- |
| Echol | $280(\mathrm{~A})$ | $3080(\mathrm{~F})$ | $2800(\mathrm{~F})$ |
| Protex | $297.5(\mathrm{~A})$ | $5057.5(\mathrm{~F})$ | $4760(\mathrm{~F})$ |
| Benz | $262.5(\mathrm{~A})$ | $3937.5(\mathrm{~A})$ | $4200(\mathrm{~A})$ |
| CT -40 | $\underline{105.0}(\mathrm{~A})$ | $\underline{315}(\mathrm{~A})$ | $\underline{420}(\mathrm{~A})$ |
|  | $945.0(\mathrm{~A})$ | $3885(\mathrm{~F})$ | $\underline{2940}(\mathrm{~F})$ |

## QUESTION FIVE

## Garnet Ltd.

Let t be the month for which forecast is required so
that; to $=$ current month
$\mathrm{t} 1=$ next month
$\mathrm{t}-1=$ previous month
Let S be the sales for the current month
The equations for use in the cash budgeting model are as follows:

$$
\text { Sales }=\mathrm{S}(1.01)^{\mathrm{t}}
$$

Costs of sales $=0.75 \mathrm{~S}$ (gross profit margin $=331 / 3 \%$ on cost of sales; therefore cost of sales $=75 \%$ of sales)
Cash collections t months from now;
$\left.0.2 \mathrm{~S}(1.01)^{\mathrm{t}}+0.8\left[0.2 \mathrm{~S}(1.01)^{\mathrm{t}-1}\right]+0.8\left[0.6 \mathrm{~S}(1.01)^{\mathrm{t}-2}\right]+0.8[0.2 \mathrm{~S} 1.01)^{\mathrm{t}-3}\right]$
Purchases t months from now;

$$
0.75 \mathrm{~S}(1.01)^{\mathrm{t}+2}
$$

Payments for purchases $t$ months from now;

$$
0.75 \mathrm{~S}(1.01)^{\mathrm{t}+1}
$$

Payments for expenses $t$ months from now;

$$
0.05 \mathrm{~S}(1.01)^{\mathrm{t}-1}+3000+10,000
$$

S for June $=£ 100,000$
$t=3$ (month of September is $t+3$ month from June)
Collections during September:
$0.2 \mathrm{~S}(1.01)^{\mathrm{t}}+0.8\left[0.2 \mathrm{~S}(1.01)^{\mathrm{t}-1}\right]+0.8\left[0.6 \mathrm{~S}(1.01)^{\mathrm{t}-2}\right]+0.8\left[0.2 \mathrm{~S}(1.01)^{\mathrm{t}-3}\right]$

$$
\begin{aligned}
= & 0.2\left(100,000(1.01)^{3}+0.8(0.2)(100,000)(1.01)^{2}+0.8(0.6)(100,000)\right. \\
(1.01) & +0.8(0.2)(100,000) \\
= & £ 20606+£ 16,322+£ 48,480+£ 16,000 \\
= & £ 101,408
\end{aligned}
$$

Payments for purchases during September;

$$
0.75 \mathrm{~S}(1.01)^{\mathrm{t}+1}=0.75(100,000)(1.01)^{4}=£ 78045
$$

Payments for expenses during September;

$$
\begin{aligned}
& =0.05 \mathrm{~S}(1.01)^{2}+3000+10,000 \\
& =£ 5100+£ 3000+£ 10,000=£ 18,100
\end{aligned}
$$

The cash flow statement for September is as follows:

|  | f |  |
| :--- | ---: | ---: |
| Receipts from sales |  | 101,408 |
| Payments; Purchases | 5,045 |  |
| Payroll | 3,100 |  |
| Utilities | $\underline{10,000}$ | $\underline{96,145}$ |
| Other costs |  | $\underline{5,263}$ |

The following procedures can be applied to incorporate uncertainty;
Sensitivity analysis e.g. by "what if?" analysis,
Expected values
Simulation

## LESSON 7

## QUESTION ONE

(a) In general, given that the customer did not pay his bill in month $n$, the probability that he will not pay his bill in month $n+1$ is $p\left(N P_{n+1} \mid N P_{n}\right)=20$, (where, NP denotes Not Pay).

Thus, the probability that the customer will not pay his bill in any of the next three months
is: $\mathrm{P}\left(\mathrm{NP}_{1}, \mathrm{NP}_{2}, \mathrm{NP}_{3}\right)=(0.20)(0.20)(0.20)=0.008$
(b) Given that the customer did not pay his bill in month $n$, what are the probabilities of bill payment in each of the months $n+1, n+2, n+3$ ?

Month $\mathrm{n}+1$ :
$\left[\begin{array}{ll}0.0 & 1.0\end{array}\right]\left[\begin{array}{ll}.70 & -10 \\ .80 & .20\end{array}\right]=\left[\begin{array}{ll}.80 & .20\end{array}\right]$
$\mathrm{P}($ Payment in month $\mathrm{n}+1)=.80$
Month $\mathrm{n}+2$ :
[0.80 .20]

$=\quad\left[\begin{array}{ll}.88 & .12\end{array}\right]$
$\mathrm{P}($ Payment in month $\mathrm{n}+2)=.88$

## Month $\mathrm{n}+3$ :

[0.88 .12]

$=\quad\left[\begin{array}{ll}.89 & .11\end{array}\right]$
$\mathrm{P}($ Payment in month $\mathrm{n}+3)=.89$
(c) Steady State Conditions:
$\left.\left[\Pi_{1}, \Pi_{2}\right]=\left[\Pi_{1}, \Pi_{2}\right] \quad \begin{array}{rr}.90 & .10 \\ .80 & .20\end{array}\right]$
$\Pi_{1}=.90 \pi_{1}+.80 \pi_{2}$
$\Pi_{2}=.10 \pi_{1}+.20 \pi_{2} \leftarrow \quad$ eliminate
$\Pi_{1}+\Pi_{2}=1.0$
$-.10 \pi_{1}+.80 \Pi_{2}=0$
$\Pi_{1}+\Pi_{2}=1.0$

Since,

$$
\begin{aligned}
& -.10 \pi_{1}=-.80 \pi_{2} \\
& \Pi_{1}=8 \pi_{2}
\end{aligned}
$$

Substituting:

$$
\begin{aligned}
& 8 \pi_{2}=\Pi_{2}=1.0 \\
& 9 \pi_{2}=1 \\
& \Pi_{2}=1 / 9=.111
\end{aligned}
$$

and,
$\pi_{1}=8 \pi_{2}$
$\pi_{1}=8(.111)$
$\Pi_{1}=.888$
$\left[\Pi_{1}, \Pi_{2}\right] \quad=\quad\left[\begin{array}{ll}.89 & .11\end{array}\right]$
QUESTION TWO

$$
\begin{aligned}
& \text { P.P }=\mathrm{P}^{2}=\left(\begin{array}{lll} 
& & - \\
.5 & .3 & .2 \\
.1 & .7 & .2 \\
.1 & .1 & .8
\end{array}\right)\left(\begin{array}{lll}
.5 & .3 & .2 \\
.1 & .7 & .2 \\
.1 & .1 & .8
\end{array}\right. \\
& \mathrm{P}^{2}= \\
& \left(\begin{array}{lll}
.30 & .38 & .32 \\
.15 & .54 & .31 \\
.14 & .18 & .68
\end{array}\right) \\
& \mathrm{P}^{3}=\mathrm{P} . \mathrm{P}^{2}=\left(\begin{array}{lll} 
& & \\
.30 & .38 & .32 \\
.15 & .54 & .31 \\
.14 & .18 & .68 \\
. & .1 & .3 \\
.1 & .2 \\
. & .8 \\
\hline
\end{array}\right.
\end{aligned}
$$

| $\mathrm{P}_{3}=$ | . . .160 .156 | .388 .454 .236 | - |  |
| :---: | :---: | :---: | :---: | :---: |
| [3000 5000 2010] |  | .220 .160 .156 | .388 .454 .236 | $\begin{array}{r}\text { - } \\ .392 \\ .386 \\ .608 \\ \hline\end{array}$ |
| $=$ | [1772 | 3906 | 4322] |  |

(b)

| $\left[\Pi_{1}, \Pi_{2}, \Pi_{3},\right]=\left[\Pi_{1}, \Pi_{2}, \Pi_{3}\right]$ |  |  |  |  | .5 .1 .1 | .3 .7 .1 | - <br> . <br> . <br> .8 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\pi{ }_{1}$ | $=$ | . 5 m 1 | + | . $1 \Pi_{2}$ | + | . $1 \pi_{3}$ |  |
| $\Pi_{2}$ | $=$ | . 3 T1 | + | . $7 \mathrm{~T}_{2}$ | + | . $1 \pi_{3}$ |  |
| $\pi 3$ | $=$ | . 2 m 1 | + | . $2 \Pi_{2}$ | + | . 8 T3 | $\leftarrow$ Eliminate |
| $\pi 1$ | $+$ | $\Pi_{2}$ | + | $\pi 3$ | $=$ | 1.0 |  |
| -. 5 T | $+$ | . $1 \Pi_{2}$ | + | . $1 \pi_{3}$ | $=$ | 0 | [1] |
| . 3 T | - | . $3 \mathrm{~T}_{2}$ | + | . $1 \Pi_{3}$ | $=$ | 0 | [2] |
| $\pi{ }_{1}$ | $+$ | $\Pi{ }_{2}$ | + | $\Pi_{3}$ | = | 1.0 | [3] |

## Equation

$[1] \quad .5 \Pi_{1}+.1 \Pi_{2}+.1 \Pi_{3}=0 \quad-.5 \pi_{1}+.1 \Pi_{2}+.1 \Pi_{3}=0$
[2] $.3 \pi_{1}-.3 \Pi_{2}+.1 \pi_{3}=0 \rightarrow-.3 \pi_{1}+.3 \pi_{2}-.1 \Pi_{3}=0$

$$
-.8 \pi_{1}+.4 \pi_{2} \quad=0[\mathrm{~A}]
$$

[3] $\Pi_{1}+\Pi_{2}+\Pi_{3}=1.0 \quad-.1 \Pi_{1}+.1 \Pi_{2}+.1 \Pi_{3}=.1$
[2] $.3 \Pi_{1}-.3 \Pi_{2}+.1 \Pi_{3}=0 \rightarrow-.3 \Pi_{1}+.3 \Pi_{2}-.1 \Pi_{3}=0$
$-.2 \Pi_{1}+.4 \Pi_{2}=.1[B]$

## Equation

[A] $-.8 \pi_{1}+.4 \pi_{2}=0$
[B] $-.2 \pi_{1}+.4 \pi_{2}=.1 \rightarrow$

| $-.8 \Pi_{1}+$ | . $4 \Pi_{2}$ | $=$ | 0 |
| :---: | :---: | :---: | :---: |
| $+.2 \Pi_{1}-$ | . $4 \mathrm{~T}_{2}$ | $=$ | -. 1 |
| $-.6 \pi_{1}$ |  | $=$ | -. 1 |
| $\Pi_{1}=$ | 1/6 | = | . 167 |

and,
[A] $-.8(.167)+.4 \Pi_{2}=0$
$.4 \pi_{2}=.134$
$\Pi_{2}=.335$
and,

$$
\text { [3] } \begin{array}{lllll}
\Pi_{1}+\Pi_{2}+\Pi_{3} & =1.0 \\
.167+.335+ & \Pi_{3} & =1.0 \\
& & \Pi_{3} & =.498
\end{array}
$$

therefore, $\pi=\left[\begin{array}{ll}167 & .335 \\ .498\end{array}\right]$, the steady state vector

To determine steady state enrolments in each college multiply each probability by 10,000 :

$$
\begin{array}{ll}
\Pi_{1} & =1670 \\
\Pi_{2} & =3350 \\
\Pi_{3} & =4980
\end{array}
$$

## QUESTION THREE

\[

\]

$\Pi_{1}-\Pi_{2}=1.0$

| $-.7 \Pi_{1}+.8 \Pi_{2}$ | $=0$ |
| ---: | :--- |
| $-.8 \Pi_{1}-.8 \Pi_{2}$ | $=-.8$ |
| $-.15 \Pi_{1}$ | $=-.8$ |
| $\Pi_{1}=8 / 15$ | $=.533$ |
| $\Pi_{1}+\Pi_{2}$ | $=1.0$ |
| $.533+\Pi_{2}$ | $=1.0$ |
| $\Pi_{2}$ | $=.47$ |
| $\Pi$ | $=[.533 .47]$ |

## LESSON 8

## QUESTION ONE

REQUIREMENT A

| Division <br> B's output (units) | B's Own <br> Processin g Costs | A's Charge to B for intermediate <br> s | B's Total costs | B's Revenue <br> (Net of selling Costs) per 1,000 units | B's <br> Total revenue | B's Net income |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| (1) | (2) | (3) | (4) $(2)+(3)$ | (5) | $\begin{gathered} (6) \\ (1) \times(5) \\ \hline \end{gathered}$ | $\begin{gathered} (7) \\ (6)-(4) \end{gathered}$ |
|  | Shs | Shs | Shs | Shs | Shs | Shs |
| 1,000 | 37,500 | 12,000 | 49,500 | 52,500 | 52,500 | 3,000 |
| 2,000 | 45,000 | 24,000 | 69,000 | 39,750 | 79,500 | 10,500 |
| 3,000 | 52,500 | 36,000 | 88,500 | 33,000 | 99,000 | 10,500 |
| 4,000 | 60,000 | 48,000 | 108,000 | 27,750 | 111,000 | 3,000 |
| 5,000 | 67,500 | 60,000 | 127,500 | 24,000 | 120,000 | $(7,500)$ |
| 6,000 | 75,000 | 72,000 | 147,500 | 19,980 | 119,880 | $(27,120)$ |

B. The most profitable policy for Division B, in the circumstances, is to set its output at either 2,000 or 3,000 units a day and to accept a profit of Shs 10,500 a day. If its output is more than 3,000 or less than 2,000 it will make even less profit.

With Division B taking 3,000 units a day from it, Division A's revenue, at Shs 12 per unit $=$ Shs 36,000 and its total costs $=$ Shs 21,000. Therefore, A's separate profit is Shs 15,000 .
C.

| Output <br> (units) | Cost of <br> Producing <br> intermediates | Cost of <br> processing to <br> completion | Total Costs | Total <br> revenue | Net <br> income |
| ---: | :---: | :---: | ---: | ---: | ---: |
| $(1)$ | $(2)$ | $(3)$ | $(4)$ | $(5)$ | $(6)$ |
| Shs | Shs | Shs | Shs | Shs |  |
| 1,000 | 15,000 | 37,500 | 52,500 | 52,500 | $-79,500$ |
| 2,000 | 18,000 | 45,000 | 63,000 | 16,500 |  |
| 3,000 | 21,000 | 52,500 | 72,500 | 99,000 | 25,500 |
| 4,000 | 24,000 | 60,000 | 84,000 | 111,000 | 27,000 |
| 5,000 | 27,000 | 67,500 | 94,500 | 120,000 | 25,500 |
| 6,000 | 30,000 | 75,500 | 105,000 | 120,000 | 15,000 |

A single profit centre will operate more profitably than the two divisions formally did. By making and selling 4,000 units a day it can earn a profit of Shs 27,000 or Shs 1,500 a day in excess of the best result achieved by the combined activities of Divisions A and B.
D. "The company is seen to have been paying a price for the luxury of divisionalization. By suboptimizing (i.e. by seeking maximum profits for themselves as separate entities), the divisions have caused the corporation to less than optimize its profits as a whole. The reason was of course, that Division B reacted to the transfer price of Shs 12 a unit by restricting both its demand for the intermediate and its own output of the finished product. By making for itself the best of a bad job, it created an unsatisfactory situation for the company. But who can blame it? Assuming that the instructions to $B$ were to maximize the division's separate profit, it did just that, given the conditions confronting it. Yet it is not fair to blame that division either, for it too was only carrying out instructions in seeking to maximize its own profit; and a transfer price of Shs 12, while it leads to a less than optimal result for the corporation, does maximize A's own profit.
"One further feature of this illustration is worth nothing. So far as its own profit was concerned, it was a matter of indifference to Divison B whether it sold 2,000 or 3,000 units. We assumed that it decided to sell 3,000 . If it had chosen to sell only 2,000 , its own profit would have been unaffected, while A's profit would have been cut from 15,000 to 6,000 , so that the corporate profit would have been diminished by Shs 9,000. In a situation like this, negotiations about the price between A and B would probably have prevented this further damage to the corporation resulting from suboptimization. But it is unlikely that the divisions, left to themselves, would arrive at an optimal solution from the corporate point of view.
"The management of the single profit centre arrived at the conclusion that 4,000 units was its optimal output through comparison of incremental costs with incremental revenue for each prospective addition to output. Pushing output beyond 4,000 did not pay because an extra 1,000 units would have added Shs 10,500 to costs while adding only Shs 9,000 to revenues. The fact that incremental costs are made up of two parts (the cost of producing the intermediate product and the cost of processing it to completion) does not affect the result. Nor, from the point of view of the firm as a whole, should the result be affected if responsibility for the two operations happens to be split between two responsibility centres.
"The second responsibility centre (second, that is, in the chain of processes) can only do what is best for the company when deciding how much of the first division's production to take if it has knowledge of the other division's incremental costs. Leaving these decisions to divisions to work out for themselves implies that transferor divisions should offer their products to other responsibility centers at a figure not in excess of the incremental cost of producing them.
"This result appears to be a very far cry from the most common basis for fixing transfer prices, namely, the price of the transferred product on the outside market, provided the product, in fact, has an outside market. Actually, however, a close examination will show that if the transferred product can be bought and sold in a competitive market, the 'incremental cost' rule and the 'market price' rule for the transfer pricing are not in conflict.
"If there really is a competitive market for the transferred products, a transferee division can satisfy its needs for intermediate products by buying them outside at the going price. It will be in the company's interest that should do so to prevent another division from incurring incremental costs of a greater amount in supplying the intermediate. To do otherwise would cause the company to incur a greater cost in production of the intermediate than in buying it. If the transfer price of the intermediate is set at its market price, the transferor division can supply as much as it wishes (which will be as much as it can produce without incurring incremental costs in excess of the price it will get), leaving the transferee division to acquire any additional supplies it may need by outside purchase. Alternatively, the transferor division may be able and willing to supply more of the intermediate at the market price than the consuming division can use. In that case, the correct course is for the supplying division to go on producing so long as its incremental cost is below the market price. It can sell on the market any output not taken by the other division."
A. General Manager's Remuneration

| Region 3 | 1990 |  | 1991 |
| :---: | :---: | :---: | :---: |
|  | $£ 000$ |  | £000 |
| Basic salary | 18,000 |  | 19,000 |
| Sales Bonus: |  |  |  |
| $£ 2,400-2,250 \times 0.75 \%$ | 1,125 | $£ 2,750-2,700 \times 0.75 \%$ | 375 |
| ROCE bonus: |  |  |  |
| $\underline{123}=6.65 \%$ |  | $\underline{147}=6.50 \%$ |  |
| 1,850 |  | 2,260 |  |
| $2 \%$ of $£ 1,850,000 \times 6.65 \%$ | 2,460 | $3 \%$ of $£ 2,260,000 \times 6.50 \%$ | 4,407 |
|  | 21,585 |  | 23,782 |
| Region 7 | 1990 |  | 1991 |
|  | £000 |  | $£ 000$ |
| Basic salary | 22,000 |  | 22,000 |
| Sales Bonus: |  |  |  |
| £ $3,700-3,400 \times 0.75 \%$ | 2,250 | £3,600-3,600 x 0.75\% | - |
| ROCE bonus: |  |  |  |
| $\underline{166}=5.93 \%$ |  | $\underline{241}=8.31 \%$ |  |
| 2,800 |  | 2,900 |  |
| $3 \%$ of $£ 2,800,000 \times 5.93 \%$ | 4,981 | $3 \%$ of $£ 2,900,000 \times 8.31 \%$ | 7,230 |
|  | 29,231 |  | 29,230 |

Region 3 General Manager's remuneration increases by $£_{2}, 197$.
Region 7 General Manager remuneration reduces by $£ 1$.
Consideration of the appropriateness of the reward to the general managers. The significant figures are:

|  | Region 3 | Region 7 |
| :---: | :---: | :---: |
| 1991v 1990 | 1991 v 1990 |  |
| Sales | $+14.6 \%$ | $-2.7 \%$ |


| Expenses | $+6.3 \%$ | $+3.0 \%$ |
| :--- | :---: | :---: |
| Profit | $+19.5 \%$ | $+45.2 \%$ |
| Gross profit/sales | $-1.0 \%$ | $+3.0 \%$ |
| Investment | $+22.2 \%$ | $+3.6 \%$ |
|  | (now over $£ 2$ million) |  |
| ROCE | $-2.3 \%$ | $+40.1 \%$ |
| Sales/Target sales | $1990+6.7 \%$ | $1990+8.8 \%$ |
|  | $1991+1.9 \%$ | $1991-$ |
| Remuneration | $+10.2 \%$ | Slightly negative |

b. Relative performance 1991 v 1990

## Region 3

The general manager is expected to exceed his sales target, but by a smaller margin than in 1990. His return on capital employed is lower than in 1990. However, capital employed will grow in the year so that by year-end the book value will exceed $£ 2$ million. At this level bonus increases from $2 \%$ to $3 \%$.

## Region 7

The general manager is only expected to just reach his sales target in 1991 whereas he exceeded it in 1990. However his return on investment is expected to improve by over $40 \%$ mainly due to a lower cost of sales/sales ratio and a lower proportionate increase in his expenses.

Overall, I do not consider the changes in the remuneration are appropriate rewards for the results expected in 1991.

## Region 3

general manager will receive a $10 \%$ increase. Half of this is due to the service increment of $£ 1,000$ and the remainder to the responsibility of handling a higher investment. Performance related to beating the sales target and ROCE are expected to be poorer than in 1990.

Region 7 general manager is expected to be slightly worse remunerated than in 1990. he has reached his maximum salary and probably based on his age is not expected to exceed his sales target. However, his experience appears to enable him to reduce expenses to give a greatly improved ROCE. The bonus for this does not completely offset his static sales performance. As ROCE should be a main criterion of performance this good work deserves a better remuneration.

Ignoring inflation an increase of $5 \%$ for Region 3 to reward experience and responsibility and $10 \%$ for Region 7 for probability would seem more appropriate.
c. Recommended changes in remuneration Basic
salary - company service and responsibility
The basic salary with ten annual increments of $£ 1,000$ each based entirely on length of service is likely to lead to dissatisfaction between managers. For example, when a manager of ten year's service is replaced by a newcomer, the incoming manager's salary will only be $55 \%$ of his predecessors.

Smaller increment for service could be offset by a salary increment based on responsibility. This could be the size of the operation measured by investment in each depot. Thus, if the service element was limited to a $25 \%$ salary differential ( $£ 3,000$ ), then $£ 7,000$ could be available for 'responsibility'. A proposed allocation could be $£ 1,000$ for each $£ 0.5$ million investment, so that the $£ 7,000$ would be received at an investment level of $£ 3.5$ million.

## Bonus - sales.

A bonus based on exceeding a pre-set sales target is a good method of rewarding performance. However, it does not seem satisfactory to have this based on the value of the vehicles operated by the region. First the 'value' is the written-down book value which in itself leads to anomalies according to the age of the vehicles. a first major improvement would be to relate these to replacement cost. The replacement cost for the vehicle should be readily available.

A much more understandable sales target should be set for each region based on the potential business available in that area.

Bonus - return on capital employed

This is the ultimate test of effectiveness and should again be judged on performance against a preset target. This will encourage the managers to operate their vehicles as cost effectively as possible in the handling of the available traffic. Where a nationwide service is offered, many company policies are established which affect each region differently. For example:
'providing an overnight service'—this might be well-used in some regions, but sparsely used in others.
`accepting business from large manufacturers at national rates'-these rates tend to be averaged for the whole country and again may be more profitable in one region than another.

As a good basis, therefore, the budget preparation needs to be done carefully with a full analysis of the likely business, available vehicles and staff requirements. The resulting expected profit can the be set against the required investment. Returns on capital employed will vary between regions, but should average to an acceptable overall figure for the company. It is against these target returns for the regions that each manager's performance should be measured. The bonus should be a straight percentage based on the improved return. The present differential relating to investment above or below the $£_{2}^{2}$ million level should be eliminated. the single step at $£_{2}$ million is too blunt an incentive and may encourage unnecessary investment just to get above the figures.

Thus the general manager would be more fairly rewarded by:

- Basic salary to reflect company loyalty and also responsibility based on the total assets entrusted to the manager.
- Bonus based:
i. on achieving above target sales, and
ii. at undertaking these sales cost effectively to achieve above target return on capital employed.


## LESSON 9

a. Whereas traditional incremental budgeting uses last year's budget as a starting point, zero-base budgeting $\quad(\mathrm{ZBB})$ theoretically starts from zero and makes it more likely that expenditure is justified. Thus, in the energy area the starting point is zero energy costs and increments justified stage by stage. For example, the first stage may be legally determined, i.e. to maintain the statutory workplace temperature. ZBB provides a systematic way of focusing attention on various facets of energy expenditure.
b. Total Quality Management (TQM) is an approach, which emphasises such things as: waste elimination
minimising cost
zero defects at lowest cost;
elimination of non-value added activities, and so on.

TQM is thus another systematic way of focusing attention on waste elimination, improving productivity. Energy related examples include: alternative ways of producing heat or insulating premises; reduction of movements to save energy; elimination of heat losses etc.

## Calton Ltd.

a. (i) Production units required before inspection process

| Perfect units required | Current situation units |  |  | With TQM procedures units |
| :---: | :---: | :---: | :---: | :---: |
|  |  | 5,000 |  | 5,000 |
| Returns from customers | (5\%) | 250 | (2.5\%) | 125 |
|  |  | 5,250 |  | 5,125 |
| Inspection process rejections | (12.5/87.5) | 750 | (7.5/92.5) | 416 |
| Units required before inspection |  | 6,000 |  | 5,541 |

(ii) Purchase of material X

|  |  |  | Sq m |  |
| :--- | :--- | :---: | :---: | :---: |
| Material in inspected units | $(6000 \times 8 \mathrm{sq} \mathrm{m})$ | 48,000 | $(5,541 \times 8 \mathrm{sq} \mathrm{m})$ | 44,328 |
| Losses due to processing faults | $(4 / 96)$ | $\underline{2,000}$ | $(2.5 / 97.5)$ | $\underline{1,137}$ |
| Process input required |  | 50,000 |  | 45,465 |
| Losses in stores and receiving | $(5 / 95)$ | 2,632 | $(3 / 97)$ | 1,406 |
| Purchases of material X | $\underline{52,632}$ |  | $\overline{48,871}$ |  |

required
Gross machine hours

| Hours for perfect | (6, |  | (5,541 $\times 0.5)$ | Hours |
| :---: | :---: | :---: | :---: | :---: |
| Rectifying hours | $(250 \times 80 \% \times 0.2)$ | 3,600 40 | $(125 \times 80 \% \times 0.2)$ | $\begin{array}{r}2,71 \\ \hline\end{array}$ |
| Operating hours required |  | 3,640 |  | 2,791 |
| Idle time | (20/80) | 910 | (12.5/87.5) | 399 |
| Gross machine hours requ |  | 4,550 |  | 3,190 |

## CALTON LTD

PROFIT AND LOSS ACCOUNT

|  | Current situation |  |  | With TQM procedures |
| :---: | :---: | :---: | :---: | :---: |
|  |  | £ |  | £ |
| Sales income: |  |  |  |  |
| Perfect units | (5,000 x £.100) | 500,000 |  | 500,000 |
| Second quality units | (750 x $£ 70$ ) | 52,500 | (416x $£^{70}$ ) | 29,120 |
| Third quality units | (200 x $£ 50$ ) | 10,000 | (100 x £ 50) | 5,000 |
| Scrap | (50x $£ 5$ ) | 250 | ( $25 \times £ 5$ ) | 125 |
| Total sales income |  | 562,750 |  | 534,245 |
| Costs | Current situation |  |  | With TQM procedures |
|  |  | $\stackrel{f}{210} 528$ |  | $\stackrel{\smile}{187.484}_{£}$ |
| Material X | $\begin{aligned} & \left(52,632 \times £^{4}\right) \\ & (52,632 \times(0.10) \end{aligned}$ | 210,528 5,263 | $\begin{aligned} & \left(46,871 \times £^{4}\right) \\ & (46,871 \times 0.10) \end{aligned}$ | 187,484 4,687 |
| Machine costs | ( $4,550 \times \mathrm{f}$, 40 ) | 182,000 | ( $3,190 \times$ ¢ 40 ) | 127,600 |
| Delivery costs for replacement | ( 250 x £ 8 ) | 2,000 | (125 x £ \% ) | 1,000 |
| Inspection, vendor vetting etc |  | 25,000 | (x 60\%) | 15,000 |
| Product liability insurance etc | ( $3 \% \times 500,000$ ) | 15,000 | (1\% x 500,000) | 5,000 |
| Selling, distn and admin |  | 60,000 | ( $\mathrm{x} 90 \%$ ) | 54,000 |
| Prevention |  | 20,000 |  | 60,000 |
| programme |  |  |  |  |
|  |  | 519,791 |  | 454,771 |
| Monthly profit |  | 42,959 |  | 72,474 |

The TQM programme will nearly double Calton's profits, the margin savings arising due to a reduction in material costs and machine costs. The TQM procedures concentrate on establishing management responsibility for each part of the internal process as well as for outputs. Every person in the organisation is expected to contribute to quality improvement and this can have a favourable impact on employee morale. The advantages are obvious in the substantial increase in Calton's profits, although the large fixed cost investment in the prevention programme can be risky if the projected quality improvements do not materialise.
Quality related costs can be classified as prevention cost, appraisal cost, internal and external failure cost.

## Internal failure cost

The CIMA defines this as 'the cost arising from inadequate quality before the transfer of ownership from supplier to purchaser.' Examples from Calton's situation include the cost of material scrapped due to inefficiencies in goods receiving procedures and in stores control, the cost of material lost in process and the cost of units rejected during the inspection process.

## (ii) External failure cost

The CIMA defines this as 'the cost arising from inadequate quality discovered after the transfer ofownership from supplier to purchaser.....'Examples from Calton's situation include the cost of product liability claims from customers and the cost of replacing and delivering returned units.
(iii) Appraisal cost

The CIMA defines this as 'the cost incurred, such as inspection and testing in initially ascertaining the conformance of the product to quality requirements.' Examples from
Calton's situation include the inspection and calibration procedures and vendor vetting
(iv) Prevention cost

The CIMA defines this as 'the cost incurred to reduce appraisal cost to a minimum.' These costs are incurred to try and improve the efficiency of checking procedures. A common example is the cost of training personnel in TQM procedures

Bushworks Ltd
a.

| Elimination of synthetic stocks | £ | £ |
| :---: | :---: | :---: |
| Stores losses ( $68,711 \times £ 1 / 100)$ |  | (687) |
| Goods inwards checks (given) |  | 14,000 |
| Savings on purchase quantity $(2,748,450-2,090,651) \times(£, 40 / 100)$ |  | 263,120 |
| Increased price (2,090,651 $\times\left(\left(£_{4} 44-£ 40\right) / 100\right)$ |  | $(83,626)$ |
| Curing/moulding costs |  |  |
| Variable costs (2,679,739-2,090,651) x $£ 20 / 100$ |  | 117,818 |
| Scrap sales forgone (267,974-20,907) x $£ 5 / 100$ |  | $(12,353)$ |

## Finishing process cost reduction

Variable cost
Existing cost (AX) (964,706 $\times$ £,15/100) 144,706
Existing cost (BX) $(1,447,059 \times £ 25 / 100) 361,765$
Less
Amended cost (AX) $(826,667 \times £ 12 / 100)$
Amended cost (BX) (1,243,077 x $£ 20 / 100)$
Scrap sales forgone
(144,706 + 217,059-20,677-31,077) x £10/100
Finished goods stock
Holding costs
$((15,000+30,000)-(500+1,000)) \times £, 15 / 1,000$

Cost of quality management programme

## b. Internal failure costs

Are costs arising within an organisation due to failure to achieve the quality specified. Examples in the question are the losses in the curing process and the finishing process, and the losses in stores.

External failure costs are costs arising outside the manufacturing organisation of failure to achieve specified quality after transfer of ownership to the customer. Thus the components that are returned by customers are examples.

Appraisal costs are the costs of assessing quality achieved. Examples are the goods inwards checks, the detection of flawed sub-components due to incorrect temperature and the detection of defective units following the finishing process.
Prevention costs represent the cost of any action taken to investigate, prevent or reduce defects and failures. Examples in the question are the JIT agreement, the improved temperature control procedures aimed at reducing the number of losses and the introduction of cellular manufacturing in finishing.

## TQM AND STANDARD COSTING

There are a number of reasons why it may be argued that, in total quality environment, variance analysis from a standard costing system is redundant.
The ethos behind a system of standard costing is that performance is satisfactory if it meets
predetermined standards. This is at odds with the philosophy of continual improvement inherent in a total quality environment.
For standard costing to be useful for control purposes, it requires a reasonably stable environment.
Products or processes must be standardised and repetitive, so that standards can be established which will be useful for monitoring and control. In a total quality environment, however, continual improvements are likely to alter prices, quantities of inputs and so on.
Standard costs often incorporate a planned level of scrap in material standards. This is at odds with the TQM aim of zero defects and there is no motivation to 'get it right first time.'
Although ideal standards can be set (no wastage, no spoilage, no inefficiencies, no idle time, no breakdowns), attainable standards, which make some allowance for wastage and inefficiencies, are common. The use of such standards conflicts with the elimination of waste which is a vital ingredient of a TQM programme.
The control aspect of standard costing systems is achieved by making individual managers responsible for the variances relating to their part of the organisation's activities. A TQM programme, on the other hand, aims to make all personnel aware of, and responsible for, the importance of supplying the customer with a quality product.
It is these differences between the aims and ideas of standard costing and those of TQM which mean that variance analysis from a standard costing system is redundant in a total quality environment.
A system of standard costing analyses labour efficiency by comparing the standard labour input for the actual output achieved with the actual output. Standard costing therefore concentrates on quantity and ignores other factors contributing to effectiveness.

In a total quality environment, quantity is not an issue, however; quality is. Effectiveness in such an environment therefore centres on high quality output (produced as a result of high quality input and the elimination of non-value adding activities) and the cost of failing to achieve the required level of effectiveness is measured in terms of internal and external failure costs.

An internal failure cost might be the costs of re-inspecting items after they have been reworked due to poor quality workmanship.
An external failure cost might be the cost of repairing products returned from customers.
Neither of these costs would be identified by a traditional standard costing analysis of labour efficiency and effectiveness but are vital measures in a TQM environment.
Standard costing systems tend to measure labour efficiency in terms of individual tasks but, in a total quality environment, labour is more likely to be viewed as a number of multi-task teams who are responsible for the completion of a part of the production process. The effectiveness of such a team is more appropriately
measured, not in terms of output, but in terms of re-working required, returns from customers, defects identified in subsequent stages of production and so on.
TRITEX PLC
Calculation of missing values for 'product units' cells
To get one unit of a process that suffers losses it is necessary to put more than one unit in.
The Finishing process must have as its end result 1.0000 unit (100\%), so that input must be $100 \% /(100 \%-70 \%)=100 / 93=1.0753$ units.

The Converting process must have as its end result 1.0753 units, so the input must be $107.53 \% /(100 \%-13 \%)=107.53 / 87=1.2360$ units.

The Making process must have as its end result 1.2360 units, so the inputs must be $123.6 \% /(100 \%-9 \%)=123.6 / 91=1.3582$ units.

Calculation of missing values for 'cost' cells

$$
\begin{aligned}
\text { Raw material cost } & =\text { units input to Making process } \times \mathrm{m}^{2} \text { per unit } \mathrm{x} \text { rate per } \mathrm{m}^{2} \\
& =1.3582 \text { units } \times 6.72 \mathrm{~m}^{2} \times £_{0} 0.85 \\
& =£ 7.758 \\
& =\text { units of output from Making process } \mathrm{x} \text { hours per unit } \mathrm{x} \text { rate per hour } \\
& =1.2360 \text { units } \times 0.142 \mathrm{hrs} \times £^{2} 4.75 \\
& =£ 0.834 \\
& =\text { units of output from Making process } \mathrm{x} \text { net processing hours per unit } \mathrm{x} \\
& \quad \text { average rate per net processing hour } \\
\text { Overheads } & =1.2360 \times 0.125 \mathrm{hrs} \times 7 \\
& =£ 1.082 \\
\text { Sub-total Making cost } & =£(7.758+0.834+1.082) \\
& =£ 9.674
\end{aligned}
$$

Calculation of missing value for 'WIP value per unit'
WIP value is the cost of the input units to the Making process divided by the output units $=£ 9.674 \div 1.236$ $=£ 7.827$
At present, the company inputs around $12 \%$ more raw materials than specified by the control standard and pays $£ 0.05$ more per square metre for those raw materials. The company is possibly using higher quality raw material, but any advantage from this is wasted because of losses in the Making process of $9 \%$ as opposed to only $5 \%$ in the control standard. These losses may be due to lack of motivation in employees, poor training for employees, an emphasis on speed of throughput as opposed to quality and so on.

Labour hours are also higher: the company takes 0.142 hours compared with a control standard of 0.108 hours to produce one unit.

Idle time is $12 \%$ of total labour hours $((0.142-0.125) / 0.142)$. The control standard requires that this should be $8 \%$ however. This implies that there is a certain amount of inefficiency at Tritex plc. The actual labour rate is 25 p lower than the control standard. Possibly the company employs less highly skilled labour: this would account for some of the losses and inefficiencies.

Overheads are also incurred at a higher rate than stipulated by the control standard ( $£ 7.00$ as opposed to $£ 6.32$ ). This could be caused by inefficiency in the sourcing of overhead items. Moreover, overheads are absorbed on the basis of processing time, which is higher than set out in the control standard.

Losses in subsequent processes are much higher than required by the control standard, implying that insufficient care is taken to control the Converting and Finishing processes.

Overall, the result is that the actual WIP unit cost of Product A is nearly $£ 1.60$ more than that stipulated by the control standard.

The implementation of total quality management (TQM) involves establishing a programme of continuous improvement with the aim of producing zero defects, supplying high quality products and eliminating waste and non-value-added activities.
TQM has had the following impact on the standard cost of Product A.
The control standard cost is clearly not the ideal since the results reckoned to be achieved following the quality drive give a further reduction in unit cost of over 16p, and it looks as if the end product will be of a better standard.
Losses in the Making and Finishing processes are reduced to just $1 \%$ and in the Converting process to $2.5 \%$, indicating a move towards zero defects and the elimination of waste.
Although raw materials input are the same under both the control standard and the $\mathrm{ABC} / \mathrm{TQM}$ standard, the cost of the raw materials per $\mathrm{m}^{2}$ to be used following the implementation of the TQM programme is 10 p higher. This is likely to lead to less wastage and give a much higher quality end product, possibly one that can be sold at a premium price.
Labour time has been reduced by 0.13 hours per unit. The question implies that there is now no idle time: employees are employed on other tasks intended to improve the efficiency of overall operations. As a result the labour rate has increased from $£ 5$ to $£ 6$, so workers not only have more varied and interesting jobs but also earn more. The reduction in idle time means that the overall labour cost is still lower than that required by the control standard.
Overheads are now absorbed on a different basis. The figures indicate that this product was formerly overcharged, since the cost has reduced from over 70p to about 37 p . The change in cost driver is thought to result in a $30 \%$ reduction in overhead cost and so the figures can be further analysed as follows.

|  | $£_{0}$ |
| :--- | ---: |
| Control standard overheads $(0.1$ hrs $\times 6.32)$ | 0.632 |
| $30 \%$ reduction $(30 \% \times 0.632)$ | $(0.190)$ |
| ABC/TQM standard overheads $(1 \times £ 0.36)$ | $\underline{(0.360)}$ |
|  |  |
| Remainder, due to improved work practices of TQM programme | 0.082 |

The adoption of a total quality philosophy will require the following additional information from the control system.
The ideal identified at present may not be as far as it is possible to go. Quality programmes generally aim at 'continuous improvement,' so more exacting targets may need to be established once the ABC/TQM standard has been met.
It may be desirable to categorise information in terms of the well-known, though perhaps old-fashioned, quality costs: prevention costs, appraisal costs, internal failure costs and external failure costs.
Other aspects of performance that the company may wish to measure include the following.
Customer satisfaction: Product A is likely to improve in quality and this ought to be measurable by means of opinion surveys, reports in the trade and consumer press and so on, as well as being reflected in sales figures. The question implies that attempts are being made to control non-value-added activities, and presumably this means that non-financial indicators relating to matters such as set-up times, materials handling and so on should be measured.
Competitive performance. It may be fruitful to benchmark performance against that of individual competitors (those considered 'best in class'), not only on cost and price but also on marketing performance, reputation and so on.
a. (i) Workings:

Total estimated minutes:
Making: $8,000 \times 5.25=42,000$
Packing: $5,000 \times 6+3,000 \times 4=42,000$
Absorption rate per product unit (both products):
Making : variable $\quad(£ 350,000 / 42,000) \times 5.25=£ 43.75$
fixed $\quad(£ 210,000 / 42,000) \times 5.25=£ 26.25$
Packing cost per minute:

$$
\begin{array}{lll}
\text { variable } & £ 280,000 / 42,000 & =£ 6.666 \\
\text { fixed } & £ 140,000 / 42,000 & =£ 3.333
\end{array}
$$

Unit costs are determined as cost per minute x minutes per unit. e.g. VG4U variable cost $=£ 6.666 \times 6$ minutes $=£ 40$
VG2 fixed cost $=£ 3.333 \times 4$ minutes $=£ 13.33$ (split $40 \%$ specific $60 \%$ company).

## COST STATEMENT

| Direct material |  | VG4U | VG2 |
| :---: | :---: | :---: | :---: |
|  |  | $\underset{30}{\text { f }}$ | ¢ |
| variable conversion cost | -making | 43.75 | 43.75 |
|  | -packing | 40.00 | 26.67 |
|  |  | 113.75 | 100.42 |
| Product specific fixed costs: |  |  |  |
| Making |  | 10.50 | 10.50 |
| Packing |  | 8.00 | 5.33 |
| Total product specific cost |  | 132.25 | 116.25 |
| Company fixed cost: |  |  |  |
| Making |  | 15.75 | 15.75 |
| Packing |  | 12.00 | 8.00 |
| Total Cost |  | 160.00 | 140.00 |
| Selling price |  | 150.00 | 180.00 |
| Profit (loss) |  | (10.00) | 40.00 |

VG4U makes a loss of $£ 10$ per unit, but makes a contribution over specific costs of $£ 150-132.25$ $=£ 17.75$ towards meeting general company fixed costs. This represents a total contribution of 5,000 $\mathrm{x} £ 17.75=£ 88,750$ for the period so that the product should be continued unless there is an alternative use for the capacity which produces more contribution.

## Workings using ABC



| Company fixed costs | $=£ 210,000+140,000-70,920-69,080$ |  |
| :---: | :---: | :---: |
|  | $=£_{2} 210,000$ |  |
| Overall average cost per unit | $=£_{2} 210,000 / 8,000$ |  |
|  | $=£_{2} 26.25$ |  |
|  | Cost summary |  |
|  | VG4U | VG2 |
|  | $£$ | $£$ |
| Direct material cost | 30.00 | 30.00 |
| Variable conversion costs | 63.72 | 103.80 |
|  | 93.72 | 133.80 |
| Product specific fixed costs | 14.18 | 23.03 |
|  | 107.90 | 156.83 |
| Company fixed costs | 26.25 | 26.25 |
|  | 134.15 | 183.08 |
| Selling price | 150.00 | 180.00 |
| Profit (loss) | 15.85 | (3.08) |

## Comments

ABC is a different convection and therefore give different costs. It is claimed to be more realistic. All that can be said in this case is that both products have a margin over specific costs ( $£ 42.10$ and 23.17) and thus contribute to meeting general fixed costs. They should be continued until higher earning products can be found.

Comments on target costing

## PAST CPA EXAMINATION PAPERS

## KENYA ACCOUNTS AND SECRETARIES NATIONAL EXAMINATIONS BOARD

## CPA PART III <br> MANAGEMENT ACCOUNTING

JUNE 2013
TIME ALLOWED: 3 HOURS

Answer ALL questions. Marks allocated to each question are shown at the end of the question. Show all your workings.

## QUESTION ONE

Briefly explain three methods that can be used to analyse uncertainty in cost-volume-profit (C-V-P) analysis. Aberdares Company Ltd. is a manufacturing company which produces and sells a single product known as $\mathrm{T}_{1}$ at a price of Sh. 10 per unit. The company incurs a variable cost of Sh. 6 per unit and fixed costs of Sh.400,000. Sales are normally distributed with a mean of 110,000 units and a standard deviation of 10,000 units. The company is considering producing a second product, $\mathrm{T}_{2}$ to sell at Sh. 8 per unit and incur a variable cost of Sh. 5 per unit with additional fixed costs of Sh. 50,000 . The demand for $\mathrm{T}_{2}$ is also normally distributed with a mean of 50,000 units and standard deviation of 5,000 units. If $\mathrm{T}_{2}$ is added to the production schedule, sales of $\mathrm{T}_{1}$ will shift downwards to a mean of 85,000 units and standard deviation of 8,000 units. The correlation coefficient between sales of $T_{1}$ and $T_{2}$ is -0.9 .

## Required:

The company's break-even point for the current and proposed production schedules. The coefficient of variation for the two proposals.
Based on your computation's in (i) and (ii) above advise the company on whether To add $\mathrm{T}_{2}$ to its production schedule.

## QUESTION TWO

"It is now fairly and widely accepted that conventional cost accounting, distorts management's view of business through unrepresentative overhead allocation and inappropriate product costing. This is because the traditional approach usually absorbs overhead costs across products solely on the basis of the direct labour involved in their manufacture. As direct labour cost expressed as a proportion of total manufacturing cost continues to fall, this leads to more an more distortion and misrepresentation of the impact of particular products on total overhead costs" (from Financial Times)

## Required:

Briefly discuss the above statement and state what approaches are being adopted by management accountants to overcome such criticism. (8 marks) Traditional budgeting systems are incremental in nature and tend to focus on cost centers.
Activity based budgeting ( ABB ) links strategic planning to the overall performance measurement aimed at continuous improvement.

## Required:

Explain the weakness of traditional incremental budgeting systems.
(4 marks)
Describe the main feature of activity based budgeting system and comment on its advantages.
(8 marks)
(Total: 20 marks)

## QUESTION THREE

Joan Odero, an independent movie producer, is negotiating with Roadshow Productions Limited on a contract for the production and marketing of her next film, titled "The rise and fall of a cock". The budget for the film is, Sh. 100 million.

Roadshow Productions Limited is offering Joan Odero a choice of one of the three contracts.

## Contract A

Roadshow Productions Limited will pay all the production and marketing costs. Joan Odero will receive a fixed fee of Sh. 10 million.
Joan Odero will receive $10 \%$ of gross revenue from the film in excess of Sh. 1 billion (no payment is made for gross revenue up to Sh. 1 billion).

## Contract B

Roadshow Productions Limited will pay $80 \%$ of all the production and marketing costs up to Sh. 100 million and $30 \%$ of production and marketing costs in excess of Sh. 100 million Joan Odero will receive $10 \%$ of all gross revenue for the film.

## Contract C

Roadshow Productions Limited will pay $50 \%$ of production and marketing costs up to Sh. 100 million. Joan Odero will receive $30 \%$ of all gross revenue from the film.

Joan Odero estimates the following probabilities for the gross revenues:
P (high demand of Sh. 2 billion) 0.1
P (medium demand of Sh. 500 million) 0.3
P (low demand of Sh. 100 million) 0.6
She estimates the following probabilities for the cost of production:
P (budgeted cost of Sh. 100 million) $\quad 0.6$
P (high cost of Sh. 200 million) 0.4

## Required:

The expected monetary value for Joan Odero under each contract for each of the six possible events. (Hint: The possible events are high demand - budgeted costs, bigh demand - bigh costs, medium demand - budgeted costs, medium demand - bigh costs, low
demand - budgeted costs, and low demand - bigh costs).
Joan Odero will choose the contract that maximizes her expected monetary value from the film. Which contract should she choose? (Show calculations).

What information might Joan Odero use in assessing the probability distribution for the production and marketing costs of "The rise an fall of cock" film?
(Total: 20 marks)

## QUESTION FOUR

High-tex Engineering Company Limited wishes to set flexible budgets for each of its operating departments. A separate maintenance department performs all routine and major repair works on the company's equipment and facilities. The company has determined that maintenance department performs all routine and major repair works on the company's equipment and facilities. The company has determined that maintenance cost is primarily a function of machine hours worked in the various production departments.
The maintenance cost incurred and the actual machine hours worked during the months of January, February, March and April 2013 were as follows:

| Month | Machine hours in <br> Production departments | Maintenance <br> department's Costs |
| :--- | :---: | :---: |
| January | 800 | 350 |
| February | 1,200 | 350 |
| March | 400 | 150 |
| April | 1,600 | 550 |

## Required:

Determine the cost estimation function using:
High-low method. (5 marks)
Regression analysis (5 marks)
Using the regression function estimate:
The maintenance costs that would have been incurred if the machine hours were expected to be 900 in the month of May 2013. (1 mark)

The maximum machine hours that would have been worked If the maintenance cost incurred had been limited to Sh.400,000 for the month of May 2013. (6 marks)

Assuming that in the month of May 2013 machine hours were 900, establish a $95 \%$ confidence interval for this point estimate. (Assume $\mathrm{t}_{\mathrm{c}}=2.7764$ and standard error of estimate, $\mathrm{se}_{\mathrm{e}}=63.25$ ).

> (3 marks)
(Total: 20 marks)

## QUESTION FIVE

Construct a flowchart to show the logic solution of a zero-sum game.
Two manufacturers compete in a market for a specialized calculator. Company A controls $75 \%$ of the market while company B controls $25 \%$ of the market. Company A is considering a vigorous annual marketing campaign which will cost Sh.35,000,000. The total market for the specialize calculator is 100,000 units per year. The profit contribution per unit is Sh.3,000.
Company B is debating how much money to invest in research and development every year. It is considering three alternatives: Sh.25,000,000, Sh.50,000,000 and Sh.80,000,000. It is estimated that if company A runs a vigorous annual marketing campaign, its share of the market after one year will be either $79 \%$ or $73 \%$, depending on company B's investment in research and development (Sh.25,000,000, 50,000,000 and Sh.80,000,000 respectively).

On the other hand, if company A does not run the marketing campaign, company B's share of the market will decrease by $1 \%$ of the total market if it invests $\mathrm{Sh} .25,000,000$ in research and development, increase by $1 \%$ if it invests Sh.50,000,000 in research and development and increase by $3 \%$ if Sh.80,000,000 is invested.

## Required:

Using the share of the market percentages only, convert the above into a zero sum game, and hence solve for the optimal strategies for both companies. (6 marks)

Obtain a pay off table consisting of contribution to profit in monetary terms, and hence solve the game. (8
marks)
(Total: 20 marks)

## KENYA ACCOUNTANTS AND SECRETARIES NATIONAL EXAMINATION BOARD <br> CPA PART III MANAGEMENT ACCOUNTING

DECEMBER 2011
TIME ALLOWED: 3 HOURS
QUESTION ONE
Kiko Ltd. Is a large cash and carry warehouses which sells electronics. Kiko Ltd. Purchases the most popular model of calculators (FX 100) directly form the manufacturer at a cost of Sh. 250 each. Average sales per a 300 day year are 475 calculators. Whenever an order with the manufacturers is placed, Kiko Ltd, Incurs a cost of Sh.50. The stock holding costs are estimated at Sh. 12.50 plus $10 \%$ opportunity cost of capital. The lead-time is three days. During the last 50 stock cycles, the demand during the lead-time has generated the following frequency distribution:

| Lead time demand | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Number of stock cycles | 1 | 2 | 6 | 8 | 10 | 8 | 8 | 5 | 2 |

Each time the warehouses runs out of stock, an emergency order is placed with an extra cost of Sh. 20 per calculator.

## Required:

The economic order quantity (EOQ) and the reorder level.
The total annual relevant costs for the order quantity in (a) above.
(Total: 20 marks)

## QUESTION TWO

Boots Ltd. manufactures a range of five similar products, $\mathrm{A}, \mathrm{B}, \mathrm{C}, \mathrm{D}$ and E . the table below shows the quantity of each of the required inputs necessary to produce one unit of each product, together with the weekly inputs available and selling prices of each product.

| Inputs | A | B | C | D | E | Weekly inputs available |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: |
| Raw materials (Kg) | 6.0 | 6.5 | 6.1 | 6.1 | 6.4 | 35,000 Kgs |
| Forming (hours) | 1.00 | 0.75 | 1.25 | 1.00 | 1.00 | 6,000 hours |
| Firing (hours) | 3.00 | 4.50 | 6.00 | 6.00 | 4.50 | 30,000 hours |
| Packing (hours) | 0.50 | 0.50 | 0.50 | 0.75 | 1.00 | 4,000 hours |
| Selling price (Sh.) | 40 | 42 | 44 | 48 | 52 |  |

The costs of each input is as follows:

| Material | Sh. 2.10 per Kg |
| :--- | :--- |
| Forming | Sh. 3.00 per hour |
| Firing | Sh. 1.30 per hour |
| Packing | Sh. 8.00 per hour |

## Required:

Formulate this problem as a Linear Programming problem.
The problem has been solved using a computer package and the following final tableau of a simplex solution has been produced:

| Basis | A | $\mathbf{B}$ | $\mathbf{C}$ | $\mathbf{D}$ | $\mathbf{E}$ | $\mathbf{X}$ | $\mathbf{S}$ | $\mathbf{T}$ | $\mathbf{U}$ | Value |
| :--- | ---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | ---: | ---: |
| $\mathbf{A}$ | 1 | 1.18 | 1.04 | 0.46 | 0 | 0.36 | 0 | 0 | -2.29 | 3,357 |
| $\mathbf{B}$ | 0 | -0.34 | 0.23 | 0.02 | 0 | -0.18 | 1 | 0 | 0.14 | 321 |
| $\mathbf{T}$ | 0 | 1.37 | 2.97 | 2.28 | 0 | -0.27 | 0 | 1 | -2.79 | 9,482 |
| $\mathbf{E}$ | 0 | -0.09 | -0.02 | 0.52 | 0 | -0.18 | 0 | 0 | 2.14 | 2,321 |
| $\mathbf{Z j}$ | 0 | 1.26 | 1.06 | 0.51 | 0 | 2.02 | 0 | 0 | 8.81 | 105,791 |

Where $\mathrm{A}, \mathrm{B}, \mathrm{C}, \mathrm{D}$ and E are the weekly production levels for the five products; X is the amount of raw material that falls short of the maximum available; $\mathrm{S}, \mathrm{T}$ an U are the respective number of hours short of maximum weekly input of forming, firing and packing time.

Use this tableau to find the optimum weekly production plan.
(4 marks)
Describe the implications of using this plan in terms of unused resources and overall contribution to profit. (3 marks)
In the context of this problem explain the meaning of "The dual or shadow price of a resource" (3 marks)
There is a proposition that the company manufactures an additional product which would sell at Sh. 50
per unit. Each unit will need 6 kg of raw material, one hour of forming time, five hours of firing time and one hour of packing time. Is it s worthwhile proposition?
(3 marks)
(Total: 20 marks)

## QUESTION THREE

Briefly explain four ways in which competitive situations (or games) can be classified. (8 marks) Kamau and Njoroge are two cousins specializing in hawking business along River road. Kamau specializes in second hand shirts while Njoroge specializes in cheap electronic goods. However, sales have been decreasing partly due to the harsh economic condition in Kenya and party due to restrictions by the City Council.

Each of the cousins is considering expanding to include in their lines of business, items on which their rivals now have a monopoly. Each knows that the other is considering this expansion and this influences each of their decisions.

Kamau figures out that if he does not expand his business and his cousin does, it will hurt his trade by Sh. 500 of profit per day. If neither of them expands inventory to include the extra product, Kamau thinks it will boost his net profit by Sh. 500 per day due to his superior location. If he expands and his cousin does also, he believes the combination of location and expanded inventory will increase his profits by Sh.1,000 per day. However, if he alone expands and his cousin does not, this will result in no net increase in business.

## Required:

Prepare a game matrix and show that a pure strategy does not exist.
(4 marks)
Solve the above game to determine the average winnings (or losses) each of the cousins would expect.
(8 marks)
(Total: 20 marks)

## QUESTION FOUR

Mega Techniques Ltd. makes special purpose equipment according to customer specifications. During the past year, one of its loyal customers, Pawa Ltd., ordered a specialized equipment to be fabricated for it. Mega

Techniques Ltd. Finished construction the equipment only to be notified that Pawa Ltd. Had recently gone into liquidation and will not therefore take the equipment.
The original price to Pawa Ltd. had been agreed at Sh. $9,108,000$ which included an estimated normal profit mark-up of 10 per cent on total costs. The costs incurred to manufacture the machine were

|  | Sh. |
| :--- | ---: |
| Direct materials | $3,420,000$ |
| Direct wages | $2,160,000$ |
| Overheads: | 540,000 |
| Variable | $1,800,000$ |
| Fixed; production | $\underline{360,000}$ |
| Fixed; selling and administration | $\underline{8,280,000}$ |

After a sustained search, the sales manager of Mega Techniques Ltd. Has managed to locate one potential buyer, Zimwi Systems Ltd, which has indicated that it could buy the machine if certain conversion work could be carried out.

Mega Techniques Ltd's production department has made a preliminary assessment which
reveals that conversion would entail extra work costed as follows:
Direct materials
Sh.576,000
Direct wages:

Department X:
Department Y:
Variable overhead:
20 per cent of direct wages

3 men for 4 weeks at Sh. 27,000 per man/week
1 man for 4 weeks at Sh. 21,600 per man/week

Fixed production overhead:
Department X: $\quad 75$ per cent of direct wages.
Department Y: 25 per cent of direct wages.
The following additional information is provided:
In the original machine, there were three types of basic materials:
Type P could now be sold to a scrap merchant for Sh.540,000.
Type Q could be sold to a scrap merchant for Sh. 360,000 but it would take 120 hours of labour paid at Sh. 270 per hour to put it into a suitable condition for sale.
Type R would need to be scrapped at a cost to Mega Techniques Ltd. of Sh.108,000
The materials for the conversion are at present in stock. If not needed for the conversion they could be used in the production of another machine in place of materials that would currently cost Sh. 684,000 . The conversion would be carried out in two departments:

Department X is currently extremely busy and it is estimated that its contribution overheads and profits is Sh.2.50 for every Sh. 1 of labour.

Department $Y$ has idle staff, for organizational reasons its labour force cannot be reduced below its present level of four employees, all of whom are paid at the standard rate of Sh. 21,600 per week.

The designs and specifications of the original machine could be sold in a neighbouring country for a sum of Sh.270,000 if the machine is scrapped.

An additional temporary supervisor would have to be engaged for the conversion work at a cost of Sh.162,000. It is the company's normal practice to charge supervision to fixed overhead.

Pawa Ltd. Had paid Mega Techniques Ltd. A non-returnable deposits of $12 \%$ of the selling price.

## Required:

The minimum price that Mega Techniques Ltd. should accept from Zimwi Systems Ltd. for the converted machine. Explain clearly how you arrive at your figure. (16 marks) State clearly any assumptions that you have made in arriving at your conclusions in (a) above.

## KENYA ACCOUNTANTS AND SECRETARIES NATIONAL EXAMINATIONS BOARD

## CPA PART III

## MANAGEMENT ACCOUTING

## DECEMBER 2010

TIME ALLOWED: 3 HOURS

## QUESTION ONE

Differentiate between a feedback control system and a feed forward control system.

In his study of: the impact of budges on people" C Argyris reported the following comment by a financial controller on the practice of participation in setting budgets in his company: "We bring in the supervisors of budget areas, we tell them that we want their frank opinion, but most of them just sit there and no their heads. We know they are not coming out with exactly what they feel. I guess budget scares them".

Explain why managers may be reluctant to participate fully in setting budgets, indicating the negative side effects, which may arise from the imposition of budgets by senior management. (10 marks)

A critic has suggested that budgets should be abolished because they introduce rigidity and hamper creativity. Discuss. (6 marks)
(Total: 20 marks)

## QUESTION TWO

Sola Ltd. Is a manufacturing company that requires component XLA20 in one of its production lines. The components are bought from outside suppliers. Form past experience, the company has determined that the demand for the component can be approximated by a normal distribution with a mean of 500 and a standard deviation of 10 , over the range 470 to 530 .

The unit is an initial stock of 2010 components and the company has decided to order in batches of 2500 whenever the stock level falls below 1500 components. Again, past experience indicates that the time between the order being placed and delivery varies as follows:

Lead time distribution
Lead time, weeks

| 1 | 2 | 3 | 4 |
| :--- | :--- | :--- | :--- |

Probability

| 0.02 | 0.50 | 0.25 | 005 |
| :--- | :--- | :--- | :--- |

The unit cost of holding stock is Sh. 5 per week applied to the total stock held at the end of each week. The cost associated with placing an order is Sh. 5.00 and the unit cost of being out of stock is Sh. 200 per week. The company does all its accounting at the end of the week and all ordering and delivery occur at the beginning of a week.

## Required:

Estimate the average cost per week of the above policy, using simulation analysis and the following random numbers:

| For Demand: | 034 | 743 | 738 | 636 | 964 | 736 | 614 | 698 | 637 |  |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
|  | 162 | 332 | 616 | 804 | 560 | 111 | 410 | 959 | 774 | 246 | 762 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| For Leadtime: | 95 | 73 | 10 | 76 | 51 | 74 |  |  |  |  |  |

## Hint:

Use 15 trial runs
Round off the demand probabilities to 3 decimal places. (Estimate these probabilities in ranges of 5)

## QUESTION THREE

Highlight how the transportation algorithm can be modified for profit maximization rather than minimization of costs. ( 3 marks)

The Executive Furnitures Ltd. (EFL) produces a unique type of computer desks. Four of EFL's main outlets are $S_{1}, S_{2}, S_{3}$, and $S_{4}$. These outlets already have requirements in excess of the combined capacity of its three production plants $\mathrm{P}_{1}, \mathrm{P}_{2}$, and $\mathrm{P}_{3}$. The company needs to know how to allocate its production capacity to maximize profits.

Distribution costs (in Sh.) per unit from each production plant to each outlet are given in the following table:

|  | To |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
|  | S 1 | S 2 | $\mathrm{S}_{3}$ | S ${ }_{4}$ |
|  | Sh. | Sh. | Sh. | Sh. |
|  | P1 $\{220$ | 240 | 220 | 360 |
| From | P2 \{ 240 | 200 | 180 | 280 |
|  | P3 260 | 200 | 260 | 240 J |

Since the four outlets are in different parts of the country and as there are differing transportation costs between the production plants and the outlets along with slightly different production costs at different production plants there is a pricing structure which enables different prices to be charged at the four outlets. Currently, the price per unit charged is Sh.2,300 at $S_{1}$, Sh.2,350 at S2, Sh.2,250 at S3, and Sh.2,400 at $\mathrm{S}_{4}$. The variable unit production costs are Sh.1,500 at plants $\mathrm{P}_{1}$ and $\mathrm{P}_{3}$ and $\mathrm{Sh}_{1} .1,550$ at plant $\mathrm{P}_{2}$. The demand at $S_{1}, S_{2}, S_{3}$ and $S_{4}$ are 850, 640, 380 and 230 desks respectively while the plant capacity at plant $P_{1}$, $\mathrm{P}_{2}$ and $\mathrm{P}_{3}$ are 625, 825 and 450 desks respectively.

## Required:

Using the transportation algorithm, determine the contribution to profit for the optimal allocation.
(17 marks)
(Total: 20 marks)

## QUESTION FOUR

Alvis Kiptoo has budgeted that output and sales of his single product will be 100,000 units in the coming year. At this level of activity, his unit variable costs are budgeted at Sh. 50 and his unit fixed costs at Sh.25. His sales manager estimates that the demand for the product would increases by 1000 units for every decreased of Sh. 1 in unit selling price (and vice versa) and that at a unit selling price of Sh. 200 demand would be nil.
Information about two price increases has just been received from suppliers: one is for materials (which are included in Alvis Kiptoo's variable costs) and one is for fuel (which included in his fixed costs). Their effect will be to increase both the variable and fixed costs by $20 \%$ each over the budgeted figures.
Alvis Kiptoo aims at maximizing profits from his business.

## Required:

Calculate before the cost increases the budgeted contribution and profit at the budgeted levels of 100,000 units. (3 marks)

Calculate the level of sales at which profits would be maximized and the amounts of these maximum profits before the cost increases. (4 marks)

Show whether and by how much Alvis Kiptoo should adjust his selling price in respect to increases in:
Fuel costs.
(2 marks)
Material costs.
(2 marks)
b) Some businesses which supply two or more separate markets from a single source may decide to charge a higher price for sales to home markets than for export sales. The businesses may justify their pricing policy by stating that they need to earn foreign exchange from foreign markets and recover their research and development costs, plus production overheads against home demand.

## Required:

Critically explain briefly the rationale for such a differential pricing policy.
Should earning of foreign exchange be a factor in a firm's pricing policy.
(Total: 20 marks)

## QUESTION FIVE

Explain the advantages of using Value Added Statements (VAS) for interdivision for comparisons in decentralized firm. (8 marks)

ABC Lt. Is a manufacturing company that makes only three products $\mathrm{P}, \mathrm{Q}$, and R . Data for the period ended last month are as follows:

|  | P | Q | R |
| :--- | :--- | :--- | :--- |
| Units produced and sold | 12,000 | 16,000 | 8,000 |
|  | $\mathbf{S h .}$ | $\mathbf{S h .}$ | $\mathbf{S h .}$ |
| Sales price per unit | 50 | 70 | 60 |
| Direct material cost per unit | 16 | 24 | 20 |
| Direct labour cost per unit | 8 | 12 | 8 |

Production overheads costs

## Total

## Cost drivers

Machining costs
Production scheduling
Set-up costs
Quality control
Receiving materials
Packing materials

Sh.

| 102,000 | Machine hours |
| ---: | :--- |
| 84,000 | Machine hours |
| 54,000 | Number of production runs |
| 49,200 | Number of production runs |
| 64,800 | Number of components receipts |
| 36,000 | Number of customer orders |

Information on the cost drier is given as follows:

|  | P | Q | R |
| :--- | :--- | :--- | :--- |
| Direct labour hours per unit | 1 | $11 / 2$ | 1 |
| Machine hours per unit | $1 / 2$ | 1 | $11 / 2$ |
| Number of components per unit | 3 | 5 | 8 |
| Number of component receipts | 18 | 80 | 64 |
| Number of customer orders | 6 | 20 | 10 |
| Number of production runs | 6 | 16 | 8 |

## Required:

Using activity based costing ( ABC ) show the cost and gross profit per unit for each product during the period.

## KENYA ACCOUNTANTS AND SECRETARIES NATIONAL EXAMINATIONS BOARD

## CPA PART III MANAGEMENT ACCOUNTING

JULY 2010
TIME ALLOWED: 3 HOURS

## QUESTION ONE

A processing company, Timao Co. Ltd., is extremely busy. It has increased its output and sales from $12,900 \mathrm{~kg}$ in $1^{\text {st }}$ quarter of the year to $17,300 \mathrm{~kg}$ in the $2^{\text {nd }}$ quarter. Although demand is still rising, it cannot increase its output more than an additional $5 \%$ from its existing labour force, which is now at its maximum.

Data for its four products in $2^{\text {nd }}$ quarter were:

|  | $\begin{gathered} \text { Product } \\ \mathrm{P} \\ \hline \end{gathered}$ | $\begin{gathered} \text { Product } \\ \mathbf{Q} \\ \hline \end{gathered}$ | $\begin{gathered} \text { Product } \\ \mathbf{R} \\ \hline \end{gathered}$ | $\begin{gathered} \text { Product } \\ \mathrm{S} \\ \hline \end{gathered}$ |
| :---: | :---: | :---: | :---: | :---: |
| Output (Kg) | 4560 | 6960 | 3480 | 2300 |
| Selling price (Sh. Per kg) | 162 | 116.40 | 99.20 | 136.80 |
| Costs (Sh. Per kg) |  |  |  |  |
| Direct labour @ Sh. 60 per hour) | 19.60 | 13.00 | 9.90 | 17.00 |
| Direct materials | 65.20 | 49.00 | 41.00 | 54.20 |
| Direct packaging | 8.40 | 7.40 | 5.60 | 7.00 |
| Fixed overhead (Absorbed on basis of direct |  |  |  |  |
| labour cost) | 39.20 | $\underline{26.00}$ | 19.80 | $\underline{34.00}$ |
|  | $\underline{132.40}$ | $\underline{95.40}$ | $\underline{76.30}$ | $\underline{112.20}$ |

The Kagocho Company has offered to supply 2010 kg of product Q at a delivered price of $90 \%$ of Timao's Co. Ltd. Selling price. Timao Co. Ltd., will then be able to produce extra of product P instead of product Q to the plant's total capacity.

## Required:

State with supporting calculations, whether Timao Co. Ltd should accept the Kagocho Company's offer. (15
Which would be the most profitable combination of subcontracting 2010 kg of one product at a price of $90 \%$
of its selling price and producing extra quantities of another product up to the plant total
capacity? Assume that the market can absorb the extra output. (5 marks)
(Total: 20 marks)

## QUESTION TWO

"Control theory offers valuable insights into the design and operation of management accounting information systems, but only under circumstances where an organization's environment is stable and predictable and outcomes are clearly measurable."
Required:
Comment on the relevance and validity of this statement within the analysis or established control theory systems within a business organization. (Total: 20 marks)

## QUESTION THREE

The Z division of XYZ Ltd., produces a component which it sells externally, and can also be transferred to other divisions within the organization. The division has set a performance target for the coming financial year of residual income of Sh.5,000,000. The following budgeted information relating to Z division has been prepared for the coming financial year.

Maximum production/sales capacity 800,000 units.
Sales to external customers: 500,000 units at Sh. 37 .
Variable cost per component Sh. 25 .
Fixed costs directly attributable to the division Sh. 1,400,000.
Capital employed: Sh. $20,000,000$ with cost of capital of $13 \%$
The X division of XYZ Ltd has asked Z division to quote a transfer price for units of the component.

## Required:

Calculate the transfer price per component which Z division should quote to X division so that its residual income target is achieved. ( 6 marks) Explain why the transfer price calculated in (i) above may lead to sub-optimal decision making from the point of view of XYZ Ltd taken as a whole. (4 marks)

A manufacturer produces and sells two products, A and B . The unit variable cost is sh. 12 and sh. 8 for $A$ and $B$ respectively. A review of selling prices is in progress and it has been estimated that, for each product an increase in the selling price would result in a fall in demand of Sh. 500 units per every Sh. 1 increase in price and similarly a decrease of Sh. 1 in price would result in an increase in demand of 500 units.

The current sales prices and sales demand are:-

|  | Price (Sh.) | Demand (Units) |
| :--- | :--- | :--- |
| A | 30 | 15,000 |
| B | 58 | 21,000 |

## Required:

Calculate the profit-maximizing price for reach product.
(10 marks)

## QUESTION FOUR

Muthothi Ltd. Operates a conventional stock control system based on re-order levels and Economic Order Quantities (EOQ). The various control levels were set originally based on estimates which did not allow for any uncertainty and this has caused difficulties because, in practice, lead times, demands and other factors do vary.

As part of a review of the system, typical stock item, part no. X 206, has been studied in detail as follows:

|  | Data for Part No.X 206 <br> Lead times <br> (Days) |  | Probability |
| :--- | :---: | :---: | ---: | | Demand |
| :--- |
| (units) |$\quad$ Probability

The company works for 360 days per year and it costs Sh.1,000 to place an order. The holding cost is estimated at Sh. 0.025 for storage plus $10 \%$ opportunity cost of capital. Each unit is purchased at Sh.2. The re-order level for this part is currently 150,000 units and it can be assumed that the demands would apply for the whole of the appropriate lead-time.

## Required:

Calculate the level of buffer stock implicit in a re-order level of 150,000 units.
Calculate the probability of stock-outs.
Calculate the expected annual stock-outs in units.
Compute the stock-out costs per unit at which it would be worthwhile raising the re-order level to 175,000 units.
Discuss the possible alternatives to a re-order level EOQ inventory system and their advantages and disadvantages.

5 marks)
(2 marks)
(4 marks)
(3 marks)
(6 marks)
(Total: 20 marks)

## QUESTION FIVE

Watt Lovell Ltd. (WLL) is trying to decide whether or not to drill for oil on a particular site in North Eastern Kenya. The Chief Engineer has assessed the probabilities that there will be oil as follow, based on past experience.

## Oil 0.2

No oil 0.8
It is possible for WLL to hire a firm of international consultants to carry out a complete survey of the site. WLL has used the firm many times before and has made the following estimates:

If there really is oil, then there is a $95 \%$ chance that the report will be favourable.
If there is no oil then there is only a $10 \%$ chance that the report will indicate that there is oil.
The following additional information is also provided:
The cost of drilling is Sh. 10 million.
The value of the benefits if oil is found is Sh. 70 million
The cost of obtaining information is Sh. 3 million.

## Required:

Advise the company on whether to acquire additional information from the consultants. (16 marks) Compute the value of imperfect information. (4 marks)

## KENYA ACCOUNTANTS AND SECRETARIES NATIONAL EXAMINATION BOARD CPA PART III MANAGEMENT ACCOUNTING

## PILOT PAPER

OCTOBER 1991
Time Allowed: 3 hours

Answer ALL questions. Marks allocated to each question are shown at the end of the question. Show all your workings.

QUESTION ONE
a. There are arguments that cost-volume-profit analysis is at best abstract and theoretical, with no relationship to reality. Its supporters argue that it is not only a useful management tool but also can be practically applied. Comment, using appropriate examples, on the usefulness and limitations of cost-volume-profit analysis when applied in a multi-product entity
(10 marks)
b. Mululu company produces only two products, Machungwa and Ndimu. These account for $60 \%$ and $40 \%$ of the total sales value of M respectively. Variable costs (as a percentage of sales) are $60 \%$ for Machungwa and $85 \%$ for Ndimu. Total fixed costs are Shs 150,000. There are no other costs.

## Required:

i. Mululu's break-even point in Shillings.
ii. Assuming that Mululu's total fixed costs increase by $30 \%$, what amount of sales in Shillings would be necessary to generate a net profit of Shs 9,000 ?
(10 marks)
(Total: 20 marks)

## QUESTION TWO

A company requiring a certain machine has the options of EITHER buying a new machine OR buying a second-hand machine which may be 1,2 or 3 years old. These respective purchase costs are as follows:

| Age at purchase | Price of Machine |
| :---: | :---: |
| Years | Shs 000 |
| New | 40 |
| One-old | 31 |
| Two-old | 20 |

Three 11
You are also given the following information with regard to repair and maintenance costs for each machine and their respective scrap values.


## Required:

a. Advise the management on the age at which the machine should be bought and when it should be replaced.
b. What is the role of abandonment value in decision making over projects?
(Total: 20 marks)

## QUESTION THREE

Ben Ltd. has run a series of regressions as a first step towards designing a flexible budget for manufacturing overhead. With regard to machine hours and units of output the following results have been obtained:

Regression 1:Overhead costs as related to machine hours.

| Constant |  |  |
| :---: | :---: | :---: |
| Machine hours |  |  |
| $\mathrm{r}^{2}$ | $=$ | 0.77 |
| Se | $=$ | 3,456 |

## Coefficient

-32,657
16.57

## Standard Error

4.32

$$
S_{e}=3,456
$$

Regression 11: Overhead costs as related to units of output.

| Constant | Coefficient | Standard Error |
| :--- | :---: | ---: |
| Machine hours | 17,865 |  |
| 13.76 .57 | 3.87 |  |

$$
\begin{aligned}
& \mathrm{r}^{2}=0.61 \\
& \mathrm{~S}_{\mathrm{c}}=3,973
\end{aligned}
$$

Regression 111: Overhead costs as related to machine hours and units of output.

|  | Coefficient | Standard Error |
| :--- | ---: | ---: |
| Constant | $-15,373$ |  |
| Machine hours | 7.37 | 3.31 |
|  |  | 10.44 |
|  |  | 4.81 |
| $\mathrm{r}^{2}$ | $=0.79$ |  |
| $\mathrm{~S}_{\mathrm{e}}=$ | 1,623 |  |

The correlation matrix shows a 0.86 relationship between machine hours and units of output.
You are further informed that there were no data gaps or serious outlier problems.

## Required:

a. Explain what is meant by the term "Computed $t$-value".
(3 marks)
b. Determine the computed t -values for all the three regression runs.
(3 marks)
c. Explain the meaning of $\mathrm{r}^{2}$ in regression I and II and $\mathrm{R}^{2}$ in regression III
d. Explain the meaning of the negative intercept in regressions I and II.
e. Critically evaluate each of the three regressions and on the basis of this evaluation advise management on which of them should form the basis for flexible budgeting. (6 marks)
(Total: 20 marks)

## QUESTION FOUR

A newly incorporated company is developing compounds for use in the Agricultural Sector. The product codes for the three products are $\mathrm{X} 1, \mathrm{X} 2$ and X 3 and the relevant information is summarised below:
i Chemical constituents: Percentage make up per tonne.

|  | Nitrate | Phosphate | Potash | Filler |
| :--- | ---: | ---: | ---: | ---: |
| X1 | 10 | 10 | 20 | 60 |
| X2 | 10 | 20 | 10 | 60 |
| X3 | 20 | 10 | 10 | 60 |

ii. Input prices per tonne:

## Shs

Nitrate 150
Phosphate 60
Potash 120
Filler 10
iii. Maximum available input in tonnes per month

Nitrate 1,200
Phosphate 2,000
Potash 22,00
Filler No limit
iv. Selling Prices of fertilizer (per tonne) Shs

X1 83
X2 81
X3 81
The manufacturing costs excluding raw materials, are estimated at Shs 11 per tonne.
Required:
a. Formulate the above data into a linear programme with the objective as the maximisation of contribution.
(3 marks)
b. Define $\mathrm{X} 4, \mathrm{X} 5$ and X 6 as the slack variables for $\mathrm{X} 1, \mathrm{X} 2$ and X 3 respectively and explain the meaning of these slack variables.
c. Construct the initial simplex tableau and indicate which will be the "entering variable" and the "leaving variables" in the first iteration.
d. The final matrix of the simplex solution is given below:

| Basic Variables | $\mathbf{X} 1$ | $\mathbf{X} 2$ | $\mathbf{X} 3$ | $\mathbf{X} 4$ | $\mathbf{X 5}$ | $\mathbf{X 6}$ | Solution |
| :---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
| $\mathbf{X 1}$ | 1 | 0 | 3 | 20 | -10 | 0 | 4000 |
| $\mathbf{X} 2$ | 0 | 1 | -1 | -10 | 10 | 0 | 8000 |
| $\mathbf{X 6}$ | 0 | 0 | -0.4 | -3 | 1 | 1 | 600 |
| $\mathbf{Z}$ | 0 | 0 | 22 | 170 | 40 | 0 | 284000 |

Interpret the matrix and specify its significance with respect to the new product development.
(9 marks)
(Total: 20 marks)

## QUESTION FIVE

Consider a project which requires the following activities:

| Activity | Preceding Activity | Activity Time (days) |  | Total Cost (Shs) |  |
| :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | Norma | Crash | Normal | Crash |
| A | - | 16 | 14 | 400 | 480 |
| B | - | 13 | 12 | 340 | 360 |
| C | A | 15 | 13 | 380 | 500 |
| D | A | 14 | 12 | 200 | 260 |
| E | A | 13 | 11 | 260 | 280 |
| F | C | 13 | 12 | 310 | 380 |
| G | D,D,E | 15 | 10 | 430 | 580 |
| H | H | 12 | 9 | 280 | 370 |
| I | F,G,I | 13 | 11 | 400 | 420 |
| J |  |  | 11 | 260 | 320 |

## Required:

a. Using normal activity durations and costs:
i. Draw the critical path network for the project and determine the critical path and its duration.
ii. Calculate the cost of the project.
ii. Calculate the total floats of the non-critical activities.
b. It is required to reduce the project duration by one day at the minimum possible cost:
i. Which activity should be crashed?
ii. What will be the new cost of the project?
(Total: 20 marks)

# KENYA ACCOUNTANTS AND SECRETARIES NATIONAL EXAMINATION BOARD CPA PART III MANAGEMENT ACCOUNTING 

Tuesday, 3 December 1991

Time Allowed: 3 hours

Answer ALL questions. Marks allocated to each question are shown at the end of the question. Show all your workings.

## QUESTION ONE

The financial controller of Monica Industries Ltd. has determined the major activities involved in the preparation of the annual financial statements. These activities are shown below:

| Activity |  | Duration (in weeks) | Immediately preceding activity |
| :---: | :---: | :---: | :---: |
| A: | Check outstanding purchase invoices | 2 | - |
| B: | Close cash book and post to general ledger | 2 | - |
| C: | Complete sales invoices | 3 | - |
| D: | Check accrued salaries and wages | 1 | - |
| E: | Count and verify stock levels | 4 | - |
| F: | Calculate stock valuation | 2 | E |
| G : | Close purchase ledger and post to general ledger | 1 | A |
| H: | Close sales ledger and post to general ledger | 1 | C |
| I: | Post salaries and wages to general ledger | 1 | D |
| J: | Close general ledger | 1 | B, G, H, I |
| K: | Prepare trial balance | 3 | J |
| L: | Apply closing adjustment to trial balance | 2 | F, K |
| M: | Re-open general ledger for new period | 1 | N |
| N : | Prepare final accounts | 6 | L |
| O: | Submit final accounts to board for approval | 1 | N |

## Required:

a. Draw a network to represent the inter-relationships between the above activities and insert the latest event times throughout.
(6 marks)
b. Assuming that preparation of the account starts at the beginning of the first week in January, calculate the earliest date the final accounts can be presented to the board.
(4 marks)
c. The end of week 13 is the end of the financial ear and the Board has indicated that the final accounts must have been approved by that time. The financial controller has suggested that to achieve this, activities A, C and D can all be completed by the end of December and also that the verification of stocks levels, E, could be done in only two weeks of additional labour available.

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Comment on these suggestions
(6 marks)
d. Explain how management may use network systems in the design of multi-stage production process.
(4 marks)
(Total: 20 marks)

## QUESTION TWO

The Oil Kenya Company currently sells three grades of petrol, regular, premium and 'regular extra' which is a mixture of regular and premium. Regular premium is advertised as being "at least 50 percent premium". Although any mixture containing 50 per cent or more premium fuel could be sold as `regular extra' it is less costly to use exactly 50 per cent. The percentage of premium fuel in the mixture is determined by one small valve in the blending machine. If the valve is properly adjusted, the machine provides mixture which is 50 percent premium and 50 percent regular. Assume that if the valve is out of adjustment the machine provides a mixture which is 60 percent premium and 40 percent regular. Once the machine is started it must continue until 100,000 litres of `regular extra' have been mixed.

The following data is available:

> Cost per litre—premium

Cost per litre-regular
Cost of checking valve
800.00

Cost of adjusting valve 400.00

Subjective estimates of the probabilities of the valve's condition are estimated to be:

| Event | Probability |
| :--- | :---: |
| Valve in adjustment | 0.7 |
| Valve out of adjustment | 0.3 |

## Required:

(a) The expected cost of checking the valve and adjusting it if necessary. (5 marks)
(b) The conditional cost of not checking the valve when it is out of adjustment (5 marks)
(c) Using the criterion of minimum expected cost, calculate the probability at which there will be need to check if the valve is out of adjustment. comment on the results.
(5 marks)
(d) Comment on the results obtained in (a) and (b) above.
(Total: 20 marks)
3. (a) Many writers in process costing advocate ignoring normal spoilage in the computation of equivalent units.

Discuss the propriety of ignoring normal spoilage in the computation of equivalent units for developing per unit costs. consider in the answer the possibility that the point of inspection, and hence the identification of spoiled units, occurs:
i. at the end of a process;
ii at the beginning of a process;
(10 marks)
(b) The Mathare Company had 8,000 units of work-in-process in its Department M as on 1 August 1991, which were $50 \%$ complete as to conversion costs. Materials are introduced at the beginning of the process. During August, 17,000 units were started, 18,000 units were completed and there were 2,000 units of normal spoilage. Mathare Company had 5,000 units of work-in-process at 31 August 1991, which were $60 \%$ complete as to conversion costs.

Under Mathare's cost accounting system, spoiled units reduce the number of units over which total cost can be spread.

## Required:

Compute, using the weighted average method, the equivalent units for August. (10 marks)
(Total: 20 marks)

## QUESTION FOUR

Westland Manufacturing Company Limited manufactures several different styles of children lunch boxes. Management estimates that during the months of July, August and September or 2014, the company will be operating at 80 percent of normal capacity. Because the company desires a higher utilisation of plant capacity, it will consider a special order.

Westland has received special-order inquiries from two companies. The first inquiry is from Sigh Plastic Limited (SPL) which would like to market a lunch box case similar to one of Westland's boxes. The SPL lunch box would be marketed under SPL's own label. SPL has offered Westland Shs 57.50 per box for 20,00 boxes to be supplied by 1 October 2014. Cost data are given below for the Westland lunch box that is similar to the lunch box desired by SPL.

|  | Shs |
| :--- | :--- |
| Regular selling price per unit | $\underline{90.00}$ |
| Cost per unit: | 25.00 |
| Raw materials | 30.00 |
| Direct labour, 0.5 hours at Shs 60 | $\underline{10.00}$ |
| Overhead, 0.25 machine hours at Shs 40 | $\underline{65.00}$ |
| Total per unit |  |

According to the specifications provided by SPL, the special order box requires less expensive raw materials. Consequently, the raw materials will only cost Shs 22.50 per box. Management has estimated that the remaining costs, labour time and machine time will be same as those for the Westland lunch box.

The second special order submitted by Odogo Foods Limited, was for 7,500 lunch boxes for Shs 75.00 per box. These boxes would be marketed under the Odogo label and would have to be supplied by October 2014. The Odogo lunch box is different from any lunch box in the Westland's line. The estimated cost per unit of this box are as follows:

## Shs

| Raw materials | 32.50 |
| :--- | :--- |
| Direct labour, 0.5 hours at Shs 60 | 30.00 |
| Overhead, 0.5 machine-hours at Shs 40 | $\underline{20.00}$ |
| Total cost per unit | $\underline{82.50}$ |

In addition, Westland will incur Shs 15,000 additional set-up costs and will have to purchase a Shs 25,000 special device to manufacture these boxes. The device will be discarded once the special order has been completed.

The Westland manufacturing capabilities are limited to the total machine-hours available. The plant capacity under normal operations is 90,000 machine-hours per year or 7,500 machine-hours per month. The budgeted fixed overhead for 2014 amounts to Shs 2,160,000. All manufacturing overhead costs (fixed and variable) are applied to production on the basis of machine-hours, at Shs 40 per hour.

During July, August and September, Westland will be able to use all of its excess capacity to work on special
orders. Management does not expect any repeat sales to be generated from either special order.
Company practice precludes Westland from sub-contracting any portion of an order when special orders are not expected to generate repeat sales.

## Required:

Should Westland Manufacturing Company Limited accept either special order?
Justify your answer and show calculations.

## QUESTION FIVE

Discuss the meaning and applications of any FOUR of the following concepts in management accounting.
a. Program planning and budgeting systems.
b. Zero-base budgeting.
c. Just-in-Time Production.
d. Game Theory.
e. Information asymmetry.

## MODEL ANSWERS TO PAST CPA EXAMINATION PAPERS

MODEL ANSWERS TO THE CPA PAPER JUNE 2013

## QUESTION ONE

Methods used to analyses uncertainty in CV-P
analysis Sensitivity analysis
This is what if analysis that considers the effect of a marginal change on each of the relevant variables to the decision.

## Point estimate of probability

This approach requires a number of different values for each of the uncertain variables to be selected. Usually three values are selected: these are the worst possible, most likely and best possible outcomes. For each of these values a probability of occurrence is estimated. The expected values and standard deviation can then be computed.

## Continuous probability distribution

(e.g. normal distribution)

The uncertain variables can be estimated as a continuous probability distribution. Estimates are made of the mean and standard deviation, which can then be used to compute expected profit, standard deviation of profits and probability that the company will break even.

## Simulation analysis

This is a method of analyzing a system by experimentally duplicating its behaviour. Simulation is used where analytical techniques are not available or would be very complex.
b) (i)Current production: Ti only

$$
\begin{aligned}
& \text { contribution }=10-6=\text { Sh. } 4 \\
& \begin{aligned}
\text { E (Profit) } & =4 \times 110,000-400,000=\text { Sh. } 40,000 \\
\delta \text { profit } & =4 \times 10,000=\text { Sh. } 40,000
\end{aligned} \\
& \begin{aligned}
\text { BEP units } & =\underbrace{\text { Total fixed costs }}_{\text {Contribution margin }} \\
= & =100,000 \text { units }
\end{aligned} \\
& \text { BEP sh. }=100,000(10)=\underline{\text { Sh. } 1,000,000}
\end{aligned}
$$

ii) Coefficient of variation C.V

$$
\mathrm{C} . \mathrm{V}=\frac{\delta}{\mathrm{E} \text { (profit) }}=\frac{40,000}{40,000}=1
$$

(i) Proposed production: Ti and T 2 .

$$
\begin{aligned}
\text { Expected profit } & =4(85,000)+3(50,000)-(400,000+50,000) \\
& =\underline{S h .40,000}
\end{aligned}
$$

$$
\begin{aligned}
& \delta_{\Pi}=\sqrt{\mathrm{CM}_{1}^{2}} \delta_{1}^{2}+C M_{2}^{2} \delta_{2}^{2}+2 r_{12}+\mathrm{CM}_{1} \mathrm{CM}_{2} \delta_{1} \delta_{2} \\
& \quad=\sqrt{4^{2}(8000)^{2}+3^{2}(5000)^{2}}+2(-0.9)(4)(3)(8000)(5000) \\
& =19621.4
\end{aligned}
$$

$$
B . E . P \text { units = Total fixed costs average }
$$

contribution margin

$$
A V \cdot C M=4\left(135^{85}\right)+3\left(135^{50}\right)=3.62962963
$$

$$
\text { BEP units }=\underline{400,000} \pm \underline{50,000}=
$$

$$
\underline{123980} \text { units } 3,62962963
$$

$$
\mathrm{T}_{1}=135^{85}(123980)=78061 \text { units }
$$

$$
\mathrm{T}_{2}=135^{50}(123980)=45919 \text { units }
$$

| in $\underline{\text { sh }}$ | $\underline{\mathrm{T} 1}$ | $\underline{\text { sh }}$ |
| :--- | :---: | :--- |
| BEP $\mathrm{Sh}=$ | $78061 \times \mathrm{Sh} 10$ | $=$ |
| 780,610 |  |  |
| BEP Sh $=$ | $\underline{\mathrm{T} 2}$ | $45919 \times 8$ |$\quad=\underline{\underline{367,352}}$| Total BEP Sh |
| :--- |

(ii) Coefficient of variation (C.V)

$$
\mathrm{C} . \mathrm{V}=\frac{\delta}{E(\text { profit })} \quad=\frac{19621.4}{40,000}=\underline{\underline{0.49}}
$$

(iii) Since the mean demand is greater than breakeven point then BEP is not a good criteria in making the decision. We should use the coefficient of variation.

The decision therefore is to add $\mathrm{T}_{2}$ to the production schedule since it r educes the coefficient of variation from 1 to 0.49 .

## QUESTION TWO

Overhead absorption is the technique of attributing departmental overhead costs to a cost unit.. Traditionally, the basis of overhead absorption was the number of labour hours expected within the budget period and this was then used to calculate an absorption rate per labour hour. This was then used to attribute costs to the cost units on the basis of the number of labour hours used to produce the cost unit.

Alternative bases of apportioning exist such as the number of machine hours or the percentage of particular elements of prime costs incurred in respect of cost units. If the method of manufacture is machine intensive for example, it is more realistic to absorb the overhead cost on the basis of the number of machine hours instead of the number of labour hours.

A further development is to divide the overheads into those costs, which are labour related, and those, which are machine hour, related and apply a separate absorption rate to each part of the overhead cost. This is the use of multiple rates similar to the principle of activity bases costing (ABC).

ABC is based on the principle that activities cause costs and therefore the use of activities should be the basis of attributing costs to cost units. Costs are identified with particular activities and the performance of those activities is linked with products.
b) (i) Incremental budgeting uses the previous year's budget as the starting point for the preparation of next year's budget. It assumes that the basic structure of the budget will remain unchanged and that adjustments will be made to allow for changes in volume, efficiency and price levels. The budget is therefore concerned with increments to operations that will occur during the period and the focus is on existing uses of resources rather than considering alternative strategies for the future budget period. Incremental budgeting suffers from the following weaknesses:
It perpetuates past inefficiencies
There is insufficient focus on improving efficiency and effectiveness.
The resource allocation tends to be based on existing strategies rather than considering future strategies. It tends to focus excessively on the short term and often leads to arbitrary cuts being made in order to achieve short-term financial targets
(ii) The answer should stress that:; The
focus is on managing activities
The focus is on the resources that are required for undertaking activities and identifying those activities resources that are un-utilized or which are insufficient to meet the requirements specified in the budget.
Attention is given to eliminating non-value-added activities.
The focus is on the control of the causes of costs (i.e. the cost drivers).

## QUESTION THREE

For (a) and (b)

|  | Fixed Fee | Share of Revenue to Joan | Share of Costs Borne By Joan | Net profit to Joan | Joint <br> Prob | Expected <br> Monetary value |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Contract A | Sh. 'm' | Sh. 'm' | Sh. 'm' | Sh 'm' |  | Sh. 'm' |
| HD - BC | 10 | 100 | - | 110 | 0.06 | 6.6 |
| HD - HC | 10 | 100 | - | 110 | 0.04 | 4.4 |
| MD - BC | 10 | 0 | - | 10 | 0.18 | 1.8 |
| MD - HC | 10 | 0 | - | 10 | 0.12 | 1.2 |
| LD - BC | 10 | 0 | - | 10 | 0.36 | 3.6 |
| LD - HC | 10 | 0 | - | 10 | $\frac{0.24}{1.0}$ | $20.0$ |
|  |  |  |  |  | $1.0=$ | $20.0$ |
| Contract B |  |  |  |  |  |  |
| HD - BC | 0 | 200 | 20 | 180 | 0.06 | 10.8 |
| HD - HC | 0 | 200 | 70 | 130 | 0.04 | 4.4 |
| MD - BC | 0 | 50 | 20 | 30 | 0.18 | 5.4 |
| $\mathrm{MD}-\mathrm{HC}$ | 0 | 50 | 70 | -20 | 0.12 | -4.8 |
| LD - BC | 0 | 10 | 20 | -10 | 0.36 | -3.6 |
| LD - HC | 0 | 10 | 70 | -60 | 0.24 | -19.2 |
|  |  |  |  |  |  | -7.0 |
| Contract C |  |  |  |  |  |  |
| HD - BC | 0 | 600 | 50 | 550 | 0.06 | 33.0 |
| $\mathrm{HD}-\mathrm{HC}$ | 0 | 600 | 150 | 450 | 0.04 | 18.0 |
| MD - BC | 0 | 150 | 50 | 100 | 0.18 | 18.0 |
| MD - HC | 0 | 150 | 150 | 0 | 0.12 | 0 |
| LD - BC | 0 | 30 | 50 | -20 | 0.36 | -7.2 |
| LD - HC | 0 | 30 | 150 | -12 | 0.24 | -28.8 |
|  |  |  |  |  |  | 33.0 |

Note
HD = High demand
$\mathrm{MD}=$ Moderate demand
LD = Low demand
$\mathrm{BC}=$ Budgeted Cost
$\mathrm{HC}=$ High Cost
b) From the solution above the

EMV for Contract A $=$ Sh. 20 million
EMV for Contract $\mathrm{B}=\mathrm{Sh} .1$ million
EMV for Contract $\mathrm{C}=\mathrm{Sh} .3$ million
Joan should choose contract C, given the objective of maximizing expected monetary value.
c) Three sources of information Joan might use are:

Her own track record of actual production and marketing relative to amounts
The tract record of the film station parts in "the rise and fall of cock" film running over budget
The geographical location of the technical nature of the stunts set the film. Examine the tract record costs against budgeted costs for films in the same location and of similar difficulty.

## QUESTION FOUR

(a) (i)

|  | Machine Hours | Maintenance |  |  |  |
| :---: | :---: | :---: | ---: | ---: | :---: |
| $\underline{\text { Month }}$ | $\underline{\mathrm{X}}$ | $\underline{\operatorname{Cost} \mathrm{Y}}$ | $\underline{\mathrm{XY}}$ | $\underline{\mathrm{X}^{2}}$ | $\underline{\mathrm{Y}^{2}}$ |
| 1 | 800 | 350 | 280,000 | 640,000 | 122,500 |
| 2 | 1,200 | 350 | 420,000 | $1,440,000$ | 122,500 |
| 3 | 400 | 150 | 60,000 | 160,000 | 22,500 |
| 4 | $\underline{1,600}$ | $\underline{550}$ | $\underline{880,000}$ | $\underline{2,560,000}$ | $\underline{302,500}$ |
| Sum | $\underline{1,000}$ | $\underline{1,400}$ | $\underline{1,640,000}$ | $\underline{4,800,000}$ | $\underline{570,000}$ |

High Low method

|  | X | Y |
| :--- | ---: | :--- |
| Highest point | 1,600 | 550 |
| Lowest point | $\underline{400}$ | $\underline{150}$ |
| Difference | $\underline{1,200}$ | $\underline{400}$ |

$$
\begin{aligned}
& \mathrm{b}=\frac{400=0.33}{1200} \\
& \hat{Y}=\mathrm{a}+\mathrm{bx}
\end{aligned}
$$

Substitute Highest point

$$
\begin{aligned}
& 550=a+0.33(1,600) \\
& a=17
\end{aligned}
$$

The cost function is $Y=17+0.3 \mathrm{X}$.
Regression analysis
(ii)

$$
\begin{aligned}
b & =\frac{\mathrm{n} \varepsilon x y-\varepsilon x \varepsilon y}{2}=\frac{4(1,640,000)}{2}=\frac{4,000(1,400)}{} \\
& =0.3
\end{aligned}
$$

$$
\mathrm{a}=\frac{\Sigma \mathrm{Y}}{\mathrm{n}}-b \quad \frac{\varepsilon x}{n}=\frac{1,400}{4}-0.3\left(\frac{4,000}{4}\right)=50
$$

The function is $\mathrm{Y}=50+0.3 \mathrm{x}$
b) (i)
$\mathrm{Y}=50+0.3 \mathrm{X}$
If $x=900$
$\mathrm{Y}=50+0.3(900)=\underline{\underline{320}}($ in Sh. '000' $)$

$$
\begin{aligned}
& X={ }^{1}+{ }^{1} \mathrm{Y} \\
& b^{1}=\underline{n \Sigma X Y-\Sigma X \Sigma Y}=\underline{4(1,640,000)-4000(1400)} \\
& N \Sigma Y^{2}-(\Sigma Y)^{2} \quad 4(570,000)-(1400)^{2} \\
& =\frac{960,000}{320,000}=3 \\
& \begin{array}{l}
1 \quad \underline{\Sigma x} \\
a=\frac{1 \Sigma Y}{n}-b \quad n
\end{array} \\
& =\begin{array}{ll}
4,000 & \underline{1,400} \\
4 & 4
\end{array}=\underline{-\frac{50}{}} \\
& X=-50+3 Y \\
& \text { If } Y=400 \\
& \mathrm{X}=-50+3(400)=1,150 \text { machine hours. } \\
& \mathrm{Y}-\mathrm{t}_{\mathrm{c}} s_{e} \leq \mathrm{Y} \leq \mathrm{Y}+\mathrm{t}_{\mathrm{c}} s_{e} \\
& 320-2.7764(63.25) \leq Y \leq 320+2.27764(63.25)
\end{aligned}
$$

(ii)
$144.39 \leq Y \leq 495.6$
We are $95 \%$ confident that maintenance cost next period will lie between Sh.144,390 and Sh.495,000

## QUESTION FIVE


b) (i)Let $A_{1}$ be company $A$ undertakes a vigorous market campaign.

A2 be Company A does not run the market campaign
$\mathrm{B}_{1}=$ Company B invests Sh. 25 m in Research and Development (R \& D)
$\mathrm{B}_{2}=$ Company B invests Sh. 50 m in R \& D
$\mathrm{B}_{3}=$ Company B invests Sh. 80 m in R \& D
Game Matrix
Company B

|  |  |
| :---: | :---: |
|  |  |
| Company A1 |  | $\mathrm{A}_{1}$| $\mathrm{A}_{1}$ | $\mathrm{~B}_{2}$ | $\mathrm{~B}_{3} \mathrm{~b}$ |  |
| :---: | :---: | :---: | :---: |
|  | $\mathrm{Max}^{2}$ |  |  |\(\left[\begin{array}{cccc}0.79 \& 0.76 \& 0.73 \& 0.73 <br>

0.76 \& 0.74 \& 0.72 \& 0.72\end{array}\right]\)

The game has a saddle point occurring at strategy $A_{3}$. These are the optimal strategies with a game value of $73 \%$ of the market share of A implying that B will get a market share of $27 \%$.
(ii)


## A's Reasonings

If $B$ plays strategy $B_{1}$, then $A$ should play strategy $A_{2}$ to maximize his winnings.
If $B$ plays strategy $B_{2}$, then $A$ should play strategy $A_{2}$.
In all cases A plays strategy A2 B's reasonings.
If A plays strategy $A_{1}$ then $B$ should play strategy $B_{1}$ to maximize his profits.
If A plays strategy $A_{2}$ then $B$ should play strategy $B_{1}$.
The saddle point occurs when A plays strategy $A_{2}$ and $B$ plays strategy $B_{1}$.
The profit contribution will be:
Company A: Sh. 228 million
Company B: Sh. 47 million

KENYA ACCOUNTANTS AND SECRETARIES NATIONAL EXAMINATIONS BOARD

## CPA PART III

## MANAGEMENT ACCOUNTING

## DECEMBER 2011

QUESTIONONE

```
\(D=475\)
Co \(=\) Sh. 50
\(\mathrm{Ch}_{\mathrm{h}}=\) Sh. \(12.50+10 \%(250)=\) Sh. 37.50
```

| Lead time demand | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| Probability | 0.02 | 0.04 | 0.12 | 0.16 | 0.20 | 0.16 | 0.16 | 0.10 | 0.04 |

$\mathrm{EOQ}=\sqrt{\frac{2 \mathrm{X} 475 \times 50}{37.50}}=35.59$ units $\approx 36$ units

Safety stock
0

Stockholding Cost
0
37.50

1

2

3

4
75

Stock out cost
$1 \times 0.04 \times 20 \times 13=10.4$ $2 \times 0.12 \times 20 \times 13=48$ $3 \times 0.16 \times 20 \times 13=124.8$
$4 \times 0.20 \times 20 \times 13=208$
$5 \times 0.16 \times 20 \times 13=208$
$6 \times 0.16 \times 20 \times 13=249.6$
$7 \times 0.10 \times 20 \times 13=182$
$8 \times 0.04 \times 20 \times 13=\frac{83.2}{1114}$
1114
$1 \times 0.12 \times 20 \times 13=31.2$
$2 \times 0.16 \times 20 \times 13=83.2$
$3 \times 0.20 \times 20 \times 13=156$
$4 \times 0.16 \times 20 \times 13=166.4$
$5 \times 0.16 \times 20 \times 13=208$
$6 \times 0.10 \times 20 \times 13=156$
$7 \times 0.04 \times 20 \times 13=72.8$ 873.6
911.1
$1 \times 0.16 \times 20 \times 13=41.6$
$2 \times 0.20 \times 20 \times 13=104$
$3 \times 0.16 \times 20 \times 13=124.8$
$4 \times 0.16 \times 20 \times 13=166.4$
$5 \times 0.10 \times 20 \times 13=\underline{130}$
$6 \times 0.04 \times 20 \times 13=\underline{629.2}$
704.2
$3 \times 37.50=112.5 \quad 1 \times 0.20 \times 20 \times 13=52$
$2 \times 0.16 \times 20 \times 13=83.2$
$3 \times 0.16 \times 20 \times 13=124.8$
$4 \times 0.10 \times 20 \times 13=104$
$5 \times 0.04 \times 20 \times 13=\underline{52}$ 416 $\underline{528.5}$

|  |  | $\begin{aligned} & 2 \times 0.16 \times 20 \times 13=83.2 \\ & 3 \times 0.10 \times 20 \times 13=78 \\ & 4 \times 0.04 \times 20 \times 13=41.6 \end{aligned}$ | $\underline{394.4}$ |
| :---: | :---: | :---: | :---: |
|  |  |  |  |
|  |  |  |  |
|  |  | 244.4 |  |
| 5 | $5 \times 37.5=187.5$ | $1 \times 0.16 \times 20 \times 13=41.6$ |  |
|  |  | $2 \times 0.10 \times 20 \times 13=52$ |  |
|  |  | $3 \times 0.04 \times 20 \times 13=\underline{31.2}$ |  |
|  |  | 124.8 | 312.3 |
| 6 | $6 \times 37.5=225$ | $1 \times 0.1 \times 20 \times 13=26$ |  |
|  |  | $2 \times 0.04 \times 20 \times 13=\underline{20.8}$ |  |
|  |  | 46.8 | $\underline{271.8}$ |
| 7 | $7 \times 37.5=262.5$ | $1 \times 0.04 \times 20 \times 13=10.4$ | $\underline{272.9}$ |
| 8 | $8 \times 37.5=300$ | 0 | 300 |

The optimal safety stock is 6 units. The reorder level will be:

$$
\begin{aligned}
& \text { ROL }=\text { Cycle Stock }+ \text { safety stock } \\
& \quad=\frac{\mathrm{DL}}{\mathrm{Q}}+\mathrm{S} \\
& =\underline{475 \times 3}+6=45.58 \approx \underline{46 \text { units }} 36
\end{aligned}
$$

b) Total annual relevant

$$
\begin{aligned}
& \text { Cost (TRC) } \\
& \begin{aligned}
\mathrm{TRC} & =\underline{\mathrm{D}} \mathrm{Co}+\left[\begin{array}{l}
1 / 2 \mathrm{Q}
\end{array}+\mathrm{S}\right. \\
& \mathrm{C}] \\
& =475(50)+(1 / 2(36)+6) 37.50=\underline{\text { Ksh.1,559.72 }}
\end{aligned}
\end{aligned}
$$

## QUESTION TWO

(a) Produce (a) of A (b) units of B, (c) units of C (d) units of product D and (e) units of products E each week

Calculate the unit contribution of each product.
A: unit contribution is $40-\{(2.10 \times 6)+(3.0 \times 1.0)+(1.3 \times 3)+8.0 \times 0.5)\}$ $=$ Shs. 16.50 per unit.

B: unit contribution is $42-\{(2.10 \times 6.5)+(3.0 \times 0.75)+(1.3 \times 4.5)+(8 \times 0.5)\}$
$=$ Shs. 16.25 per unit
C: unit contribution is $44-\{(2.10 \times 6.10)+(3.0 \times 1.25)+(1.3 \times 6)+(8 \times 0.5)\}$

$$
=\text { Shs. } 15.64 \text { per unit }
$$

D: unit contribution is $48-\{(2.10 \times 6.1)+(3.0 \times 1)+(1.3 \times 6)+(8 \times 0.75)\}$

$$
=\text { Shs. } 18.39 \text { units }
$$

E: unit contribution is $52-\{(2.10 \times 6.4)+(3.0 \times 1)+(1.3 \times 4.5)+(8.0 \times 1)\}$ $=$ Shs. 21.71 per unit

Maximize total weekly contribution, Shs. P where;
$\mathrm{P}=16.5 \mathrm{a}+16.25 \mathrm{~b}+15.64 \mathrm{c}+18.39 \mathrm{~d}+21.71 \mathrm{e}$ Shs $/$ Week
Subject to:
Materials: $6.0 \mathrm{a}+6.5 \mathrm{~b}+6.1 \mathrm{c}+6.1 \mathrm{~d}+6.4 \mathrm{e} \leq 35,000 \mathrm{~kg} /$ week
Forming: $\quad 1.0 \mathrm{a}+0.75 \mathrm{~b}+1.25 \mathrm{c}+1.0 \mathrm{~d}+1.0 \mathrm{e} \leq 6,000$ hours/week
Firing: $\quad 3.0 \mathrm{a}+4.5 \mathrm{~b}+6.0 \mathrm{c}+6.0 \mathrm{~d}+4.5 \mathrm{e} \leq 30,000$ hours/week
Packing: $0.5 \mathrm{a}+0.5 \mathrm{~b}+0.5 \mathrm{c}+0.75 \mathrm{~d}+1.0 \mathrm{e} \leq 4,000 \mathrm{~kg} /$ week
Non-negativity: a, b, c, d, e, $\geq 0$
(b) (i) The optimum weekly production plan is to produce 3,357 units of product
$\mathrm{A}, 2,321$ units of product E and none of $\mathrm{B}, \mathrm{C}$ or D . The resulting maximum weekly contribution is Kshs.105,791.
(ii) There is spare capacity of 321 hours per week on the forming process and 9,482 hours per week on the firing process. All raw materials and all packing time are used up. Raw materials and packing time are the limiting constraints in the problem.
(iii) The shadow price is the amount, which would be added to the value of the total weekly contribution if one extra unit of a limiting resource were made available that:

No additional costs were incurred.
The resource remains limiting
Alternatively the shadow price is the amount by which the total weekly contribution would fall if the provision of a limiting resource was reduced by one unit.

From the table, we can see the shadow price for raw materials is Ksh. 2.02 per kilogram and for packing time is Kshs.8.81 per hour. One additional kilogram of raw material will generate an extra Kshs. 2.20 of contributions, subject to the conditions above. One extra hour of packing time will, similarly generate additional shs. 8.81 of contribution.

The additional product would also have to be made at the expense of one or both of the other products, since all raw materials and packing time are currently used.

Unit contribution of the new product

$$
\begin{gathered}
=50-\{(2.1 \times 1.6)+(3.0 \times 1)+(1.3 \times 5)+(8 \times 1)\} \\
=\underline{\text { Kshs.19.9 }}
\end{gathered}
$$

If one unit of this new product was made, the provision of raw materials for the other two products would effectively be reduced by 6 kilogrammes, this would reduce the current total contribution by 6 x Kshs.2.02 = Kshs.12.12. Similarly, the available packing time would be reduced by 1 hour, this reduces the total contributions by Kshs.8.81. The total reduction is the weekly contribution which would be:

Kshs. $12.12+$ Kshs. $8.81=\underline{\text { Kshs. } 20.93}$
The gain from one unit of the new product is shs. 19.90 therefore, if one unit of the new product is made, there will be a net loss of

Shs. 19.90 - Shs. 20.93 = Shs.1.30. the proposition is not worthwhile.

## QUESTION THREE

a) Four ways in which competitive situation can be classified are:

Number of competitors e.g. two persons and N - persons game.
Nature of payoff e.g. zero sum and non zero sum games
Number of strategies available to each player e.g. $2 \times 2$ game, $2 \times 3$ game etc.
Amount of information the competitors have e.g. games with perfect information or Games with imperfect information.
b) (i)

|  | Game matrix |  |  |
| :--- | :--- | :--- | :--- |
| Kamau | Njoroge |  |  |
|  |  | $\mathrm{K}_{1}$ | $\left(\begin{array}{l}\mathrm{N}_{1} \\ 500\end{array}\right.$ |
| $\mathrm{K}_{2}$ | -500 |  |  |
| 0 | 1,000 |  |  |
| Max | 500 | 1,000 |  |$) \quad$| Min |
| :--- |
|  |

Where:
$\mathrm{K}_{1}$ is Kamau does not expand
$\mathrm{K}_{2}$ is Kamau expands
$\mathrm{N}_{1}$ is Njoroge does not expand
$\mathrm{N}_{2}$ is Njoroge expand

## Note:

Since there is no entry that simultaneously a maximum of the now minima and a minumum of the column maxima, then a saddle point does not exist. There is therefore no pure strategy.
(ii) Let K be proportion of time Kamau does not expand $1-\mathrm{K}$ is the proportion of time Kamau expands.

$$
\begin{aligned}
500 \mathrm{~K}_{1} & +0\left(1-\mathrm{K}_{1}\right)=-500 \mathrm{~K}_{1}+1,000\left(1-\mathrm{K}_{1}\right) \\
500 \mathrm{~K}_{1} & +=-1,500 \mathrm{~K}_{1}+1,000 \\
2,000 \mathrm{~K}_{1} & =1,000 \\
\mathrm{~K}_{1} & =\underline{0.5} \\
\mathrm{~K}_{2} & =\underline{0.5}
\end{aligned}
$$

Let $\mathrm{N}_{1}$ be proportion of time Njoroge does not expand
$1-\mathrm{N}_{1}$ be proportion of time Njoroge expands.
$500 \mathrm{~N}-500\left(1-\mathrm{N}_{1}\right)=\mathrm{O}_{1} \mathrm{~N}+1,000\left(1-\mathrm{N}_{1}\right)$
$1,000 \mathrm{~N}_{1}-500=1,000-1,000 \mathrm{~N}$
$2,000 \mathrm{~N}_{1}=1,500$

$$
\begin{aligned}
& \mathrm{N}_{1}=\underline{1,500}=\underline{0.75} \\
& 2,000 \\
& \mathrm{~N}_{2}=\underline{0.25}
\end{aligned}
$$

| Strategies | Joint probability | Payoff | Pay offs |
| :---: | :---: | :---: | :---: |
| $\mathrm{K}_{1} \mathrm{~N}_{1}$ | $0.5(0.75)=0.375$ | 500 | 187.5 |
| $\mathrm{K}_{1} \mathrm{~N}_{2}$ | $0.5(0.25)=0.125$ | -500 | -62.5 |
| $\mathrm{K}_{2} \mathrm{~N}_{1}$ | $0.5(0.75)=0.375$ | 0 | 0 |
| $\mathrm{K}_{2} \mathrm{~N}_{2}$ | $0.5(0.25)=0.12$ | 1,000 | 125 |
|  |  |  | 250 |

Kamau would expect to increase his profits by Sh. 250 per day on average while Njoroge expects to lose Sh. 250 per day on average.

## QUESTIONFOUR

(a) The minimum price of Mega Techniques Ltd is the price which reflects the relevant costs(opportunity costs) of the work. These are established as follows:

Cost of original machine. Past costs are not relevant, and the shs.8, 280,000 of costs incurred should be excluded form the minimum price calculation. It is necessary, however, to consider the alternative use of the direct materials (opportunity cost), which would be forgone if the conversion work is carried out.

| Type P | Shs. |
| :--- | :--- |
| Revenue from sales as scrap (note 1) | 540,000 |

## Type Q

Revenue from sales as scrap, Minus the additional cash costs necessary to
Prepare it for sale $(360,000-\{120 \times 270\})$ note $1 \quad 327,600$

## Type R

Cost of Disposal if the machine is not converted (a negative opportunity cost) note 2

108,000
Total opportunity costs of materials Types P, Q, R
885,600
By agreeing to the conversion of the machine Mega Techniques Ltd would therefore lose net revenue of Shs. 885,600 from alternative use of these materials.

## Notes

1. Scrap sales would be lost if the work for Zimwi systems Limited goes ahead.
2. These costs would be incurred unless the work goes ahead.

The cost of additional materials for conversion is shs.576, 000 but this is an historical cost. The relevant cost of close materials is the Shs.684, 600 that would be spent on new purchases if the conversion is carried out. If the work in stock would be unavailable goes ahead, the materials in stock
would be unavailable for production of the other machine mentioned item (2) of the question and so the extra purchases of khs.684, 000 would be needed.

Direct labour in Department X and Y is a fixed cost and the labour force will be paid regardless of the work they do or not do. The cost of labour for conversion in Department $Y$ is not a relevant cost because the work could be done without any extra cost the company.
In Department X, however, acceptance of the conversion work would be oblige the company to divert production from other profitable jobs. The minimum contribution from using Department X labour must be sufficient to cover the cost of the labour and variable overheads and then make an additional Shs.2.50 in contribution per direct labour hour.

Department X - costs for direct labour hours spent in conversion;
3 men x 4 weeks x 27,000
Shs.324, 000
Variable overhead cost:
Shs.324, $000 \times 20 \%$
Shs. 64,800
Contribution forgone by diverting
Labour from other work
Shs. 2.5 per shs. 1 of labour cost
$=324,000 \times 150 \%$
Shs.486, 000
Variable overheads in Department Y are relevant costs because they will only be increased if production work is carried out (It's assumed that if the work done is idle, no variable overheads would be manned).

$$
\text { Department } Y=20 \% \text { of }(1 \text { man } x 4 \text { weeks } x \text { shs. } 21,600)=86,400
$$

If the machine is converted, the company cannot sell the designs and specifications to the overseas companyhs. 270,000 is relevant (opportunity) cost of accepting the conversion order.

Fixed overhead, being manly undercharged regardless of what the company decided to do should be ignored because they are not relevant (incremental) costs. The additional cost of supervision should, however, be included as a relevant cost of order because the shs. 162,000 will not be spent unless the conversion work is done.

The money received from Pawa Limited should be ignored and should not be deducted in the calculation of the minimum price. Just as costs incurred in the past are irrelevant to a current decision about what to do in the future, revenue collected in the past are also irrelevant.

## ESTIMATED MINIMUM PRICE FOR THE MACHINE

|  | Shs. | Shs. |
| :--- | :---: | ---: |
| Opportunity cost of using the direct |  | 885,600 |
| Material types P, Q, R | 684,000 |  |
| Opportunity cost of additional materials for |  |  |
| Conversion | 324,000 |  |
| Opportunity cost of work in Department X: | 64,800 |  |
| Labour | $\underline{486,000}$ | 874,800 |
| Variable overhead |  | 270,000 |
| Contributions forgone |  | 86,400 |
| Opportunity cost: sale of design \& specifications | $\underline{162,000}$ |  |
| Incremental costs: | $\underline{2,962,800}$ |  |
| Variable production overheads in Department Y |  |  |
| Fixed production overheads |  |  |
| Minimum price |  |  |

(b) (i) cost behavior patterns are known.
(ii) The amount of fixed costs, unit variable costs, sales price and sales demand are known with certainty.

The objective of decision-making in the short-run is to minimize "satisfaction" which is often regarded

## MODEL ANSWERS TO THE CPA PAPER SET DECEMBER 2010

## QUESTION ONE

## Feed forward control

Describes a control system in which deviations in the system are anticipated in a forecast of future results, so that 'corrective action' can be taken in advance of any deviations actually happening while on the other hand, Feedback control system is information about actual achievements. In business organization, it is information about actual results, produced from within the organization (for example management accounting control reports) with the purpose of helping the control decisions.

In his statement Chris Argyris, he identified situations why mangers could be reluctant in setting budgets: as follows:
The budget is seen as a pressure device, based by management to force ' lazy' employees to work harder. The intention of such pressure is to improve performance, hut the unfavourable reactions of subordinates against is seems to be at the core of the budget problem.

The accounting department is usually responsible for recording actual achievement and comparing this against budget. Accountants therefore are 'budget man' is the failure of another manager and this failure causes loss of interest and declining performance. The accountant, on the other hand, fearful of having his budget derailed by factory management, obscures his budget and variance reporting, and deliberately makes it difficult to understand.

The budget usually sets targets for each department, achieving the departmental target becomes of paramount importance regardless of the effect this may have on the other departments and the overall company performance.

Budgets are used by mangers to express their character and patterns of leadership on subordinate; subordinates, resentful of their leadership style, blame the budget rather than the leader thus it looses meaning.

The decision calls for the analysis of benefits and problems of budgeting.

## Benefits

It's the major formal way in which the organizational objectives are translated into specific plans, basics, and objectives related to individual managers and supervisors. It should provide clear guidelines for current operations.
It's an important medium of communication for organizational plans and objectives and the progress towards meeting those objectives.
The development of budgets (done properly) helps to achieve co-ordination between the various departments and functions of the organization.
The involvement of all levels of management with setting budgets, the acceptance of derived targets, the two way flow of information and other facets of a properly organized budgeting system all help to promote a coalition of interest and to increase motivation.
Management's time can be saved and alterations directed to areas of most concern by the 'exception principle' which is at the heart of budgetary control.
Performance of all levels is systematically reported and monitored thus aiding the control of current activities.

The investigation of operations and procedures, which is part of budgetary planning and the subsequent monitoring of expenditure, may lead to reduced costs and greater efficiency.

## Problems

There may be too much reliance on the technique as a substitute for good management.
The budgetary system perhaps of undue pressure or poor human relations, may cause antagonism and decrease motivation.
Variances are just as frequently due to changing circumstances, poor forecasting or general uncertainties due to managerial performance.
Budgets are developed round existing organizational structures and departments, which may be inappropriate for current conditions and may not reflect the underlying economic realities.
The very existence of well documented plans and budgets may cause rigidity and lack of flexibility in adapting to change.
In conclusion, budget should not be abolished as a company or an organization might not adjust to its set objectives without a budget system.

## QUESTION TWO

The variables in the problem are the demand and the lead time. Since the demand is approximated by the continuous normal distribution we will consider demand insteps of $5 \times$ LA 20
Allocation of random numbers to lead time.

## Lead Time

## Cumulative



## Probability

0.20

2
0.50
$3 \quad 0.25$
4
0.05
probability
0.20
0.70
0.95
1.00

## Random

number
00-19
20-69
70-94
95-99
Allocation of random numbers ranges to weekly demand

| Demand/ <br> Week | Probability | Cummulative <br> Probability | Random <br> Number |
| :---: | :---: | :---: | :---: |
| 470 | 0.003 | 0.003 | $000-002$ |
| 475 | 0.009 | 0.012 | $003-011$ |
| 480 | 0.028 | 0.040 | $012-039$ |
| 485 | 0.066 | 0.106 | $040-105$ |
| 490 | 0.121 | 0.227 | $106-226$ |
| 495 | 0.175 | 0.402 | $227-401$ |
| 500 | 0.197 | 0.599 | $402-598$ |
| 505 | 0.175 | 0.774 | $599-773$ |
| 510 | 0.121 | 0.895 | $774-894$ |
| 515 | 0.066 | 0.961 | $895-960$ |
| 520 | 0.028 | 0.989 | $961-986$ |
| 525 | 0.009 | 0.998 | $989-997$ |
| 530 | 0.003 | 1.000 | $998-999$ |
|  |  |  |  |

## Simulation of Stock Control

| Number Week | Opening Stock | Demand |  | Closing Stock | Reorder?YES/NO | Lead-Time |  | Shortage |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | RN | Amount |  |  | RN | Weeks |  |
| 1 | 2,000 | 034 | 480 | 1,520 |  |  |  |  |
| 2 | 1,520 | 743 | 505 | 1,015 |  |  |  |  |
| 3 | 1,015 | 738 | 505 | 510 | YES | 95 | 4 |  |
| 4 | 510 | 636 | 505 | 5 |  |  |  |  |
| 5 | 5 | 964 | 520 | 0 |  |  |  | 515 |
| 6 | 0 | 736 | 505 | 0 |  |  |  | 505 |
| 7 | 2,500 | 614 | 505 | 1,995 |  |  |  |  |
| 8 | 1,995 | 698 | 505 | 1,490 |  |  |  |  |


| 9 | 1,490 | 637 | 505 | 985 | YES | 73 | 3 |  |
| :---: | :--- | ---: | ---: | ---: | :--- | :--- | :--- | :--- |
| 10 | 985 | 162 | 490 | 495 |  |  |  |  |
| 11 | 495 | 332 | 495 | 0 |  |  |  |  |
| 12 | 2,500 | 616 | 505 | 1,995 |  |  |  |  |
| 13 | 1995 | 804 | 510 | 1,485 |  | YES | 10 | 1 |
| 14 | 1,485 | 560 | 500 | 985 | YES |  |  |  |
| 15 | 3,485 | 111 | 490 | 2,995 |  |  |  |  |
| Total |  | 7,525 | 15,475 |  |  | 1,020 |  |  |

Mean demand $=\frac{7525}{15}=501.7 \times$ LA20 $/$ Week
Mean closing stock $=\frac{15,475}{15}=1,031.6 \times \mathrm{LA} /$ Week
Mean shortage $=\underline{1,020}=68 \times$ LA20/Week 15
Number of orders placed during the 15 weeks period $=3$
Therefore, mean number of orders/week $=3 / 15=0.2$
The expected Average cost per week
$=(1,031.67 \times$ Shs. 5$)+(68 \times$ Shs. 200$)+(0.2 \times 500)$
$=\underline{\text { Shs. } 18,858.35}$

## QUESTION THREE

How can the transportation algorithm be modified to maximize rather than minimize? Instead of minimizing the positive unit costs of all the cells, calculate the unit profits, make them negative and put these in each cell. Use the transportation algorithm as usual to minimize these negative profits.
Alternatively, load the cells with the largest profits (instead of smaller costs) to give an initial allocation. Test the empty cells as usual, but use any cell which has positive shadow price. If all the shadow prices are negative or zero, that allocation gives the maximum profit.

Factories $\mathrm{P}_{1} \mathrm{P}_{2} \mathrm{P}_{3}$ supply outlets $\mathrm{S}_{1} \mathrm{~S}_{2} \mathrm{~S}_{3} \& \mathrm{~S}_{4}$
The contribution $=$ selling price - variable cost - factory outlet transport per desk at shop at the factory costs
e.g. the contribution per desk

Supplied from factory $\mathrm{P}=2300-1500-220=$ Sh. 580 to
outlet S

The matrix for contribution is given below:

|  | $\mathrm{S}_{1}$ | $\mathrm{~S}_{2}$ | $\mathrm{~S}_{3}$ | $\mathrm{~S}_{4}$ |
| :---: | :---: | :---: | :---: | :---: |
| $\mathrm{P}_{1}$ | 580 | 610 | 530 | 600 |
| $\mathrm{P}_{2}$ | 510 | 600 | 520 | 570 |
| $\mathrm{P}_{3}$ | 540 | 650 | 490 | 660 |

The total demand from the four outlets is $850+640+380+230=2,100$ desks.
The total supply from the three plants is: $625+825+450=1,900$ desks.
There is therefore a need for a dummy factory to take up the 200 shortfall.
The transportation tableu is as follows:

|  |  | $\begin{aligned} & \mathrm{K}_{1}=58 \\ & \mathrm{~S}_{1} \end{aligned}$ | $\begin{aligned} & \hline \mathrm{K}_{2}=67 \\ & \mathrm{~S}_{2} \end{aligned}$ | $\begin{aligned} & \hline K_{3}=59 \\ & S_{3} \end{aligned}$ | $\begin{aligned} & \hline \mathrm{K}_{4}=68 \\ & \mathrm{~S}_{4} \\ & \hline \end{aligned}$ | Total Capacity |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\mathrm{R}_{1}=0$ | P1 | $\begin{array}{l\|l} \hline 625 & 58 \\ \hline \end{array}$ |  |  |  | 625 | $1 \not 143$ |
| $\mathrm{R}_{2}=-7$ | $\mathrm{P}_{2}$ |  | ${ }_{420} \quad 60$ |  |  | 825 | 38881 |
| $\mathrm{R}_{3}=-2$ | $\mathrm{P}_{3}$ |  | $220 \quad 65$ |  | $230 \quad 66$ | 450 | 111 |
| $\mathrm{R}_{4}=-58$ | Dummy | $\begin{array}{\|l\|l\|} \hline 200 & 0 \\ \hline \end{array}$ |  |  |  | 200 | 00000 |
| Total Demand |  | 850 | 640 | 380 | 230 | 2,100 |  |
|  |  | $\begin{aligned} & \hline 4,4,7, \\ & 51,51 \\ & \hline \end{aligned}$ | 4, 4, 4, 60 | $\begin{aligned} & \hline 1,1,1,52, \\ & 52 \\ & \hline \end{aligned}$ | 6 |  |  |

## Note

The initial solution is determined by use of VAM.
The contributions are divided by 10 simplify the computations.
The mode is used to solve for optimality.

## Note

$\mathrm{m}+\mathrm{n}-1=7$
No of filled cells $=7$
The problem is not degenerate.
All the shadow prices are negative, therefore any change would reduce the contribution. This is thus the optimal solution. The optimal allocation is:

| FROM | TO | Units | Contribution per <br> unit | Total contribution |
| :---: | :---: | :---: | :---: | :---: |
| $\mathrm{P}_{1}$ |  | Sh. | Sh. | Sh. |
| $\mathrm{P}_{2}$ | $\mathrm{~S}_{1}$ | 625 | 580 | 362,500 |
| $\mathrm{P}_{2}$ | $\mathrm{~S}_{1}$ | 25 | 510 | 12,750 |
| $\mathrm{P}_{2}$ | $\mathrm{~S}_{2}$ | 420 | 600 | 252,000 |
| $\mathrm{P}_{5}$ | $\mathrm{~S}_{3}$ | 380 | 520 | 197,600 |
| $\mathrm{P}_{3}$ | $\mathrm{~S}_{2}$ | 220 | 650 | 143,000 |
| Dummy | $\mathrm{S}_{4}$ | 230 | 660 | 151,800 |
| Total contribution | $\mathrm{S}_{1}$ | 200 | 0 | 0 |

## QUESTION FOUR

a) (i) If the selling price is sh. 200 , demand will be zero. To increase demand by one unit, selling
price must be reduced by Sh. 1000 or Sh.0.001. Hence the demand function is $\mathrm{P}=$ $200-0.001 \mathrm{Q}$

At the output level of 100,000 units.

$$
\begin{aligned}
\mathrm{P} & =200-0.001(100,000) \\
& =\text { Sh. } 100 \text { per unit. }
\end{aligned}
$$

The total contribution at an output level of 100,000 units

|  | Sh |
| :---: | :---: |
| Contribution $=100,000(100-50)$ | $5,000,000$ |
| Less fixed cost | $\underline{2,500,000}$ |
| Profit | $\underline{\underline{2,500,000}}$ |

(ii) Profit is maximized when $\mathrm{MC}=\mathrm{MR}$
$\mathrm{MC}=\mathrm{Sh} .50$ per unit variable cost.
$M R=\frac{\mathrm{dTR}}{\mathrm{dQ}}$
$T R=200 Q-0.001 Q^{2}$
$\underline{\mathrm{dTR}}=200$
0.002 Q dQ

The profit is maximized at
$50=200-0.002 \mathrm{Q}$
$Q=75,00$ units
The profit maximizing selling price
$=200-0.001(75,000)=\underline{\text { Sh. } 125}$

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The maximum profits
Total contribution $75,000 \times$ Sh. $75=$
Less fixed costs
Maximum profit

Sh.
5,625,000
2,500,000
3,125,000

## (iii) Change in fuel costs

Revised fixed costs $=$ Sh.3,000,000
The optimal output level will not be affected by a change in fixed costs. Therefore the selling price should not be changed. Profits will decline by Sh.500,000.

Change in Material Costs
Revised marginal costs $=$ Sh. 60
The new optimum is where $\quad 60=200-0.002$

$$
\mathrm{Q}=70,000
$$

At this output level, $\mathrm{P}=200-0.001$

$$
(70,000)=\text { Sh. } 130
$$

The price should be increased to Sh. 130 to maximize profits.
b)
(i) The price in the home market is based on full absorption cost plus pricing, whereas the price in the overseas market is based on partial absorption or variable cost-plus pricing. Therefore both price methods are on cost-plus basis. The rationale for such an approach is as follows:

## Home Market

Absorption cost-plus pricing is the norm in the home market, with all companies adopting this approach. Consequently the pricing method encourages price stability.
The home market provides high volume sales and can therefore bear the full costs.

## Export Market

The export market is more competitive, and a price penetration policy might be adopted in order to obtain a significance share of the market. Consequently, the pricing objective might be to set a selling pricing in excess of incremental costs.
Firms might view export business as a means of utilizing any unused capacity. Consequently, overheads have already been recovered in the home market and contribution pricing methods are adopted in the overseas market.
The firm might consider sales in the export market to be uncertain, and short-term prices are set so as to cover short-run costs only.
(ii) The main objection to the above pricing methods is that they are cost-based and ignore price demand relationships. Prices should be set by equating the marginal cost schedule with the sum of the marginal revenue schedules of the two countries.

## QUESTION FIVE

## (a) Advantages of Value added Statement

Managers might be in a better position to control their organization's own inputs than the cost or usage efficiency of purchased material and services. If this is so, value added statements focus attention on what managers can do something about. They would also reflect the quality of such management's effort.
Value added statements also focus attention on how the benefits are shared out, and in particular: -

Whether the employees are getting paid too much for what they are doing. If the value added per unit of labour is declining, management will be made aware of the need to keep labour costs under control. On the other hand, an improving value added per shilling of labour cost would suggest that there is some scope for rewarding employees more highly.
Whether enough funds are being returned in the business (depreciation plus retained profits) to provide for asset replacement and internally -funded growth.

In organizations where the material cost content is a high proportion on total costs, the total profit will be influenced by changes in material prices (largely outside management control) and possibly also by occasional stock losses or profits when material prices alter value added statements, by taking out material costs as a separate item, allow alterations to be directed at activities within management's control. Value added in relations to labour effort and labour costs provides excellent measures of productivity, and so far comprising the relative productivity of two or more divisions.
Overhead costs (Activities)
Machinery cost
Production scheduling
Set up cost
Quality control
Receiving materials
Packing materials
Total overhead cost
Units produced
Overhead cost/unit

| $\mathbf{P ( S h s )}$ | $\mathbf{Q ( S h s )}$ |
| :---: | ---: |
| 18,000 | 48,000 |
| 16,800 | 44,800 |
| 10,800 | 28,800 |
| 9,848 | 26,240 |
| 7,200 | 32,000 |
| $\underline{6,000}$ | $\underline{16,000}$ |
| $\underline{\mathbf{6 8 , 6 4}}$ | $\underline{\mathbf{1 9 9 , 8 4 0}}$ |
| 12,000 | 16,000 |
| Shs. $\underline{\mathbf{5 . 7 2}}$ | Shs. $\underline{\mathbf{1 2 . 4}}$ |
|  |  |
| res |  |
| hining cost $=\underline{102,000}$ |  |
| hine hours 34,000 |  |
| shs. $3 /$ machine hour |  |

$\{$ Budgeted machine hours $=1 / 2(12,0000+(16,000)+11 / 2(8,000)=34,000\}$
Production scheduling $=\underline{\text { budged production scheduling cost }}=$ 84,000 No. of production runs 30

$$
=\underline{\text { Shs. } 2,800 / \text { production run }}
$$

iii. Set up costs $=\underline{\text { Budgeted Set Up Cost }}=\underline{54,000}=\underline{\text { shs. } 1,800 / \text { production run }}$

No. of production runs 30,000
iv. $\quad$ Quality control $=\underline{\text { Budgeted Quality Control Cost }}=\underline{49,200}=\underline{1,640 / \text { production run }}$

No. of production runs 30
v. $\quad$ Receiving materials $=\underline{\text { Budgeted Receiving Materials cost }}=\underline{64,800}=\underline{400 \text { Receipt }}$ No. of components Receipts 162
vi. $\quad$ Packing Materials $=\underline{\text { Packing Material's cost }}=\underline{36,000}=\underline{1,000 / \text { Customer order }}$ No. of customers orders 36

Total cost statement and profit (shillings per unit)

|  | P | $\mathbf{Q}$ | R |
| :--- | ---: | :--- | ---: |
| Direct materials | 16.00 | 24.00 | 20.00 |
| Direct labour | 8.00 | 12.00 | 8.00 |
| Overhead cost (as above) | $\underline{5.72}$ | $\underline{12.49}$ | $\underline{15.19}$ |
| Total production cost | 29.72 | $\underline{12.49}$ | $\underline{15.19}$ |
| Sales price | $\underline{50.00}$ | $\underline{70.00}$ | $\underline{60.00}$ |

## MODEL ANSWERS TO THE CPA PILOT PAPER SET JULY 2010

## QUESTION ONE

| (a)Existing capacity |  |  |  | Kshs |
| :---: | :---: | :---: | :---: | :---: |
| P | P | $4560 \times 19.6$ | $=$ | 89,376 |
|  | Q | $6960 \times 13.0$ | = | 90,480 |
| R | R | $3480 \times 9.9$ | = | 34,452 |
| S | S | $2300 \times 17.0$ | $=$ | 39,100 |
| Total Existing Capacity |  |  |  | 253,408 |
| Add 5\% increase to full |  |  |  |  |
| Capacity 5\%x 253,408 |  |  |  | 12,670.4 |
| Total Direct Labour of |  |  |  |  |
| Full capacity |  |  |  | 266,678.4 |

Switching of 2010 kg of Q releases Direct Labour cost by-: which is switch to P .

| $2010 \times 13$ | 26,000 |
| :--- | :--- | :--- |
| Add $5 \%$ increase | $\underline{12,670.4}$ |
| Available cost to be switched | $\underline{38,670.4}$ |
| Labour cost of P | $=19.6$ |

Therefore units to be switched $=\underline{38,670.4}=1973 \mathrm{Kg}$ 19.6

Increased contribution therefore is: -

Sales $197 \times 162$
Shs.
Less: Variable Cost
Direct labour (1973 x 19.6) 38,670.8
Direct materials (1973 x 65.20) 128,639.6
Direct packaging $91973 \times 8.4$ ) $\underline{16,573.2}$
Contribution of P
(183,883.6)

Less: Lost contribution from
$\mathrm{Q}=2010\{(0.9 \times 116.40)-(13+49+7.4)\}$
135,742.4
(70,720)
Incremental Contribution

## Decision

Timao Company Limited should subcontract 2010kg from Kagocho Company due to the incremental contribution of Kshs.65,022.4

| (b) | P | Q | R | S |
| :---: | :---: | :---: | :---: | :---: |
| Timao's selling prices (A) | 162 | $\underline{116.40}$ | 99.20 | $\underline{136.80}$ |
| Subcontracts price $=(90 \% \times 4)$ | 145.80 | 104.76 | 89.28 | 123.12 |
| Less: Variable cost of marking |  |  |  |  |
| Direct labour | 19.60 | 13.00 | 9.90 | 17.00 |
| Direct materials | 65.20 | 49.00 | 41.00 | 54.20 |
| Direct packing | 8.40 | 7.40 | 5.60 | 7.00 |
| Total Variable cost | 93.20 | $\underline{69.40}$ | 56.50 | 78.20 |
| Lost Contribution | 52.60 | $\underline{35.40}$ | 32.90 | 44.90 |

Switching of 2010kg to different products. This can be done in a matrix form as follows.
Additional Production $(\mathrm{Kg})$ from switching direct labour cost.

| Source of units | P | Q | R | S |
| :--- | :--- | :--- | :--- | :--- |
| Shs.39,200 from P (a) | 0 | $3015(\mathrm{e})$ | $3959(\mathrm{f})$ | $2305(\mathrm{~g})$ |
| Shs.26,000 from Q (b) | $1326(\mathrm{~h})$ | 0 | $2626(\mathrm{i})$ | $1529(\mathrm{j})$ |
| Shs.19,800 from R (c) | $1010(\mathrm{k})$ | $1523(\mathrm{l})$ | 0 | $1164(\mathrm{~m})$ |
| Shs.34,000 from S (d) | $1734(\mathrm{n})$ | $2615(\mathrm{o})$ | $3434(\mathrm{p})$ | 0 |
| Extra 5 \% of capacity Shs.12,670.4 | $646(\mathrm{q})$ | $974(\mathrm{r})$ | $1280(\mathrm{~s})$ | $745(\mathrm{t})$ |

## Workings

| $2010 \times 19.60$ | (e) | $39,200 \div 13$ | (i) | $26,000 \div 9.9$ |
| :--- | :--- | :--- | :--- | :--- |
| $2010 \times 13.00$ | (f) | $39,200 \div 9.9$ | (j) | $26,000 \div 17$ |
| $2010 \times 9.90$ | (g) | $39,200 \div 17$ | (k) | $19,800 \div 19.6$ |
| $2010 \times 17.00$ | (h) | $26,000 \div 19.6$ | (l) | $19,800 \div 13$ |
|  |  |  |  |  |
| $19,800 \div 17$ | (q) | $12,670.4 \div 19.6$ |  |  |
| $34,000 \div 19.60$ |  | (r) | $12,760.4 \div 13$ |  |
| $34,000 \div 13$ | (s) | $12,670.4 \div 9.9$ |  |  |
| $34,000 \div 9.9$ | (t) | $12,670.4 \div 17.00$ |  |  |

Extra contribution gained in Shs.

| 速 | P | Q | R | S |
| :---: | :---: | :---: | :---: | :---: |
| Contribution per $\mathrm{Kg} / \mathrm{Sh}$. | $\underline{68.80}$ | 47 | $\underline{42.70}$ | 58.6 |
| 2010 Kg of P subcontract | 0 | 82,283(i) | 118,500(ii) | 73,530 |
| 2010 Kg of Q subcontract | 64,954 | 0 | 96,070 | 62,536 |
| 2010 Kg of R subcontract | 48,373 | 51,788 | 0 | 46,307 |
| 2010 Kg of S subcontract | 73,900 | 78,843 | 111,448 | 0 |

## Workings

Incremental contribution - lost contribution
i.e. (i) $\{(3015+974) 47\}-\{(2010 \times 52.6)\}=82,280$
(ii) $\{(3959+1280) 42.7)\}-\{(2010 \times 52.6)\}=118,500$ etc

## Decision

The best profitable contribution is to subcontract 2010 kg of P and replace it with $5239 \mathrm{~kg}(3959+1280) \mathrm{kg}$ of R leading to the highest contribution of shs. $118,500$.

## QUESTION TWO

Two important concepts in control theory are firstly, that a system must have a purpose and must have controls if it's to remain cohesive and secondly, that is a system can be divided into a number of subsystems and sub-sub-systems, each with it's own purpose and controls. Controls provide the binding force, which kept every various elements within the system all working towards a common objective. Control theory can be used to analyse or to establish control systems within a business organization. A model can be constructed and used as follow:

The system as a whole, and for each sub-system (and sub-sub-systems) one or more objectives are identified.
Actual achievements of the system and sub- system are
monitored. Actual achievements are compared with the objective.
Reasons for any differences between the objectives and achievements are identified
Where suitable, corrective measures are taken to bring the system under control

When actual achievements are measured as actual outcomes and results, the comparison of results with objectives is called a feedback control loop. When actual achievements are measured as what the system is not expected to achieve and future expectations are compared with objectives (Such as projected completion dates for a project) we have feed forward control.
A control model can also be made to recognize environmental influences, and the ways in which environment can affect the system's achievements and objectives.
The concepts of control theory can provide valuable insights into the design and operation of a management accounting information system (MAIS) because:-

Business organizations need to be controlled by their management.
Management accounting provides an information system for control, based largely on system of a budgets. This information acts as a feedback loop.
The way in which a MAIS is structured and used can be determined by modeling techniques.
A control model for a MAIS would: -
Identify the sub-systems within the organization
Establish objectives for each sub-system, and for the system as a whole. These objectives must be measurable, and would usually take the form of budgets, with the control system being a budgetary control system.
Measure actual achievements for each sub-system, for the system as a
whole. Compare actual results with the objectives (budgets)
Identify significant differences, and the reasons for them, indicating where control action should be taken.
A MAIS cannot initiate control action itself, but can only indicate where control measures might see appropriate, control measures must be taken by managers, perhaps using their judgment. In this respect, a MAIS falls short of the ideals' of a cybernetic control model.
The practical application of control principles to a MAIS, using a budgetary control system does depend on the stability of the environment and accurate measurement of results.
When an organization's environment is unstable ad unpredictable forecasts of achievements will be uncertain; and a comparison of actual results against plan might be meaningless. It might also be necessary to alter the system's objectives in response to environmental change.
If environmental changes are continual, or frequent, the problems of redefining systems objectives will be considerable and budgets would have to be revised at frequent intervals. In addition, the significance of differences between actual results and budget would be difficult to assess for control purposes.

Outcome needs to be fairly clearly measurable for control system to operate successfully. In practice, there may be problems in applying quantative measures to qualitative outputs, and control information might be imperfect and incomplete. This always the prospect that unless results can be measured objectively managers will manipulate and 'judge' the figures, so that the problems of human behaviour damage the operation of the control system.
In conclusion, control theory can provide a useful framework for a MAIS but control of a business is not "automatic". Business organizations are largely 'human systems,' ad there will inevitably be difficulties with applying the theoretical structure of a control model in practice. Further more, although some environmental change can be achieved for in a control mode, frequent changes caused by unstable environment could remove the practical value of feedback systems for control.

## QUESTION

## THREE a)

Sh. ‘ 000 '
(i) Desired Residual Income

5,000
Current Income from external sales Contribution $=500(37-25) \quad 6,000$
Fixed costs $\quad(1,400)$
Capital cost $13 \% \times 20 \mathrm{~m} \quad(2,600)$
2,000
Contribution to be generated by internal transfers
3,000
Contribution per unit $=\frac{3,000}{300}=$ Sh. 10 per unit
Transfer price $=$ Sh. $25+$ Sh. $10=$ Sh. 35 per unit
(ii) The transfer price above may motivate the Z division manager to want to sell the components externally at Sh. 37 rather than to transfer them to other divisions at $\operatorname{Sh} .35$. This may result in the other divisions being forced to buy components externally and thus incur buying costs while $Z$ will incur selling cots. The net effect is that the company as a whole losses.
b) The demand function can be determine as follows:

$$
\begin{aligned}
& \mathrm{P}=\mathrm{A}-\mathrm{bV} \\
& \text { Where } \mathrm{P} \text { is the price per unit } \\
& \mathrm{V} \text { is the volume of sales at that price } \\
& \mathrm{A} \text { is the price at which } \mathrm{V}=\mathrm{O} \text { (Maximum price) } \\
& \mathrm{b} \text { is the rate at which the price falls for volume increases a proportion of } \\
& \text { sales volume. }
\end{aligned}
$$

## Product A

Demand is currently 15,000 units at a price of Sh.30. The demand changes by 500 units for each Sh. 1 change in price.

$$
A=30+\frac{15,000}{500} \times 1=\operatorname{Sh} .60
$$

The maximum price $=$ Sh. 60
$b=\frac{1-}{500}$
The demand function will be

$$
\mathrm{P}=60-1 / 500 \mathrm{Q}
$$

Total revenue $=P Q=60 Q-\frac{1}{500} Q^{2}$
Profit is maximized where $\mathrm{MR}=\mathrm{MC}$
$\mathrm{MR}=\frac{\mathrm{dTR}}{\mathrm{dQ}}=60-\frac{2 \mathrm{Q}}{500}=60-\frac{\mathrm{Q}}{250}$
MC is the unit variable cost $=\mathrm{Sh} .12$

At Maximum profit MR $=\mathrm{MC}$
$60-\underline{Q}=12$
250
$\mathrm{Q}=12,000$ units
Substituting to find P

$$
\mathrm{P}=60-\frac{12,000}{500}=\underline{\mathbf{S h} .36}
$$

The profit maximizing price is Sh. 36 and profit maximizing Quantity is 12,000 units.

## Product B

This is solved in the same way as A

$$
\begin{aligned}
& A=58+\frac{21,000}{500} \times 1=S h .100 \\
& \mathrm{P}=100-\frac{1 \mathrm{Q}}{500} \\
& \mathrm{TR}=100 \mathrm{Q}-\frac{\mathrm{Q}^{2}}{500}
\end{aligned}
$$

$$
\mathrm{MR}=\frac{\mathrm{dTR}}{\mathrm{dQ} 250}=100-\mathrm{Q}_{2}
$$

$\mathrm{MC}=\mathrm{Sh} .8$
At maximum profit $\mathrm{MR}=\mathrm{MC}$

$$
\begin{aligned}
& 100-\frac{\mathrm{Q}}{250}=8 \\
& \mathrm{Q}=23,000 \text { units } \\
& \quad \text { Substituting }
\end{aligned}
$$

$$
\mathrm{P}=100-\frac{23,000}{500}=\underline{\mathbf{S h} .54}
$$

The profit maximizing price is Ksh. 54 while the profit maximizing quantity is Sh.23,000 units

## QUESTION FOUR

Expected Value of Usage


Bufter stock at 150,000 units re- order level $=(150,000-127,100)$
$=\underline{22,900 \text { units }}$
(b) The P (stock out cost i.e. Demand in excess of 150,000 units)

$$
=(25 \times 7,000)=175,000 \text { units }
$$

$\therefore \mathrm{P}($ stock out cost $)=0.18$
(c) $\mathrm{EOQ}=$

$$
\underline{2 \times(6,200 \times 360) \times 1,000}=140,855 \text { units }
$$

$$
0.0025+(0.1 \times 2)
$$

Daily Demand $=5,000(0.4)+7,000(0.6)=6,200$
No of average orders per annum $=\frac{6,200 \times 360}{140,855}=15.85$
$\therefore \quad$ The expected annual stock outs in units per annum
$=\{(0.225)(175,000-150,000)\} \times 15.85=89,156$ units
(d) The additional annual holding cost if the re-order level is increased to 175,00 units: $15(175,000-150,000)(0.025 \times 1.1 \times 2)=1,375$
Therefore, are-order level of 150,000 units the expected value of stock outs per annum is 10,766 units.

Then the increase in stock is justified where stock out cost per unit is greater then Shs. 0.3 (1,375/10, 766)

JIT (Just in time) it involves a continuous commitment to re-pursuit of excellence in all phrases off manufacturing systems design an operation.

## Advantages of JIT

$\square$ Leads to substantial savings in stockholding costs.Elimination of waste
$\square$ Savings in factory and warhorse space, which can be used for other profitable activities.
$\square$ Reduction in obsolete stocks
$\square$ Considerable reduction in paper work arising from a reduction in purchasing, stock and accounting transactions

## Disadvantages of JIT

$\square$ Additional investment costs in new machinery, changes in plant layout and goods inwards facilities.
$\square$ Difficulty in predicting duty or weekly demand, which is a key feature of the JIT philosophy.
$\square$ Increased risk due to the greater probability of stock out costs arising from strikes, or other unforeseen circumstances, then restrict production or supplies.

## QUESTION FIVE

Modification of the probability by use of Bayes Theorem

$$
B(B / A)=\frac{P(B) \times P}{(A / B)} P(A)
$$

Steps to follow in modification of probabilities

## Step 1

Interpretation of the formula into the question:
B is either oil ( O ) or not oil ( N )
A is the result of the report either favourable ( F ) or unfavourable ( U ) under each of the above situations.

$$
\begin{aligned}
& P(o / F)=\frac{P(O) \times P(F / O)}{P(F)} \\
& P(O / U)=\frac{P(O) \times P(U / O)}{P(U)} \\
& P(N / F)=\frac{P(N) \times P(F / N)}{P F} \\
& P(N / U)=\frac{P(N) \times P(U / N)}{P(U)} \\
& \text { Step two }
\end{aligned}
$$

Construction of probability tree.
g


## Step three

Derivation of probabilities from step two
$\mathrm{P}(\mathrm{O})=0.2$
$\mathrm{P}(\mathrm{F} / \mathrm{O})=0.1$
$\mathrm{P}(\mathrm{N})=0.3$
$\mathrm{P}(\mathrm{F} / \mathrm{O})=0.95$
$\mathrm{P}(\mathrm{U} / \mathrm{N})=0.9$
$\mathrm{P}(\mathrm{U} / \mathrm{O})=0.05$
$\mathrm{P}(\mathrm{F}) \quad=0.95(0.2)+0.1(0.8)=0.27$
$\mathrm{P}(\mathrm{U})=1-0.27=0.73$

## Step four

Incorporation of the probabilities into the formulas in step 1
$\mathrm{P}(\mathrm{O} / \mathrm{F})=\frac{\mathrm{P}(\mathrm{O}) \times \mathrm{P}(\mathrm{F} / \mathrm{O})}{\mathrm{P}(\mathrm{F})}=\frac{0.2 \times 0.95}{0.27}=0.704$
$\mathrm{P}(\mathrm{O} / \mathrm{U})=\frac{\mathrm{P}(\mathrm{O}) \times 9 \mathrm{U} / \mathrm{O})}{\mathrm{P}(\mathrm{U})}=\frac{0.2 \times 0.05}{0.73}=0.014$
$\mathrm{P}(\mathrm{N} / \mathrm{F})=\frac{\mathrm{P}(\mathrm{N}) \times(\mathrm{F} / \mathrm{N})}{\mathrm{P}(\mathrm{F})}=\frac{0.8 \times 0.1}{0.27}=0.296$
$\mathrm{P}(\mathrm{N} / \mathrm{U})=\mathrm{P} \frac{(\mathrm{N}) \times(\mathrm{U} / \mathrm{N})}{\mathrm{P}(\mathrm{U})}=\frac{0.8 \times 0.9}{0.73}=0.0986$

## Step five

Construct a Decision tree and evaluate


Evaluation using EMV
Emv @ $\mathrm{A}=70(0.704)+0(0.296)=49.28$
Emv @ $B=70(0.014)+0(0.986)=0.98$

$$
\begin{aligned}
& \text { Emv @ C = } 70(0.2)+0(0.8)=14 \\
& \text { Emv @ D = 39.28 (0.27) + } 0(0.73)=10.6056 \\
& \text { At } \mathrm{D}_{2} \Rightarrow \text { Drill }=49.28-10 \mathrm{~m}=\underline{39.28} \\
& \Rightarrow \text { Don't Drill }=0 \\
& \text { At } \mathrm{D}_{3} \Rightarrow \text { Drill }=0.98-10 \mathrm{~m}=-9.02 \\
& \Rightarrow \text { Don't Drill } \quad=0 \\
& \text { At } \mathrm{D}_{4} \Rightarrow \text { Drill }=14-10 \mathrm{~m}=4 \\
& \Rightarrow \text { Don't Drill } \quad=0 \\
& \begin{array}{cc}
\text { At } \mathrm{D}_{1} \Rightarrow \text { Hire } 10.6056-3= & 7.6056 \\
\text { Don't Hire } & =0
\end{array}
\end{aligned}
$$

Note

1. At Decision Box choose the highest value
2. At outcome point use probabilities on values to get the expected monetary value.

Step six Make Decision or Advice -
Walt Lovell Limited (WLL) should use a consultants given the report is favourable drill as this will release a net benefit of Kshs. 7.6056 million.

The value of imperfect information is:
Value of imperfect (sample) information $=$
Expected monetary value with IPI - Expected monetary value without IPI

## MODEL ANSWERS TO THE CPA PILOT PAPER OCTOBER 1991

## QUESTION ONE

## A

The basic CVP model is based on a number of assumptions:

1. Selling price per unit remains constant during the period in which the model is being used irrespective of changes in activity.
2. The variable cost per unit remains constant during the period in which the model is being used irrespective of changes in activity.
3. Fixed cost remail?s unchanged throughout the possible activity range.
4. The analysis of costs into fixed and variable elements have been achieved with reasonable accuracy.
5. Changes in activity level is the only factor affecting costs and revenues. The CVP Model may be used to calculate
(a) Breakeven Point expressed in units or monetary value
(b) The units or sales value Shs at which a specific net profit will be earned. The above assumptions are likely to apply only to a limited activity'range and are an over simplification of the conditions which are likely to apply even in the very short term. The basic CVP Model should be seen as a crude decision making tool the longer the time scale the more likely it is that the pattern of costs and revenues will change thus reducing the validity of any decisions made.
The situation where multi-products are concerned adds to the possibility of departures from the basic model because of the increase in the factors/situations involved so emphasizing the models limitations.

## B

1. Contribution per unit Machungwa $40 \%$ of Shs. Of Sales

Ndimu $15 \%$ of Shs. Of Sales

|  |  | Contribution per Sh of Sales |
| :---: | :---: | ---: |
| Sales mix weighting M | $60 \%$ of $40 \%$ | $24 \%$ |
| weighting N | $40 \%$ of $15 \%$ | $6 \%$ |

Instaj Contribution per Shs of Sales

Shs0.3

150,000
$0.3 \quad$ Shs500,000

PROOF SALES ANALYSIS

| Sales | X | $=60 \%$ of 500,000 | $=300,000$ |
| :--- | :--- | :--- | :--- |
| Sales | Y | $=40 \%$ of 500,000 | $=200,000$ |
| Contribution | X | $=40 \%$ of 300,000 | $=120,000$ |
| Contribution | Y | $=15 \%$ of 200,000 | $=30,000$ |

Total Contribution on 500,000
Sales in required mix $=150,000$
2. To obtain contribution of KShs $150,000+30 \%+9,000=204,000$ SALES $=\underline{204,000}$ Shs 680,000

Insta] 0.3
PROOF SALES ANALYSIS Shs 680,000

| Sales | X | $=60 \%$ of 680,000 | $=408,000$ |
| :--- | :--- | :--- | :--- | :--- |
| Sales | Y | $=40 \%$ of 680,000 | $=272,000$ |
| Contribution | $X$ | $=40 \%$ of 408,000 | $=163,200$ |
| Contribution | Y | $=15 \%$ of 272,000 | $=40,800$ |

Total contribution on 680,000 in required mix $=208,000$

## QUESTION TWO

A.

Price New 1 Year Old 2 Year Old 3 Year Old
=
Sh 40,000 Sh 31,000 Sh 20,000 Sh 11,000
=
$=$

| Age | Purchase <br> Price | Sale <br> Price |  <br> Maintenance | Total Cumulative <br> Cost | Average <br> Cost | Scrap Value (at date <br> of resale |  |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| 0 | 40,000 |  | - |  |  |  | 0 |
| 1 | 31,000 |  | 3,000 |  |  | 2,800 | 1 |
| 2 |  | 4,000 |  | 18,000 | 2 |  |  |
| 3 |  | 6,000 |  | 10,000 | 3 |  |  |
| 4 |  | 9,000 |  |  | 4,000 | 4 |  |

When machine is new $=$ Sh 40,000

|  | Depreciation cost |  <br> Maintenance Cost | Total Cost | A verage cost per yr |
| :--- | :--- | :--- | :--- | :--- |
| 1 | 12,000 | 3,000 | 15,000 | 15,000 |
| 2 | 22,000 | $3,000+4,000$ | $29,000 / 2$ | 14,500 |
| 3 | 30,000 | 13,000 | $43,000 / 3$ | $14,333.3$ |
| 4 | 36,000 | 22,000 | $58,000 / 4$ | $14,500.0$ |

Buy 1 Year Old

|  | Total Depreciation <br> cost |  <br> Maintenance | Total Cost | A vg. cost per year |
| :--- | :--- | :--- | :--- | :--- |
| 2 | $31,000-18,000$ | 4,000 | $13,000+4,000$ | 17,000 |
| 3 | $31,000-10,000$ | 6,000 | $21,000+10,000$ | $31,000 / 2=15,500$ |
| 4 | $31,000-4,000$ | 9,000 | $27,000+19,000$ | $46,000 / 3=15,333.3$ |

Buy 2 Year Old

|  | Total <br> Depreciation |  <br> Maintenance | Total Cost | Av. cost per <br> year |
| :--- | :--- | :--- | :--- | :--- |
| 3 | $20,000-10,000$ | 6,000 | 16,000 | 16,000 |
| 4 | $20,000-4,000$ | 9,000 | $16,000+15,000$ | 15,500 |

Buy 3 Year Old

|  | Total <br> Depreciation |  <br> Maintenance | Total Cost | A v. cost per year |
| :--- | :--- | :--- | :--- | :--- |
| I 4 | $11,000-4,000$ | 9,000 | $7,000-9,000$ | 16,000 |

Given the numbers revealed from the above table it would be advisable for the company to purchase new and sell at the end of Year 3 to reduce the aggregate average cost to 14.33 per annum for maintenance cost and depreciation.
The cost of capital interest has not been identified but assuming $10 \%$ the profits revealed in the foregoing is not significantly inpacted as the expected scrap value generally correspond to the price of second hand machines.

## B.

Abandonment Value
The amount which could be recovered from an investment project if it were immediately to be abandoned. It is of importance in the field of capital budgeting (g.v.) as a concept relevant to the monitoring and review of ongoing capital projects. No decision to invest should be regarded as irrevocable, and if at any time the abandonment of a project is of greater value than its continuance then abandonment is indicated. The simple decision rule is that a project should be abandoned if its abandonment value exceeds the net present value (g.v.) of its projected cash flows. .
EXAMPLE. A certain project, nearing the end of its useful life, is expected to last for two further years and to yield at the end of these years positive cash flows of $£ 8,000$ and $£ 6,000$ respectively. If abandoned now, the plant and equipment used in the project could be sold for $£ 12,500$. After two further years of use it will have no value. The cost of capital (g.v) is $10 \%$ per annum.

## Present value of future returns:

| Year | Returns | Discount factor | Present value |
| :--- | :--- | :--- | :--- |
|  | $£$ |  | $£$ |
| 1 | 8,000 | 0.909 | 7,272 |
| 2 | 6,000 | 0.826 | $\underline{4,956}$ |
|  |  |  | $\underline{12.228}$ |

Since it is worth only $£ 12,228$ to continue the project but $£ 12,500$ can be obtained by abandoning it, it should be abandoned. Failure to abandon is the equivalent of investing the $£, 12,500$ forgone into a project with a negative net present value.

## QUESTION THREE

## Multiple Regression

## Regression I

Overhead costs $\quad-32657+16.57 \times$ machine hours
Std error 4.32 (for machine hours)
$\mathrm{r} 2 \quad \mathrm{Se}=\quad 0.773 .456$

## Regression II

Overhead costs $\quad=17.865+13.76 \mathrm{x}$ units of output
Std error 3.87 (for units of outplit)
r2 $\quad \mathrm{Se}=0.613 .973$

## Regression III

Overhead costs $=-15.373+7.37 \mathrm{x}$ machine hours +10.44 x units of output
Std error 3.31 (for machine hours) 3.81 (units of output)
r2 Se=0.79 1.623
$=$ The correlation mix shows a 0.86 relationship between machine hours and units of output.

## (a)

Meaning of Computed t-value
This is a sample t-statistic for the constant, the regression coefficient, correlation relation coefficient
For correlation coefficient This is compared against value from given tables at ( $n-2$ ) degrees of freedom
$t$-statistic for regression coefficient
$\mathrm{t} \quad \frac{\mathrm{b}-0}{\text { estimated std. error of } b}$

In general

Sample statistic - parameter assumed in
Ho best estimate of standard error of statistic
(b) t value for all the three
regressions

> J!... std. error not
> given Sea
. Machine
hours

$$
\begin{array}{cll}
=\begin{array}{ll}
\mathrm{JL} & \frac{16.57}{4.32}=3.8356 \\
& \\
& \text { Seb }
\end{array} \quad \begin{array}{l}
\text { (Std } \\
4.32)
\end{array} & \text { given }
\end{array}
$$

H. Output

| 1.3.76 - | 3.55 | (Std |
| :---: | :---: | :---: |
| 3.87 |  | 3.87) |
| hours and |  |  |
| 7.37 | 2.23 |  |
| 3.31 |  |  |
| 10.44 | $=2.74$ |  |
| 3.81 |  |  |

(c) Meaning r2 in $77 \%$ of the variation in overhead costs can be explained i. from changes in machinehours
$61 \%$ of variation in overhead costs can be explained from changes in units of output.
iii. Correlation
mix
R or $\quad 0.79$
R2
0.6241

Only $62 \%$ explained, due to both output and machine hours
Hence output does not significantly add to more accurate forecast
(d) Negative intercept has in general
no
value
Value of intercept in (i) when machine-hours $=0$, what are overhead costs?, they can't be negative. We must have minimum machine hours (and maximum) in order that the data is valid.
(e) Overhead costs $=$ constant + machine hours (because number of units produced does not significantly improve the forecast).

## QUESTION FOUR

Three products Xl X2

Nurate Phosphate Potash Filler II Fertilizer Selling price/tonne

| 0.1 | 0.1 | 0.2 | 0.6 | $R$ |
| :--- | :--- | :--- | :--- | :--- |
| 0.1 | 0.2 | 0.1 | 0.6 | 81 |
| 0.1 | 0.1 | 0.1 | 0.6 | 81 |
| 0.2 | Sh 60 | Sh 120 | Sh 10 |  |
| Sh 150 | tonnes 1200 | tonnes 2010 | tonnes 2200 | No limit |

X3
Price per tonne
Max. available
Selling Price per tonne
Manufacturing cost
Fixed Sh 11 per tonne (Excluding raw material)
Z $\quad 21 \mathrm{Xl}+25 \mathrm{X} 2$ + 16X3
0.1 XI + 0.1 X2 + 0.2 X3 ::; 1200 (1) 0.1 XI + 0.2 X2 + 0.1 X3 ::; 2010 (2) $0.2 \mathrm{Xl}+0.1 \mathrm{X} 2+0.1$ X3 ::; 2200 (3)
Xj,X2,X3 ~ 0

## Cost price product XI

$0.1 \times 150+0.1 \times 60+0.2 \times 120+0.6 \times 10=$
$15+6+24+6$
$=\quad$ Sh $45+\mathrm{Sh} .6$
Total price $\quad=51+11$ Sh 62

## Product X2

$0.1 \times 150+0.2 \times 60+0.1 \times 120+0.6 \times 10+$
$1115+12+12+6+11$
Sh56

## Product X3

```
0.2 x 150+0.1 x60+0.1 x 120+0.6x 10+ 11
= 30+6+12+6+11
= Sh 65
```

Contribution for Xl $=83-62=$ Sh 21
$\mathrm{X} 2=81-56=\operatorname{Sh} 25$
$\mathrm{X} 3=81-65=\mathrm{Sh} 16$
$\mathrm{Z}=21 \mathrm{Xl}+25 \mathrm{X} 2+16$
$0.1 \mathrm{Xl}+0.1 \mathrm{X} 2+0.2 \mathrm{X} 3+) 4=1200($ Nitrate in tonnes) $0.1 \mathrm{X} 2+0.2 \mathrm{X} 2+0.1 \mathrm{X} 3+\mathrm{Xs}=$ 2010 (phosphate in tonnes) 0.2 XI $+0.1 \mathrm{X} 2+0.1 \mathrm{X} 3+\mathrm{X}<;=2200$ (potash in tonnes)
z 21 XI + 25 X2 + 16 X3 (Maxi
mise )
(b) )4, when there is no production of XI> X2, X3, )4 give total nitrate available in tonnes.

When all ) 4 is consumed, the final tableau gives shadow price of Nitrate.
Similarly Xs and X6
(c)

Initial S'
Tabl

(d) Final matrix as given in Q4 (d)

## Interpretation

Production
Produce 4000 units of product Xl
Produce 8000 units of product X2
Do not produce product X3
The total contribution from this production is Sh 284,000
Calculated as follows:
$\mathrm{z}=21 \mathrm{Xl}+25 \mathrm{X} 2+16$
X3 $21 \times 4000+25 \times 800084,000+$
200,000 Sh 284,000

Dual Prices or Shadow prices
Chemical Nitrate has been fully, used and is a scarce quantity. Everyone tonne of this chemical available (above 1200 tonnes) will increase the profitability by Sh 170 (subject to maximum which can be calculated).

Similarly chemical phosphates has been fully used, every extra tonne over 2010 tonnes, will increase the profit by Sh 40 (subject'to a maximum which can be calculated).

Potash not been fully used, there is still a surplus of 600 tonnes i.e. $2200-600=1600$ tonnes has been used. Hence it has no scarcity value.

Production of X3 will reduce the overall profit by Sh 22 per unit. Hence on economic grounds it should not be produced.

| Activity | Preceding <br> Act | Activity <br> Normal | Time (days) <br> Crash | Total Cost (Sh) | Crash cost <br> per day <br> Sh |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| A | - | 16 | 14 | 400 | 480 | 40 |
| B | - | 13 | 12 | 340 | 360 | 20 |
| C | A | 15 | 13 | 380 | 500 | 60 |
| D | A | 14 | 12 | 200 | 260 | 30 |
| E | A | 13 | 11 | 260 | 280 | 10 |
| F | C | 13 | 12 | 310 | 380 | 70 |
| G | D | 15 | 10 | 430 | 580 | 30 |
| H | B,D,E | 15 | 9 | 280 | 370 | 15 |
| I | H | 12 | 11 | 400 | 420 | 20 |
| J | F,G,I | 13 | 11 | 260 | 320 | 30 |

(a)

ii.
III. Total Float for non-critical activities

| Activity | Total Float LSTJ-ESTr-Dij |
| :---: | :---: |
| B |  |
| C | 17 |
| E | 13 |
| F | 1 |
| G | 13 |

b)
1.
ii.

H (reduce H by 1 day)
New cost of project $=3,260+$ $15=$ Sh 3,275

## MODEL ANSWERS TO PAST CPA PAPER DECEMBER 1991

## QUESTION ONE

## (a) Network Analysis

## Time in weeks


(b) Start Jan Week 1- May 1st Week
$31+28+31+30 \quad 120$ days 17 weeks
(End April/Beginning May)
(c) A, C, D can be finished end of December.

E may take only 2 weeks


51
G
B
~1/ 0
E is immaterial to the duration
The minimum, the project will take is $17-2=15$
weeks Cd)
A network diagram may be defined as a diagram which illustrates the sequences in which activities must be done in a given project. The more complex the production process, the greater the need for precision in selecting the most cost effective sequence of operations. Discipline of the technique enables the production management to better appreciate and communicate to their peers the logic of the preferred routing

## QUESTION TWO

| Petrol regular premium |  |  |
| :---: | :---: | :---: |
| Value properly adjusted | 50\% premium |  |
|  | 50\% regular | minimum cost |
| Value out of adjustment | 60\% premium |  |
|  | 40\% regular | quantity required |
|  | 100,000 litres | value is adjusted |

## Per litre

| Sh |  |  |  |
| :---: | :---: | :---: | :---: |
| Cost premium | 3.20 |  |  |
| Cost regular | 3.0 |  |  |
| Cost checking value 800.00 |  |  |  |
| Cost adjusting the value |  | 400.00 |  |
|  |  | Probability |
| Event Value in adjustment |  |  | 0.7 |
| Value out of adjustment |  |  | 0.3 |

(a) Expected cost of checking the value of adjusting if necessary

|  | Cost | Prob. |  |  |
| :--- | :---: | :--- | :--- | :--- |
| Value OK | 800 | 0.7 | 560 |  |
| Value needs adjustment | 1200 | 0.3 |  | $\underline{360}$ |
|  |  |  | Sh | 920 |

OR

| Cost of checking |  |  | 800 |
| :--- | :---: | :--- | :--- |
| + Cost of adjustment | $0.3 \times 400$ |  | 120 Sh |
|  | $800+$ | 120 | 920 |

(b)

| Value out of adjustment | Prob. $=0.3$ |  |
| :--- | :--- | :--- |
| Cost/litre if value $\mathrm{OK}=$ | $\frac{3.20+3.00}{2}$ | Sh 3.1O/litre |

Cost/litre if value not OK $\quad 0.6 \times 3.20+0.4 \times 3.0$
$1.92+1.20$
Sh 3. 12/litre

| Cost of 10,000 litres if value OK | $3.10 \times 100,000$ | Sh 310,000 |
| :--- | ---: | ---: |
| Cost of 10,000 litres if value not OK | $3.12 \times 100,000$ | Sh 312,000 |
|  |  | Difference | Sh 2,000

The probability is 0.3

$$
\text { Expected cost }=\quad 2,000 \times 0.3=\text { Sh } 600
$$

(c) The extra cost is Sh 2,000

```
Let the Probability be p
\(2010 \mathrm{p} \quad 800+400 \quad \mathrm{p}\)
```

(d) Comment on the result (a) and (b) above

It is not worth checking the value

$$
\mathrm{A}
$$

The premise by which normal spoilage is ignored in the computation of equivalent units is that because of the nature of the processing operation and the anticipated efficiency of the machinery used in the process. Such factors are deemed to be outside management control. The level of loss which is selected as being the standard for the period under review may be based on past experience, quality control records from past periods or industry averages.
The cost of such losses is recovered by inflating the cost of output achieved to a $\sim$ sorb the cost of the losses.

## QUESTION THREE

The selection of the point of inspection should provide the quality control department and the management accountant with the most accurate valuation of work in progress totals consistent with considerations of cost effectiveness on the factory floor.
B.

DEPARTMENT M

|  | Units |  | Units |
| :---: | :---: | :---: | :---: |
| Opening W.I.P | 8,000 | Normal Spoilage | 2,000 |
| Input material | 17,000 |  |  |
|  |  | Good Output | 18,000 |
|  |  | Closing W.LP | 5,000 |
|  | $\underline{25.000}$ |  | $\underline{25.000}$ |
| Equivalent units for August conversion cost |  |  |  |
|  |  | Good Output W.LP | 18,000 |
|  |  | 5,000 x 60\% | 3,000 |
|  |  |  | 21,000 |

Equivalent units for August material assuming all W. LP is $100 \%$ complete for material.

## QUESTION FOUR

| Q4. |  | SPL | $\begin{aligned} & \text { ODOG } \\ & \text { O } \end{aligned}$ |
| :---: | :---: | :---: | :---: |
|  | 20,000 units @ | 57.50 7,500 units | 75.00 |
| COSTS |  |  |  |
|  | MAT | 22.50 | 32.50 |
|  | LAB | 30.00 | 30:00 |
|  | ON 0.25 | $\underline{10.00}$ | $\underline{20.00}$ |
|  |  | 62.50 | 82.50 |
|  | Plus special one-off costs for start up M/C has total capacity p.a. Monthly | 15,000 |  |
|  |  | 25,000 |  |
|  |  | 90,000 |  |
|  |  |  |  |
|  |  | 7,500 |  |

Available Capacity
July,August,September
$20 \%$ of $3 x 7,500 \quad 22500=4500$ HRS

| SPL Order Capacity Requirement | Odogo | Order |  |
| :--- | :---: | :---: | :---: |
| $20,000 \times 0.255000 \mathrm{hrs}$ | 7500 x 0.5 | 3750 | 3750 hrs |

Fixed OV/HD 2, 160000 OF $90000=60 \%$
$60 \%$ of Shs 40 per hour $=$ Shs 24 contribution to
fixed. Recovery per M/CHR
$\frac{2,160,000}{90,000} \quad$ Shs24

Fixed OV/HD Contribution
Fixed OV/HD Contribution

From Westland Order
5000hrs x Shs 24 Shs 120,000
From OdogoOrder
3750hrs x 24 Shs 90,000
Less loss on sale Less loss on sale
57.50-62.50 Cost

Shs5x 20,000
$=100,000$
7500-82.50
7.5x 7500

Shs56,250
Less start up costs Shs 40,000
Net Contribution
From order
Shs 20,000
=Shs 21875
Shs(6,250)

Given that the opportunities are the only ones available to Westland. The choice between the two opportunities can be identified reasonably easily. The SPL opportunity gives contribution of KShs 20,000 compared to Odongo Foods order of $(6,250)$.
However in order to meet the SPL delivery date some rescheduling is necessary to meet the 1st order delivery date as only $4,500 \mathrm{hrs}$ are available in July, August, September and the SPL orders requires 5,000 . This relatively small imbalance may be managed either with negotiation with SPL or by adjustment to Westland Stocking Policy.

## QUESTION FIVE

A. Programme planning and budgeting systems and priority based budgeting share some commonality with ZBB Below. PPBS establishes programs as opposed to decision units which must be justified before acceptance. The term program may relate to an educational program such as the integration of technology into schools and colleges or a local authority program say to improve safety on the roads by spending money on traffic control. PBB demands that activities be prioritised in order that
. the relative merits and costs of those activities can be assessed.

## B

Zero -base budgeting ( ZBB ) is a cost-benefit whereby it is assumed that the cost al10wance for an item is zero, and will remain so until the manager responsible justifies the existence of the cost item and the benefits the expenditure brings. In this way a questioning attitude is developed wher~by each cost item and its level has to be justified in relation to the way it helps to meet objectives and how the expenditure benefits the organization. This is a forward looking approach as opposed to the all too common method of extrapolating past activities and costs, which is a feature of the incremental budgeting approach.
ZBB is formally defined by the CIMA thus, 'A method of budgeting whereby all activities are reevaluated each time a budget is formulated. Each functional budget starts with the assumption that the function does not exist and is at zero cost. Increments of cost are compared with increments of benefit, culminating in the planning maximum benefit for a given budgeted cost' (Terminology)
The use of ZBB was pioneered by P Phyrr in the United States in the early 1970s and has gained wide acceptance probably because it is a simple idea obviously based on common- sense. ZBB is concerned with the evaluation of the costs and benefits of alternatives and, implicit in the technique, is the concept of opportunity cost.

## Where ZBB can be applied

ZBB can be applied in both profit seeking and non-profit seeking organization. The technique gained wide publicity when the then President Carter directed that all US government departments adopt ZBB. In a manufacturing firm, ZBB is best applied to service and support expenditure including; administration, marketing, personnel, information and computer services, research and development, finance and accounting, production planning and so on. These activities are less easily quantifiable by conventional methods and are more discretionary in nature. Manufacturing costs such as direct materials and labour and production overheads can be more easily controlled by well established methods which compare production outputs with resource inputs rather than using ZBB. Budgeting and controlling manufacturing expenditure uses techniques such as work study and standard costing which are described later in the manual.
ZBB can successfully be applied to service industries and to a wide range of non-profit seeking organizations. For example local and central government departments, educational establishments, hospitals and so on. ZBB could be applied in any organization where alternative levels of provision for each activity are possible and the costs and benefits can be separately identified. ZBB is concerned with alternatives and means that established activities have to be compared with alternative uses of the same resources. ZBB takes away the implied right of existing activities to continue to receive resources, unless it can be shown that this is the best use of those resources.

## Just-In- Time Production

IIT Production works on a demand- pull basis and seeks to eliminate all waste and everything which does not add value to the product. As an example consider the lead times associated with making and selling a product. These include:
Inspection time - Transport time - Quening time - Storage time - Processing time
Of these, only processing time adds value to the product whereas all the others add cost, but not value. The ideal for JIT systems is to convert materials to finished products with a lead time equal to processing time so eliminating all activities which do no add value. A way of emphasizing the importance of reducing throughput time is to express the above lead time as follows:
Throughput time $=$ Value-added time + Non-value added time
The JIT pull system means that components are not made until requested by the next process. The usual way this is done is by monitoring parts consumption at each state and using a system of markers (known as kanbans) which authorise production and movement to the process which requires the parts. A consequence of this is that there may be idle time at certain work stations but this is considered preferable to adding to work-in-progress inventory.

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Poor and uncertain quality is a prime source of delays hence the drive in JIT systems for zero defects and Total Quality Control (TQc). When quality is poor, higher W.I.P is need to protect production from delays caused by defective parts. Higher inventory is also required when there are long set-up and changeover times. Accordingly there is continual pressure in JIT systems to reduce set-up times and eventually eliminate them so that the optimal batch size can become one. With a batch size of one, the work can flow smoothly to the next stage without the need to store it and schedule the next machine to accept the item.
D.

## Game Theory

Game theory is used to determine the optimum strategy in a competitive situation.
When two or more competitors are engaged in making decisions, it may involve conflict of interests.
In such a case the outcome depends not only upon an individual's action but also upon the actions of the others. Both (competing) sides face a similar problem. Hence game theory is a science of conflict. Game theory does not concern itself with finding an optimum strategy but it helps to improve the decision process.
Game theory has been used in business and industry to develop bidding tactics, pricing policies, advertising strategies, timing of the introduction of new models into market, etc.

## RULES OF GAME THEORY

i. The number of competitors is finite.
11. There is a conflict of interests between the participants.
iii. Each of these participants has available to him a finite set of available courses of action i.e. choices.

The rules governing these choices are specified and known to all the players.
iv. While playing each player chooses a singh~ course of action from the list of choices available to him.
v. The outcome of the game is affected by choices made by all of the players. The choices are to be made simultaneously so that no competitor knows his opponent's choices until he is already committed to his own.
vi. The outcome for all specific choices by all the players is known in advance and numerically defined.
vii. The players act rationally and intelligently.

When a competitive situation meets all these criteria above, we call it a game.
Note: Only in a few real competitive situations can game theory be applied because all the rules are difficult to apply at the same time to a given situation.
E.

Infonnation Asymmetry
Distortion and noise
A communication system is conceived as a transmitter connected to a receiver by a wire or, more correctly, by a sub-system comprising a communications channel. In the channel, the signal which originated at the transmitter is subject to change so that the signal arriving at the receiver may not coincide exactly with the signaI"leaving the transmitter. The two major causes for the change are distortion and noise.

Distortion can be illustrated by a classroom example commonly called 'Chinese Whispers'. One person in this class is given a message, without anyone else being able to know what the message is. That person has to whisper the message to a neighbour, without anyone else being able to hear. The neighbour cannot ask for the message to be repeated but must immediately pass the message to another neighbour, and so on, until all members of the class have heard the message. the final person in the chain then speaks the message out loud. A good example is given by the initial military message:
'Send three and four pence, we are going to dance.'
If the exercise is repeated in a classroom where everyone is shouting, the effects of noise can also be established.
Distortion changes the form of the message. Bias, discussed in the next chapter, is an example of a way in which information can be distorted. A manager may increase a planned cost budget by $10 \%$, say so that apparently good results will be shown by budgetary control reports. Noise is random and can obliterate the message entirely, in extreme circumstances. The problems of accounting for the effec $\sim$ of random deviations from standard or budget will be discussed; in .other words, the problems facing the management accountant when faced with noisy data will be recognised. Noisy data includes incorrect entries on operational control documents such as goods received notes. Communications theory states that noise is unavoidable. Distortion can be countered if the effects that the communications channel creates are sufficiently well understood. For instance, good quality hi-fi does not distort input signals significantly. Less good quality hi-fi can distort input signals but the distortion can be corrected by means of graphic equalisers. In management accounting systems, if the effects of distortion can be corrected by equal and opposite corrections, the signal can be received in its proper form. If it is known that a manager regularly increases budgeted cost levels by $10 \%$, the management accountant can reduce the final budgeted level by $10 \%$ to compensate

# MOCK EXAMINATION <br> CPA PART III <br> MANAGEMENT ACCOUNTING 

Time Allowed: 3 hours

## Answer ALL questions. Show all your workings.

## To be carried out under Examination conditions at home and is TO BE SENT to the

 Distance Learning Administrator for Marking by Strathmore University
## QUESTION ONE

The Government of the Republic of Nyake has decided as a matter of top priority to build an oil pipeline joining the two main towns of Pwani and Victoria. Because of the need to complete the project as quickly as possible the work has been divided into five stages which are to be built simultaneously. Within Nyake there are six companies large enough to undertake the construction of any of the five stages and each company has been invited to submit a tender for each stage of the project. The tenders (in billions of Nyake shillings) are as follows:

| Company | 1 | 2 | 3 | 4 | 5 |
| :--- | :--- | :--- | :--- | :--- | :--- |
|  | Shs | Shs | Shs | Shs | Shs |
| Z | 39 | 74 | 53 | 72 | 58 |
| Y | 43 | 82 | 52 | no bid | 57 |
| X | 44 | 76 | 57 | 68 | 58 |
| W | 36 | 76 | 52 | 66 | no bid |
| V | 47 | 84 | 56 | 73 | 60 |
| U | 40 | 72 | 55 | 70 | 62 |

## Required:

a. Assuming that non of the six companies is large enough to undertake the work of more than one stage, advise the government on how the five contracts should be allocated. what is the minimum total cost for the project.
b. On speaking to representatives of the six companies, it is discovered that $\mathrm{Z}, \mathrm{YW}$ and U have the capacity to undertake any two stages simultaneously and that X can undertake any three stages simultaneously. Show how the problem may now be formulated and solved using the "transportation" algorithm. What is now the minimum cost allocation of contracts? (JUN `94)

## QUESTION TWO

a. What is prisoners dilemma game?
b. Explain how the prisoners dilemma game can be applied in management problems.
c. Collective bargaining is relatively new among academic staff in institutions of higher learning. the collegial atmosphere in such institutions and universities, plus a strong commitment to professionalism would seem to make lecturers impossible to unionize. The pressure of "increasing enrolment, inflation, increased administrative controls, lack of facilities and other factors", however, have brought the idea of forming a union. One university, anticipating a vote on collective bargaining, established a senate sub-committee to investigate this unusual phenomenon. The committee was to refrain from any recommendations, pro or con, but was to examine the potential impact in the event a bargaining agent were elected to office. The committee's report ranged over a variety of topics. among some philosophical observations, two general features with respect of collective bargaining which are relevant to this report were apparent; the adversary nature of collective bargaining and the zero-sum game concept underlying collective bargaining.

It is the belief of this committee that although both sides in any collective bargaining situation should present their cases as ably as possible, the adversary nature of such proceedings should be "played down" and attempt should be made to arrive at conclusions at least partly satisfactory to both sides. Surely in academic, objectivity, nationality and the exercise of good manners and a decent respect for the view points of others are not outside the realm of the possible. This committee also takes the stand that collective bargaining may be a co-operative non zero-sum game wherein any losses to either or both parties can be offset by substantially larger gains.

## Required:

i. Develop an argument supporting the notion that collective bargaining is a non zero-sum game between the union and management.
ii. Develop an argument supporting the notion that collective bargaining is a zero-sum game.
iii. Which do you believe collective bargaining really is: zero-sum game or non zero-sum game? (DEC `94)

## QUESTION THREE

The Hatari Weapons Ltd. desires to submit a tender for 32 "string-to-surface" rockets required by Vita Ltd. It is estimated that each rocket will cost approximately Shs 40,000,000 for material and variable overhead costs. Total fixed costs will amount to approximately Shs $1,600,000,000$ over the two years it will take to build the rockets, all of which would have to be recovered against this contract.

The company, as a result of past experience, anticipates it could expect a 75 per cent learning curve and that the steady state would not be achieved during this production run. Building the first rocket would require approximately 400,000 hours of direct labour at a direct labour cost of Shs 1.50 per hour. Variable overhead costs which vary with direct labour amount to Shs 50 per direct labour hour.

Eight rockets will be built during the first year of the contract and the remaining 24 will be completed during the second year. The Hatari Weapons Ltd. always adds 25 per cent profit margin to the estimated costs of the contract for which they tender.

## Required:

a. Calculate the total labour hours that will be required to build the 32 rockets.
b. Draw up a quotation showing the total price to be quoted, with details of the constituent parts of the cost structure and the profit added.
c. Assuming the contract is awarded to the company, and no costs are deferred over the two year period, draft estimated income statements for the first and second years of the contract life. Revenue is to be recognised on the basis of completed rockets. Fixed costs are incurred equally each year.
(JUN `93)

## QUESTION FOUR

Meeta Ltd. is faced with a scheduling problem for its three main product lines. Each of the three products requires the operations of casting, machining, assembly and packaging. Where specialised casting is required, the casting is done within the company otherwise casting could be sub-contracted.

The company has recently been re-organised and a Management Services Department has been established. This department is in the process of reviewing production policies with the objective of exploring opportunities for maximising profits. Towards this end the following data has been gathered:

| Table I: Costs; Prices and Contribution Margins |  |  |  |
| :--- | :--- | :--- | :--- |
|  | Product 1 <br> Shs | Product 2 <br> Shs | Product 3 <br> Shs |
| Cost of Casting: |  |  |  |
| Produced at Meets Ltd. | 0.3 | 0.5 | 0.4 |
| Sub-contracted | 0.5 | 0.6 | - |
| Cost of Machining | 0.2 | 0.1 | 0.27 |
| Cost of assembly and Packaging | 0.3 | 0.2 | 0.2 |
| Price | 1.5 | 1.8 | 1.97 |


| $\|$Table II:Casting Machining, Assembly and Packaging times per Product    <br> (in minutes)    |
| :--- |
|  |
|  |
| Product 1 |
| Product 1 (S/C) |
| Product 2 |

N.B. S/C $\quad=\quad$ Sub-contracted.

## Required:

a. Set up the problem as a linear programming model.
b. Using the Simplex Method, solve the linear program to obtain maximum profits.
c. Briefly explain the term "integer programming in the context of management accounting.

## QUESTION FIVE

Your Finance Director has been invited by the University Management Accounting Students Association to address them on the marketing policies of your company with specific reference to:
a. Decentralisation and measurement of performance in both local and overseas markets.
b. Transfer pricing within the Eastern and Central African region where the company has manufacturing plants in six different countries.

## Required:

Write a detailed paper explaining in clear and concise terms the main issues the Financial Director should concentrate on. (JUN `94)

## END OF THE MOCK EXAMINATION

## NOW SEND YOUR ANSWERS TO THE DISTANCE LEARNING CENTRE FOR MARKING

Areas under the Standard Normal Curve from 0 to $Z$


| Z | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 0.0 | 0.0000 | 0.0040 | 0.0080 | 0.0120 | 0.0160 | 0.0199 | 0.0239 | 0.0279 | 0.0319 | 0.0359 |
| 0.1 | 0.0398 | 0.0438 | 0.0478 | 0.0517 | 0.0557 | 0.0596 | 0.0636 | 0.0675 | 0.0714 | 0.0754 |
| 0.2 | 0.0793 | 0.0832 | 0.0871 | 0.0910 | 0.0948 | 0.0987 | 0.1026 | 0.1064 | 0.1103 | 0.1141 |
| 0.3 | 0.1179 | 0.1217 | 0.1255 | 0.1293 | 0.1331 | 0.1368 | 0.1406 | 0.1443 | 0.1480 | 0.1517 |
| 0.4 | 0.1554 | 0.1591 | 0.1623 | 0.1664 | 0.1700 | 0.1736 | 0.1772 | 0.1808 | 0.1844 | 0.1879 |
| 0.5 | 0.1915 | 0.1950 | 0.1985 | 0.2019 | 0.2054 | 0.2088 | 0.2123 | 0.2157 | 0.2190 | 0.2224 |
| 0.6 | 0.2258 | 0.2291 | 0.2324 | 0.2357 | 0.2389 | 0.2422 | 0.2454 | 0.2486 | 0.2518 | 0.2549 |
| 0.7 | 0.2580 | 0.2612 | 0.2642 | 0.2673 | 0.2704 | 0.2734 | 0.2764 | 0.2794 | 0.2823 | 0.2852 |
| 0.8 | 0.2881 | 0.2910 | 0.2939 | 0.2967 | 0.2996 | 0.3023 | 0.3051 | 0.3073 | 0.3106 | 0.3133 |
| 0.9 | 0.3159 | 0.3186 | 0.3212 | 0.3238 | 0.3264 | 0.3289 | 0.3315 | 0.3340 | 0.3365 | 0.3389 |
| 1.0 | 0.3413 | 0.3438 | 0.3461 | 0.3485 | 0.3508 | 0.3531 | 0.3554 | 0.3577 | 0.3599 | 0.3621 |
| 1.1 | 0.3643 | 0.3665 | 0.3686 | 0.3708 | 0.3729 | 0.3749 | 0.3770 | 0.3790 | 0.3810 | 0.3830 |
| 1.2 | 0.3849 | 0.3869 | 0.3888 | 0.3907 | 0.3925 | 0.3944 | 0.3962 | 0.3980 | 0.3997 | 0.4015 |
| 1.3 | 0.4032 | 0.4049 | 0.4066 | 0.4082 | 0.4099 | 0.4115 | 0.4131 | 0.4147 | 0.4162 | 0.4177 |
| 1.4 | 0.4192 | 0.4207 | 0.4222 | 0.4236 | 0.4251 | 0.4265 | 0.4279 | 0.4292 | 0.4306 | 0.4319 |
| 1.5 | 0.4332 | 0.4345 | 0.4357 | 0.4370 | 0.4382 | 0.4394 | 0.4406 | 0.4418 | 0.4429 | 0.4441 |

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| Revision Aid |  |  |  |  | $389$ |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.6 | 0.4452 | 0.4463 | 0.4474 | 0.4484 | 0.4495 | 0.4505 | 0.4515 | 0.4525 | 0.4535 | 0.4545 |
| 1.7 | 0.4554 | 0.4564 | 0.4573 | 0.4582 | 0.4591 | 0.4599 | 0.4608 | 0.4616 | 0.4625 | 0.4633 |
| 1.8 | 0.4641 | 0.4649 | 0.4656 | 0.4664 | 0.4671 | 0.4678 | 0.4686 | 0.4693 | 0.4699 | 0.4706 |
| 1.9 | 0.4713 | 0.4719 | 0.4726 | 0.4732 | 0.4738 | 0.4744 | 0.4750 | 0.4756 | 0.4761 | 0.4767 |
| 2.0 | 0.4772 | 0.4778 | 0.4783 | 0.4788 | $0.4793$ | $0.4798$ | $0.4803$ | $0.4808$ | $0.4812$ | 0.4817 |
| 2.1 | 0.4821 | 0.4826 | 0.4830 | 0.4834 | 0.4838 | 0.4842 | 0.4846 | 0.4850 | 0.4854 | 0.4857 |
| 2.2 | 0.4861 | 0.4864 | $0.4868$ | 0.4871 | 0.4875 | 0.4878 | 0.4881 | 0.4884 | 0.4887 | 0.4890 |
| 2.3 | 0.4893 | 0.4896 | 0.4898 | 0.4901 | 0.4904 | 0.4906 | 0.4909 | 0.4911 | 0.4913 | 0.4916 |
| 2.4 | 0.4918 | $0.4920$ | 0.4922 | $0.4925$ | 0.4927 | 0.4929 | 0.4931 | 0.4932 | $0.4934$ | 0.4936 |
| 2.5 | 0.4938 | 0.4940 | 0.4941 | 0.4943 | 0.4945 | 0.4946 | 0.4948 | 0.4949 | 0.4951 | 0.4952 |
| 2.6 | 0.4953 | $0.4955$ | $0.4956$ | $0.4957$ | 0.4959 | 0.4960 | 0.4761 | 0.4962 | 0.4963 | 0.4964 |
| 2.7 | 0.4965 | 0.4966 | 0.4967 | 0.4968 | 0.4669 | 0.4970 | 0.4971 | 0.4972 | 0.4973 | 0.4974 |
| 2.8 | 0.4974 | $0.4975$ | 0.4976 | 0.4977 | 0.4877 | 0.4978 | 0.4979 | 0.4979 | 0.4780 | 0.4781 |
| 2.9 | 0.4981 | 0.4982 | 0.4982 | 0.4983 | 0.4984 | 0.4984 | 0.4985 | 0.4985 | 0.4986 | 0.4986 |
| 3.0 | 0.4987 | $0.4987$ | $0.4987$ | $0.4988$ | $0.4988$ | $0.4989$ | $0.4989$ | $0.4989$ | $0.4990$ | $0.4990$ |
| 3.1 | 0.4990 | 0.4991 | 0.4991 | 0.4991 | 0.4992 | 0.4992 | 0.4992 | 0.4992 | 0.4993 | 0.4993 |
| 3.2 | 0.4993 | 0.4993 | 0.4994 | 0.4994 | 0.4994 | 0.4994 | 0.4994 | 0.4995 | 0.4995 | 0.4995 |
| 3.3 | 0.4995 | 0.4995 | 0.4995 | 0.4996 | 0.4996 | 0.4996 | 0.4996 | 0.4996 | 0.4996 | 0.4997 |
| 3.4 | 0.4997 | 0.4997 | 0.4997 | 0.4997 | 0.4997 | 0.4997 | 0.4997 | 0.4997 | 0.4997 | 0.4998 |
| 3.5 | 0.4998 | 0.4998 | 0.4998 | 0.4998 | 0.4998 | 0.4998 | 0.4998 | 0.4998 | 0.4998 | 0.4998 |
| 3.6 | 0.4998 | 0.4998 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 |
| 3.7 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | $0.4999$ |
| 3.8 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 | 0.4999 |
| 3.9 | 0.5000 | 0.5000 | 0.5000 | 0.5000 | 0.5000 | 0.5000 | 0.5000 | 0.5000 | 0.5000 | 0.5000 |

[^0]

0 Z

| Z | 0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| P | 0.500 | 0.460 | 0.421 | 0.382 | 0.345 | 0.308 | 0.274 | 0.242 | 0.212 | 0.184 |
| Z | 1.0 | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.7 | 1.8 | 1.9 |
| P | 0.159 | 0.136 | 0.115 | 0.097 | 0.081 | 0.067 | 0.055 | 0.045 | 0.036 | 0.029 |
| Z | 2.0 | 2.1 | 2.2 | 2.3 | 2.4 | 2.5 | 2.6 | 2.7 | 2.8 | 2.9 |
| P | 0.023 | 0.018 | 0.014 | 0.011 | 0.008 | 0.006 | 0.005 | 0.003 | 0.003 | 0.002 |
| Z | 3.0 | 3.1 | 3.2 | 3.3 | 3.4 |  |  |  |  |  |
| P | 0.0013 | 0.0010 | 1.0007 | 0.0005 | 0.0003 |  |  |  |  |  |

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Table III

Percentage points of the $t$ distribution.

The table gives the values for the area in both tails.


|  | Area in both tables combined |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Degree of freedom | . 10 | . 05 | . 02 | . 01 |
| $\mathrm{v}=1$ | 6.314 | 12.706 | 31.821 | 63.657 |
| 2 | 2.920 | 4.303 | 6.965 | 9.925 |
| 3 | 2.353 | 3.182 | 4.541 | 5.841 |
| 4 | 2.132 | 2.776 | 3.747 | 4.604 |
| 5 | 2.015 | 2.571 | 3.365 | 4.032 |
| 6 | 1.493 | 2.447 | 3.143 | 3.707 |
| 7 | 1.895 | 2.365 | 2.998 | 3.499 |
| 8 | 1.860 | 2.306 | 2.896 | 3.355 |
| 9 | 1.833 | 2.262 | 2.821 | 3.250 |
| 10 | 1.812 | 2.228 | 2.764 | 3.169 |
| 11 | 1.796 | 2.201 | 2.718 | 3.106 |
| 12 | 1.782 | 2.179 | 2.681 | 3.055 |
| 13 | 1.771 | 2.160 | 2.650 | 3.012 |
| 14 | 1.761 | 2.145 | 2.624 | 2.977 |
| 15 | 1.753 | 2.131 | 2.602 | 2.947 |
| 16 | 1.746 | 2.120 | 2.583 | 2.921 |
| 17 | 1.740 | 2.110 | 2.567 | 2.898 |
| 18 | 1.734 | 2.101 | 2.552 | 2.878 |
| 19 | 1.729 | 2.093 | 2.539 | 2.861 |
| 20 | 1.725 | 2.086 | 2.528 | 2.845 |


|  | Area in both tables combined |  |  |  |
| :---: | :---: | :---: | :---: | :---: |
| Degrees of freedom | . 10 | . 05 | . 02 | . 01 |
| $\mathrm{v}=21$ | 1.721 | 2.080 | 2.518 | 2.831 |
| 22 | 1.717 | 2.074 | 2.508 | 2.819 |
| 23 | 1.714 | 2.069 | 2.500 | 2.807 |
| 24 | 1.711 | 2.064 | 2.492 | 2.797 |
| 25 | 1.708 | 2.060 | 2.485 | 2.787 |
| 26 | 1.706 | 2.056 | 2.479 | 2.779 |
| 27 | 1.703 | 2.052 | 2.473 | 2.771 |
| 28 | 1.701 | 2.048 | 2.467 | 2.763 |
| 29 | 1.699 | 2.045 | 2.462 | 2.756 |
| 30 | 1.697 | 2.042 | 2.457 | 2.750 |
| 40 | 1.684 | 2.021 | 2.423 | 2.704 |
| 60 | 1.671 | 2.000 | 2.390 | 2.660 |
| 12 | 1.658 | 1.980 | 2.358 | 2.6170 |
| $\infty$ | 1.645 | 1.960 | 2.326 | 2.576 |

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Table
The $\mathrm{X}^{2}$ distribution

| Degrees of freedom | Level of significance |  |
| :---: | :---: | :---: |
|  | 5\% | 1\% |
| $\mathrm{v}=1$ | 3.841 | 6.635 |
| 2 | 5.991 | 9.210 |
| 3 | 7.815 | 11.345 |
| 4 | 9.488 | 13.277 |
| 5 | 11.070 | 15.086 |
| 6 | 12.592 | 16.812 |
|  | 14.067 | 18.475 |
| 8 | 15.507 | 20.090 |
| 9 | 16.919 | 21.666 |
| 10 | 18.307 | 23.209 |

Table V

Percentage points of the $f$ distribution


Right tail of the distribution for $\mathrm{P}=.05$
Right tail of the distribution for $\mathrm{P}=.01$ (in brackets).

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Table VI
(a) Table of individual Poisson probabilities

|  |  |  |  |  |  |  |  |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  | Mean $(\mathrm{m})$ |  |  |  |  |  |  |
|  | 0 | 0 | 1 | Number of occurrences ( x ) |  |  |  |
|  | 0.1 | 0.9048 | 0.0905 | 0.0045 | 0.0002 | 4 | 5 |
| 0.2 | 0.8187 | 0.1637 | 0.0164 | 0.0011 | 0.000 | 0.000 | 0.000 |
| 0.3 | 0.7408 | 0.2222 | 0.0333 | 0.0033 | 0.0003 | 0.000 | 0.000 |
| 0.4 | 0.6703 | 0.2681 | 0.0536 | 0.0072 | 0.0007 | 0.000 | 0.000 |
| 0.5 | 0.6065 | 0.3033 | 0.0758 | 0.0126 | 0.0016 | 0.0002 | 0.000 |
| 0.6 | 0.5488 | 0.3293 | 0.0988 | 0.0198 | 0.0030 | 0.0004 | 0.000 |
| 0.7 | 0.4966 | 0.3476 | 0.1217 | 0.0284 | 0.0050 | 0.0007 | 0.0001 |
| 0.8 | 0.4493 | 0.3595 | 0.1438 | 0.0383 | 0.0077 | 0.0012 | 0.0002 |
| 0.9 | 0.4066 | 0.3659 | 0.1647 | 0.0494 | 0.0111 | 0.0020 | 0.0003 |
| 1.0 | 0.3679 | 0.3679 | 0.1839 | 0.0613 | 0.0153 | 0.0031 | 0.0005 |

Table shows probability of a given number of occurrences for a given mean ( m )
(b) Table of cumulative Poisson probabilities

| Mean $(\mathrm{m})$ | Number of occurrences (x) |  |  |  |  |  |  |
| ---: | ---: | ---: | ---: | ---: | ---: | ---: | ---: |
|  |  | 0 | 1 | 2 | 3 | 4 | 5 |

Table shows probability of finding x or fewer occurrences for a given mean ( m ).

Table VII
Compound interest
Table shows value of $£_{1} 1$ at compound interest $(1+r)^{n}$

| rest rates |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Years (n) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1 | 1.010 | 1.020 | 1.030 | 1.040 | 1.050 | 1.060 | 1.070 | 1.080 | 1.090 | 1.100 | 1.110 |
| 2 | 1.020 | 1.040 | 1.061 | 1.082 | 1.102 | 1.124 | 1.145 | 1.166 | 1.188 | 1.210 | 1.232 |
| 3 | 1.030 | 1.061 | 1.093 | 1.125 | 1.158 | 1.191 | 1.225 | 1.260 | 1.295 | 1.331 | 1.368 |
| 4 | 1.041 | 1.082 | 1.126 | 1.167 | 1.216 | 1.262 | 1.311 | 1.360 | 1.412 | 1.464 | 1.518 |
| 5 | 1.051 | 1.104 | 1.159 | 1.217 | 1.276 | 1.338 | 1.403 | 1.469 | 1.539 | 1.610 | 1.685 |
| 6 | 1.061 | 1.126 | 1.194 | 1.265 | 1.340 | 1.419 | 1.501 | 1.587 | 1.677 | 1.772 | 1.870 |
| 7 | 1.072 | 1.149 | 1.230 | 1.316 | 1.407 | 1.504 | 1.606 | 1.714 | 1.828 | 1.949 | 2.076 |
| 8 | 1.083 | 1.172 | 1.267 | 1.369 | 1.477 | 1.594 | 1.718 | 1.851 | 1.993 | 2.144 | 2.304 |
| 9 | 1.094 | 1.195 | 1.305 | 1.423 | 1.551 | 1.689 | 1.838 | 1.999 | 2.172 | 2.358 | 2.558 |
| 10 | 1.105 | 1.219 | 1.344 | 1.480 | 1.629 | 1.791 | 1.967 | 2.159 | 2.367 | 2.594 | 2.839 |
| 11 | 1.116 | 1.243 | 1.384 | 1.539 | 1.710 | 1.898 | 2.105 | 2.332 | 2.580 | 2.853 | 3.152 |
| 12 | 1.127 | 1.268 | 1.426 | 1.601 | 1.796 | 2.012 | 2.252 | 2.519 | 2.813 | 3.138 | 3.498 |
| 13 | 1.138 | 1.294 | 1.468 | 1.665 | 1.886 | 2.133 | 2.410 | 2.720 | 3.066 | 3.452 | 3.883 |
| 14 | 1.149 | 1.319 | 1.513 | 1.732 | 1.980 | 2.261 | 2.578 | 2.937 | 3.342 | 3.797 | 4.310 |
| 15 | 1.161 | 1.346 | 1.558 | 1.801 | 2.079 | 2.397 | 2.759 | 3.172 | 3.642 | 4.177 | 4.785 |
| 20 | 1.220 | 1.486 | 1.806 | 2.191 | 2.653 | 3.207 | 3.870 | 4.661 | 5.604 | 6.727 | 8.062 |
| 25 | 1.282 | 1.641 | 2.094 | 2.666 | 3.386 | 4.292 | 5.427 | 6.848 | 8.623 | 10.835 | 13.585 |
| Interest rates (r) \% |  |  |  |  |  |  |  |  |  |  |  |
| Years ( n ) | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 25 | 30 |
| 1 | 1.120 | 1.130 | 1.140 | 1.150 | 1.160 | 1.170 | 1.180 | 1.190 | 1.200 | 1.250 | 1.300 |
| 2 | 1.254 | 1.277 | 1.297 | 1.322 | 1.346 | 1.367 | 1.392 | 1.416 | 1.440 | 1.562 | 1.690 |
| 3 | 1.405 | 1.443 | 1.481 | 1.521 | 1.561 | 1.602 | 1.643 | 1.685 | 1.728 | 1.953 | 2.197 |
| 4 | 1.573 | 1.630 | 1.689 | 1.749 | 1.811 | 1.874 | 1.939 | 2.005 | 2.074 | 2.441 | 2.856 |
| 5 | 1.762 | 1.842 | 1.925 | 2.011 | 2.100 | 2.192 | 2.288 | 2.386 | 2.488 | 3.052 | 3.713 |
| 6 | 1.974 | 2.082 | 2.195 | 2.313 | 2.436 | 2.565 | 2.700 | 2.840 | 2.986 | 3.815 | 4.827 |
| 7 | 2.211 | 2.353 | 2.502 | 2.660 | 2.826 | 3.001 | 3.186 | 3.379 | 3.583 | 4.768 | 6.275 |
| 8 | 2.476 | 2.658 | 2.853 | 3.059 | 3.278 | 3.511 | 3.759 | 4.021 | 4.300 | 5.960 | 8.157 |
| 9 | 2.773 | 3.004 | 3.252 | 3.518 | 3.803 | 4.108 | 4.435 | 4.785 | 5.159 | 7.451 | 10.604 |
| 10 | 3.106 | 3.395 | 3.707 | 4.046 | 4.411 | 4.807 | 5.234 | 5.695 | 6.192 | 9.313 | 13.786 |
| 11 | 3.478 | 3.836 | 4.226 | 4.662 | 5.117 | 5.624 | 6.176 | 6.777 | 7.430 | 11.641 | 17.922 |
| 12 | 3.896 | 4.334 | 4.818 | 5.350 | 5.936 | 6.580 | 7.288 | 8.064 | 8.916 | 14.552 | 23.298 |
| 13 | 4.363 | 4.898 | 5.492 | 6.153 | 6.886 | 7.699 | 8.599 | 9.596 | 10.699 | 18.190 | 30.287 |
| 14 | 4.887 | 5.535 | 6.261 | 7.076 | 7.988 | 9.007 | 10.147 | 11.420 | 12.839 | 22.737 | 39.374 |
| 15 | 5.474 | 6.254 | 7.138 | 8.137 | 9.265 | 10.539 | 11.974 | 13.589 | 15.407 | 28.422 | 51.186 |
| 20 | 9.646 | 11.523 | 13.743 | 15.366 | 19.461 | 23.106 | 27.393 | 32.429 | 38.338 | 86.736 | 190.050 |
| 25 | 17.000 | 21.230 | 26.462 | 32.920 | 40.874 | 50.658 | 62.669 | 77.388 | 95.396 | 264.698 | 705.641 |

## Present value factors. Present value of $£_{1}^{1}(1+\mathrm{r})^{-n}$

| Periods |  |  |  | st rate |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| (n) | 1\% | 2\% | 4\% | 6\% | 8\% | 10\% | 12\% | 14\% | 15\% |
| 1 | 0.990 | 0.980 | 0.962 | 0.943 | 0.926 | 0.909 | 0.893 | 0.877 | 0.870 |
| 2 | 0.980 | 0.961 | 0.925 | 0.890 | 0.857 | 0.826 | 0.797 | 0.769 | 0.756 |
| 3 | 0.971 | 0.942 | 0.889 | 0.840 | 0.794 | 0.751 | 0.712 | 0.675 | 0.658 |
| 4 | 0.961 | 0.924 | 0.855 | 0.792 | 0.735 | 0.683 | 0.636 | 0.592 | 0.572 |
| 5 | 0.951 | 0.906 | 0.822 | 0.747 | 0.681 | 0.621 | 0.567 | 0.519 | 0.497 |
| 6 | 0.942 | 0.888 | 0.790 | 0.705 | 0.630 | 0.564 | 0.507 | 0.456 | 0.432 |
| 7 | 0.933 | 0.871 | 0.760 | 0.665 | 0.583 | 0.513 | 0.452 | 0.400 | 0.376 |
| 8 | 0.923 | 0.853 | 0.731 | 0.627 | 0.540 | 0.467 | 0.404 | 0.351 | 0.327 |
| 9 | 0.914 | 0.837 | 0.703 | 0.592 | 0.500 | 0.424 | 0.361 | 0.308 | 0.284 |
| 10 | 0.905 | 0.820 | 0.676 | 0.558 | 0.463 | 0.386 | 0.322 | 0.270 | 0.247 |
| 11 | 0.0896 | 0.804 | 0.650 | 0.527 | 0.429 | 0.350 | 0.287 | 0.237 | 0.215 |
| 12 | 0.887 | 0.788 | 0.625 | 0.497 | 0.397 | 0.319 | 0.257 | 0.208 | 0.187 |
| 13 | 0.879 | 0.773 | 0.601 | 0.469 | 0.368 | 0.290 | 0.229 | 0.182 | 0.163 |
| 14 | 0.870 | 0.758 | 0.577 | 0.442 | 0.340 | 0.263 | 0.205 | 0.160 | 0.141 |
| 15 | 0.861 | 0.743 | 0.555 | 0.417 | 0.315 | 0.239 | 0.183 | 0.140 | 0.123 |
| 16 | 0.853 | 0.728 | 0.534 | 0.394 | 0.292 | 0.218 | 0.163 | 0.123 | 0.107 |
| 17 | 0.855 | 0.714 | 0.513 | 0.371 | 0.270 | 0.198 | 0.146 | 0.108 | 0.093 |
| 18 | 0.836 | 0.700 | 0.494 | 0.350 | 0.250 | 0.180 | 0.130 | 0.095 | 0.081 |
| 19 | 0.828 | 0.686 | 0.475 | 0.331 | 0.232 | 0.164 | 0.116 | 0.083 | 0.070 |
| 20 | 0.820 | 0.675 | 0.456 | 0.312 | 0.215 | 0.149 | 0.104 | 0.073 | 0.061 |
| 21 | 0.811 | 0.660 | 0.439 | 0.294 | 0.199 | 0.135 | 0.093 | 0.064 | 0.053 |
| 22 | 0.803 | 0.647 | 0.422 | 0.278 | 0.184 | 0.123 | 0.083 | 0.056 | 0.046 |
| 23 | 0.795 | 0.634 | 0.406 | 0.262 | 0.170 | 0.112 | 0.074 | 0.049 | 0.040 |
| 24 | 0.788 | 0.622 | 0.390 | 0.247 | 0.158 | 0.102 | 0.066 | 0.043 | 0.035 |
| 25 | 0.780 | 0.610 | 0.375 | 0.233 | 0.146 | 0.092 | 0.059 | 0.038 | 0.030 |


| Periods | Interest rates (r) \% |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| (n) | 16\% | 18\% | 20\% | 22\% | 24\% | 25\% | 26\% | 28\% | 30\% |
| 1 | 0.862 | 0.847 | 0.833 | 0.820 | 0.806 | 0.800 | 0.794 | 0.781 | 0.769 |
| 2 | 0.743 | 0.718 | 0.694 | 0.672 | 0.650 | 0.640 | 0.630 | 0.610 | 0.592 |
| 3 | 0.641 | 0.609 | 0.579 | 0.551 | 0.524 | 0.512 | 0.500 | 0.477 | 0.455 |
| 4 | 0.552 | 0.516 | 0.482 | 0.451 | 0.423 | 0.410 | 0.397 | 0.373 | 0.350 |
| 5 | 0.476 | 0.437 | 0.402 | 0.370 | 0.341 | 0.328 | 0.315 | 0.291 | 0.269 |
| 6 | 0.410 | 0.370 | 0.335 | 0.303 | 0.275 | 0.262 | 0.250 | 0.227 | 0.207 |
| 7 | 0.354 | 0.314 | 0.279 | 0.249 | 0.222 | 0.210 | 0.198 | 0.178 | 0.159 |
| 8 | 0.305 | 0.266 | 0.233 | 0.204 | 0.179 | 0.168 | 0.157 | 0.139 | 0.123 |
| 9 | 0.263 | 0.225 | 0.194 | 0.167 | 0.144 | 0.134 | 0.125 | 0.108 | 0.094 |
| 10 | 0.227 | 0.191 | 0.162 | 0.137 | 0.116 | 0.107 | 0.099 | 0.085 | 0.075 |
| 11 | 0.195 | 0.162 | 0.135 | 0.112 | 0.094 | 0.086 | 0.079 | 0.066 | 0.056 |
| 12 | 0.168 | 0.137 | 0.112 | 0.192 | 0.076 | 0.069 | 0.062 | 0.052 | 0.043 |
| 13 | 0.145 | 0.116 | 0.093 | 0.075 | 0.061 | 0.055 | 0.050 | 0.040 | 0.033 |
| 14 | 0.125 | 0.099 | 0.178 | 0.062 | 0.049 | 0.044 | 0.039 | 0.032 | 0.025 |
| 15 | 0.108 | 0.084 | 0.065 | 0.051 | 0.040 | 0.035 | 0.031 | 0.025 | 0.020 |
| 16 | 0.093 | 0.071 | 0.054 | 0.042 | 0.032 | 0.028 | 0.025 | 0.019 | 0.015 |
| 17 | 0.080 | 0.060 | 0.045 | 0.034 | 0.026 | 0.023 | 0.020 | 0.015 | 0.012 |
| 18 | 0.069 | 0.051 | 0.038 | 0.028 | 0.021 | 0.018 | 0.016 | 0.012 | 0.009 |
| 19 | 0.060 | 0.043 | 0.031 | 0.023 | 0.017 | 0.014 | 0.012 | 0.009 | 0.007 |
| 20 | 0.051 | 0.037 | 0.026 | 0.019 | 0.014 | 0.012 | 0.010 | 0.007 | 0.005 |
| 21 | 0.044 | 0.031 | 0.022 | 0.015 | 0.011 | 0.009 | 0.008 | 0.006 | 0.004 |
| 22 | 0.038 | 0.026 | 0.018 | 0.013 | 0.009 | 0.007 | 0.006 | 0.004 | 0.003 |
| 23 | 0.033 | 0.022 | 0.015 | 0.010 | 0.007 | 0.006 | 0.005 | 0.003 | 0.002 |
| 24 | 0.028 | 0.019 | 0.011 | 0.008 | 0.006 | 0.005 | 0.004 | 0.003 | 0.002 |
| 25 | 0.024 | 0.016 | 0.010 | 0.007 | 0.005 | 0.004 | 0.003 | 0.002 | 0.001 |


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