# Class Test Solution (CPM-PERT) 24-02-2019

## Answer key

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1. | (c) | 16. | (c) | 31. | (c) | 46. | (d) | 61. | (b) |
| 2. | (b) | 17. | (b) | 32. | (c) | 47. | (d) | 62. | (c) |
| 3. | (b) | 18. | (d) | 33. | (c) | 48. | (c) | 63. | (c) |
| 4. | (b) | 19. | (c) | 34. | (a) | 49. | (a) | 64. | (d) |
| 5. | (b) | 20. | (c) | 35. | (a) | 50. | (a) | 65. | (d) |
| 6. | (c) | 21. | (d) | 36. | (a) | 51. | (a) | 66. | (c) |
| 7. | (b) | 22. | (a) | 37. | (c) | 52. | (d) | 67. | (d) |
| 8. | (b) | 23. | (c) | 38. | (c) | 53. | (d) | 68. | (b) |
| 9. | (a) | 24. | (c) | 39. | (c) | 54. | (c) | 69. | (c) |
| 10. | (d) | 25. | (c) | 40. | (d) | 55. | (d) | 70. | (c) |
| 11. | (a) | 26. | (b) | 41. | (d) | 56. | (c) | 71. | (d) |
| 12. | (d) | 27. | (c) | 42. | (a) | 57. | (d) | 72. | (c) |
| 13. | (b) | 28. | (b) | 43. | (c) | 58. | (d) | 73. | (a) |
| 14. | (b) | 29. | (b) | 44. | (c) | 59. | (d) | 74. | (a) |
| 15. | (a) | 30. | (a) | 45. | (d) | 60. | (c) | 75. | (d) |

**1. (c)**

The main purpose of monitoring is to rerail the project with minimum time over-run. During monitoring information is analyzed and the project plan is brought upto date with the necessary changes required to keep the project as per schedule.

**2.(b)** Limitations of bar charts

(i) They can be used only for small projects.

(ii) It does not show the interdependencies between the various activities in the project. This is a serious limitation of the bar chart

(iii) The progress of the work in the project can not be monitored scientifically.

(iv) Delays in the work cannot be detected

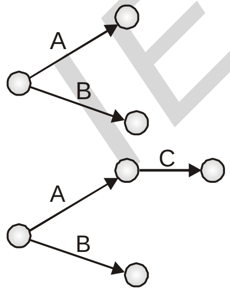
(v) It does not indicate the critical activities of the project

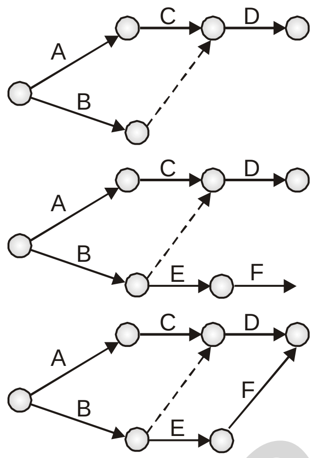
(vi) It gives some idea about the physical progress of the project, but the financial aspect involved is not known.

(vii) Bar chart cannot be used as a controlling device by the project manager to take any timely action.

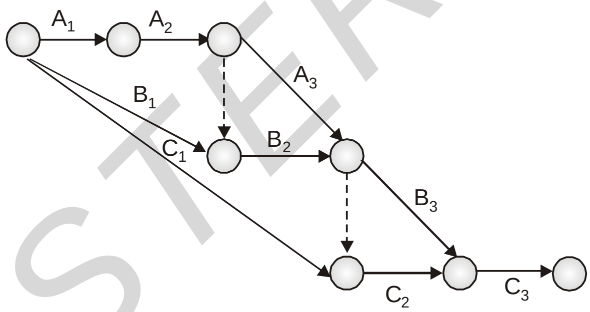
**3. (b)** Work break down structure is a device that identifies the functional elements of a project and their inter-relationship. It is a process of breaking the project into easily identifiable major systems, their sub-systems and discrete activities is called the work breakdown structure. It follows top to down approach.

**4. (b)**



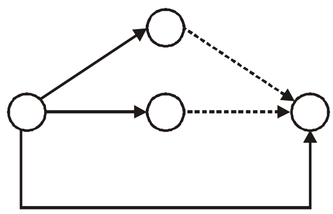




**5.(b)**




Optimum no. of dummy arrow = 2

**6. (c)**



**7. (b)**

Total cycle time = 5 + 30 + 3 + 14 + 23 = 75 min

$= \frac{75}{60} = 1.25 \text{ hr}$

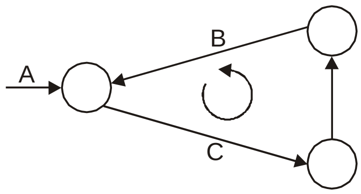
Output of TM per hr = $\frac{6}{1.25} = 4.8 \text{ m}^3/\text{hr}$

No. of TM required = $\frac{60}{4.8} = 12.5 \approx 13$.

**8. (b)**

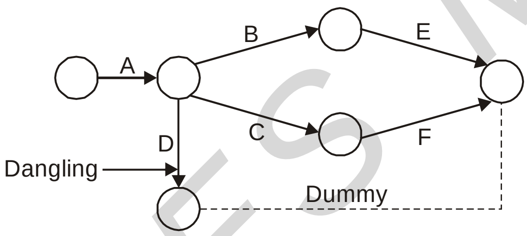
**Interface event :** An interface event is a common event which shows the linkages between activities performed by more than one agencies. It may also denote linkage between activities belonging to two or more sub-groups or two or more projects.

**9. (a)** **Looping :** If an activity were represented as going back in time, a closed loop would occur.




A closed loop would produce an endless cycle in computer programmes without a built-in routine for detection or identification of the cycle. This situation can be avoided by checking the precedence relationship of the activities and by numbering them in a logical order. Thus, one property of a correctly constructed network diagram is that it is non-cyclic.

**Dangling :** No activity should end without being joined to the end event. If it is not so, a dummy activity is introduced in order to maintain the continuity of the system. Such end-events other than the end of the project as a whole are called dangling events.




In the above network, activity D leads to dangling. A dummy activity is, therefore introduced to avoid this dangling.

Nodes are numbered to identify an activity uniquely. Tail node (starting point) should be lower than the head node (end point) of an activity.

Event numbering should be carried out on a sequential basis from left to right.

**10. (d)**

$$\sigma_{individual} = \frac{10-4}{6} = 1$$

$$X_1 = \sigma_{complete\,project}$$

$$= \sqrt{1^2+1^2+1^2+1^2+1^2+1^2}$$

$$X_1 = \sqrt{6}$$

When activities are clubbed

$$\sigma_{each} = \sqrt{1^2+1^2} = \sqrt{2}$$

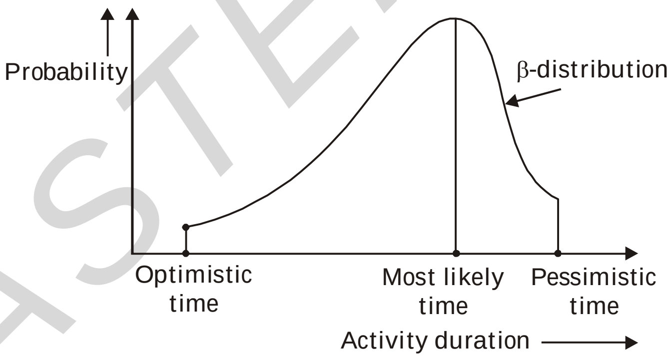
$$X_2 = \sigma_{project}$$

$$= \sqrt{(\sqrt{2})^2+(\sqrt{2})^2+(\sqrt{2})^2}$$

$$X_2 = \sqrt{6}$$

**11. (a)**

Each activity in a PERT network is assumed to follow $\beta$-distribution.




**12. (d)** Given that the two events K and L can cause delay in the activity when occurring either each independently or both together but the two events are not independent of each other.

Hence, probability of occurrence of delay is equal to the probability of occurrence of event K (or L) given that the event L (Or K) has happened i.e. P(K/L) or P(L/K)

Since, $P(K \cup L) = P(K) + P(L) - P(K/L).P(L)$

or, $P(K \cup L) = P(K) + P(L) - P(L/K).P(K)$

Since, $P(L) = P(K)$ and

$P(L/K) = P(K/L)$

Given, $P(K \cup L) = 0.75$

and, $P(K) = P(L) = 0.45$

$$\Rightarrow \quad P(K/L) = \frac{-P(K \cup L)+P(K)+P(L)}{P(L)}$$

$$\therefore \quad P(K/L) = \frac{0.45+0.45-0.75}{0.45}$$

$$= \frac{2\times 0.45-0.75}{0.45}$$

**13. (b)**

**14. (b)** $t_e = \frac{t_0 + 4t_m + t_p}{6} = \frac{8+4\times 9+13}{6} = 9.5$

$$\sigma_t^2 = \frac{(t_p - t_0)^2}{36} = \frac{(13-8)^2}{36} = \frac{25}{36}$$

**15. (a)** Silent points about PERT analysis

(i) Uses Probabilistic approach which absorbs uncertainties in estimation of time.

(ii) It is used for projects where there is insufficient or no background information i.e. of non-repetitive type eg. R & D type of projects.

(iii) As there is not much information available about the activities hence events are established for the planning purpose and emphasis is given to the events of the projects.

**16. (c)**

$$Z = \frac{T_s - 60}{3}$$

As,

$$\sigma^2 = 9$$

$$\sigma = 3$$

$$1.647 = \frac{T_s - 60}{3}$$

$$T_S = 64.941$$

**17. (b)** Path B is critical

$$Z = \frac{T_s - T_E}{\sigma} = \frac{42-45}{12} = -0.25$$

For $Z = 0.25$ $F(z) = 0.598$

$\therefore$ For $Z = -0.2$, $F(z) = 1 - 0.598$

$F(z) = 0.402$

**18. (d)**

**19. (c)**

**20.(c)** Variance is commonly used in statistics as measure of variability of the distribution. Greater the variable, greater will be uncertainy. On the other hand, smaller variance, the more reliable time of completion and more confidence in ability to complete the project on time.

Proposal A has mean time of completion 150 days with standard deviation of 15. This implies that the proposal A will be completed in 150 days with 50% probability but uncertainty involved is more as compared to that of the proposal B.

Proposal B has mean time of completion 160 days with standard deviation of 12. This implies that the proposal B will be completed in 160 days with 50% probability but with lesser uncertainly.

The proposal B takes to complete tha project in 160 days which is more than that of A. Due to this indirect cost involved in proposal B will be more than that of A but direct cost involved will be lesser than that of the project A.

Even if the proposal A is completed in 160 days (due to more uncertainly involved), the probability of completion of project A will be more than 50%

Thus proposal A is preferred to B

**21.(d)** Total float is the time span by which the starting (or finishing) of an activity can be delayed without delaying the completion of the project.

Consider an activity i-j. The time duration available for this activity is equal to the difference between its earliest start time ($T_E^i$) and the latest finish time ($T_L^j$):

\ Max. time available= $T_L^j - T_E^i$

Activity time required= $t^{ij}$

\Total float ($F_T$) = max available time available – time required

**22. (a)**

**23. (c)** **Activity:** It is a resource consuming element of a project.

**Event:** It is a instant of time or state at which some specified milestone is achieved in the project.

**Dummy:** It is a special type of activity which does not consumes any resource.

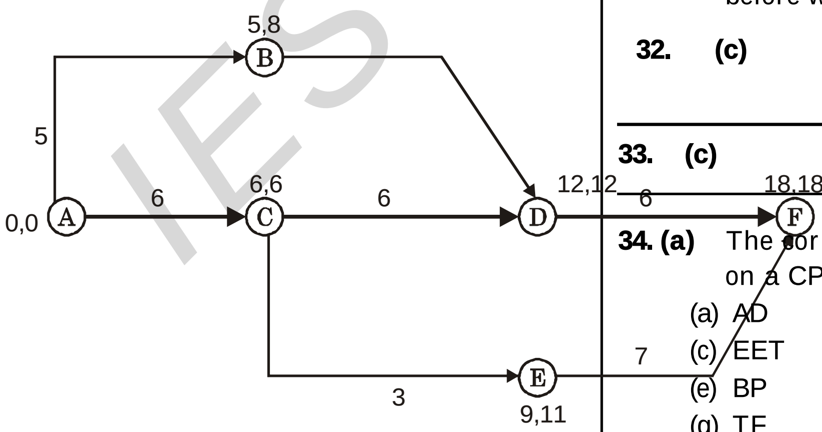
**Float:** It is the time by which starting or finishing of an activity can be delayed without affecting the project completion time.

**24. (c)** Total float is the difference between time required available time and actual time required for the completion of the activity. Maximum available time we get when activity starts at EST and finishes by LFT. Therefore it affects preceeding and succeeding activities.

Free float is the amount of time by which an activity can be delayed without affecting the EST of succeeding activity. Hence it only affects the preceding activity.

Independent float is the amount of time by which an activity can be delayed when all the preceding activities are completed as late as possible and all succeeding activities starts as early as possible. Hence it affects only concerned activity.

**25. (c)**



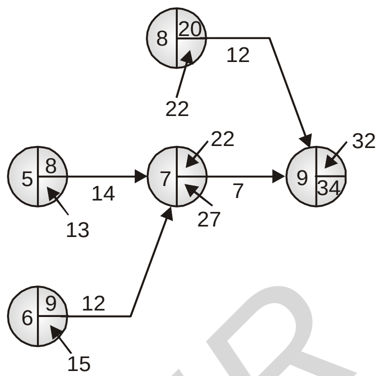

$F_{T\,(AB)} = 3$

$F_{T\,(CE)} = 2$

$F_{F(EF)} = 2$

**26. (b)**

**27. (c)**




For activity 6–7

$F_T$ = LST – EST = 15–9 = 6 unit

$F_F = F_T - S_j$ = 6 – 5 = 1 unit

**28. (b)** Precedence networks and decision CPM networks are deterministic in nature.

**29. (b)** At present, A-O-A seems to be the most popular method and it was the first method to be introduced, developed and computeriesed. It is also easier to associate with time flow of activities.

**30. (a)**

**31. (c)** Critical path defines the longest duration needed to complete the project and it also defines the shortest permissible duration before which project can not be completed.

**32. (c)**

**33. (c)**

**34. (a)** The correct sequence of time computation on a CPM network will be as below

| | |
|---|---|
| (a) AD | (b) FP |
| (c) EET | (d) PD |
| (e) BP | (f) LET |
| (g) TF | |

**35. (a)**

**36. (a)** Max day in which it can be completed with min cost

= 2000 + 2500 + 800 (10 + 8 + 12 days)

= 5300 Rs (30 days)

To reduce total no. of days by one, increment of cost of

Activity A = 2200 – 2000 = 200

Activity B = 2800 – 2500 = 300

Activity C = 900 – 800 = 100

Since

Min increment is in C $\Rightarrow$ total cost for 29 days = 5300 + 100 = 5400

Again for reducing total days by one, increment in cost of activity C is min.(1000 – 900 = 100)

Total cost for 28 days 5400 + 100 = 5500 Rs

**37. (c)** Direct cost when project duration = 8 + 10 = 18 days

D.C = 12 + 15 = 27 units

Crashing of activity A by 1 day

P.D = 17days.

D.C = 27 + 2 = 29

Crashing of activity B by 1 day

P.D = 16 days

D.C = 29+2 = 31 units

Crashing of activity B by 1 day

P.D = 15 days

D.C = 31 + 2 = 33 units

Crashing activity B by 1 day

P.D = 14 days

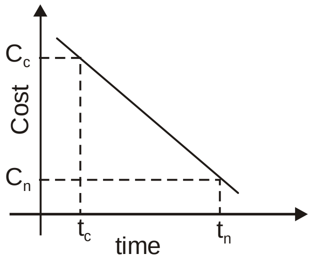
D.C = 33 + 2 = 35 units

Crashing activity A by 1 day

P.D = 13 days

D.C = 35 + 3 = 38 units

**38. (c)** Cost Slope = $\frac{C_C - C_n}{t_n - t_c}$




**39. (c)** The S-curve is a powerful project management tool. S-curve a display of cumulative costs, labour hours or other quantities plotted against time. The name derives from the S-like shape of the curve, flatter at the beginning and end and steeper in the middle which is typical of most projects. The beginning represents a slow, but accelerating start while the end represents a deceleration as the work runsout.

There are a viariety of S-curves that are applicable to project management applicators, including

- **Man hours versus time S-curve**
- **Costs verses time S-curve**
- **Baseline S-curve**
- **Actual S-curve**
- **Target S-curve**
- **Value and percentage S-curve**

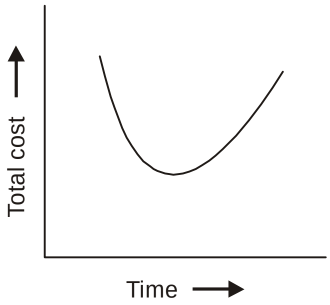
**Cost Verses Time Curve**

The cost versus Time S-curve is appropriate for projects that contain labour and non-labour (e.g. material supply/hire/subcontract) tasks. It shows cumulative costs expended over time for the duration of the project and may be used to assist in the calculation of the project's cash flow, and cost to complete.

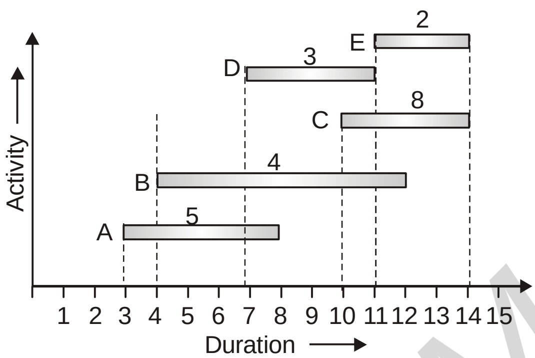
**U Shaped Curve**

For any project, the direct cost of completing the project activities increases when the project duration is reduced. But the indirect costs reduce with a reduction in project duration. For various project lengths, the indirect cost is added to the direct cost and a plot of points is obtained to get a relationship between the project length and the total project cost. This U-Shaped curve is called a project cost curve.

With the help of this curve, a project manager can select the optimal project duration that will minimise the total costs. Corresponding to the optimal value of project duration, the optimal durations of all jobs, the cost of crashing, and the critical path can be determined.




**41. (d)** Calculation of resource loading per day has been done as below:




On $12^{th}$ day $\rightarrow$ resource loading = 4+8 + 2 = 14

On $14^{th}$ day $\rightarrow$ resource loading = 8 + 2 = 10

On $11^{th}$ day $\rightarrow$ resource loading = 4 + 8+ 3 = 15

On $8^{th}$ day $\rightarrow$ resource loading = 5 + 4 + 3 = 12

**42. (a)** The $15^{th}$ – $16^{th}$ week demands most resources, because four activities A, B, C, D will run in parallel in that week.

\ Resource demand = 6 + 4 + 3 + 7 = 20

| Week | Resources for Activity | | | | Total |
|---|---|---|---|---|---|
| | A | B | C | D | |
| 9 | 6 | 0 | 0 | 0 | 6 |
| 10 | 6 | 0 | 0 | 0 | 6 |
| 11 | 6 | 4 | 0 | 0 | 10 |
| 12 | 6 | 4 | 0 | 0 | 10 |
| 13 | 6 | 4 | 0 | 7 | 17 |
| 14 | 6 | 4 | 0 | 7 | 17 |
| **15** | **6** | **4** | **3** | **7** | **20** |
| ***16*** | ***6*** | ***4*** | ***3*** | ***7*** | ***20*** |
| 17 | 0 | 4 | 3 | 7 | 14 |
| 18 | 0 | 4 | 3 | 7 | 14 |
| 19 | 0 | 4 | 3 | 7 | 14 |
| 20 | 0 | 4 | 3 | 7 | 14 |
| 21 | 0 | 0 | 3 | 7 | 10 |
| 22 | 0 | 0 | 3 | 7 | 10 |
| 23 | 0 | 0 | 0 | 7 | 7 |
| 24 | 0 | 0 | 0 | 7 | 7 |

**43. (c)**

**44. (c)** The main principal of resource levelling is that maximum demand of resource requirement shall not exceed the limit of availability of resources.

To satisfy this conditions activities are rescheduled such that peak demand is reduced to below or equal to the resources constraint value and parallel resources are adjusted such that there is a least variation in their demand.

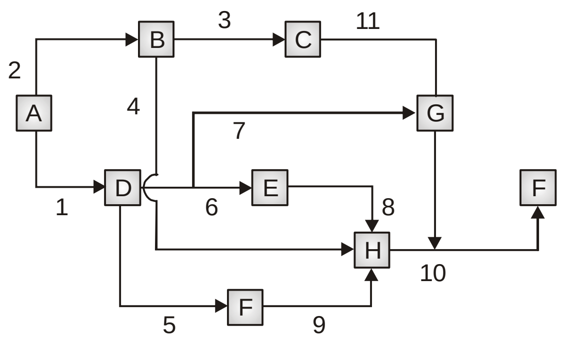
**45. (d)**

**46. (d)** **PTC trade-off :** The crashing of a network increases the direct cost because of expedition of activities. But it results in decreased project completion time. This in turn reduces indirect costs like cost of supervision, security personnel's salaries etc. Hence, there is a trade-off between the direct cost and indirect cost when a project is crashed. So, the objective is to crash the project until it becomes uneconomical.

For the activity which is selected based on the minimum cost slope, compression limit for the activity time is given by the following formula — compression limit = min [crash limit, free float]

crash limit is the difference between the current duration and the crash duration of the selected activity.

**47. (d)**




AON Network

**48. (c)** Deletable links are 1-3 and 1-6

**49. (a) Comparison of alternatives:** Construction management often involves cost comparisons between alternatives of different engineering efficiency for example, one with high initial cost and low operation and maintenance cost, compared with a low initial cost but high operating and maintenance cost. The most common basis of comparison are:

(i) The present worth amount

(ii) The annual equivalent amount

(iii) The capitalised amount

(iv) the rate of return method

**The Capitalized Amount Method**

· This method is very useful to compare long term projects.

· In this method, the annual equivalent amount obtained is assumed to extend for infinity long period and then capitalized amount is obtained as $\frac{'A'}{i}$.

| Option | A | B | C | D | E |
|---|---|---|---|---|---|
| Investment Rs. × $10^6$ | 10 | 15 | 18 | 21 | 24 |
| Capitalized benefits Rs × $10^6$ | 16 | 24 | 28 | 35 | 39 |
| Capitalised benefit-Investment (Rs × $10^6$) | 6 | 9 | 10 | 14 | 15 |

As the difference of capitalsed benefit-investment is maximum for option 'E', the most preferable option is 'E'.

**50. (a)** Present capitalized equivalent income =

$$\frac{A}{i}\times\left[\frac{i}{(1+i)^n-1}\right]$$

$$=\frac{4000}{0.08}\times 0.222=11{,}100$$

**51. (a)**

$$\text{CRF} = \frac{i(1+i)^n}{(1+i)^n-1}=\frac{0.06(1.06)^5}{(1.06)^5-1}$$

$$= 0.24$$

$$\text{S.F.F.} = \text{CRF} - i = 0.18$$

$$A_1 = 600 \text{ Unit}$$

$$A_2 = 800-\frac{100}{i}[1-n\times \text{SFF}]$$

$$= 800-\frac{100}{0.06}(1-5\times 0.18)$$

$$A_2 = 633.33$$

$$A_3 = 400+\frac{100}{i}[1-n\times \text{SFF}]$$

$$= 400+\frac{100}{0.06}(1-5\times 0.18)$$

$$A_3 = 566.67$$

$$A_4 = \text{CRF}\times\left[\frac{400}{(1+i)}+\frac{400}{(1+i)^2}+\frac{600}{(1+i)^3}+\frac{800}{(1+i)^4}+\frac{800}{(1+i)^5}\right] = 592.47$$

Order of choice $A_2 > A_1 > A_4 > A_3$

**52. (d)** Annual equivalent cost of tunnel = Pxi

=30,00,000 × 0.08

$\left(P = \frac{A}{i}\right) = 2,40,000$

Total cost of tunnel = Annual cost + operating cost annual = 240000 + 60000 = 300000

Annual cost of pipe line = P × C.R.F = 2000000 × 0.10185 = 203700

Operating cost of pipe line = 92000

Total cost of tunnel Annually = 203700 + 92000 = 295700

Relative disadvantage of tunnel = 300000 – 295700 = 4300

**53. (d)**

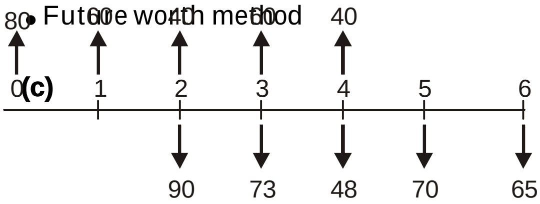
**Sol. AC analysis (Annual Cost analysis) :**

Annual cosy method of evaluating alternatives, compares the annual costs of obtaining service from different equipments.

- While comparing different alternatives, one can use any one of the following approaches to select the best alternative.

- Payback period method
- Rate of return method
- Present worth method
- Annual equivalent method
- Future worth method

**54. (c)**




Cash Flow Diagram

\The net cash flow after 4 months are complete (in terms of the money units)

= (90+73 + 48) – (80 + 60 + 40 + 60 + 40)

= –69 units

**55. (d)** Single payment compound amount factor = SPCAF

Capital Recovery Factor = $\frac{i(1+i)^n}{(1+i)^n - 1}$

For 3 years

$$CRF = \frac{0.1 \times 1.3310}{1.3310 - 1} = 0.4021$$

**56. (c)**

$$\frac{A_1}{P} = CRF = SFF + i$$

$$A_1 = P\ (SFF + i)$$

$$A_1 = 15000\ (0.1638 + 0.1)$$

$$A_1 = 3957$$

$$\frac{A_2}{S} = SFF = 0.1638$$

$$A_2 = 0.1638 \times 1000$$

$$A_2 = 163.8$$

Annualized cost = 3957 + 5000 –163.8= 8793.2

**57. (d)** $P_{avg} = \frac{P + \left(\frac{P - S}{n}\right) + S}{2} =$

$$\frac{P(n+1) + S(n-1)}{2n} = \frac{25 \times 6 + 5 \times 4}{2 \times 5} = 17$$

**58. (d)**

**59. (d)** Average annual cost of the equipment is found out in the following ways:-

**Case I:** When there is no salvage value of the equipment

$$P_{av} = \frac{p + \frac{p}{n}}{2} = \frac{p(n+1)}{2n}$$

Where, P = Total initial Cost

$P_{av}$ = Average Value

n = Life in years.

**Case II:** When there is salvage value of the equipment; the average value of the equipment is the sum of the values at the beginning of the first year and the end of the last year divided by 2.

$$P_{av} = \frac{p + \frac{p-s}{n} + s}{2} = \frac{p(n+1)+s(n-1)}{2n}$$

Where, P = Total Original Cost

$P_{av}$ = Average Value

n = Life in years

s = Salvage value

Here by equation;

$$\text{Annual depreciation} = \frac{10,000 - 2000}{5} = 1600$$

$$P_{av} = \frac{p(n+1)+s(n-1)}{2n}$$

$$= \frac{10,000(5+1)+2000(5-1)}{2 \times 5}$$

= 6,800/-

\ Total annual cost = 6,800 × 0.1 + 1600

= Rs. 2,280/-

**60. (c)** Depreciation,

$$D = \frac{C_i - C_s}{n}$$

$$D = \frac{25000 - 1600}{8}$$

D = 2925

Book value at the beginning of 6th year will be equal to

$B_5$ = 25000 – 5 × 2925

$B_5$ = 10375

**61. (b)** Book value from declining balance method

$B_n = C_i\,(1\text{-FDB})^n$

In this method there is large amount of write off i.e depreciation in the early year of utility period is more than in comparison to later years of utility period.

**62. (c)**

$$\text{FDDB} = \frac{2}{n} = \frac{2}{5} = 0.4$$

$B_2 = C_i(1 - \text{FDDB})^2$

$B_2 = 2,00,000(1–0.4)^2$

$B_2$ = 72,000

**63.** **(c)** Consined effect of pressure and temperature on IC engine.

We have,

$$H_C = H_O \frac{P_s}{P_o}\sqrt{\frac{T_o}{T_s}}$$

Where,

$H_C$ = Corrected power for standard condtidion

$H_O$ = Observed power as determined for test

$P_s$ = Standard barometric pressure (760 mm of Hg)

$P_O$ = Observed barometric pressure in mm of Hg at time of test

$T_O$ = Absolute observed tempt

$T_s$ = Absolute tempt for standard condition

\ $H_O$ = 87 kW

$P_O$ = 750 mm of Hg

$T_O$ = 273 + 18 = 291 k

$T_s$ = 273 + 15 = 288 k

$P_s$ = 760 mm of Hg

$$\backslash\ H_s = 87 \times \frac{760}{750}\sqrt{\frac{291}{288}} = 88.62\,\text{kW}$$

**64. (d)** $\frac{H_S}{H_0} = \frac{P_S}{P_0}\sqrt{\frac{T_0}{T_S}}$

$H_S$ = Corrected horse power for standard condition

$H_0$ = Observed horse power as determined for test

$P_S$ = Standard barometric pressure (760 mm of Hg)

$P_0$ = Observed barometric pressure in mm of Hg at time of test

$T_0$ = absolute observed temperature

$T_S$ = Absolute temperature for standard condition.

**65. (d) When loaded**

Rimpull = Total resistance × weight

Total resistance = grade resistance + rolling resistance.

= 2% +3.5 % = 5.5 %

$$\text{Rimpull} = \frac{5.5}{100}\times(27+14\times1.8)\times1000\times10$$

= 28710 N

**When unloaded**

Total resistance = Rolling resistance – grade resistance

= 3.5% – 2% = 1.5%

$$\text{Rimpull} = \frac{1.5}{100}\times27\times1000\times10 = 4050\text{N}$$

**66 (c)**

**67. (d)** Effective Cycle time

= Forward time + Return time + fixed time

$$= \left(\frac{60}{240\times0.8}+\frac{60}{0.8\times300}\right)\times60+25$$

= 58.75 sec.

**68. (b)** Rubber tyre mounted bulldozer gives better output on hard surface whereas crawler mounted gives better output on soft soil.

Rubber tyre bulldozer results in lesser operator fatigue because it has steering control where as crawler mounted has stick control.

**69. (c)** Derrick crane is mainly used for hoisting. Dump truck is mainly used for transportation and converging.

Power shovel is mainly used for excavation

Dragline is mainly used for excavation and transportation of excavated material for short distance.

**70. (c)** Production in 4 hour shift

$$= 4\times\frac{50\times60}{64}\times0.9\times1.6 = 270\ \text{m}^3$$

**71. (d)** Wheeled tractors are preferred over crawler tractor because of following reasons :

(i) Wheeled unit can travel 3 to 4 times faster than crawler units and have an additional advantage where travel distances are long and travel speed is important.

(ii) Crawler units are generally more costly than wheeled units due to expensive track system.

(iii) Wheeled units have wheel steering control and are easily manoeuvred, while crawler units have stick control for steering and need greater skill in operation.

(iv) Transportation of crawler units over long distances is usually done on trailers due to their slow speeds of travel and to avoid excessive strain on the tracks whereas wheeled units can be self-driven over long distances.

(v) Crawlers tractors, if moved on pavements or tarred roads, are likely to damage them unless fitted with special shoes.

(vi) Crawler units generally require more skill in operation, maintenance and repairs than wheeled units.

**72. (c)** Shutter vibrator are clamped rigidly to the form work at the predetermined points so that the form and concrete are vibrated. These vibrators are more often used for pre-casting of in-situ sections of such shape and thickness as cannot be compacted by internal vibrators. Needle vibrators does not get choked by the leaking in of cement paste.

**73. (a)** A project constitutes of all the activities in it and to develop the time cost relationship of the whole project, we must know the time cost relationship of every activity.

**74. (a)** In resource allocation we may have to consider positive cost slope because availability of resources may be scares.

**75. (d)**

**Sol.** Total float (TF) is the amount of time available for scheduling an activity. It is the time that start of an activity can be delayed beyond the ES without affecting the final completion date of the project. It is the difference between the early start and late start (LS-ES) or early finish and late finish (LF-EF) of any given activity. Total float must be calculated in one of the above ways since it does not appear directly on diagram. In the precedence diagramming system, if start to start or finish to finish lags are usded, it is possible for the total float on the start and finish of an activity to differ. In such an instance the start float may be more critical (smaller) than the finish float or vice-versa. Total float is the most significant float calculation. Free float (FF) is a feature which signifies only float available without affecting the next activity early start.

If start to start or finish to finish relationships are included, they may dictate the Early Start (ES), Late Start (LS), Early Finish (EF), or Late Finish (LF) dates for an activity in such a way that (ES) + duration is not the ES and LF-duration is not the LS. This occurs when that the start to start lags and the finish to finish lags dictate a period between start and finish longer than the activity duration.