GATE – CIVIL ENGINEERING

CONCRETE STRUCTURES (RCC & PSC)
Construction Materials and Management

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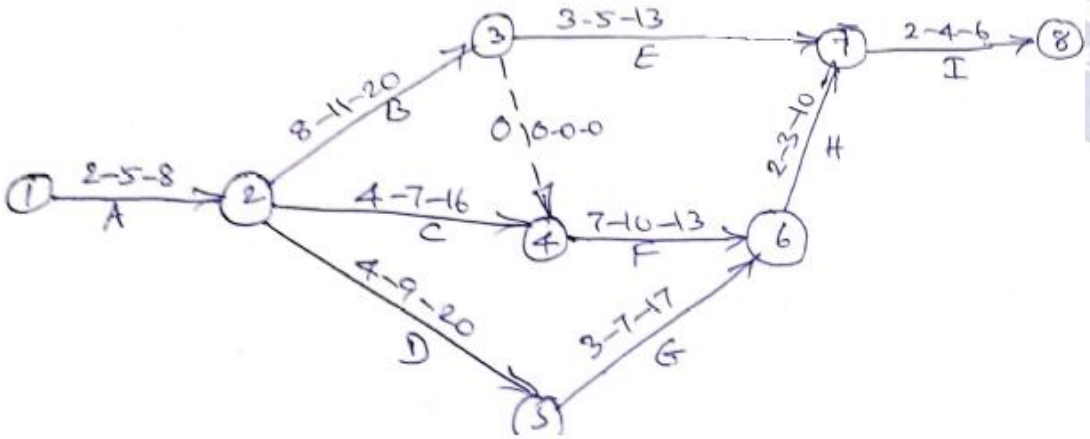
5. A construction work consists of activities with PERT durations in weeks as given below.

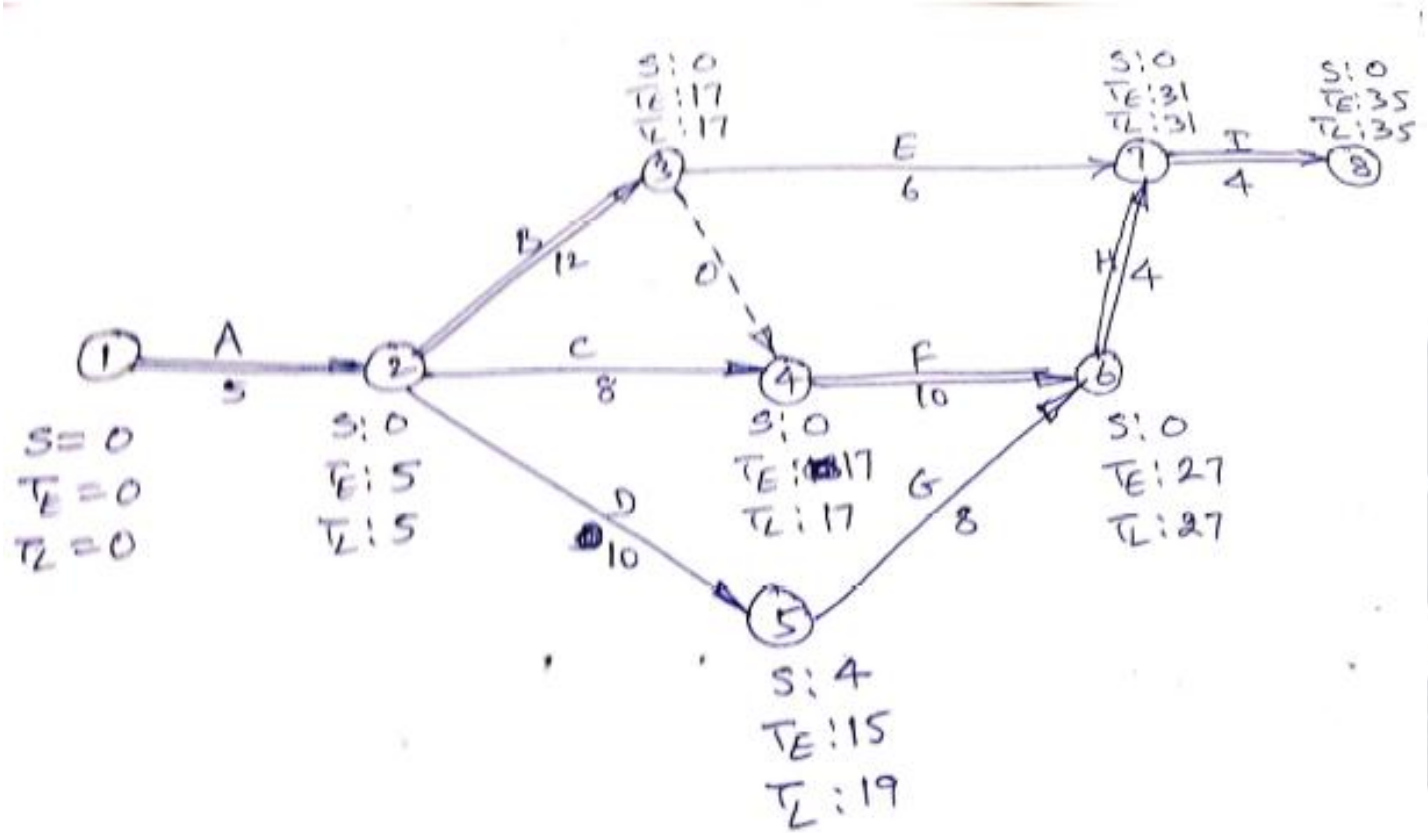
Activity	A	B	C	D	E	F	G	H	I
Predecessors	-	A	A	A	B,C	C	D	F,G	E,H
t_o, weeks	2	8	4	4	3	7	3	2	2
t_m, weeks	5	11	7	9	5	10	7	3	4
t_p, weeks	8	20	16	20	13	13	17	10	6

Z	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7
Probability, %	81.59	84.13	86.43	88.49	90.32	91.92	93.32	94.52	95.54

a. The net work corresponding to the given activities is….



b. The critical path for the network is….



Activity	t_0	t_m	t_p	t_e	σ
A	2	5	8	5	1
B	8	11	20	12	2
C	4	7	16	8	2
D	4	9	20	10	2.67
O	0	0	0	0	0
E	3	5	13	6	1.67
F	7	10	13	10	1
G	3	7	17	8	2.33
H	2	3	10	4	1.33
I	2	4	6	4	0.67

Critical path: path joining the events of zero lack

$:1-2-3-4-6-7-8$

$:A-B-0-F-H-I$

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c. Expected duration of the project is…..

Duration of critical path $= 5+12+0+10+4+4$

$= 35\,weeks$

For path $A-B-E-I: 5+12+6+4 = 27\,weeks$

$A-B-0-F-H-I: 5+12+0+10+4+4 = 35\,weeks$

$A-C-F-H-I: 5+8+10+4+4 = 31\,weeks$

$A-D-G-H-I: 5+10+8+4+4 = 31\,weeks$

Hence, critical path is: $A-B-0-F-H-I$

Expected duration of the project $= 35\,weeks$

d. Standard deviation for the network is…

$$\sigma = \sqrt{\sigma_A^2 + \sigma_B^2 + \sigma_0^2 + \sigma_F^2 + \sigma_H^2 + \sigma_I^2}$$

$$= \sqrt{1^2 + 2^2 + 0^2 + 1^2 + 1.33^2 + 0.67^2} = 2.867$$

e. The duration required for 95% probability of completing the project is….

$$\text{For } 95\% \text{ probability, } Z = 1.6 + \frac{1.7 - 1.6}{95.54 - 94.52}(95 - 94.58) = 1.647$$

$$z = \frac{T_L - T_S}{\sigma} \Rightarrow 1.647 = \frac{T_L - 25}{2.867} \Rightarrow T_L = 39.72 \, weeks$$

f. The duration required for 85% probability of completing the project is….

$$\text{for } 85\% \text{ probability, } z = 1.0 + \frac{1.1 - 1.0}{86.43 - 84.13}(85 - 84.13) = 1.038$$

$$z = \frac{T_L - T_S}{\sigma} \Rightarrow 1.038 = \frac{T_L - 35}{2.867} \Rightarrow T_L = 37.98 \;\; weeks$$

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g. The duration required for 50% probability of completion of the project is…..

$$\text{for } 50\% \text{probability}, \sigma = 0$$

$$T_L = T_S = 35 \; weeks$$

h. The probability of completing the project in 32.133 weeks is……

$$Z = \frac{T_L - T_S}{\sigma} = \frac{32.133 - 35}{2.867} = -1$$

$$\text{Probability of completing the project} = 100 - 84.13 = 15.87\%$$

INTRODUCTION : CRITICAL PATH METHOD

- Critical path method is abbreviated as CPM
- M.R. Walker and J.E. Kelley involved in development of CPM for the construction of chemical plants in united states.
- Both CPM and PERT are the tools used for planning, scheduling and controlling of various projects.
- The major difference between the two techniques is that CPM does not incorporate uncertainties in job times i.e. time estimate is deterministic.
- It assumes that activity times are proportional to the amount of resources allocated to them and by changing the level of resources, the activity times and the project completion time can be varied.
- CPM is mostly used in construction projects when there is prior experience in handling similar projects from which relationships between resources and job time are available.

Comparison between PERT and CPM.

PERT	CPM
• Network diagram is event oriented.	• Network diagram is activity oriented.
• It uses Probabilistic approach	• It uses Deterministic approach
• Suitable for research & development and non repetitive project	• Suitable for repetitive type of project.
• Three time estimates are given for completion of an activity.	• Single time estimate is given for each activity.
• Follows β distribution.	• Follows Normal distribution.
• Cost of project is directly proportional to time and to minimize the project cost, the project completion time is minimized.	• Cost model has to be developed using which minimum cost of the project is found
• Critical events are identified by using the concept of slack.	• Critical activities are identified by using concept of float
• Critical path will be path joining the critical events.	• Critical path will be the path joining all the critical activities.

CPM – NETWORKS

- Networking principals involved in CPM are similar to PERT.
- Main difference is that CPM networks are activity oriented whereas PERT network are event oriented

Time estimate of an Activity

- After finalizing of the network, next step is to estimate the time required for the execution of an activity.
- Time estimation can be done in two ways a. Probabilistic approach and
  b. Deterministic approach.
- PERT uses probabilistic approach to absorb the uncertainties associated for the achievement of events where as CPM is concerned with problems which do not involve significant uncertainties and hence deterministic approach is used.
- In CPM, estimated activity time is represented simply by t, which is directly used for network analysis.
- In CPM, the time of completion for any activity i-j is denoted by symbol t^{ij}, whereas in PERT it was t_e^{ij}

EVENT TIME

- After deciding the estimated time duration (t) for an activity, it is necessary to determine the time of occurrence of the events.

Earliest occurrence time (T_E)

- It is earliest time at which an event can occur i.e. the time by which all the activities leading to an event under consideration are complete.
- It is also called as Earliest Event time.

$$T_E{}^j = \text{Maximum } (T_E{}^i + t^{ij})$$

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Latest allowable occurrence time (T_L)

- It is latest (delayed) time by which an event must be completed to such that the project completion time is not affected.
- Latest allowable occurrence time is calculated same as in PERT by Backward pass rule. i.e. $T_L{}^i = \text{Minimum } (T_L{}^j - t^{ij})$
- If the scheduled completion time (T_S) of the project is given, then latest event time of the final/ end event will be equal to T_S
- If the scheduled completion time (T_S) is not specified, then T_L is taken equal to the earliest event time of the end/final event.

START AND FINISH TIMES OF ACTIVITY

CPM networks are activity oriented

1. Earliest start time (EST)

- It is the earliest time by which the activity can commence.
- It is equal to the earliest event time T_E, for the event from which the activity arrow originates.
- If the activity is denoted by i – j, $(EST)_i = T_E^{\ i}$

  where, $T_E^{\ i}$ = Earliest event time for the tail event.

2. Earliest Finish Time (EFT)

- It is the earliest time by which the activity can be completed.
- It is equal to the earliest start time plus the activity duration.
- If the activity is denoted by i-j, $(EFT)_{ij}$= Earliest start time + activity duration

$$(EFT)_{ij} = (EST) + t^{ij}$$

$$(EFT)_{ij} = T_E^{\ i} + t^{ij}$$

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3. Latest Start Time (LST)

- It is the latest (or delayed) time by which activity can be started, without delaying the completion of the project.
- LST is equal to the latest occurrence time T_L, for the event at which the activity arrow terminates minus the duration of the activity.

  For activity i-i, $(LST)_{ij} = T_L{}^{j} - t^{ij}$

4. Latest Finish Time (LFT)

- It is the latest (or delayed) time which the activity can be finished, without delaying the completion of the project.
- It is equal to the latest occurrence time T_L of the event at which the activity terminates. For activity i-j, $(LFT)_{ij} = T_L{}^{j}$

  Also, $(LFT)_{ij} = (LST)_{ij} + t^{ij}$

  $(LST)_{ij} = (LFT)_{ij} - t^{ij}$

  Activity name, EST and EFT are written above the arrow, while the activity duration, LST and LFT are written below the arrow.

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FLOAT

- Float indicates the time by which starting or finishing of an activity can be delayed without affecting the project completion time.
- Float is associated with an activity and is analogous to the term slack.

1. Total float

- The difference between maximum time available and actual time required for the completion of the activity

  F_T = (Maximum available Time) – Actual time required.

- Maximum available time we can get when activity start at Earliest start time and finish by latest finish time.

  Maximum available time = LFT – EST

  $$F_T = T_L{}^{j} - (T_E{}^{i} + t^{ij})$$

  $$F_T = LFT - EFT$$

- total Float of an activity is a measure of a particular activity but it depends on the succeeding and preceding activities by the virtue of T_L and T_E respectively.

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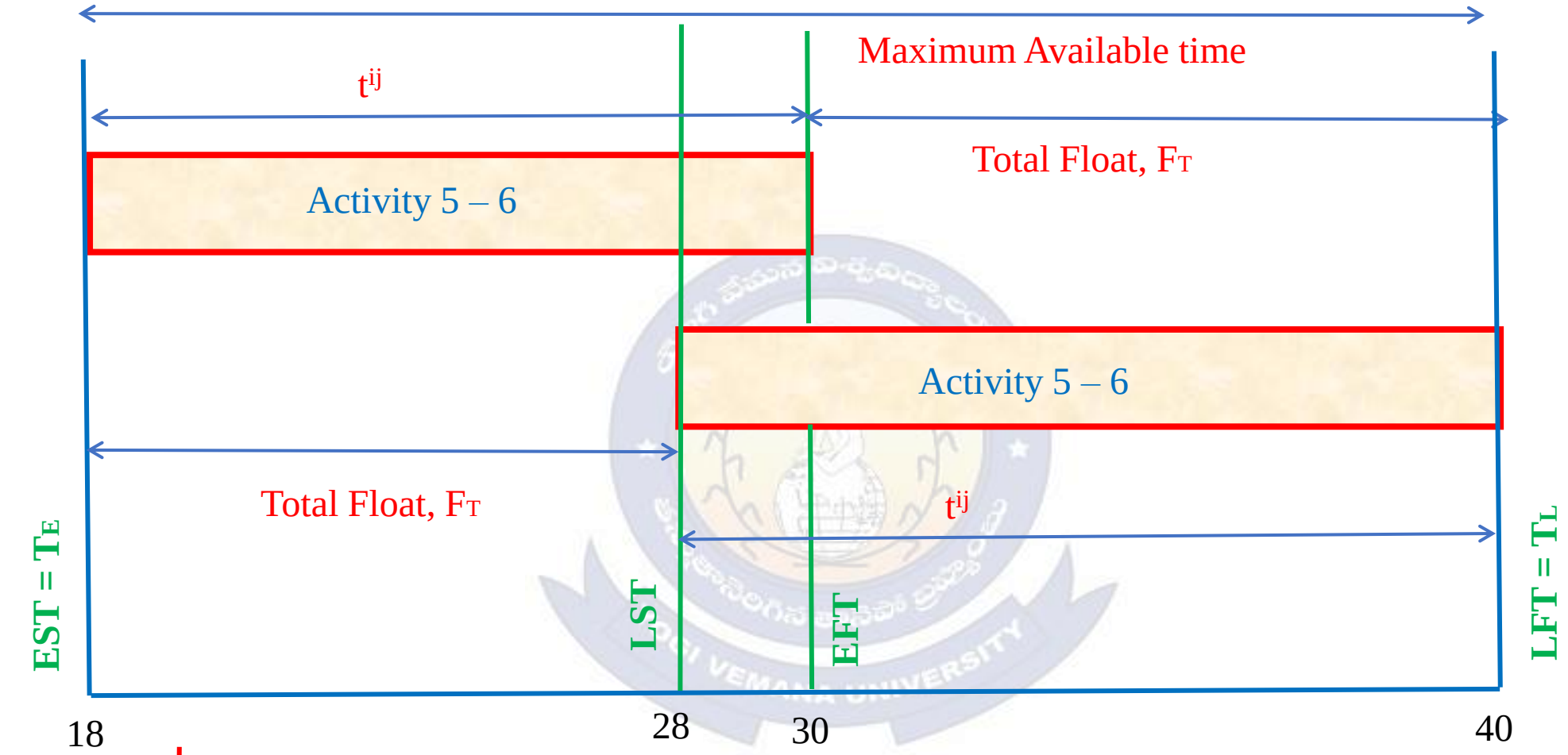

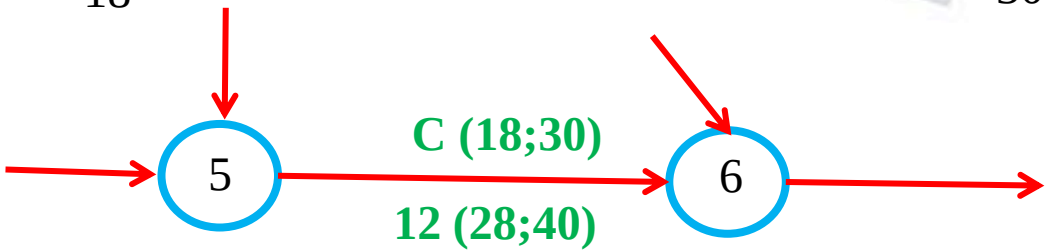

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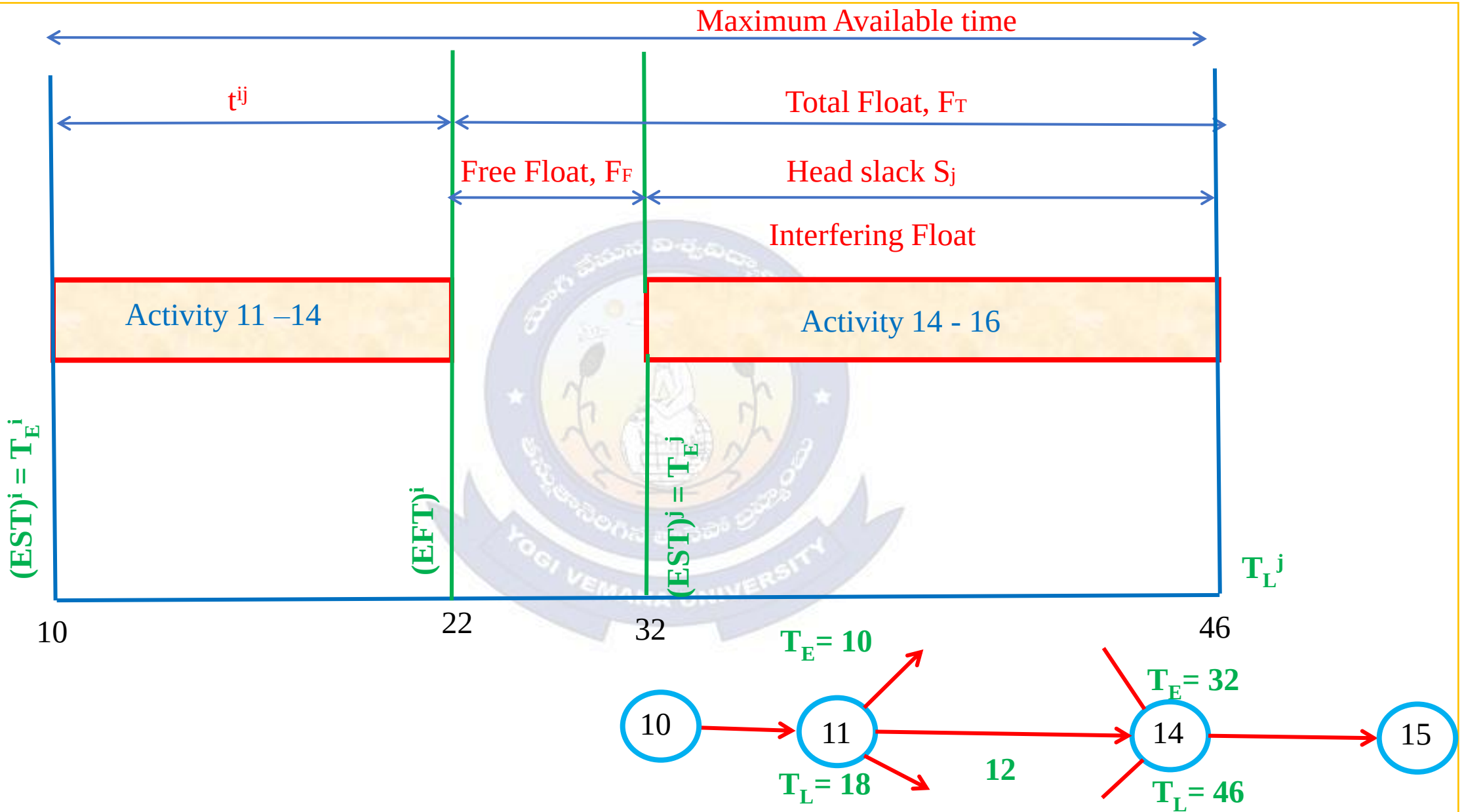

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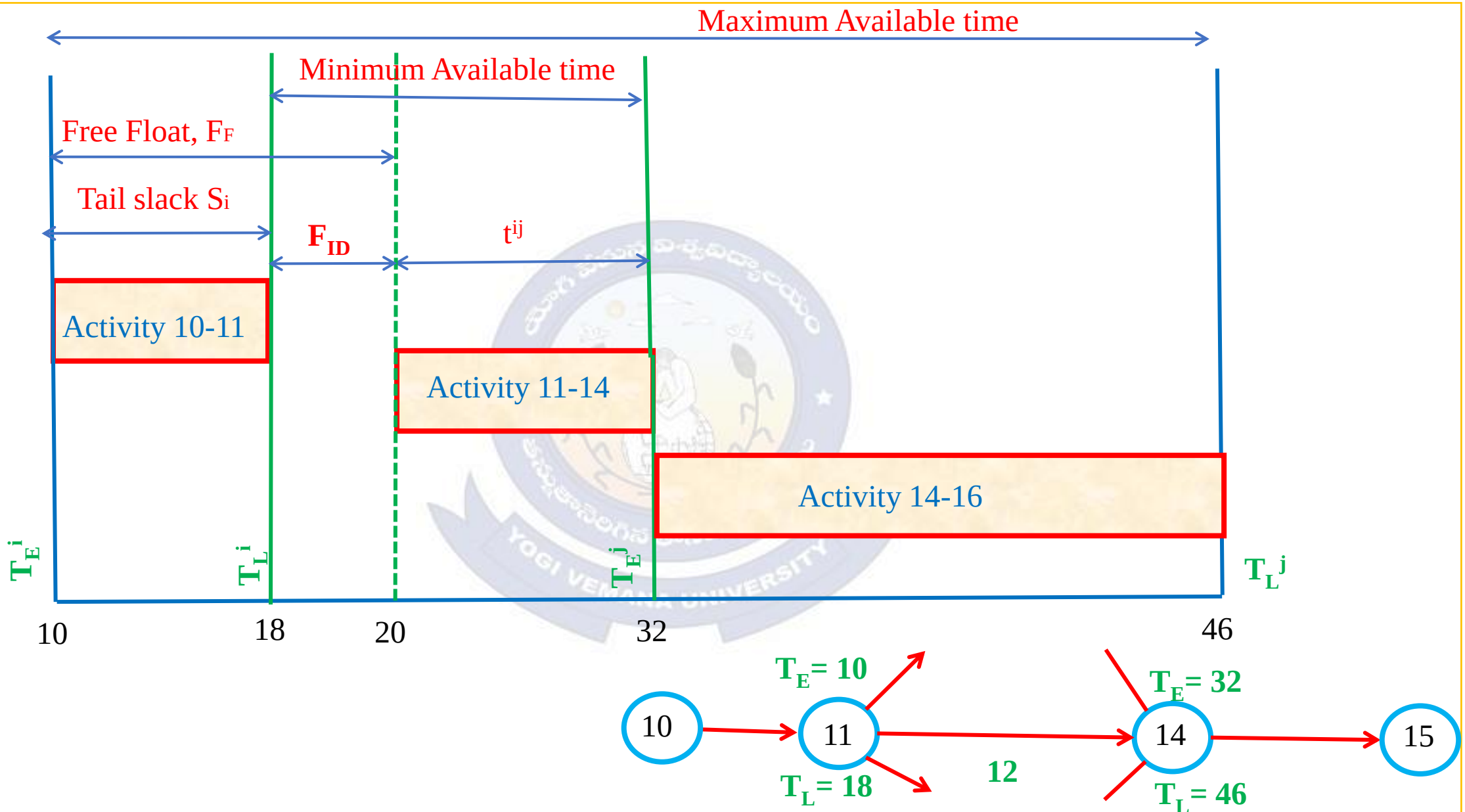

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2. Free Float

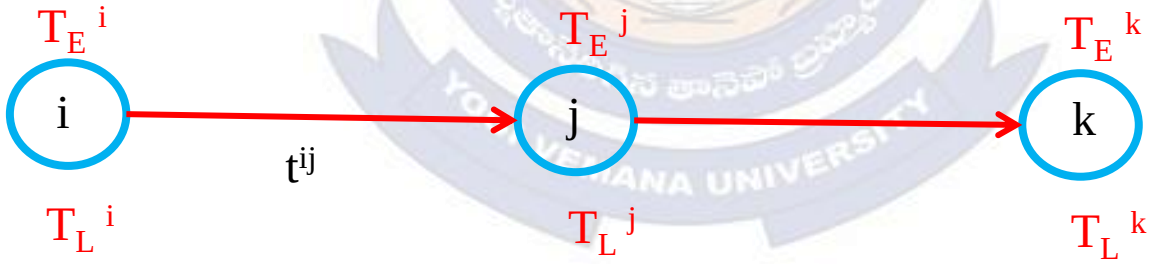
- It is defined as the amount of time by which an activity can be delayed without affecting the EST of succeeding activity.
- It is that portion of total float that can be used by an activity without delaying any succeeding activity.

Free Float for i-j $F_F = T_E^{\ j} - (T_E^{\ i} + t^{ij})$

F_F = EST of successor activity (j-k) – activity EFT of present Activity i – j

$F_F = F_T - S_j$

where. S_j = slack for event or slack of head event of activity i-j



- Free float is the amount of time an activity can be delayed without affecting the commencement of a subsequent activity at its EST, but may affect the float of a previous activity.

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3. Independent Float

- It 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 started as early as possible.
- Independent float is the excess of minimum available time over the required activity duration.
- If activity c-d is under consideration, and activity b-c finish as its latest possible time T_L^i and succeeding activity j-k start at its earliest time T_E^j

  Difference between $(T_E^j - T_L^i)$ and t^{ij} is known as Independent float for activity i-j

  Independent float for i-j,

$$F_{ID} = (T_E^j - T_L^i) - t^{ij}$$

$$F_{ID} = F_F - S_i$$

where S_i is the slack for event i or slack for tail event of activity i – j

- Independent float doesnot affect the float of preceding and the succeeding activities

4. Interfering Float (F_{IT})

- It is defined as difference of Total float and free float of an activity
- It is also equal to the slack of head event of head activity as shown below

$$F_{IT} = F_T - F_F$$

$$F_{IT} = T_L{}^j - T_E{}^j$$

$$F_{IT} = S_j$$

SUPER CRITICAL, CRITICAL AND SUBCRITICAL ACTIVITIES

The most important type of float is total float because it is involved with the overall project duration.

The total float is the difference between maximum available time and the activity duration.

1. Negative Total Float (F_T <0)

- If the maximum available time for an activity is less the activity time, the total float will be a negative value.
- Such activities demands special attention because available time is less than required time and hence these are termed as supercritical activities.
- For such activities activity time are adjusted by deploying extra resources such that total float either becomes zero or positive, from the original negative value

2. Total Float Zero ($F_T = 0$)

- If the maximum available time for an activity is equal to the activity time then for this activity total float will be zero.
- Activities for which total float is equal to zero is known as critical activity, because such activity demands above normal attention with no freedom of delay.

3. Total float positive ($F_T > 0$)

- If the maximum available time for an activity is more than the activity time, then for this activity total float will have positive value.
- Activity for which total float is positive is known as subcritical activity. Demanding normal attention but allowing some Critical path:

Critical path:

- Critical path is the longest path time wise in a project.
- Project duration is the total time along the critical path.
- In CPM, critical path passes through the critical activities i.e. activities having total float equal to zero.

PERT and CPM

Previous GATE Questions

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01. For a construction project, the mean and standard deviation of the completion time are 200 days and 6.1 days, respectively. Assume normal distribution and use the value of standard normal deviate z=1.64 for the 95% confidence level. The maximum time required (in days) for the completion of the project would be CE2 2017

Ans. 210

Mean completion time, T_E= 200 days

Standard deviation of completion time, σ = 6.1 days

Standard normal variate z=1.64 for 95% confidence level.

Maximum time required for completion of project, T_S=?

$$Z = \frac{T_S - T_E}{\sigma}$$

$$1.64 = \frac{T_S - 200}{6.1} \Rightarrow T_S = 210 \; days$$

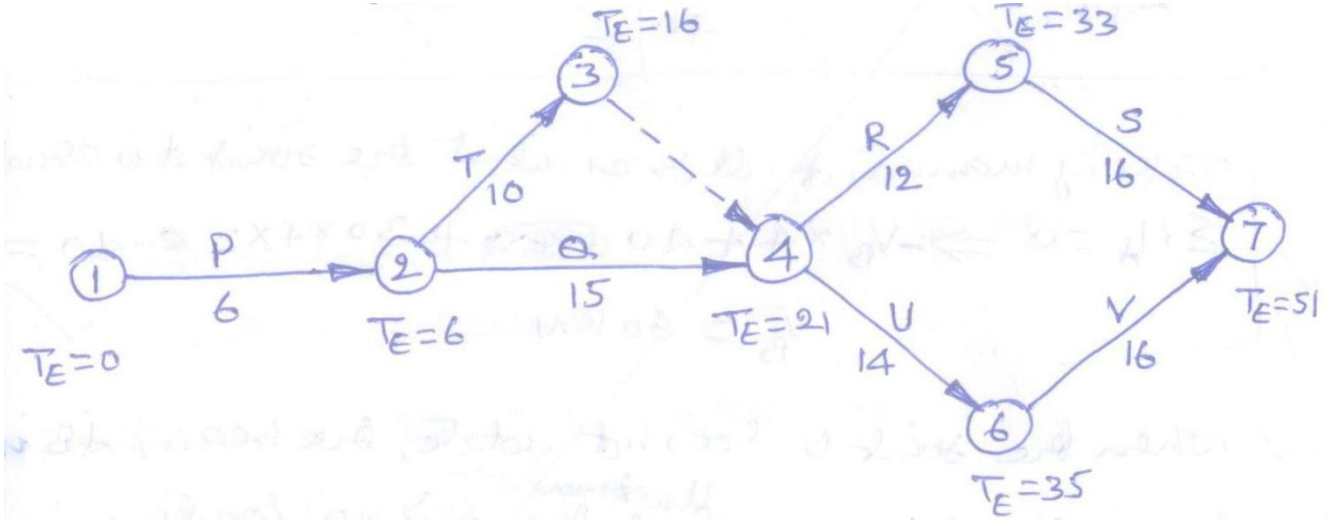
03. The activity details of a project are given below CE1 2017

Activity	Depends on	Duration (in days)
P	-	6
Q	P	15
R	Q.T	12
S	R	16
T	P	10
U	Q.T	14
V	U	16

The estimated minimum time (in days) for the completion of the project will be …….

Ans. 51

The Activity on Arrow (AOA) diagram for the activity details of project is shown in fig.



Critical path: 1-2-4-6-7

Estimated minimum time for completion of the project =6+15+14 + 16 = 51 days

Time along path 1-2-4-5-7 = 6 + 15 + 12 + 16 = 49 days

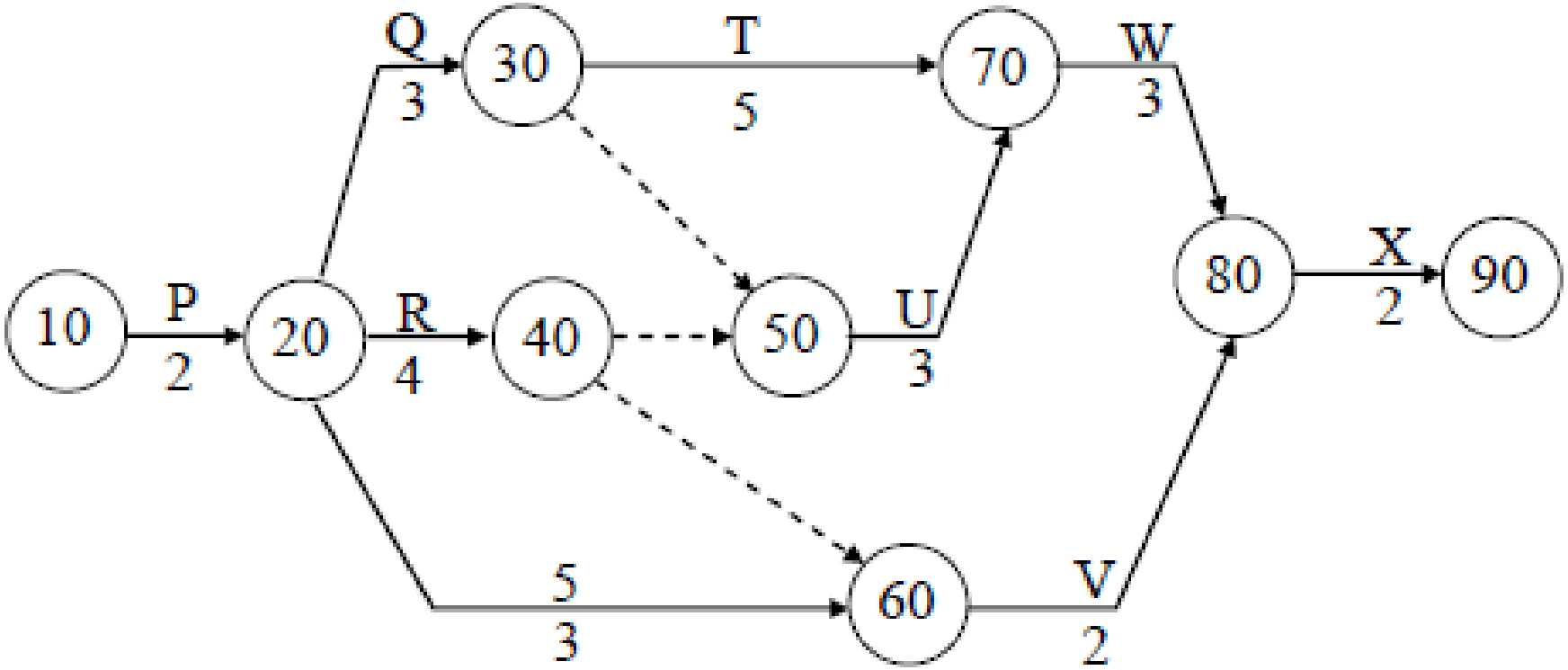
Time along path 1-2-3-4-6-7 = 6+10+0+14+16 = 46 days

Time along path 1-2-4-6-7 = 6 + 15 + 14 + 16 = 51 days

Minimum time for the completion of project = 51 days

04. The activity-on-arrow network of activities for a construction project is shown in figure. The durations (expressed in days) of the activities are mentioned below the arrows.

CE2 2016



The critical duration for this construction project is

a. 13 days b. 14 days **c.** 15 days d. 16 days

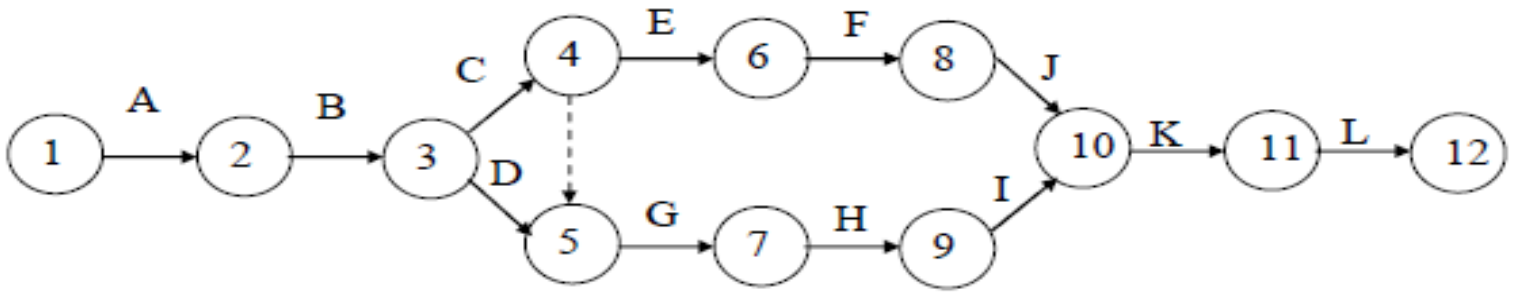
Ans. c

Path	Duration
P-Q-T-W-X	2+3+5+3+2=15
P-Q-Dummy-U-W-X	2+3+0+3+3+2=13
P-R-Dummy-U-W-X	2+4+0+3+3+2=14
P-R-Dummy-V-X	2+4+0+2+2=10
P-S-V-X	2+3+2+2=9

Critical path duration = 15 days

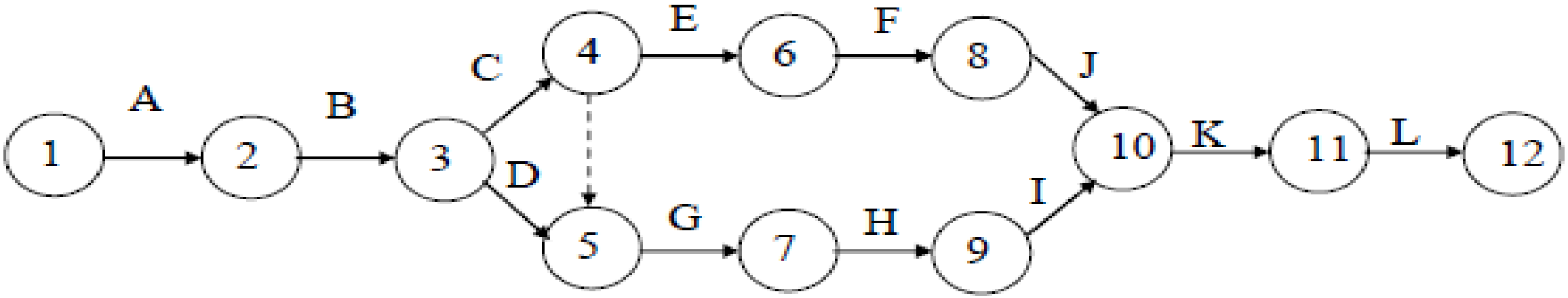
05. A construction project consists of twelve activities. The estimated duration (in days) required to complete each of the activities along with the corresponding network diagram is shown below. CE2 2016

	Activity	Duration (days)		Activity	Duration (days)
A	Inauguration	1	G	Flooring	25
B	Foundation work	7	H	Electrification	7
C	Structural construction-I	30	I	Plumbing	7
D	Structural construction-2	30	J	Wood work	7
E	Brick masonry work	25	K	Coloring	3
F	Plastering	7	L	Handing over function	1



Total floats (in days) for the activities 5-7 and 11-12 for the project are, respectively

a. 0.25 and 1 b. 1 and 1 **c.** 0 and 0 d. 81 and 0



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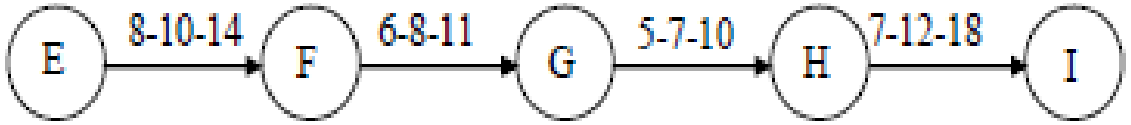
Ans. c

Path	Duration
A-B-C-E-F-J-K-L	1+7+30+25+7+7+3+1=81
A-B-C-Dummy-G-H-I-K-L	1+7+30+0+25+7+7+3+1=81
A-B-D-G-H-I-K-L	1+7+30+25+7+7+3+1=81

All the possible paths are critical and all activities are critical. Hence, total floats of activities 5-7 and 11-12 are 0 and 0 respectively.

06. The Optimistic Time (O), Most likely Time (M) and Pessimistic Time (P) (in days) of the activities in the critical path are given below in the format O-M-P. CE1 2016



The expected completion time (in days) of the project is …..

Ans. 38

$\boxed{E}\ 8-10-14\ \boxed{F}\ 6-8-11\ \boxed{G}\ 5-7-10\ \boxed{H}\ 7-12-18\ \boxed{I}$

Activity	**Expected completion time** $t_E = \frac{t_0 + 4t_m + t_p}{6}$
E-F	$\frac{8+4(10)+14}{6} = 10.33$
F-G	$\frac{6+4(8)+11}{6} = 8.16$
G-H	$\frac{5+4(7)+10}{6} = 7.16$
H-I	$\frac{7+4(12)+18}{6} = 12.16$
Expected completion time of the project	$37.81 \lfloor$ 38 days

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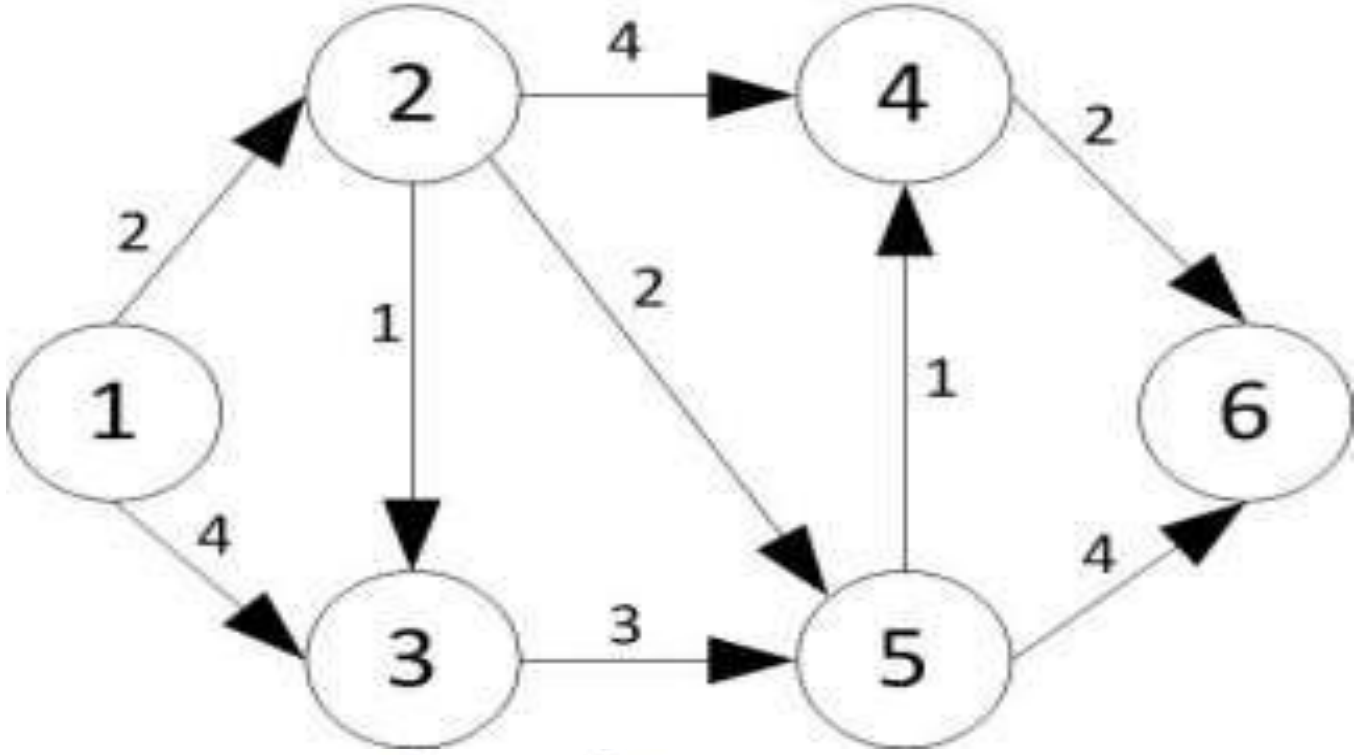
01. The arc lengths of a directed graph of a project are as shown in the figure. The shortest path length from node 1 to node 6 is _____. ME2 2018



Ans. 7 to 7 (or) 11 to 11

1. path length along

$$1-2-4-6=2+4+2=8$$

$$1-2-3-5-6=2+1+3+4=10$$

$$1-2-3-5-4-6=2+1+3+1+2=9$$

$$1-2-5-6=2+2+4=8$$

$$1-2-5-4-6=2+2+1+2=7$$

$$1-3-5-6=4+3=4=11$$

$$1-3-5-4-6=4+3+1+2=10$$

Shortest path length $=7$ *or* 11

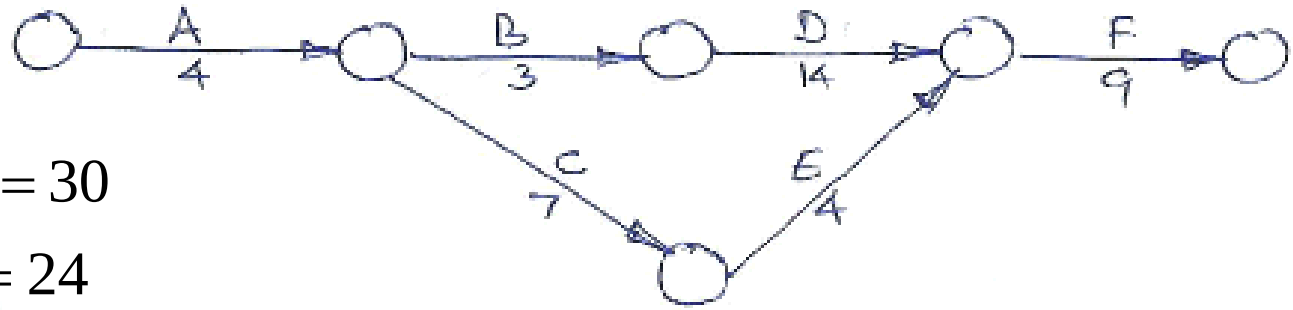
02. A project starts with activity A and ends with activity F. The precedence relation and durations of the activities are as per the following table. ME 2017

Activity	Immediate predecessor	Duration (days)
A	-	4
B	A	3
C	A	7
D	B	14
E	C	4
F	D,E	9

The minimum project completion time (in days) is…..

Ans. 30

2.



Expected time along

$path\ A-B-D-F = 4+3+14+9 = 30$

$path\ A-C-E-F = 4+7+4+9 = 24$

Hence critical path is along $A-B-D-F$

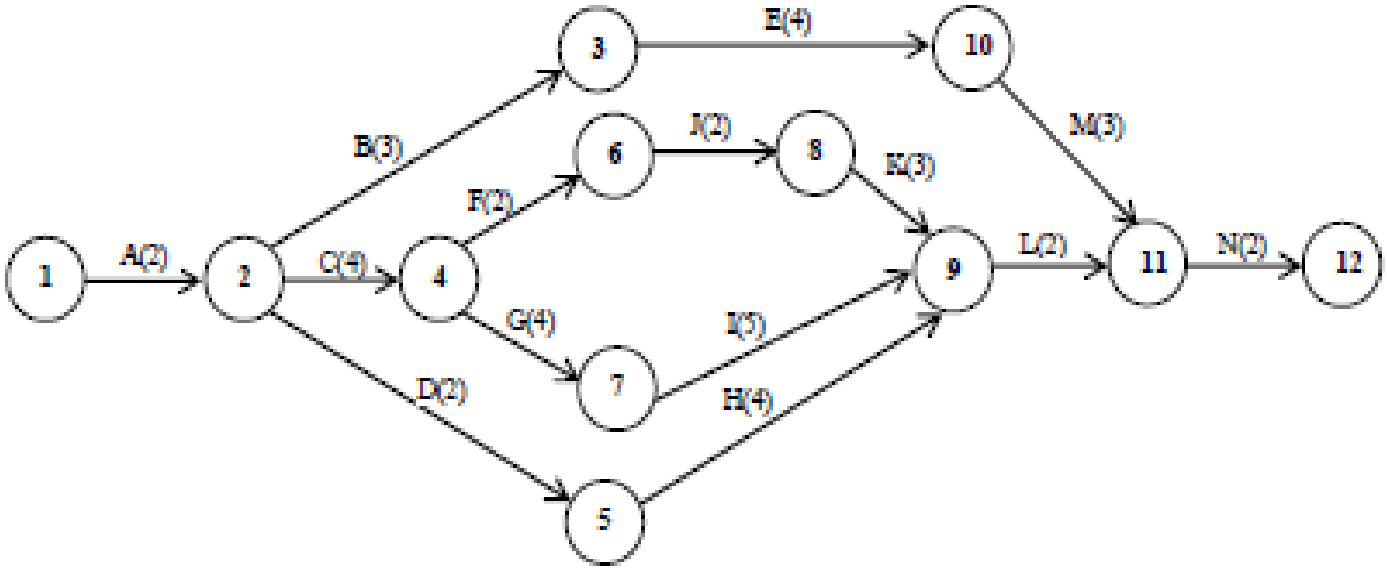
Minimum project completion time = 30 days

03. In PERT chart, the activity time distribution is ME3 2016

a. Normal b. Binomial c. Poisson **d.** Beta

Ans. d

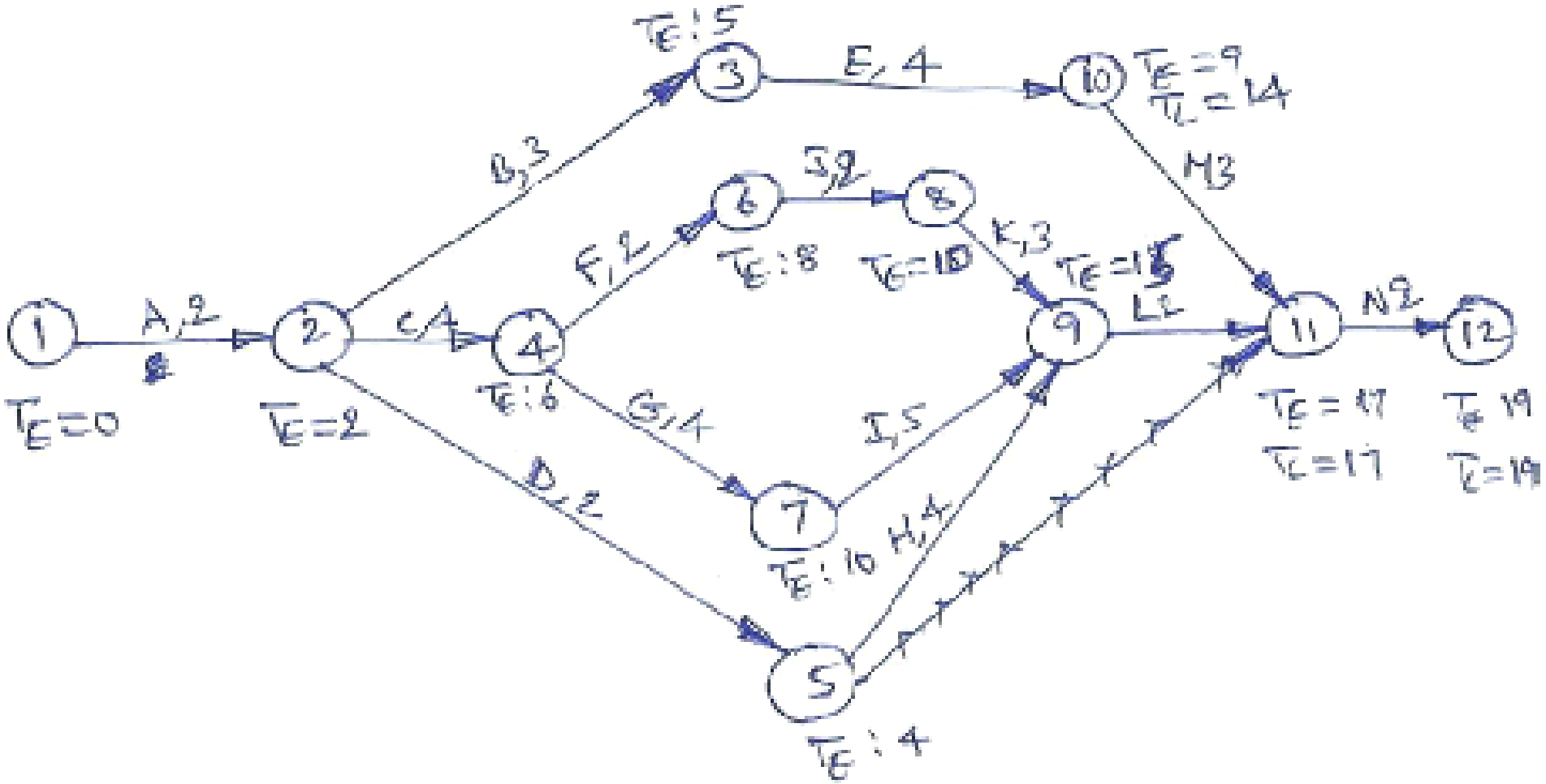
04. A project consists of 14 activities, A to N. The duration of these activities (in days) are shown in brackets on the network diagram. The latest finish time (in days) for node 10 is _____ ME2 2016



Ans. 14 to 14

04.

Latest finish time for node 10 = 14



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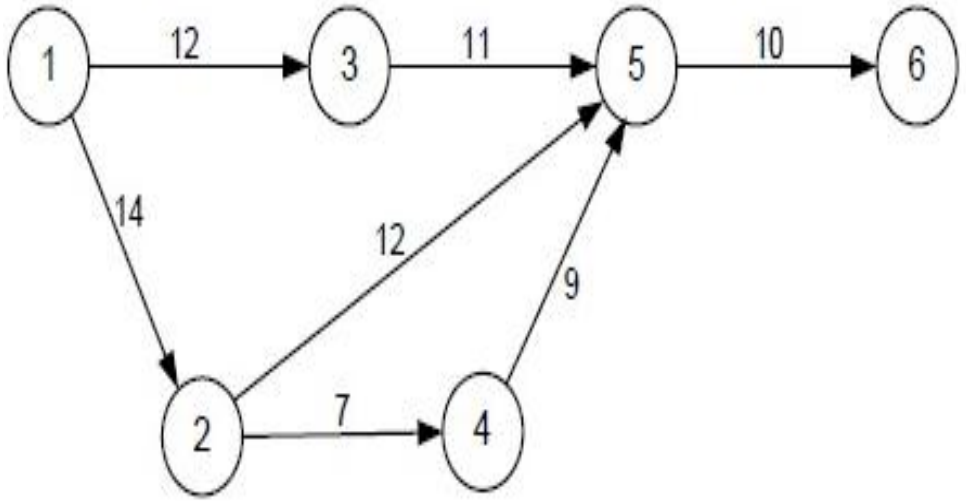
05. A project consists of 7 activities. The network along with the time durations (in days) for various activities is shown in the figure ME 2015



The minimum time (in days) for completion of the project is ……

Ans. 39 to 40

05.

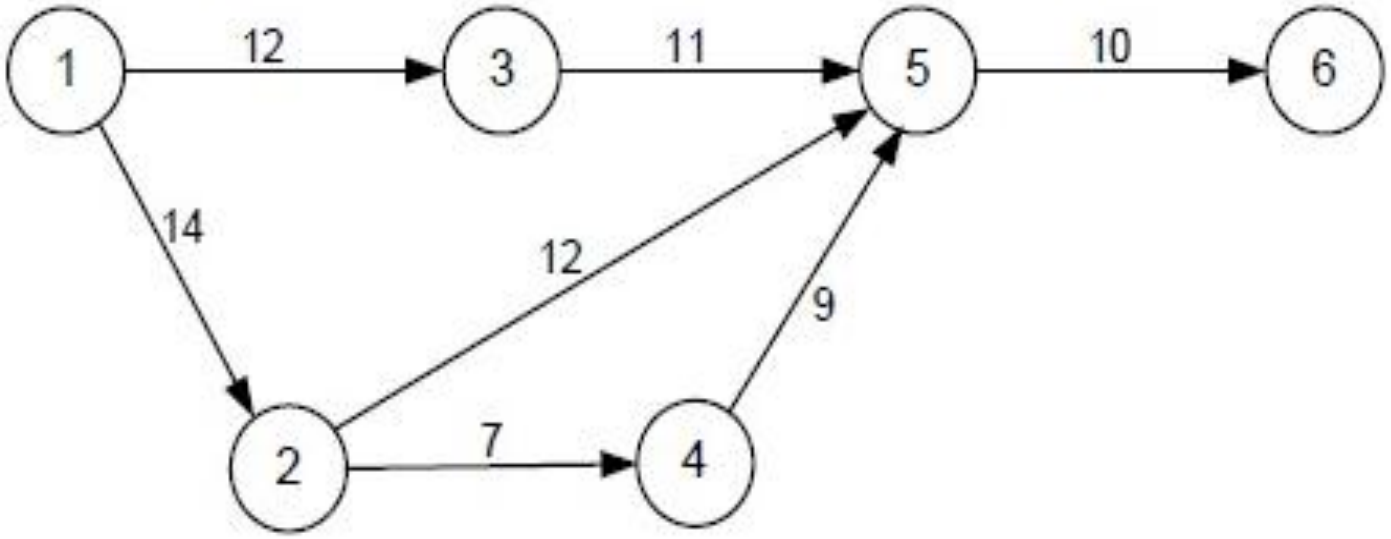
Expected time along $path\ 1-3-5-6 = 12+11+10 = 33$

$path\ 1-2-5-6 = 14+12+10 = 36$

$path\ 1-2-4-5-6 = 14+7+9+10 = 40$

$The\ critical\ \ path\ is\ along\ 1-2-4-5-6$

Minimum project duration = 40 days



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06. Following data refers to the activities of a project, where, node 1 refers to the start and node 5 refers to the end of the project. ME 2015

Activity	Duration (Days)
1-2	2
2-3	1
4-3	3
1-4	3
2-5	3
3-5	2
4-5	4

The critical path (CP) in the network is

a. 1, 2, 3, 5 **b.** 1, 4, 3, 5 c. 1, 2, 3, 4, 5 d. 1, 4, 5

Ans. b

06.

Expected time along

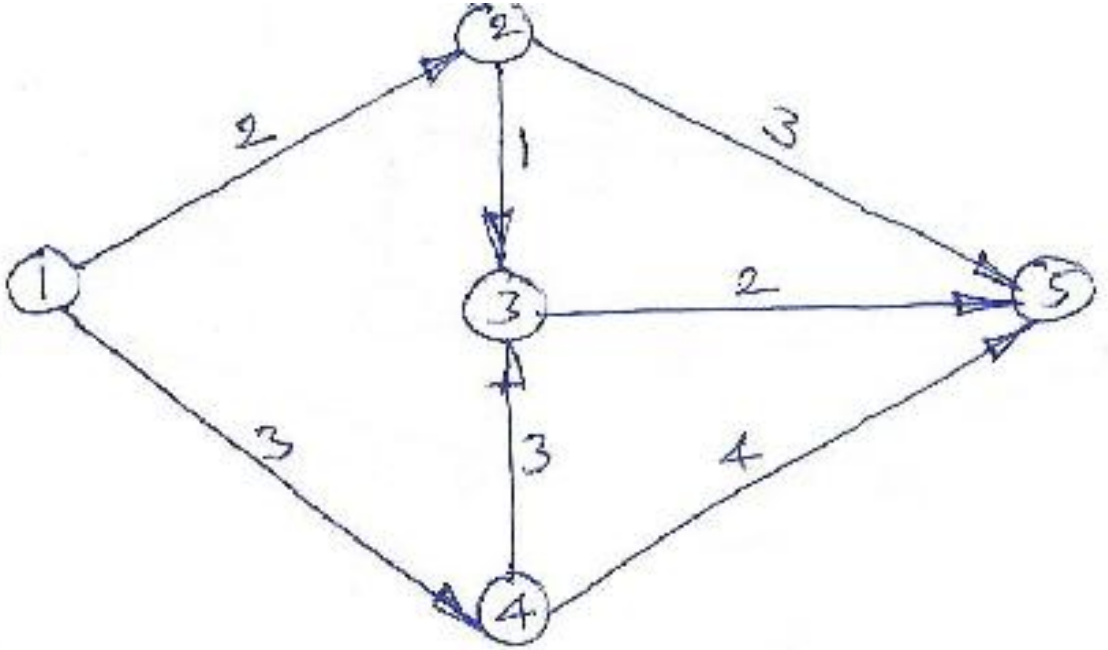
$$path\ 1-2-5=2+3=5$$

$$path\ 1-2-3-5=2+1+2=5$$

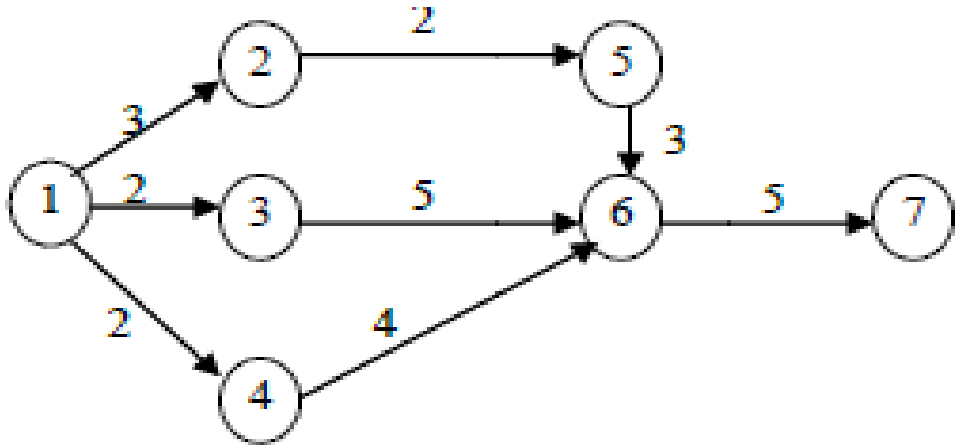
$$path\ 1-4-5=3+4=7$$

$$path\ 1-4-3-5=3+3+2=8$$

$$Critical\ \ path\ is\ along\ 1-4-3-5$$



07. Consider the given project network, where numbers along various activities represent the normal time. The free float on activity 4-6 and the project duration, respectively, are ME3 2014



a. 2,13 b. 0,13 c. -2,13 d. 2,12

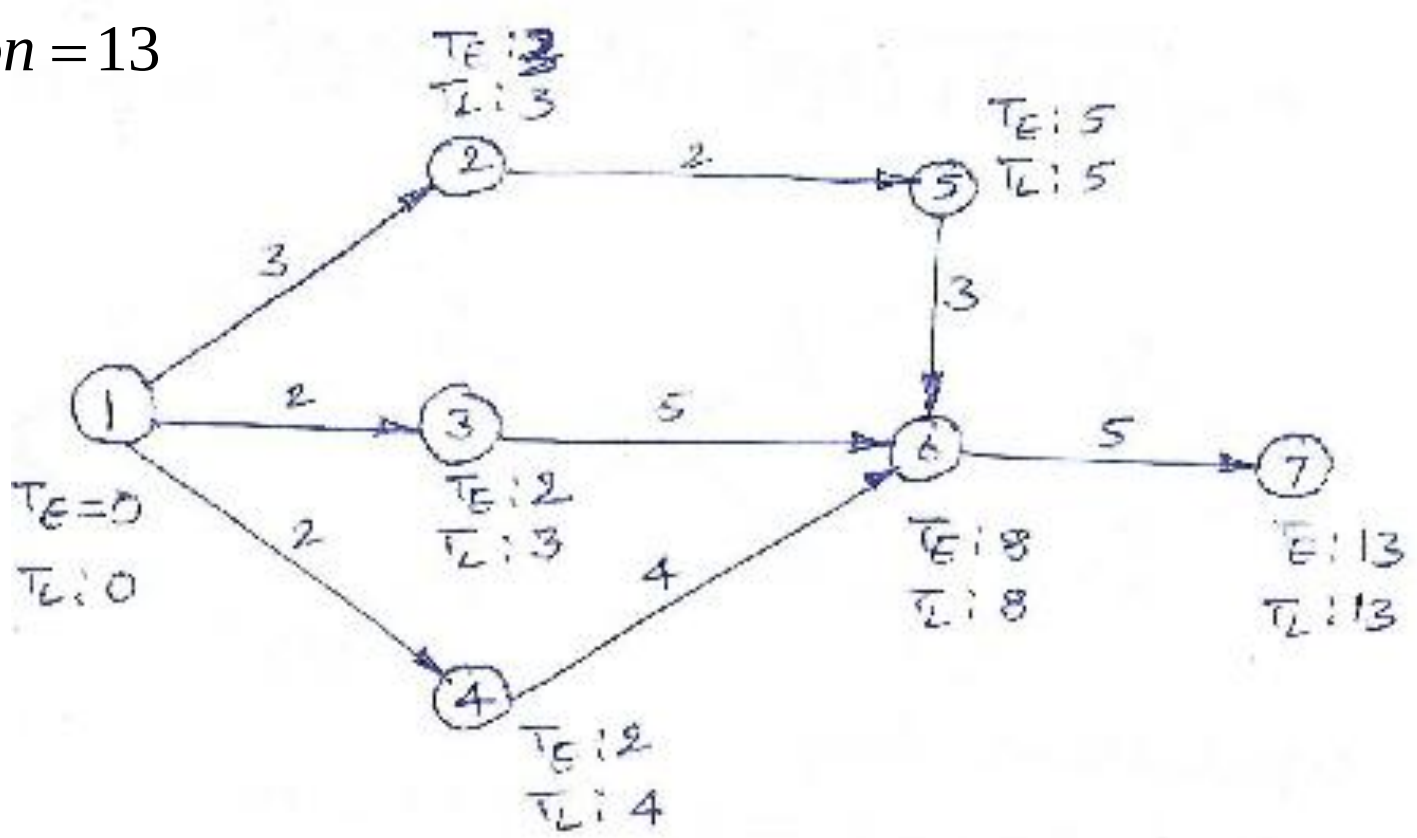
Ans. a

07.

$$Free\ float, F_T = \left(T_E^j - T_E^i\right) - t_{ij}$$

$$Free\ float\ for\ 4-6, F_t = 8-2-4 = 2$$

$$Total\ project\ duration = 13$$



Linked Answer Questions 09 and 10

For a particular project, eight activities are to be carried out. Their relationships with other activities and expected durations are mentioned in the table.

Activity	Predecessors	Duration (days)
a	-	3
b	a	4
c	a	5
d	a	4
e	b	2
f	d	9
g	c, e	6
h	f, g	2

09. The critical path for the project is ME 2012

a. a-b-e-g-h b. a-c-g-h **c**. a-d-f-h d. a-b-c-f-h

Ans. c

Activity	Predecessors	Duration (days)
a	-	3
b	a	4
c	a	5
d	a	4
e	b	2
f	d	9
g	c, e	6
h	f, g	2

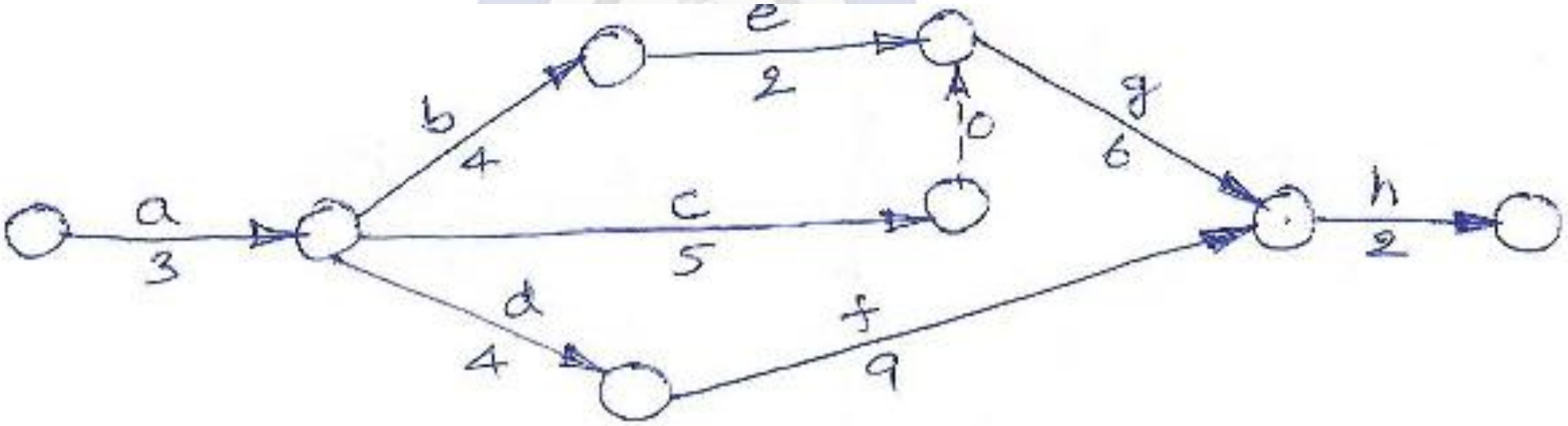
09.

Expected time along $path\ a-b-e-g-h=3+4+2+6+2=17$

$path\ a-c-0-g-h=3+5+6+2=16$

$path\ a-d-f-h=3+4+9+2=18$

$Critical\ \ path\ of\ the\ project: a-d-f-h$



10. The critical path for the project is ME 2012

a. Critical path remains the same and the total duration to complete the project changes to 19 days.

b. Critical path and the total duration to complete the project remains the same.

c. Critical path changes but the total duration to complete the project remains the same.

d. Critical path changes and the total duration to complete the project changes to 17 days.

Ans. a

13.

Expected time along

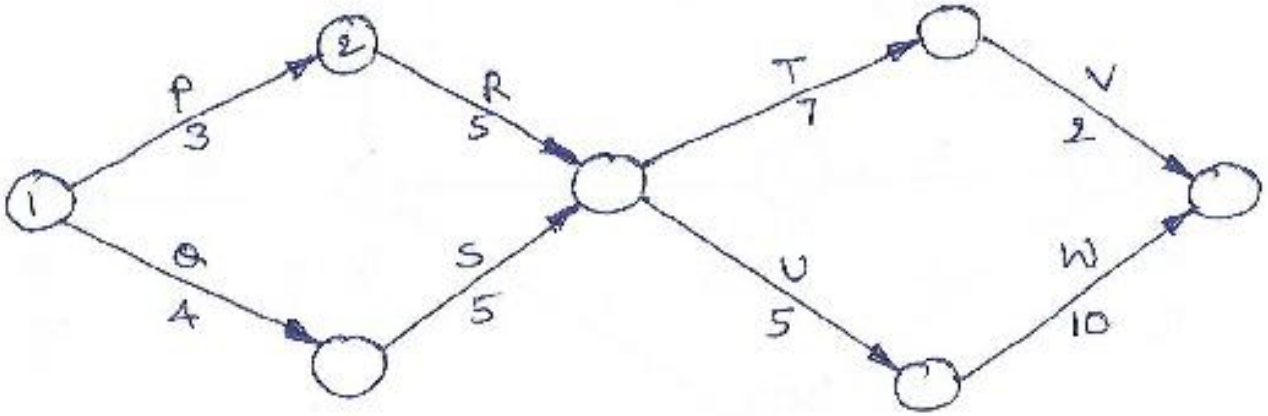
$path\ P-R-T-V=3+5+7+2=17$

$path\ P-R-U-W=3+5+5+10=23$

$path\ Q-S-T-V=4+5+7+2=18$

$path\ Q-S-U-W=4+5+5+10=24$

$Critical\ \ path\ of\ \ the\ project: Q-S-U-W$



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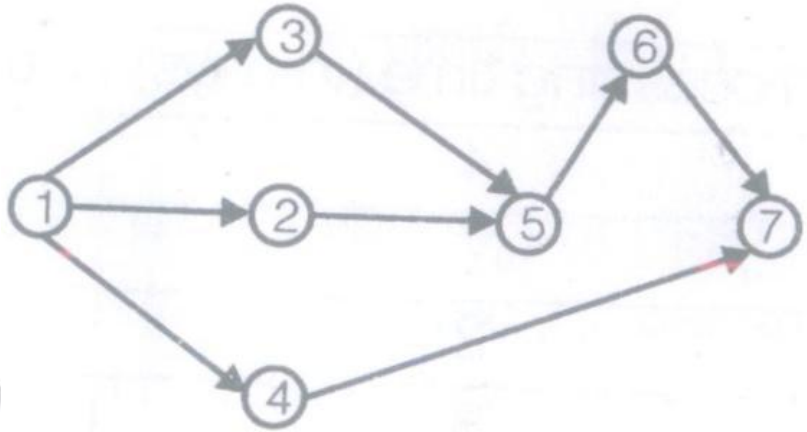
Common data for questions 14 and 15

Consider the following PERT network.

The optimistic time, most likely time and pessimistic time of all the activities are given in the table below:

Activity	Optimistic time (Days)	Most likely Time (days)	Pessimistic Time (days)
1-2	1	2	3
1-3	5	6	7
1-4	3	5	7
2-5	5	7	9
3-5	2	4	6
5-6	4	5	6
4-7	4	6	8
6-7	2	3	4



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14. The critical path duration of the network (in days) is ME 2009

a. 11 b. 14 c. 17 **d**. 18

Ans. d

14. $Expected\ time, t_e = \frac{t_0 + 4t_m + t_p}{6}$

Expected time along

$path\ 1-3-5-6-7 = 6+4+5+3 = 18$

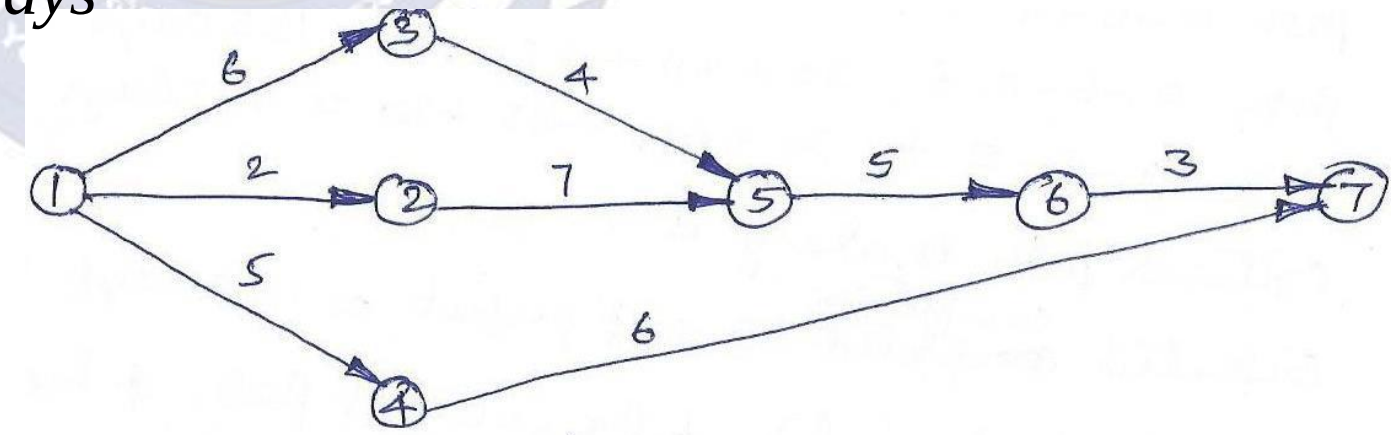
$path\ 1-2-5-6-7 = 2+7+5+3 = 17$

$path\ 1-4-6 = 5+6 = 11$

$the\ critical\ path\ is\ along\ 1-3-5-6-7$

$Critical\ \ path\ duration = 18\ days$

Activity	t_0	t_m	t_p	t_e
1-2	1	2	3	2
1-3	5	6	7	6
1-4	3	5	7	5
2-5	5	7	9	7
3-5	2	4	6	4
5-6	4	5	6	5
4-7	4	6	8	6
6-7	2	3	4	3



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15. The standard deviation of the critical path is ME 2009

a. 0.33 b. 0.55 **c**. 0.88 d. 1.66

Ans. C

15. Standard deviation of critical path,

$$\sigma = \sqrt{\sigma_{13}^2 + \sigma_{35}^2 + \sigma_{56}^2 + \sigma_{67}^2}$$

$$\sigma = \sqrt{\left(\frac{7-5}{6}\right)^2 + \left(\frac{6-2}{6}\right)^2 + \left(\frac{6-4}{6}\right)^2 + \left(\frac{4-2}{6}\right)^2} = 0.882$$

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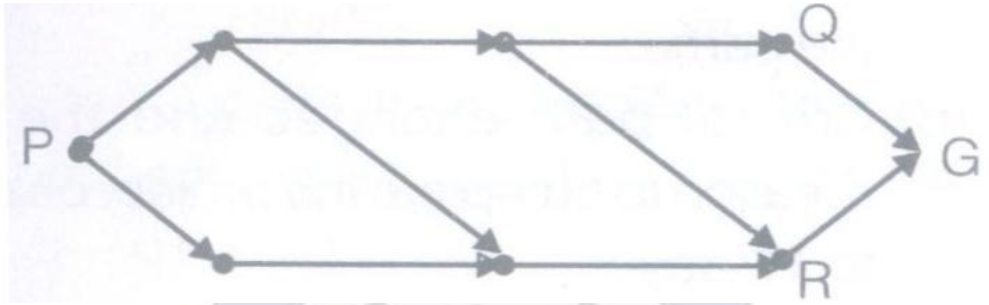
17. The expected time (t_e) of a PERT activity in terms of optimistic time (t_o), pessimistic time (t_p) and most likely time (t_l) is given by ME 2009

a. $t_e = \frac{t_0 + 4t_l + t_p}{6}$ b. $t_e = \frac{t_0 + 4t_p + t_l}{6}$ c. $t_e = \frac{t_0 + 4t_l + t_p}{3}$ d. $t_e = \frac{t_0 + 4t_p + t_l}{6}$

Ans. a

18. For the network below, the objective is to be find the length of the shortest path from node P to node G. Let be the length of directed arc from node i to node j.



Let S_j be the length of the shortest path from P to node j. Which of the following equations can be used to find S_G? ME 2008

a. $S_G = \text{Min}\{S_Q, S_R\}$

b. $S_G = \text{Min}\{S_Q - d_{QG}, S_R - d_{RG}\}$

c. $S_G = \text{Min}\{S_Q + d_{QG}, S_R + d_{RG}\}$

d. $S_G = Min\{d_{QG}, d_{RG}\}$

Ans. c

Linked answer questions 20 and 21

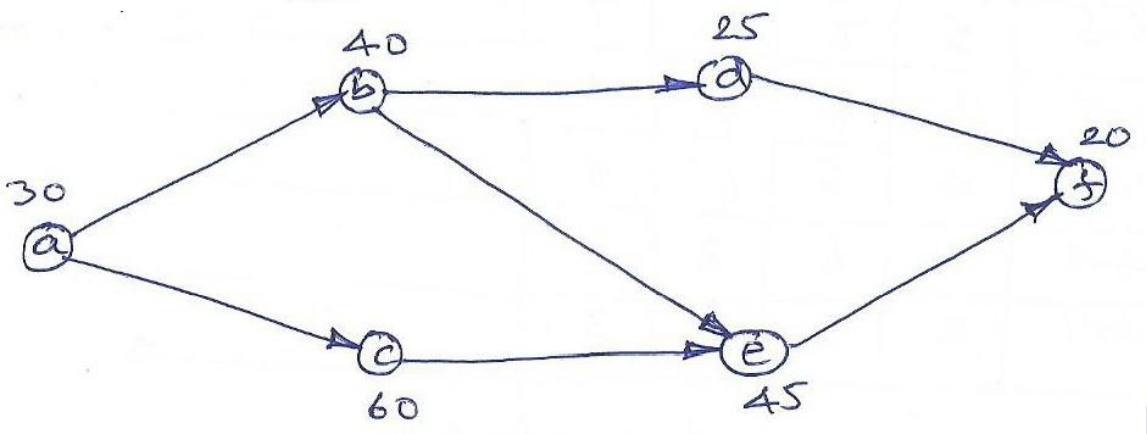
Consider a PERT network for a project involving six tasks (a to f)

Task	Predecessor	Expected task time (in days)	Variance of the task time (in days^2)
a	-	30	25
b	a	40	64
c	a	60	81
d	b	25	9
e	b,c	45	36
f	d,e	20	9

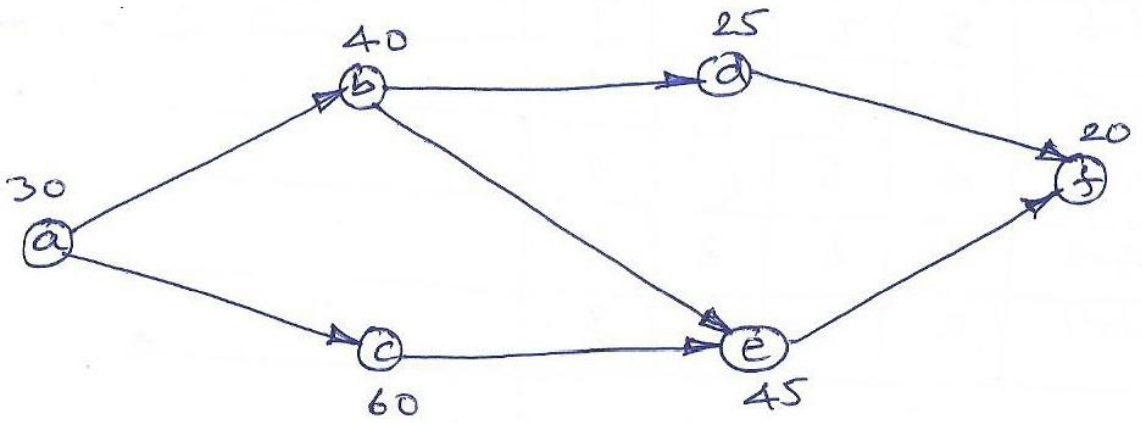
20. The expected completion time of the project is ME 2006

a. 238 days b. 224 days c. 171 days **d**. 155 days

Ans. d



9. The PERT network is shown in fig.



Expected task time along

$$path\ a-b-d-f: 30+40+25+20=115\ days$$

$$path\ a-b-e-f: 30+40+45+20=135\ days$$

$$path\ a-c-e-f: 30+60+45+20=155\ days$$

$$critical\ \ path\ is\ along\ \ a-c-e-f$$

$$Expected\ completion\ time\ of\ \ project=155\ days$$

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21. The standard deviation of the critical path of the project is ME 2006

a. $\sqrt{151}$ days b. $\sqrt{155}$ days c. $\sqrt{200}$ days d. $\sqrt{238}$ days

Ans. a

10.Standard deviation of the critical path of the project,

$$\sigma = \sqrt{\sigma_a^2 + \sigma_c^2 + \sigma_e^2 + \sigma_f^2}$$

$$= \sqrt{25 + 81 + 36 + 9} = \sqrt{151} \text{ days}$$

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22. A project has six activities (A to F) with respective activity durations 7, 5, 6, 6, 8, 4 days. The network has three path A-B-C-D and E-F. All the activities can be crashed with the same crash cost per day. The number of activities that need to be crashed to reduce the project duration by 1 day is ME 2005

a. 1 b. 2 **c.** 3 d. 6

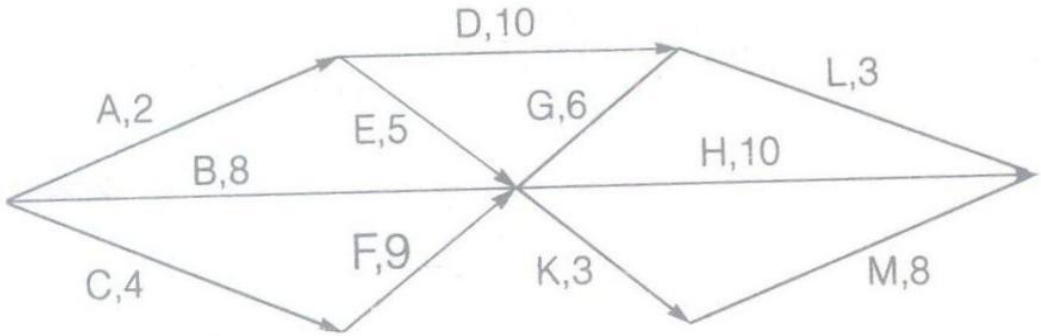
Ans. c

24. In PERT analysis a critical activity has ME 2004

a. maximum float **b**. zero float c. maximum cost d. minimum cost

Ans. b

25. A project consists of activities A to M shown in the net in the following figure with the duration of the activities marked in days. ME 2003



The project can be completed

a. between 18, 19 days
b. between 20, 22 days
c. between 24, 26 days
d. between 60, 70 days

Ans. c

27. A dummy activity is used in PERT network to describe ME 1997

a. precedence relationship b. necessary time delay

c. resource restriction d. resource idleness

28. In PERT, the distribution of activity times is assumed to be ME 1995

a. Normal b. Gamma **c**. Beta d. Exponential

Ans. c

29. In the construction of networks, dummy activities are introduced in order to

ME 1990

a. Compute the slack on all events
b. Transfer resources, if necessary, during monitoring
c. Clearly designate a precedence relationship
d. Simplify the crashing plan

Ans. c