Express Packets guarantee 95%of their deliveries are on time. In a recent week 80 deliveries were made and 6 were late and the management says that, at the 95%level there has been a significant improvement in deliveries.

Can the MD's statement be supported?
If not, at what level of confidence can it be supported?
A batch of weighing machines has been purchased and one machine is selected at random for testing. Ten weighing tests have been conducted and the errors found are noted as follows:

Test	**Errors (gms)**
1	4.6
2	8.2
3	2.1
4	6.3
5	5.0
6	3.6
7	1.4
8	4.1
9	7.0
10	4.5

The purchasing manager has previously accepted machines with a mean error of 3.8 gms and asserts that these tests are below standard.
Test the assertions at 5% level.

Compare your answers with those given in lesson 9 of the study pack

CHAPTER NINE

TIME SERIES ANALYSIS

Specific Objectives

At the end of the this topic the trainee should be able to:

- Describe the components of time series;
- Describe the time series models;
- Evaluate trend and seasonal variation in the series;
- Explain the concept of deseasonalization;
- Apply time series analysis to business problems

INTRODUCTION

Businesses and governments use statistical analysis of information collected at regular intervals over extensive periods of time to plan future policies. For example, sales values or unemployment levels recorded at yearly, quarterly or monthly intervals are examined in an attempt to predict their future behavior. Such sets of values observed at regular intervals over a period of time are called time series. The analysis of this data is a complex problem as many variable factors may influence the changes. The first step is to plot the observations on a scattergraph, which differs from those scattergraphs we have considered previously as the points are evenly spaced on the time axis in the order in which they are observed, and the time variable is always the independent Variable. This scattergraph gives us a good visual guide to the actual changes, but is of very little help in showing the component factors causing these changes or in predicting future movements of the dependent variable.

Statisticians have constructed a number of mathematical models to describe the behavior of time series, and several of these will be discussed in this study unit.

COMPONENTS OF A TIME SERIES

These mathematical models assume that the changes are caused by the variation of four main factors; they differ in the relationship between these factors. It will be easier to understand the theory in detail if we relate it to a simple time series so that we can see the calculations necessary at each stage. Consider a factory employing a number of people in producing a particular commodity, say thermometers. Naturally, at such a factory during the course of a year some employees will be absent for various reasons. The following table shows the number of days lost through sickness over a five-year period. Each year has been broken down into four quarters of three months. We have assumed that the number of employees at the factory remained constant over the five years.

Table 9.1: Days lost through sickness at a thermometer factory

Year	Quarter	Days Lost

2003	1	30
	2	20
	3	15
	4	35
2004	1	40
	2	25
	3	18
	4	45
2005	1	45
	2	30
	3	22
	4	55
2006	1	50
	2	32
	3	28
	4	60
2007	1	60
	2	35
	3	30
	4	70

We will begin by plotting a time-series graph for the data, as shown in Figure 9.1.

Note the following characteristics of a time-series graph:

- It is usual to join the points by straight lines. The only function of these lines is to help your eyes to see the pattern formed by the points.
- Intermediate values of the variables cannot be read from the graph.
- Every time-series graph will look similar to this, but a careful study of the change of
- Pattern over time will suggest which model should be used for analysis.

There are four factors that influence the changes in a time series – trend, seasonal variations, cyclical fluctuations, and irregular or random fluctuations. Now we will consider each in turn.

Trend

This is the change in general level over the whole time period and is often referred to as the secular trend. You can see in Figure 9.1 that the trend is definitely upwards, in spite of the obvious fluctuations from one quarter to the next. A trend can thus be defined as a clear tendency for the time series data to travel in a particular direction in spite of other large and small fluctuations.

Seasonal Variations

These are variations which are repeated over relatively short periods of time. Those most frequently observed are associated with the seasons of the year, e.g. ice cream sales tend to rise during the summer months and fall during the winter months. You can see in our example of employees' sickness that more people are sick during the winter than in the summer. If you can establish the variation throughout the year then this seasonal variation is likely to be similar from one year to the next, so that it would be possible to allow for it when estimating values of the variable in other parts of the time series. The usefulness of being able to calculate seasonal variation is obvious as, for example, it allows ice cream manufacturers to alter their production schedules to meet these seasonal changes.

As this type of fluctuation is difficult to determine, it is often considered with the final (fourth) element, and the two together are called the residual variation.

Irregular or Random Fluctuations

Careful examination of Figure 9.1 shows that there are other relatively small irregularities which we have not accounted for and that do not seem to have any easily seen pattern. We call these irregular or random fluctuations; they may be due to errors of observation or to some one-off external influence which is difficult to isolate or predict. In our example (Table1) there may have been a measles epidemic in 2006, but it would be extremely difficult to predict when and if such an epidemic would occur again.

Summary

To sum up, a time series (Y) can be considered as a combination of the following four factors:

- Trend (T)
- Seasonal variation (S)
- Cyclical fluctuation (C)
- Irregular fluctuations (I).

Time series models:

Additive Model

Time series value = T +S +C +R

Where S, C and R are expressed in absolute value.

This model is best suited where the component factors are independent e.g. where the seasonal variation is unaffected by trend.

Multiplicative Model:
Time series value = T × S× C × R
Where S, C and are expressed as percentage or proportions.

This model is best applied where characteristics interact e.g. where high trends increase seasonal variations. Multiplicative model is more commonly used in practice.
Of the four elements of time series the most important are **trend** and **seasonal variation**. The following illustration shows how the trend (T) and seasonal variation (S) are separated out from a time series and how the calculated T and S values are used to prepare forecast. The process of separating out the trend and seasonal variation is known as deseasonalising the data.
There are two approaches to this process: one is based on regression through the actual data points and the other calculates the regression line through moving average trend points. The method using the actual data is demonstrated first followed by the moving average method.