Class Test Solution (OCF & CPM) 22-07-2019
Answer key

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

OCF AND CPM CLASS TEST-SOLUTIONS

1. (b)

$$F = \frac{V}{\sqrt{gA/T}} = \frac{Q}{\sqrt{gA^3/T}} = \frac{Q}{Z\sqrt{g}}$$

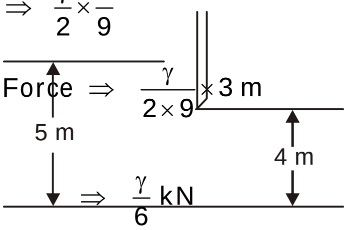
$$Q = \sqrt{g}\,FZ$$

$$= \sqrt{9.81} \times 2 \times 1.5 = 9.4\ m^3s.$$

2. (a)

$$\text{Force/metre width} = \frac{\gamma}{2}\frac{(y_1 - y_2)^3}{y_1 + y_2}$$

$$\Rightarrow \frac{\gamma}{2} \times \frac{1}{9}$$



$$\text{Force} \Rightarrow \frac{\gamma}{2\times 9} \times 3\ m$$

$$\Rightarrow \frac{\gamma}{6}\ kN$$

3. (c)

4. (b)

5. (d)

6. (b)

$$F_r = \frac{V}{\sqrt{g\frac{A}{T}}}$$

where $$A = \frac{1}{2}yT$$

so, $$F_r = \frac{V}{\sqrt{g\frac{y}{2}}}$$

7. (b)

For efficient channel

$$R = \frac{h}{2} = \frac{A}{P} = \frac{bh + 2\left(\frac{h}{2}\right)\times(2h)}{b + 2h(5)^{1/2}}$$

$$\Rightarrow \quad b = 2h(5)^{1/2} - 4h$$

$$\boxed{b = 0.472\ h} \quad \text{...(i)}$$

To accommodate max. velocity

$$A = 12.74/0.92 = bh + 2h^2$$

$$\Rightarrow \quad b = (13.85 - 2h^2)/h \quad \text{...(ii)}$$

Equating (i) and (ii), we get

h = 2.37 m and b = 1.12 m.

8. (b)

Using Manning's equation

$$0.92 = \frac{(2.37/2)^{2/3} \times S^{1/2}}{0.025}$$

$$\Rightarrow \quad S = 0.00042$$

$$\Rightarrow \quad \boxed{S = 42 \times 10^{-5}}$$

9. (c)

Semicircular section has least wetted perimeter among all sections with the same flow area.

10. (c)

$$D = 1.5m$$

$$R = \frac{1.5}{2} = 0.75\ m$$

$$S = \frac{1}{1000}$$

$$C = 60$$

For maximum discharge

$$\theta = 154° \text{ or } \frac{154\pi}{180} = 2.68 \text{ rad}$$

Wetted perimeter for a circular channel is given by equation as

$$P = 2$$

$$R\theta = 2 \times \frac{D}{2} \times 2.6878$$

$$P = 4.03\ m$$

Welted area A is given by equation as

$$A = R^2\left(\theta - \frac{\sin 2\theta}{2}\right)$$

$$= 0.75^2\left[2.6878 - \frac{\sin(2\times154°)}{2}\right]$$

$$= 1.7335\ m^2$$

Hydraulic mean depth

$$R = \frac{A}{P} = 0.43$$

Maximum discharge is given by

$$Q = AC\sqrt{RS}$$

$$Q = 1.7335\times 60\sqrt{0.43\times\frac{1}{1000}}$$

$$Q = 2.156\ m^3/s$$

11. (c)

For an most efficient trapezoidal channel

$$B = 2y/\sqrt{3}$$

$$A = \sqrt{3}\ y^2$$

$$Q = \frac{1}{n}A\times R^{2/3}S^{1/2}$$

$$y^{8/3} = \frac{100\times 0.015\times 2^{2/3}\times(5000)^{1/2}}{\sqrt{3}}$$

$$y = 5.56\ m$$

$$B = \frac{2y}{\sqrt{3}} = \frac{2\times 5.56}{\sqrt{3}} = 6.42m$$

12. (d)

$$\text{Hydraulic depth } D = \frac{A}{T} = \frac{\sqrt{3}\ y^2}{B+2zy}$$

$$= \frac{\sqrt{3}y^2}{\frac{2y}{\sqrt{3}}+\frac{2y}{\sqrt{3}}} = \frac{3}{4}\times y = 4.17m$$

Velocity,

$$V = \frac{Q}{A} = \frac{100}{\sqrt{3}\times(5.56)^2} = 1.87 m/s$$

$$\text{Froude number } F = \frac{1.87}{\sqrt{9.81\times 4.17}}$$

$$F = 0.292$$

13. (c)

$$V_0 = 0.8\ m/s$$

$$V_{0.4} = 0.6\ m/s$$

$$V_{1.0} = 0.4\ m/s$$

Using two point method mean velocity

$$V = \frac{V_{0.4}+V_{1.2}}{2}$$

$$V = \frac{0.6+0.4}{2} = 0.5\ m/s$$

Discharge, $Q = A \times V$

$$Q = \frac{1}{2}\times 6\times 2\times 0.5$$

$$Q = 3\ m^3/s$$

14. (d)

$$R = y$$

$$V = \frac{1}{n}R^{2/3}S^{1/2}$$

$$V = \frac{1}{n}y^{2/3}S^{1/2}$$

$$Q = AV$$

$$Q = \frac{B}{n}y\times y^{2/3}\times s^{1/2}$$

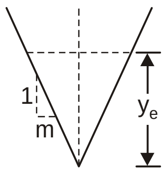
$$Q \propto y^{5/3}$$

$$\frac{\Delta Q}{Q}\times 100 = \frac{(1.2y)^{5/3}-y^{5/3}}{y^{5/3}}\times 100$$

$$= 35.50\%$$

15. (b)

For critical flow



$$\frac{A^3}{T} = \frac{Q^2}{g}$$

here $y_c = 1.4\ m$

$$y_c = \left(\frac{2Q^2}{gm^2}\right)^{1/5}$$

Sp. energy at critical depth will be E_c

$$= y_c + \frac{v_c^2}{2g} = y_c + \frac{Q^2}{2gA^2}$$

$$= y_c + \frac{A}{2T}$$

$$= y_c + \frac{my_c^2}{2\times 2my_c} = y_c + \frac{y_c}{4}$$

$$= 1.25\ y_c$$

$\therefore$ $E_c = 1.25\ y_c$

$= 1.25 \times 1.4 = 1.75$ m

16. (b)

For triangular section $E_c = \frac{5}{4}y_c$

So, $y_c = 4$ m

$$E_c = y_c + \frac{V^2}{2g}$$

$$5 = 4 + \frac{V^2}{2g}$$

$$V = \sqrt{2g}$$

17. (c)

$E = E_c + \Delta Z_{max}$

$Q = A \times V$

$3.3 = 1.5 \times 2 \times V$

$V = 1.1$ m/s

$$\Rightarrow 1.5 + \frac{1.21}{2\times 9.81} = \frac{3}{2}\left(\frac{q^2}{g}\right)^{1/3} + \Delta Z_{max}$$

$$\Rightarrow 1.5 + \frac{1.21}{2\times 9.81} = \frac{3}{2}\left[\frac{\left(\frac{3.3}{2}\right)^2}{9.81}\right]^{1/3} + \Delta Z_{max}$$

$$\Rightarrow \boxed{\Delta Z_{max} = 0.583\text{ m}}$$

18. (d)

$$Fr = \frac{V}{\sqrt{gy}} = \frac{15/(1.0\times 3.2)}{\sqrt{9.81\times 1.0}} = 1.5$$

$\because$ $Fr > 1$

$\Rightarrow$ Flow is supercritical.

B_{min} (For no choking)

$$1 + \frac{V^2}{2g} = \frac{3}{2}\times\left(\frac{q'^2}{g}\right)^{1/3}$$

$$1 + \frac{\left(15/3.2\right)^2}{2\times 9.81} = \frac{3}{2}\times\left[\frac{\left(15/B'\right)^2}{9.81}\right]^{1/3}$$

$$\boxed{B'_{min} = 2.85\text{ m}}$$

As the section is being contracted to 2.25 m so, choking will occur and, depth at upstream section will decrease, such that

$$E_{u/s} = E_c$$

$$y' + \frac{V^2}{2g} = \frac{3}{2}\times\left(\frac{q^2}{g}\right)^{1/3}$$

$$q' = \frac{15}{2.25} = 6.67\text{ m}^3/\text{s/m}$$

$$q = \frac{15}{3.2} = 4.69\text{ m}^3/\text{s/m}$$

$$y' + \frac{q^2}{2gy'^2} = \frac{3}{2}\times\left(\frac{q'^2}{g}\right)^{1/3}$$

$$y' + \frac{4.69^2}{2\times 9.81\times y'^2} = \frac{3}{2}\times\left(\frac{6.67^2}{9.81}\right)^{1/3}$$

$$y' + \frac{1.12}{y'^2} = 2.48$$

$\Rightarrow y'^3 - 2.48y'^2 + 1.12 = 0$

$\Rightarrow$ $y' = 2.26\text{ m}, 0.82\text{ m}$

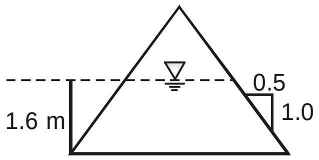
$\because$ Flow supercritical.

$$\boxed{y' = 0.82\text{ m}}$$

19. (c)

$$T_C = 3.0 - 2 \times 0.5 \times 1.6$$

$$T_C = 1.40 \text{ m}$$



$$A_C = \left(\frac{3.0+1.40}{2}\right) \times 1.60$$

$$A_C = 3.52 \text{ m}^2$$

$$\frac{Q^2}{g} = \frac{A_C^3}{T_C} = \frac{(3.52)^3}{1.40} = 31.153$$

$$Q = 17.48 \text{ m}^3/\text{s}$$

$$V_C = \frac{Q}{A_C} = \frac{17.48}{3.52} = 4.96 \text{ m/s}$$

$$\frac{V_C^2}{2g} = \frac{(4.966)^2}{2 \times 9.81} = 1.257 \text{ m}$$

$$E_C = y_C + \frac{V_C^2}{2g} = 1.60 + 1.257$$

$$\boxed{E_C = 2.857 \text{ m}}$$

20. (a)

Since $$F_r = \frac{Q}{(By) \times \sqrt{gy}}$$

$$F_r \propto \frac{1}{(y)^{3/2}}$$

$$\text{factor} = \left(\frac{4}{3}\right)^{3/2} = \frac{8}{3\sqrt{3}} = 1.54$$

21. (a)

Given, $Q = 15 \text{ m}^3/\text{s}$, $B = 2.8$ m, $y = 1.4$ m.

$$q = \frac{15}{2.8} = 5.357 \text{ m}^3/\text{s/m}$$

$$Fr = \frac{V}{\sqrt{gy}} = \frac{\frac{15}{2.8 \times 1.4}}{\sqrt{9.81 \times 1.4}} = \frac{3.8265}{\sqrt{9.81 \times 1.4}} = 1.033$$

$\because$ $Fr > 1$

Flow is supercritical.

At the verge of change in upstream flow, flow at downstream will become critical.

i.e. $E_{u/s} = E_{d/s}$

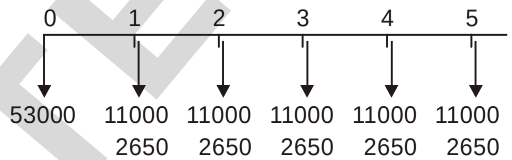
$E_{u/s} = E_c$

$$\Rightarrow 1.4 + \frac{3.82652^2}{2 \times 9.81} = \frac{3}{2} \times \left(\frac{\frac{Q^2}{B'^2}}{9.81}\right)^{1/3}$$

$$2.146 = \frac{3}{2} \times \left(\frac{15^2/B'}{9.81}\right)^{1/3}$$

$$\Rightarrow B' = 2.798 \text{ m} \approx 2.8 \text{ m}$$

22. (d)



Initial investment fo the equipment,

P = Rs. 53,000/-

$\therefore$ Annual equivalent cost of the equipment, A

= P × i = 53000 × 0.15

= Rs. 7,950/-

Annual depreciation = Rs. 11,000/-

Annual paid tax = 53,000× 0.05 = Rs. 2,650/-

$\therefore$ Annual total cost of the equipment

= 7950 + 11000 + 2650

= Rs. 21,600/-

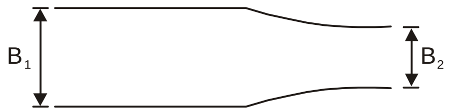
As the equipment is used for 1800 hrs during each year.

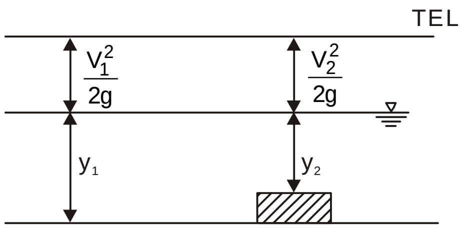
$\therefore$ Lonly ownership cost for the equipment

$$= \frac{21600}{1800} = 12/-$$

23. (a)

From the figure :





$$\frac{V_1^2}{2g} = \frac{V_2^2}{2g}$$

$$\Rightarrow \frac{Q^2}{2gB_1^2y_1^2} = \frac{Q^2}{2gB_2^2y_2^2}$$

$$\Rightarrow B_1^2y_1^2 = B_2^2y_2^2$$

$$\Rightarrow y_2^2 = \left(\frac{B_1}{B_2}\right)^2 \times y_1^2 = \left(\frac{8}{5}\right)^2 \times 1.5^2$$

$$\boxed{y_2 = 2.4 \text{ m}}$$

$\therefore$ ΔZ = 2.4 – 1.5 = 0.9 m (drop).

24. (d)

25. (c)

26. (c)

27. (d)

y_1 = 0.5 m y_2 = 2.0 m

$$y_c^3 = \frac{2y_1^2\ y_2^2}{(y_1+y_2)} = \frac{2\times(1/2)^2\times(2)^2}{(2+1/2)}$$

$$\therefore\ y_C = \left(\frac{4}{5}\right)^{1/3}$$

28. (a)

$$F_r = \frac{V}{\sqrt{gy}} = \frac{2.4}{\sqrt{9.81\times1.2}} < 1$$

$\Rightarrow$ initial flow is subcritical

$$y_c = \left(\frac{(vy)^2}{g}\right)^{1/3}$$

= 0.945 m

$\Rightarrow$ E_C = 1.418 m

$$E_1 = 1.2 + \frac{(2.4)^2}{2g} = 1.493 \text{ m}$$

$$E_1 - \Delta z < E_c$$

$\Rightarrow$ Flow is chocked

$\Rightarrow$ $E_2' = E_c + \Delta z$

$\Rightarrow$ Flow u/s will increase

29. (a)

30. (a)

31. (d)

The surface profile of water surface in an open channel is given by

$$\frac{dy}{dx} = S_0 \frac{1-\left(\frac{y_n}{y}\right)^3}{1-\left(\frac{y_c}{y}\right)^3}$$

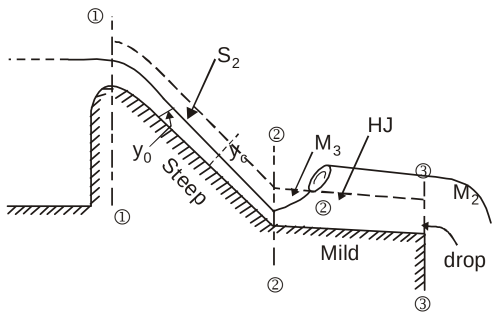
for $\frac{dy}{dx} > 0;$

(i) $y > y_n$ and $y > y_c$

and (ii) $y < y_n$ and $y < y_c$

32. (b)

33. (a)



Water surface profile

34. (b)

$$E_1 = E_3$$

$$\Rightarrow y_1 + \frac{v_1^2}{2g} = y_3 + \frac{v_3^2}{2g}$$

$$1+v_1^2/[(2)(9.8)] = 0.30+v_3^2/[(2)(9.8)] \quad ...(i)$$

$$y_1v_1 = y_3v_3$$

$$v_1 = y_3v_3/y_1 = (0.30)(v_3/1)$$

$$= 0.3v_3 \quad ...(ii)$$

$$1 + (0.3v_3)^2/[(2)(9.8)] = 0.30 + v_3^2/[(2)(9.8)]$$

$$v_3 = 3.88 \text{ m/s}$$

35. (a)

Given, $Fr_2 = 0.15$

$\Delta E = 10$ m

$$\frac{y_1}{y_2} = \frac{1}{2}\left(\sqrt{1+8Fr_2^2}-1\right)$$

$$\frac{y_1}{y_2} = 0.04313$$

$$y_2 = 23.180y_1$$

$$\Delta E = \frac{(y_2-y_1)^3}{4y_1y_2}$$

$$10 = \frac{(23.18y_1-y_1)^3}{4\times 23.18y_1\times y_1}$$

$$10 = \frac{10912.78y_1}{4\times 23.18}$$

$$y_1 = 0.0849 \text{ m}$$

36. (a)

$V_1 = q/y_1 = 10/1.25 = 8.00$ m/s

$F_r = V/\sqrt{gy}$

$(F_r)_1 = 8.00/\sqrt{(9.87)(1.25)} = 2.285$

$2y_2/y_1 = -1 + \left[1+8(F_r)_1^2\right]^{1/2}$

$2y_2/1.25 = -1 + [1 + (8)(2.285)^2]^{1/2}$

$y_2 = 3.46$ m

$V_1y_1 = V_2y_2$

$(8.00)(1.25) = (V_2)(3.46)$

$V_2 = 2.89$ m/s

37. (b)

$(N_F)_2 = 2.89/\sqrt{(9.807)(3.46)} = 0.496$

$E_j = (y_2 - y_1)^3/4y_2y_1 = (3.46 - 125)^3/[(4)(3.46)(1.25)] = 0.624$ m

$E_1 = y_1 + v_1^2/2g = 1.25 + 8.00^2/[(2)(9.807)]$

$= 4.51$ m

Percentage dissipation = E_j/E_1 = 0.624/4.51 = 0.138 or 13.8 percent

38. (d)

39. (d)

An arrow cannot have any shape. Its direction on the network diagram is from left to right although the length of the arrow is indicative only.

40. (d)

41. (d)

42. (b)

The milestone chart is a modification over the original bar chart. In every activity, there are certain key events which are to be carried out for the completion of the activity. Such key events are called milestones and they are represented by a square or circle.

43. (c)

Time required in ladder network =

$$36+\frac{24}{3}+\frac{21}{3} = 51 \text{ days}$$

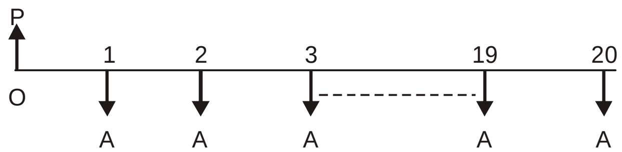
44. (c)

45. (b)

46. (b)

47. (d)

Capital recovery factor (CRF) – Finding A given P



$$\because \quad P = A\left[\frac{(1+i)^{25}-1}{i(1+i)^{25}}\right]$$

Where i = 10% = rate of annual interest.

$$\therefore \quad \frac{A}{P} = \left[\frac{i(1+i)^{20}}{(1+i)^{20}-1}\right] = CRF$$

Here, if amount is withdrawn equally each year, the amount = CRF × P = 0.11746 × 1,00,000 = Rs. 11,746/-

As the withdrawal is at the end of 2^{nd}, 4^{th}, 6^{th} ... 18^{th}, 20^{th} years (ie. at the interval of two years each), Rs. 11,746/- and its interest for one year will be added to give the required withdrawal at the interval of 2 years each

∴ each instalment of withdrawal

= 11,746 + 11,746 × (1 + 0.1)

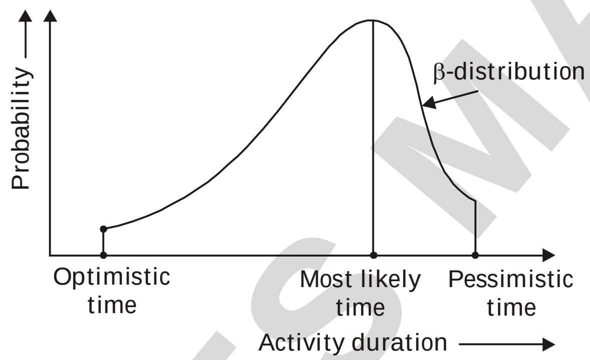
= Rs. 24,667/-

≃ Rs. 24,667/-

48. (a)

49. (a)

Each activity in a PERT network is assumed to follow β-distribution.



50. (d)

Slack may be simply defined as the difference the latest allowable time and the earliest expected time of an event.

$$\therefore \quad S = T_L - T_E$$

51. (b)

52. (b)

53. (c)

Standard deviation =

$$\sqrt{\left(\frac{t_p - t_0}{6}\right)^2} = \left(\frac{21-5}{6}\right) = 2.67$$

Expected time =

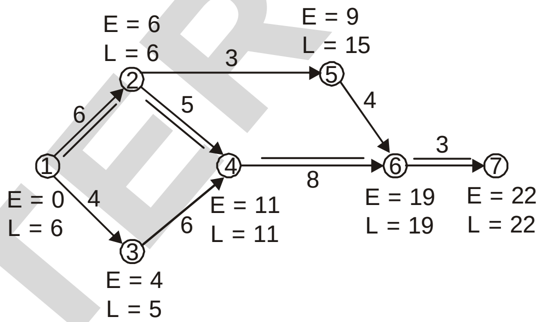
$$\frac{t_p + 4t_m + t_0}{6} = \frac{21 + 4\times 10 + 5}{6} = 11$$

54. (c)

CPM is activity oriented and deterministic in nature.

55. (b)

56. (d)



Critical path 1-2-4-6-7

Option (d) is correct.

57. (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):

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

Activity time required = t^{ij}

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

58. (c)

Sub-critical activities: When float is +ve. The activity needs normal attention and has some flexibility.

59. (c)

60. (b)

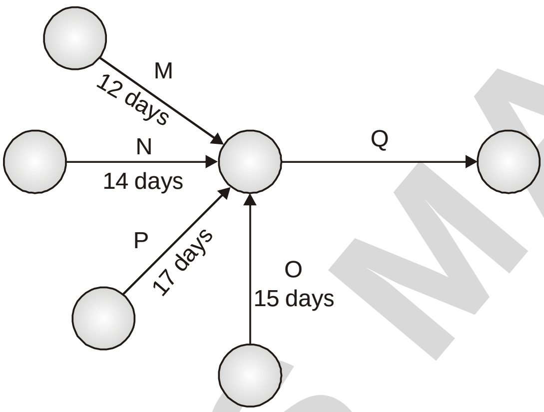
$$S.F.F = \frac{i}{(1+i)^n - 1}$$

$$= \frac{0.04}{(1+0.04)^5 - 1}$$

$$= 0.184.$$

61. (d)

The earliest expected time is the time when an event can be expected to occur. The earliest expected time is computed by adding the expected times of all the activities along an activities path leading to that event. If more than one activity paths lead to that event, then the maximum of the sum of expected time along the various paths will give the earliest expected time.



62. (b)

63. (c)

64. (a)

65. (a)

66. (c)

67. (b)

68. (d)

69. (c)

70. (a)

71. (a)

72. (d)

73. (d)

Value of an asset at the end of its utility period is called as its Salvage value i.e. Resale value at the end of a particular time.

Salvage value implies that asset has further utility, but due to some reason it is for resale.

Salvage value is more in the initial period of the equipment and decreases as the equipment ages, because as equipment ages the amount of depreciation increases

74. (d)

75. (b)