PART-1
Quality Control.

Questions-Answers
Long Answer Type and Medium Answer Type Questions

Que 4.1. **Define quality control. What are the objectives and significance of quality control ?**

Answer

A. Quality control is the set of measures and procedures to follow in order to ensure that the quality of a product is maintained and improved against a set of benchmarks and any errors encountered are either eliminated or reduced.

B. **Objectives of quality control :** Following are the important objectives of quality control :

1. To establish the desired quality standards which are acceptable to the customer.
2. To discover flaws or variations in the raw materials and the manufacturing processes in order to ensure smooth and uninterrupted production.
3. To evaluate the methods and processes of production and suggest further improvements in their functioning.
4. To study and determine the extent of quality deviation in a product during the manufacturing process.
5. To analyse in detail the causes responsible for such deviation.
6. To undertake such steps which are helpful in achieving the desired quality of the products.

C. **Significance of quality control :**

1. Detects Quality Deviation
2. Acceptance by customers
3. Earns goodwill
4. Develops Quality Consciousness
5. Timely delivery of goods
6. Improves productivity
7. Motivates employees

Que 4.2. **Give a brief description of statistical quality control.**

AKTU 2013-14, Marks 10

OR

What is SQC ?

Answer

1. Statistical Quality Control (SQC) refers to the use of statistical methods in monitoring and maintaining the quality of products and services.
2. SQC uses following different tools to analyze quality problem :

i. **Descriptive statistics :** Descriptive statistics involves in describing quality, characteristics and relationships.

ii. **Statistical Process Control (SPC) :** SPC involves in inspecting random sample of output from process for characteristic.

iii. **Acceptance sampling :** Acceptance sampling involves batch sampling by inspection.

3. All the tools of SQC are helpful in evaluating the quality of services.

Techniques of statistical quality control :

1. The important techniques used for statistical quality control can be broadly classified into two categories: Statistical Process Control (SPC) (or Process Control) and Product Control.
2. These techniques are further classified into different categories as shown in Fig. 4.2.1.

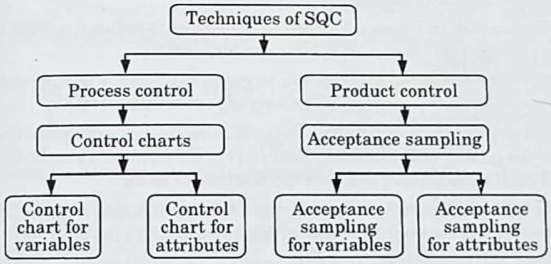

Fig. 4.2.1. Classification of SQC techniques.

Statistical Process Control (SPC) : Statistical process control is a technique used for understanding and monitoring the process by collecting data on quality characteristics periodically from the process and analyze them and take suitable actions whenever there is a difference between actual quality and the specifications or standard.

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Product Control : Product control means to control the products in such a way that these are free from defects and conform to their specifications.

Objectives of SQC :

1. It provides a means of detecting error at inspection.
2. It leads to more uniform quality of production.
3. It improves the relationship with the customer.
4. It reduces inspection costs.
5. It reduces the number of rejects and saves the cost of material.
6. It provides a basis for attainable specifications.
7. It points out the bottlenecks and trouble spots.
8. It provides a means of determining the capability of the manufacturing process.
9. It promotes the understanding and appreciation of quality control.

Que 4.3. **What are the advantages and limitations of statistical quality control ?** **AKTU 2015-16, Marks 7.5**

Answer

A. Advantages of SQC :

1. **Ease of Application :** Statistical quality control is easy to apply. Even those persons who have not had extensive specialised training can apply statistical methods easily.
2. **Reduction in Costs :** The cost of inspection is reduced in SQC as only a part or fraction of a lot is taken and inspected.
3. **Greater Efficiency :** It provides greater efficiency as inspectors are more alert while using SQC as only of part is inspected.
4. **Early Detection of Faulty Units :** SQC consists of continuous checking of the quality of the product. Therefore, SQC ensures an early detection of faults and results in minimum wastage of items.
5. **Helpful in Specification :** Using SQC, we can find out whether the item meets the specifications within the tolerance limits or not.
6. **Ensures Overall Coordination :** SQC methods ensure coordination between managers managing specifications, production and inspection.
7. **Determination of the Effect of Change in the Process :** With the help of control charts, we can easily detect whether or not a change in the production process results in a significant change in the quality.
8. **Equilibrium in Consumer's and Producer's Risk :** Methods such as quality control and acceptance sampling help in maintaining equilibrium between the consumer's risk and producer's risk.

9. **Wider Applications :** It is not only useful in the examination of items produced in small numbers, but also when bulk production has to be done.

B. Limitations of SQC :

1. When a sample of the items drawn from the lot is not a true representative of the entire lot and does not have the same characteristics as the lot from which it is drawn. Then a good lot may be rejected and a bad one may be accepted. This is the main limitation of SQC.
2. SQC is cannot be used mechanically for any production process without studying the process and without having adequate knowledge about the process.
3. SQC applied on a production process provides only the information that the process is under control or out-of-control. It cannot take any action for improvement.

PART-2

Control Charts.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.4. **What is a control chart ? Discuss the types of control charts for 'variables' (mean chart and range chart).**

AKTU 2016-17, Marks 7.5

AKTU 2017-18, Marks 10

OR

Define control charts. Explain various charts briefly.

Answer

1. Control chart is a graph used to study how a process changes over time.
2. Data are plotted in time order.
3. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit.

Basic procedure for control chart :

i. Choose the appropriate control chart for given data.

ii. Determine the appropriate time period for collecting and plotting data.

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iii. Collect data, construct the chart and analyze the data.

iv. Look for out-of-control signals on the control chart and if it is identified, mark it on the chart and investigate the cause.

Types of control charts :

1. **Variable charts :** Variable data are quantitative data that can be measured. **Example :** The diameter of a bearing, the thickness of newly minted coin or length of a screw.
2. **Attributes charts :** Attributes data are qualitative data that can be counted. **Example :** Surface finish of a product, count of scratches per item or brightness of an item.

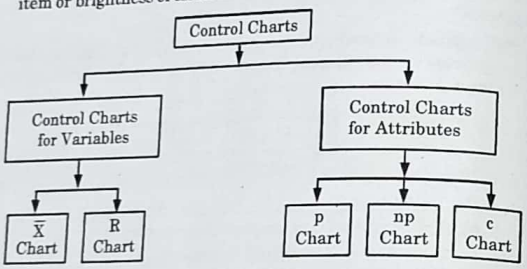

Fig. 4.4.1.

Types of variable control charts :

1. **$\bar{X}$-Chart or mean Chart :** $\bar{X}$-chart is a variable control chart that is used to monitor the arithmetic means of successive samples of constant size. This type of control chart is used for characteristics that can be measured on a continuous scale, such as weight, temperature, thickness etc.,
2. ***R*-Chart or Range Chart :** In statistical quality control, *R*-chart is used when the quality controller is interested in the range or difference between the largest and smallest measurements.

Types of attribute control charts :

1. ***p*-Chart (For Fraction Defective) :** In this chart, each item is classified as good (non-defective) or bad (defective). This chart is used to control the general quality of the component parts. *p*-chart is used to plot and control fraction defectives when the sample size remains uniform or it varies.
2. ***np*-Chart (For Number of Defectives) :** A *np*-chart is appropriate when the numbers of items used to calculate each proportion is same. For example, 100 reports may be reviewed each week and categorized as either accurate or inaccurate. The proportion of inaccurate reports could be plotted on a *p*-chart or the actual number of inaccurate reports could be plotted on an *np*-chart. If the number of reports reviewed each week varies, then a *p*-chart must be used.
3. ***c*-Chart (For Number of Defects per unit) :** *c*-chart is used to records the number of defects founds in a given sample size. This chart is used where average number of defects is much less than the number of defects which would occur.

Que 4.5. **What are the advantages of attribute and variable control charts ?**

Answer

A. Advantages of attribute control charts :

1. Allowing for quick summaries, that is, the engineer may simply classify products as acceptable or unacceptable, based on various quality criteria.
2. Thus, attribute charts sometimes bypass the need for expensive, precise devices and time consuming measurement procedures.
3. More easily understood by managers who are not familiar with quality control procedures.

B. Advantages of variable control charts :

1. More sensitive than attribute control charts.
2. Variable control charts may alert us to quality problems before any actual "unacceptable" (as detected by the attribute chart) will occur.
3. Variable control charts are leading indicators of trouble that will sound an alarm before the number of rejects increases in the production process.

Que 4.6. **Discuss the need, construction and applications of control charts for variables.** **AKTU 2015-16, Marks 10**

Answer

A. Control Charts for Variables :

1. Control charts for variable are used to achieve and maintain an acceptable quality level for a process.
2. Variables control charts plot continuous measurement process data, such as length or pressure, in a time-ordered sequence.
3. Variables control charts, like all control charts, help us to identify the causes of variation to investigate, so that we can adjust our process without over-controlling it.

B. Construction of charts :

The $\bar{X}$ (arithmetic mean) and R (range) control chart is used with variables data. The steps for constructing this type of control chart are :

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Step 1 : Determine the data to be collected. Decide what questions about the process you plan to answer.

Step 2 : Collect and enter the data by subgroup. The sample size relates to how large the subgroups are. Enter the individual subgroup measurements in time sequence in the portion of the data collection section of the control chart labelled measurement.

Sept 3 : Calculate and enter the average for each subgroup. Use the formula to calculate the average (mean) for each subgroup and enter it on the line labelled Average in the data collection section.

Step 4 : Calculate and enter the range for each subgroup. Enter the range for each subgroup on the line labelled Range in the data collection section.

Range = (Largest value in each subgroup) – (Smallest value in each subgroup)

Step 5 : Calculate the grand mean of the subgroup's average. The grand mean of the subgroup's average $\bar{X}$ becomes the centreline for the upper plot.

Step 6 : Calculate the average of the subgroup ranges. The average of all subgroups becomes the centreline for the lower plotting area.

Step 7 : Calculate the upper control limit (UCL) and lower control limit (LCL) for the averages of the subgroups.

Step 8 : Calculate the upper control limit for the ranges.

Step 9 : Select the scales and plot the control limits, centreline, and data points, in each plotting area.

Step 10 : Document the chart.

C. Applications :

i. To monitor a process for those special causes of variation that can occur and remove them so they don't occur again.

ii. To estimate the process average. Another purpose is to estimate the variation.

iii. To judge the impact of process improvement efforts.

Que 4.7. Describe the method of constructing variable charts and attribute charts. And explain how these charts help in determining "Lack of Control". **AKTU 2017-18, Marks 10**

Answer

A. Method of constructing variable charts : Refer Q. 4.6, Page 4–7Y, Unit-4.

B. Method of constructing attribute charts :

1. *p*-chart (proportion chart) :

When to Use :

i. Sample sizes are NOT equal.

ii. Have discrete data.

Step 1 : Measure $\bar{p}$:

$$\bar{p} = \text{Fraction rejected}$$
$$= \text{Total defectives / Total inspected.}$$

Step 2 : Find Control Limits :

$$3\,SD = 3 \times \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

n refers to a single instance of a sample size, not the number of sample sizes (or rows) listed. Since there are multiple sample sizes, we use the largest one on the list.

Upper control limit = $\bar{p} + 3\,SD$

Lower control limit = $\bar{p} - 3\,SD$

2. *np*-chart :

When to Use :

i. Sample sizes are equal.

ii. Subgroups are the same size.

iii. Attributes are discrete and binary (Example : yes vs. no; up vs. down)

Step 1 : Calculate $\bar{p}$ as above.

Step 2 : Calculate $n\bar{p}$.

$$n\bar{p} = \text{Total number of defective / Total samples.}$$

The total samples are the number of rows listed.

Step 3 : Calculate the control limits

$$UCL = n\bar{p} + 3\sqrt{n\bar{p}(1-\bar{p})}$$

$$LCL = n\bar{p} - 3\sqrt{n\bar{p}(1-\bar{p})}$$

3. *c*-charts :

When to Use :

i. Total opportunity population is large compared to number of defects.

ii. When you cannot count "not a defect."

iii. Data type is discrete but each count has an equal opportunity of coming up.

Step 1 : c = Total number of defects / Number of units

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Step 2 : $UCL = \bar{c} + 3\sqrt{c}$

$LCL = \bar{c} - 3\sqrt{c}$

Now, we interpret the result. If all sample points lie on or in between the upper and lower control limits, the control chart indicates that the process is under control. If one or more points lie outside the upper or lower control limits, the control chart indicates that the process is not under statistical control (Lack of control) and some assignable causes are present in the process.

Que 4.8. **What do you understand by process control ? Define control chart and give the objectives of $\bar{X}$ and R charts.**

AKTU 2014-15, Marks 10

Answer

A. **Process Control :** Process control is activities involved in ensuring a process is predictable, stable, and consistently operating at the target level of performance with only normal variation.

B. **Control chart :** Refer Q. 4.6, Page 4–7Y, Unit-4.

C. **Objectives of $\bar{X}$ and R charts :** Refer Q. 4.4, Page 4–5Y, Unit-4.

Que 4.9. **Differentiate between $\bar{X}$-R chart and p-chart.**

Answer

S. No.	$\bar{X}$-R chart	p-chart
1.	These are control charts for variables.	These are control charts of attributes.
2.	Cost of data collection is higher due to actual dimensional measurements.	Data collection is comparatively cheaper.
3.	Sample sizes are relatively small.	Larger size samples are to be taken.
4.	The control limits are affected by sample size.	There is less effect of the sample size over control limits.
5.	For different measurable quality characteristics different charts are to be drawn.	Same p-chart may be applied to any one item under inspection.
6.	This method is much superior in diagnosing the cause of variability.	This method is comparatively inferior regarding diagnosing the causes of rejections.

PART-3

Acceptance Sampling.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.10. **What do you understand by acceptance sampling ? What are its advantages and limitations ?**

Answer

A. **Definition :** A sampling inspection in which a decision about acceptance or rejection of a lot is based on one or more samples that have been inspected is known as acceptance sampling.

Acceptance sampling is a technique in which a small part or a fraction of the units/items is selected randomly from a lot and the selected units are inspected to decide whether the lot should be accepted or rejected on the basis of the information provided by the sample inspection.

B. **For example :** Suppose a manufacturer of cricket balls supplies them in lots of 500. A buyer wants to inspect 20 balls from each lot before accepting the lot and takes a decision about acceptance or rejection of the lot on the basis of the information provided by this sample. This is an example of acceptance sampling because the decision about the lot is taken on the basis of a sample.

C. **Advantages of acceptance sampling :**

i. It is less expensive in terms of money, time and labour in comparison to 100 % inspection.

ii. For items, which cannot be used after single inspection, such as crackers, bulbs, tube lights, food, etc., 100 % inspection is not practicable. Sampling inspection is the only way for inspecting such items.

iii. In acceptance sampling, a sample of a small number of items or units is inspected and hence smaller inspection staff is required.

iv. Due to quick inspection through the acceptance sampling, the scheduling and delivery times are saved.

D. **Limitations of acceptance sampling :**

i. Since, in acceptance sampling, the entire lot is accepted or rejected on the basis of conclusions drawn from one or more samples, there is always some risk of making wrong inference about the quality of the lot.

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ii. The success of acceptance sampling depends on the randomness of the sample, quality characteristics to be tested, lot size, acceptance criteria, etc. Therefore, it is a specialised job requiring careful planning and execution and every one cannot undertake it.

Que 4.11. What is single sampling plan ? Describe the single sampling procedure.

Answer

A. **Definition :** A sampling plan in which a decision about the acceptance or rejection of a lot is based on a single sample that has been inspected is known as a single sampling plan.

B. **For example :** Suppose a buyer purchases cricket balls in lots of 500 from a company manufacturing cricket balls. To check the quality of the lots, the buyer draws a random sample of size 20 from each lot and takes a decision about accepting or rejecting of the lot on the basis of the information provided by this sample. Since the buyer takes the decision about the lot on the basis of a single sample, this sampling plan is a single sampling plan.

C. **Parameters :** There are two parameters :

n-size of the sample, and

c-acceptance number for the sample.

D. **Procedure :** The procedure for implementing the single sampling plan to arrive at a decision about the lot is described in the following steps:

Step 1 : We draw a random sample of size n from the lot received from the supplier or the final assembly.

Step 2 : We inspect each and every unit of the sample and classify it as defective or non-defective. At the end of the inspection, we count the number of defective units found in the sample. Suppose the number of defective units found in the sample is d.

Step 3 : We compare the number of defective units (d) found in the sample with the stated acceptance number (c).

Step 4 : We take the decision of acceptance or rejection of the lot on the basis of the sample.

Que 4.12. What is double sampling plan ? Describe the procedure of double sampling plan.

Answer

A. **Definition :** A sampling plan in which a decision about the acceptance or rejection of a lot is based on two samples that have been inspected is known as a double sampling plan.

B. **For example :** Suppose a buyer purchases cricket balls in lots of 500 from a company. To check the quality of the lots, the buyer and the company decide that the buyer will draw two samples of sizes 10 (first sample) and 20 (second sample) and the acceptance numbers for the plan are 1 and 3. The buyer takes two samples and makes the decision of acceptance or rejection of the lot on the basis of two samples.

C. **Parameters :** There are four parameters :

n_1 size of the first sample,

c_1 acceptance number for the first sample,

n_2 size of the second sample, and

c_2 acceptance numbers for both samples combined.

D. **Procedure :** The procedure for implementing the double sampling plan to arrive at a decision about the lot is described in the following steps :

Step 1 : We draw a random sample (first sample) of size n_1 from the lot received from the supplier or the final assembly.

Step 2 : We inspect each and every unit of the sample and classify it as defective or non-defective. At the end of the inspection, we count the number of defective units found in the sample. Suppose the number of defective units found in the first sample is d_1.

Step 3 : We compare the number of defective units (d_1) found in the first sample with the stated acceptance numbers c_1 and c_2.

Step 4 : We take the decision on the basis of the first sample as follows :

If $d_1 \le c_1$, sample is accepted

If $d_1 > c_2$, sample is rejected

Step 5 : If $c_1 < d_1 \le c_2$, we draw a second random sample of size n_2 from the lot.

Step 6 : We inspect each and every unit of the second sample and count the number of defective units found in it. Suppose the number of defective units found in the second sample is d_2.

Step 7 : We combine the number of defective units (d_1 and d_2) found in both samples and consider $d_1 + d_2$ for taking the decision about the lot on the basis of the second sample as follows:

If $d_1 + d_2 \le c_2$, sample is accepted

If $d_1 + d_2 > c_2$, sample is rejected.

Que 4.13. Write short note on sequential sampling plan.

Answer

1. The sequential-sampling plan is refinement of the double sampling plan, in which we randomly selects items from the lot and inspects them one by one.

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2. Each time an item is inspected, a decision is made to (1) reject the lot, (2) accept the lot, or (3) continue sampling, based on the cumulative results so far.
3. We count the total number of defectives against the cumulative sample size, and if the number of defectives is less than a certain acceptance number (c_1), the lot is accepted.
4. If the number is greater than another acceptance number (c_2), the lot is rejected.
5. If the number is somewhere between the two, another item is inspected.

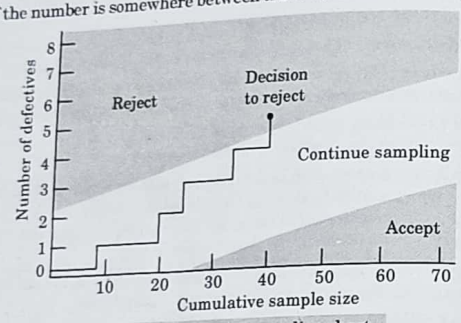

Fig. 4.13.1. Sequential sampling chart.

Fig. 4.13.1, illustrates a decision to reject a lot after examining the 40th unit. Such charts can be easily designed with the help of statistical tables that specify accept or reject cut-off values c_1 and c_2 as a function of the cumulative sample size.

Que 4.14. **What do you understand by acceptance sampling ? Explain the methods of double sampling and sequential acceptance sampling.** **AKTU 2014-15, Marks 10**

OR

What is acceptance sampling ? Describe the single, double and sequential sampling procedures. **AKTU 2016-17, 2017-18; Marks 10**

Answer

Acceptance sampling : Refer Q. 4.10, Page 4–11Y, Unit-4.

1. **Single sampling plan :** Refer Q. 4.11, Page 4–12Y, Unit-4.
2. **Double sampling plan :** Refer Q. 4.12, Page 4–12Y, Unit-4.
3. **Sequential sampling plan :** Refer Q. 4.13, Page 4–13Y, Unit-4.

PART-4

Introduction to TQM.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.15. **What is Total Quality Management ? Why is it important for engineering organisations ?** **AKTU 2013-14, Marks 10**

OR

Write short note on Total Quality Management. **AKTU 2013-14, Marks 05**

Answer

1. Total Quality Management, abbreviated as TQM is a people-oriented management system, wherein all the members of the organization, makes continuous efforts so as to maintain high work standards, in all the operations of the company.
2. Its main aim is to make a continuous increase in the customer loyalty and satisfaction, at constantly lower cost.

Phases of Total Quality Management :

Planning Phase : In this phase, the employees are required to discover the problems faced by them, during regular operations along with their root-cause. For this, a comprehensive research is done by the employees to collect the relevant data, with a view to finding solutions to their problems.

Doing Phase : At this stage, employees find out solutions to their problems, stated in the previous stage. Strategies are created and executed to cope with the problems experienced by the employees, while at work. Moreover, the evaluation of the usefulness of strategies and solutions are also done in this phase.

Checking Phase : The performance is analysed by making a comparison of before and after data, for validating the effectiveness of the processes and measuring the outcome.

Acting Phase : The outcome of the process is documented at this stage, and the employees prepare themselves to confront other challenges.

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2. Each time an item is inspected, a decision is made to (1) reject the lot, (2) accept the lot, or (3) continue sampling, based on the cumulative results so far.
3. We count the total number of defectives against the cumulative sample size, and if the number of defectives is less than a certain acceptance number (c_1), the lot is accepted.
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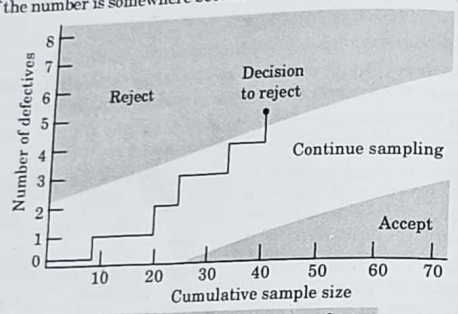

Fig. 4.13.1. Sequential sampling chart.

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OR

What is acceptance sampling ? Describe the single, double and sequential sampling procedures. **AKTU 2016-17, 2017-18; Marks 10**

Answer

Acceptance sampling : Refer Q. 4.10, Page 4–11Y, Unit-4.

1. **Single sampling plan :** Refer Q. 4.11, Page 4–12Y, Unit-4.
2. **Double sampling plan :** Refer Q. 4.12, Page 4–12Y, Unit-4.
3. **Sequential sampling plan :** Refer Q. 4.13, Page 4–13Y, Unit-4.

PART-4

Introduction to TQM.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.15. **What is Total Quality Management ? Why is it important for engineering organisations ?** **AKTU 2013-14, Marks 10**

OR

Write short note on Total Quality Management. **AKTU 2013-14, Marks 05**

Answer

1. Total Quality Management, abbreviated as TQM is a people-oriented management system, wherein all the members of the organization, makes continuous efforts so as to maintain high work standards, in all the operations of the company.
2. Its main aim is to make a continuous increase in the customer loyalty and satisfaction, at constantly lower cost.

Phases of Total Quality Management :

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Acting Phase : The outcome of the process is documented at this stage, and the employees prepare themselves to confront other challenges.

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Principles of Total Quality Management : There are a few principles, which guide the success of total quality management, described as under :

1. Long-term management commitment to quality
2. Customer-focused
3. Preventing, and not detecting defects
4. Universal quality responsibility
5. Measurement of quality
6. Process-centered
7. Constant refinement and learning
8. Statistical thinking
9. Value improvement
10. Synergy of teams
11. Training

Benefits of Total Quality Management :

1. This will increase the awareness of quality culture within the organization.
2. A special emphasis on team work will be achieved.
3. TQM will lead to a commitment towards continuous improvement.

Que 4.16. Explain total quality management. Discuss various statistical tools used for quality control and improvement.

AKTU 2017-18, Marks 10

Answer

A. **TQM :** Refer Q. 4.15, Page 4–15Y, Unit-4.

B. There are several types of tools that can be used for quality control and improvement. However, there are seven management tools for quality control that are the most common.

1. **Stratification :** A technique that separates data gathered from a variety of sources so that patterns can be seen (some lists replace "stratification" with "flowchart" or "run chart").
2. **Check sheet :** A structured, prepared form for collecting and analyzing data; a generic tool that can be adapted for a wide variety of purposes.
3. **Cause-and-effect diagram (Ishikawa or fishbone chart) :** Identifies many possible causes for an effect or problem and sorts ideas into useful categories.
4. **Pareto chart :** Shows on a bar graph which factors are more significant.
5. **Control charts :** Graphs used to study how a process changes over time. Comparing current data to historical control limits leads to conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation).

6. **Histogram :** The most commonly used graph for showing frequency distributions, or how often each different value in a set of data occurs.
7. **Scatter diagram :** Graphs pairs of numerical data, one variable on each axis, to look for a relationship.

Que 4.17. Define Quality. What is the difference between Quality and Total Quality Management ?

AKTU 2014-15, Marks 10

OR

Explain the difference between quality management and total quality management.

AKTU 2015-16, Marks 10

Answer

Definition of quality : Quality is the degree of perfectness of the object with respect to the standard.

S. No.	Total Quality Management	Quality Management
1.	TQM is managing the whole organization in an efficient manner, to achieve excellence.	Quality management is concerned with defect detection by using post production inspection procedure.
2.	TQM is managing quality through the whole process of production, including management and all the other departments.	Main focus is on the product *i.e.*, what is wrong with the product.
3.	TQM is a management technique that empowers the workforce to produce a product that meets and improves the quality objectives of the business naturally.	In quality management the extent of employee involvement is minimal.
4.	Total quality management is focused on the organization/ business to adopt the culture of quality.	Quality management is focused on product/service quality and the means to achieve it.
5.	It takes three to five years to install a total quality management system.	It takes a real short time to install a quality management system.

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5 UNIT

Project Management

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PART-1

Project Management.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.1. **Define project management. Why it is important ?**

Answer

A. **Project Management :** It is the practice of initiating, planning, executing, controlling and closing the work of a team to achieve specific goals and meet specific success criteria at the specified time.

B. **Importance of Project Management :**

1. Project management is important because it ensures proper expectations are set around what can be delivered, by when, and for how much.
2. Effective project managers should be able to negotiate reasonable and achievable deadlines and milestones across stakeholders, teams, and management.
3. The importance of project management is an important topic because all organisations, be it small or large at one time or other are involved in implementing new undertakings.
4. These undertakings may be diverse such as the development of a new product or service; the establishment of a new production line in a manufacturing enterprise; a public relations promotion campaign; or a major building programme.

Que 5.2. **What are the various stages in the total life cycle of a project ? Explain with suitable diagram.**

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Answer

The project management context contains two elements :

A. **Project Life Cycle :**

1. The sequence of phases through which the project will evolve is known as project life cycle.
2. In simple words, a project life cycle is basically defined by its phases, according to which a project swims through and finally reaches to handover stage.
3. The phases in project life cycle are as :

a. **Phase 1 : Start up / Conceptualization of Project :**

It contains the following keywords :

i. Purpose,
ii. Strategic fit,
iii. Objective,
iv. Scope,
v. Terms of reference, and
vi. Draft schedule.

b. **Phase 2 : Planning of Project Activities and Resources :**

It contains following keywords :

i. Scope,
ii. Select team members,
iii. Plan delivery,
iv. Quality plan,
v. Baseline schedule,
vi. Baseline budget,
vii. Risk analysis,
viii. Issue register,
ix. Approvals, and
x. Communication plan.

c. **Phase 3 : Execution of Project :**

It contains following keywords :

i. Production of key deliverables,
ii. Monitor / control,
iii. Quality management,
iv. Cost management,
v. Risk management,

vi. Issue resolution, and
vii. Change control reporting.

d. **Phase 4 : Termination of Project :**

It contains following keywords :

i. Contract close out,
ii. Team feedback,
iii. Recommendation for further action, and
iv. Post implementation review.

4. The level of activity required during project life cycle will vary with time.
5. This can be illustrated by project life cycle curve as shown in Fig. 5.2.1.

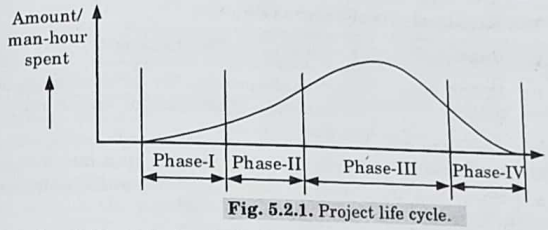

Fig. 5.2.1. Project life cycle.

6. The level of activity is relatively low during the early phases, increases through the implementation stage where the major volume of work is done.
7. This pattern is shown as a group of cumulative expenditure against time in Fig. 5.2.2.

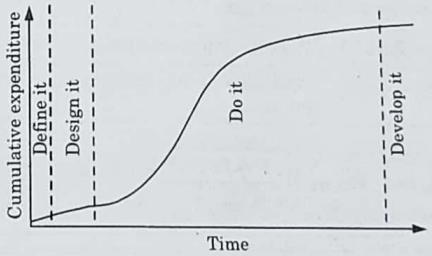

Fig. 5.2.2. Graph of cumulative expenditure against time.

Que 5.3. **Describe the phases and requirement of various phases of project management.**

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Answer

A. Phases of Project Management :

1. The process of project management may be divided into six broad phases as shown in Fig 5.3.1.

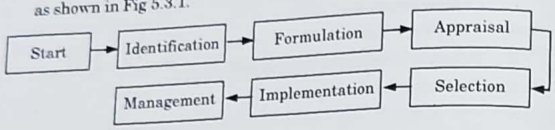

Fig. 5.3.1. Phases of project management.

B. The Requirements of Various Phases :

S. No.	Phase	Requirements
1.	Identification	Selection of a project after sound scanning of the environment of investment opportunity and potential returns.
2.	Formulation	Translation of the project idea into a concrete project by analysis of important parameters. Preparation of feasibility report.
3.	Appraisal	Analysis and evaluation of market, technology, financial and economic parameters break-even analysis, rate of return and profitability assessment.
4.	Selection	Project selection based on objectives and constraints.
5.	Implementation	Project completion within allotted resources.
6.	Management	Operation of enterprise with maximization of returns.

PART-2

Project Network Analysis.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.4. **Define project network analysis in brief. Also, give its importance and objectives.**

Answer

A. Project Network Analysis :

1. The network analysis methods are related to the concept of network diagram, which is a view of the project as a diagram which expresses various links between the project activities.
2. The network diagrams and network analysis methods are based on the graph theory.

B. Importance of Network Analysis / Network Technique :

1. A project has divided into many small activities and these activities can be analyzed with the help of network technique to achieve the objectives of the project.
2. Network analysis helps management to minimize the total cost and total maintenance time.

C. Objectives of Network Analysis : Followings are the main objectives of network analysis :

i. **To Minimize Idle Resources :** Allowing for large variations in the use of limited resources may disturb the whole plan. Thus, efforts should be made to avoid the cost incurred due to idle resources.

ii. **To Minimize the Total Project Cost :** The total cost of the project can be calculated and then efforts can be made to minimize the total cost by calculating the cost of delay in the completion of an activity of the project in addition to the cost of the resources required to carry out the jobs at various speeds (*i.e.*, normal or over time rates of pay).

iii. **To Trade Off between Time and Cost of Project :** The idea of trade off between time and cost of project is centered on the idea that duration of same activities can be cut down if additional resources are allocated to them.

iv. **To Minimize Production Delays, Interruption and Conflict :** This is achieved by identifying all activities involved in the project, their precedence constraints, etc.

Que 5.5. **Discuss network along with advantages and disadvantages of network analysis.**

Answer

A. Network : A network signifies a number of people and resources, and the relationships between them, that are able to capture, transfer and create knowledge for the purpose of creating value.

B. Advantages of Network Analysis :

1. A logical planning of whole project is ensured.
2. The critical activities are identified and rate of progress of the project can be controlled.

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3. Helps management to plan alternative ways of optimization of direct and indirect costs to achieve minimum total cost.

C. Disadvantages of Network Analysis :

1. Limited to evaluation interactions.
2. Requires multiple software UCINET for analysis, Netdraw for network maps.

PART-3

CPM, PERT.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.6. Discuss PERT and CPM with their advantages and disadvantages.

Answer

A. PERT:

1. The main object in the analysis through PERT is to find out the completion for a particular event within specified date. If yes, what are the chances of completing the job ?
2. The PERT approach takes uncertainties into the account.
3. In this approach, three different times are associated with each activity : The optimistic time, the pessimistic time, and the most likely time.
4. These three times provide a measure of uncertainty associated with that activity.

i. Advantages of PERT :

1. It is a very good management tool to plan the best use of resources possible to achieve a given goal within overall time and cost limits.
2. It helps the management to handle the uncertainties involved in project execution programs as no standard time data are available.
3. It helps to take right action, at the right point and at the right time.

ii. Disadvantages of PERT :

1. The activities involved in a project are non-repetitive. Therefore, it is very difficult to estimate time of completion of activities which are new.
2. The resources required at various stages of the project are not considered.

3. Frequent updating and revision of PERT calculations are needed for active control of the project. This can be quite costly.

B. Critical Path Method (CPM) :

1. CPM uses networking principle for planning and controlling projects.
2. It is very widely used only next to PERT model :
   i. CPM uses two time-cost estimates for each activity, one for normal situation and the other for crash situation.
   ii. The estimation of time in CPM does not use any statistical analysis.
   iii. It works on the assumption that each activity will takes a precise known time.

i. Advantages of CPM :

1. It is used to schedule all types of large and small projects.
2. It helps in fixing the time schedule.
3. It is a management tool for easy control of project.
4. It helps in better and detailed planning.

ii. Disadvantages of CPM :

1. Statistical analysis is not used to estimate precise time.
2. It works on the assumption that each activity of the project will take a precise time for completion which may not be true in actual practice.
3. It is a static planning model and not a dynamic controlling technique. Whenever changes have to be incorporated in the network, whole of evaluation work of the project has to be repeated.

Que 5.7. Define critical path and its importance in network analysis.

Answer

A. Critical Path :

1. The sequence of critical activities in a network is called critical path.
2. The critical path is longest path in the network from the starting event to ending event and defines the minimum time required to complete the project.
3. The critical path is denoted by darker or double lines to distinguish it from the other non-critical paths.
4. The critical path has two principle features :
   a. First, if the project has to be shortened some of the activities on that path must be shortened.
   b. The variation in actual performance from the expected activity duration time will be completely reflected in one to one fashion in the anticipated completion of the whole project.

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B. Importance of Critical Path in Network Analysis :

1. Analysis and breakdown the project in terms of specific activities and / or events.
2. Determine the independence and sequence of specific activities and prepare a network.
3. Assign estimates of time, cost or both to all the activities of the network.
4. Identify the longest or critical path through the network.
5. Monitor, evaluate and control the progress of the project by replanting, rescheduling and reassignment of resources.
6. The critical path of a project can change during the course of the project, due to uncertainties in completing the activities as per the original plan. For this purpose the network needs to be updated from time to time from the start of the project till the end of the project.

Que 5.8. **Differentiate between PERT and CPM.**

Answer

S. No.	PERT	CPM
1.	It originated from military situation.	It originated from industrial situation.
2.	The approach is event oriented.	The system is activity oriented.
3.	There is allowance for uncertainty.	There is no such allowance.
4.	There are three time estimations.	There is only one time estimation.
5.	There is emphasis on time.	There is emphasis on cost.
6.	It is a probabilistic model with uncertainty in activity duration.	It is deterministic model on well known single time based on past experience.
7.	There is no difference between critical and non-critical activities.	The critical activities are marked.
8.	Suitable for projects requiring high precision in time estimates. Examples : Defence projects.	Suitable for projects requiring reasonable precision in time estimates. Examples : Civil construction projects, industrial expansion schemes.

Que 5.9. **What are the time estimations used in PERT ?**

Answer

In PERT, we use three time estimations for each activity as given below :

A. Optimistic Time (t_o) :

1. It is the shortest possible time required for the completion of an activity under ideal conditions.
2. In calculating optimistic time, it is assumed that everything is favourable in completing the activity in shortest possible time.

B. Pessimistic Time (t_p) :

1. The maximum possible time, the activity will take under worst condition.
2. For pessimistic time, it is assumed that everything is unfavourable for completing the activity in time and thus activity will take maximum time to occur.

C. Most Likely Time (t_m) :

1. The most likely time is the time an activity will take if executed under normal conditions.
2. This time lies between optimistic and pessimistic time.
3. For calculating, most likely time, it is assumed that conditions are neither favourable nor unfavourable but normal.
4. On the basis of above three time estimations, expected time (t_e) or average time of completion of an activity can be calculated as

$$t_e = \frac{t_o + 4t_m + t_p}{6}$$

Que 5.10. **Explain the terms : Total float, free float, independent float, slack, critical event, critical activities.**

Answer

A. Total Float :

1. It may be defined as "the amount of time by which completion of an activity could be delayed beyond the earliest expected completion time without affecting overall project duration time."
2. Total Float, $TF_{ij} = LS_{ij} - ES_{ij} = (L_j - t_{ij}) - E_i$

$$= L_j - E_i - t_{ij}$$

Where, E_i = Earliest expected completion time of tail event.

= Earliest starting time for an activity (i, j).

and L_j = Latest allowable completion time of head event.

= Latest finish time of an activity (i, j).

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3. Obviously, the total float of critical activities is always zero.

B. Free Float :

1. This is concerned with commencement of subsequent activity.
2. It may be defined as "the time by which the completion of an activity can be delayed beyond the earliest finish time without affecting the earliest start of a subsequent activity".
3. Using notations given earlier, the free float for activity (i, j) can be expressed as follows :

$$FF_{ij} = \text{Earliest event time for subsequent activity } j - \text{Earliest event time for activity } i - \text{Activity time for } (i, j)$$

$$= (E_j - E_i) - t_{ij}$$

$$= E_j - (E_i + t_{ij})$$

$$= \text{Min } \{ES_{ij}\} - EF_{ij}$$

C. Independent Float :

1. This is concerned with prior and subsequent activities.
2. It may be defined as "the amount of time by which the start of an activity can be delayed without affecting the earliest start time of any immediately successor activities, assuming that the preceding activity has finished at its latest finish time".
3. Independent float of an activity (i, j) is given by :

Independent Float $(IF_{ij}) = (E_j - L_i) - t_{ij}$

D. Slack of an Event :

1. The basic difference between slack and float times is that slack is used for events only whereas float is applied for an activity.
2. For any given event, the event slack is defined as the difference between the latest event and earliest event times. For a given activity (i, j) let us define :

Head slack $(HS) = L_j - E_j$ and

Tail slack $(TS) = L_i - E_i$

3. We can represent all the floats defined earlier, in terms of head and tail slack as shown below :

Total float $= L_j - E_i - t_{ij}$

Free float = Total float – Head slack

$= L_j - E_i - t_{ij} - (L_j - E_j)$

4. Independent float = Free float – Tail slack

$= E_j - E_i - t_{ij} - (L_i - E_i)$

E. Critical Event :

1. The slack of an event is the difference between the latest and earliest event times or slack $(i) = L_i - E_i$.

2. The events with zero slack time are known as critical events.

F. Critical Activities :

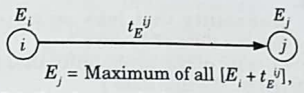
1. The difference between the least start time and earliest start time of an activity will indicate the amount of time by which the activity can be delayed without affecting the total project duration.
2. This difference is usually called the total float. Activities with zero total float are known as critical activities.

Que 5.11. Explain the following terms in PERT / CPM.

i. Earliest time, ii. Latest time,
iii. Total activity time, iv. Event slack, and
v. Critical path.

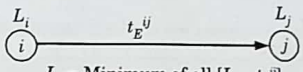
Answer

i. **Earliest Time :** It is the time at which an event is accepted to be completed at the earliest.



E_j = Maximum of all $[E_i + t_E^{ij}]$,

ii. **Latest Time :** It is the time at which a particular event must be completed at the latest.

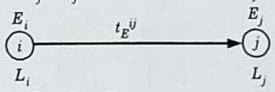


L_i = Minimum of all $[L_j - t_E^{ij}]$,

iii. **Total Activity Time :** It is defined as the time at which the project completed all its activities.

iv. **Event Slack :** It is define as the difference between latest event and earliest event times. Mathematically, for a given activity (i, j),

Head event slack $= L_j - E_j$, Tail event slack $= L_i - E_i$.



$S_i = L_i - E_i$

$S_j = L_j - E_j$

v. **Critical Path :** Refer Q. 5.7, Page 5–8Y, Unit-5.

Que 5.12. The following table lists the jobs of a network along with their time estimates :

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Jobs	Duration in days		Pessimistic
	Optimistic	Most likely	
01 to 02	3	6	15
02 to 03	6	12	30
02 to 04	5	11	17
03 to 04	3	9	27
03 to 05	1	4	7
05 to 06	2	5	8
03 to 06	4	19	28
04 to 06	2	5	14

i. **Draw the network and calculate the length and variance of critical path.**

ii. **What is the probability that jobs on critical path will be completed by the due date of 40 days ?**

iii. **What is your estimate of the probability that the entire project will be completed by the due date ?**

Answer

1. The various time estimates are shown in the following table :

Activity	t_o	t_m	t_p	$t_e = \frac{t_o + t_p + 4t_m}{6}$	$\sigma^2 = \left(\frac{t_p - t_o}{6}\right)^2$
1 – 2	3	6	15	7	4
2 – 3	6	12	30	14	16
2 – 4	5	11	17	11	4
3 – 4	3	9	27	11	16
3 – 5	1	4	7	4	1
5 – 6	2	5	8	5	1
3 – 6	4	19	28	18	16
4 – 6	2	5	14	6	4

2. The network is shown in Fig. 5.12.1. The earliest and latest time of each have been computed and indicated on the network.

3. With the help of latest times, the longest path $1 \rightarrow 2 \rightarrow 3 \rightarrow 6$ can be traced.
Length of critical path = 7 + 14 + 18 = 39 days.

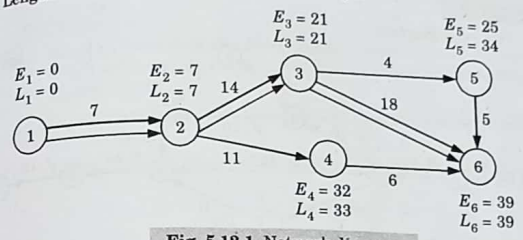

Fig. 5.12.1. Network diagram.

4. Standard deviation for critical path,

$$\sigma = \sqrt{4 + 16 + 16} = \sqrt{36} = 6 \text{ days}$$

5. The probability to complete the project before due date

$$Z = \frac{\text{Due date} - \text{Expected date}}{\sqrt{\sigma^2}}$$

$$= \frac{40 - 39}{\sqrt{36}} = 0.5662 = 56.62\ \%$$

6. Standard deviation of whole project

$$\sigma = \sqrt{4 + 16 + 4 + 16 + 1 + 1 + 16 + 4} = \sqrt{62} \text{ days}$$

7. The probability that the entire project will be completed by the due date

$$Z = \frac{40 - 39}{\sqrt{62}} = 0.127$$

$$= 0.5505 = 55.05\%$$

Que 5.13. **The following table shows the sequence of different activities performed during a project :**

Task	Immediate predecessors	Time (days)
A	–	14
B	A	22
C	B	10
D	B	16
E	B	12
F	C	10
G	C	6
H	F, G	8
I	D, E, H	24
J	I	16

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i. **Draw a network diagram of activities for the project.**
ii. **Indentify the critical path. What is its length ?**

Answer

i. Network diagram :

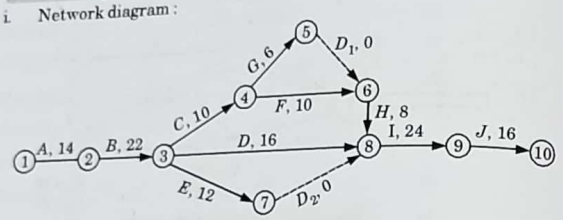

Fig. 5.13.1.

where, D_1 and D_2 are the dummy activities.

ii. Path (1 – 2 – 3 – 4 – 5 – 6 – 8 – 9 – 10) duration

$= 14 + 22 + 10 + 6 + 0 + 8 + 24 + 16$

$= 100$ days

Path (1 – 2 – 3 – 4 – 6 – 8 – 9 – 10) duration

$= 14 + 22 + 10 + 10 + 8 + 24 + 16$

$= 104$ days

Path (1 – 2 – 3 – 8 – 9 – 10) duration

$= 14 + 22 + 16 + 24 + 16$

$= 92$ days

Path (1 – 2 – 3 – 7 – 8 – 9 – 10) duration

$= 14 + 22 + 12 + 0 + 24 + 16$

$= 88$ days

Since, path (1 – 2 – 3 – 4 – 6 – 8 – 9 – 10) has maximum duration.

Hence, this is the critical path and duration = 104 days.

PART-4

Project Crashing.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.14. **What is the need of crashing the network ? What is the direct and indirect cost associated with network diagram ?**

Answer

A. **Need of Crashing the Network :** In order to find optimum duration which will result in minimum cost, we need to crash the network.

B. **Direct Cost :**

1. Direct cost decreases with increase of time and increases with crashing the activity.
2. It includes equipment, labour, material cost etc.

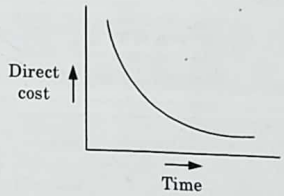

Fig. 5.14.1.

3. Slope of the direct cost is defined as

$$\text{Cost slope} = \frac{\Delta C}{\Delta T} = \frac{C_c - C_n}{t_n - t_c}$$

Where, t_n = Normal time of completion of an activity,
t_c = Minimum time of completion of an activity or crash time,
C_c = Crash cost (direct cost needed to complete the activity in t_c crash time), and
C_n = Cost corresponding to time t_n.

B. **Indirect Cost :**

1. It increases with increase of time and decrease with crashing.
2. Indirect cost includes overhead loss and other losses.
3. It also includes the expenditure of office, supervision cost, rental cost and other penalties etc.

Que 5.15. **Describe in detail about crashing of operation.**

Answer

In crashing following steps should be followed one by one :

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Step 1 : Find critical path and normal project duration.

Step 2 : Find cost slope of each activity.

Step 3 : Select the activity with minimum cost slope and crash it first. While crashing, it should be remembered that it should not be crash beyond limit such that other paths become critical.

Step 4 : Select next higher cost slope with critical activity. While doing so, there may be one or more than one critical path. Then, one activity from each path should be crashed simultaneously by same amount of duration.

Step 5 : Repeat the above steps unless total minimum cost and optimum duration is obtained.

PART-5

Resource Levelling.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.16. **Write short note on resource leveling.**

Answer

A. Resource Levelling :

1. There are various activities in a project demanding varying levels of resources. The demand on certain specified resources should not go beyond the prescribed level. This operation of resources allocation is called resource levelling.
2. In the process of resource levelling, whenever the availability of resource becomes less than its maximum requirement, the only alternative it to delay the activity having larger float.
3. In case, two or more activities require the same amount of resources, the activity with minimum duration is chosen for resource allocation. Resource levelling is done if the restriction is on the availability of resources.

B. Steps Involved in Resource Levelling :

1. Lower the peak requirement of the resources by staggering the resource input on non-critical activities. If necessary, sub-critical and critical activities can also be tackled to bring peak demands below the specified levels. Thus, completion of work may be delayed due to resource constraints.

2. Either increase the duration of critical activities or place some of the concurrent activities in series to reduce the peak demands of the scarce resources. This will increase the duration of the project.
3. Rearrange the activities in descending order of the magnitude of the positive float, as resources can be conveniently diverted from the activities which possess large amount of float.

Que 5.17. **Write the advantages and disadvantages of resource levelling.**

Answer

A. Advantages of Resource Levelling :

1. When resources are used on a more constant basis, they require less management.
2. It may enable project managers to use a just-in-time inventory type of policy for using subcontractors or other expensive resources.
3. It results in fewer problems for project personnel and accounting department.
4. It often improves morale.

B. Disadvantages of Resource Levelling :

1. Tends to cause a buildup of resources towards the end of the project.
2. Increasing the number of critical activities.

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