Solutionbank D1

Edexcel AS and A Level Modular Mathematics

Exercise A, Question 1

Question:

The steps involved in starting a car and moving forwards in a straight line are given below.

A Check that car is in neutral.
B Start engine.
C Depress clutch.
D Select first gear.
E Check that it is safe to move off.
F Release the handbrake.
G Raise the clutch and depress the accelerator.

Draw a precedence table for this process.
(There is more than one possible solution.)

Solution:

One possible solution is:

Activity	Depends on
A	–
B	A
C	B
D	C
E	D
F	E
G	F

Another possible solution is:

Activity	Depends on
A	–
B	A
C	–
D	B, C
E	D
F	E
G	F

You can start the engine with the clutch depressed.

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Exercise A, Question 2

Question:

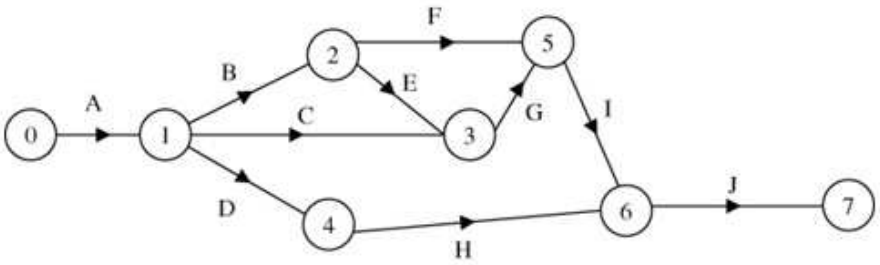
The development of a commercial computer program is divided into activities A to J.
Activity A does not depend on any other activity.
Activities B, C and D all require that Activity A is completed before they can start.
Activities E and F depend on activity B.
Activity G cannot be started until activities C and E have been completed.
Activity H requires the completion of activity D, while activity I requires that both activities F and G are completed first.
Activity J requires the completion of all activities before it may be started.

a Draw a precedence table to represent the development of the computer program.

b Use the precedence table to draw the corresponding activity network.

Solution:

Activity	Depends on
A	–
B	A
C	A
D	A
E	B
F	B
G	C, E
H	D
I	F, G
J	H, I



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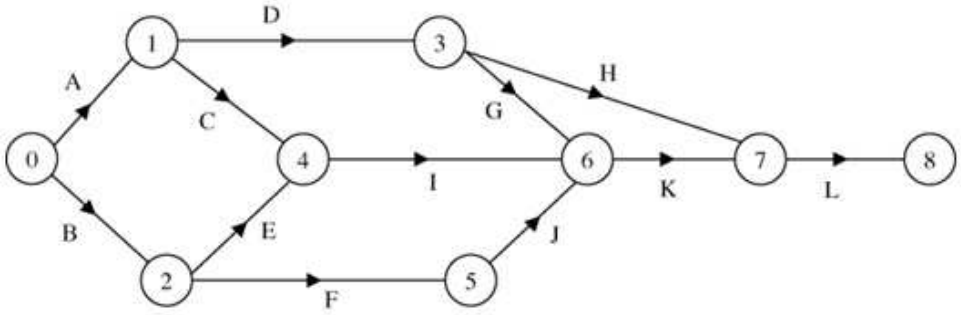
Exercise A, Question 3

Question:

The precedence table for a project is shown below.
Draw the corresponding activity network.

Activity	Depends on
A	—
B	—
C	A
D	A
E	B
F	B
G	D
H	D
I	C, E
J	F
K	G, I, J
L	H, K

Solution:



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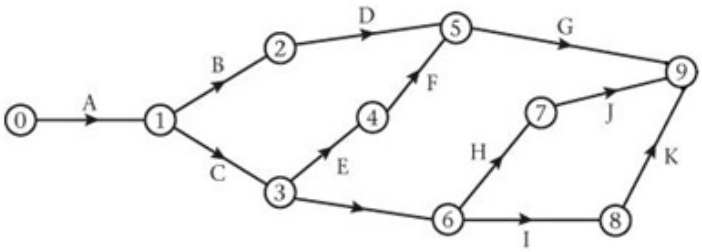
Exercise A, Question 4

Question:

Here is an activity network for a project.



Draw a precedence table to represent the project.

Solution:

Activity	Depends on
A	–
B	A
C	A
D	B
E	C
F	E
G	C
H	D, F
I	G
J	H
K	I
L	J

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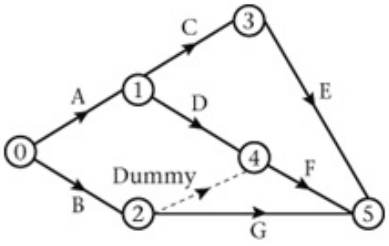
Exercise B, Question 1

Question:

Draw the precedence table for this activity network.



Explain the purpose of the dummy.

Solution:

Activity	Depends on
A	–
B	–
C	A
D	A
E	C
F	B, D
G	B

The dummy shows that activity F depends on activities B and D, whereas activity G only depends on activity B.

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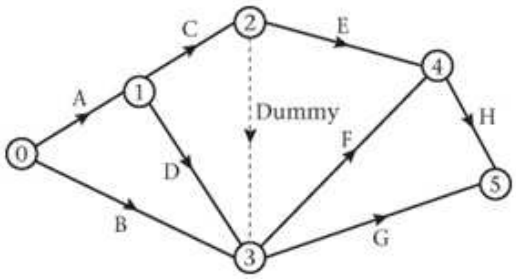
Exercise B, Question 2

Question:

This activity network contains a dummy.



Draw a precedence table for the network.

Solution:

Activity	Depends on
A	–
B	–
C	A
D	A
E	C
F	B, C, D
G	B, C, D
H	E, F

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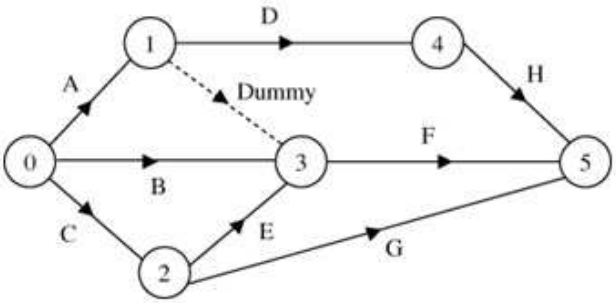
Exercise B, Question 3

Question:

Draw an activity on arc network to represent the precedence table below. Your network should contain exactly one dummy.

Activity	Must be preceded by
A	–
B	–
C	–
D	A
E	C
F	A, B, E
G	C
H	D

Solution:



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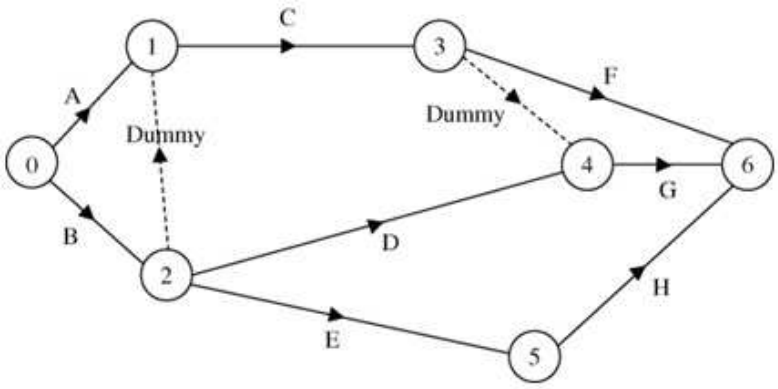
Exercise B, Question 4

Question:

Draw an activity on arc network to represent the precedence table below.
Your network should contain exactly two dummies.

Activity	Depends on
A	—
B	—
C	A, B
D	B
E	B
F	C
G	C, D
H	E

Solution:



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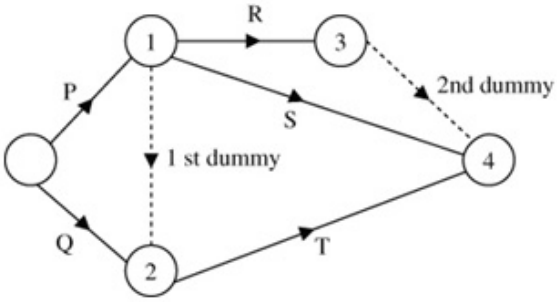
Exercise B, Question 5

Question:

Draw an activity on arc network for this precedence table using exactly two dummies.
Explain the purpose of each dummy.

Activity	Depends on
P	—
Q	—
R	P
S	P
T	P, Q

Solution:



1st dummy ②.
S depends on P only.
T depends on P and Q.

2nd dummy.
So that S and R don't share a start and end event.

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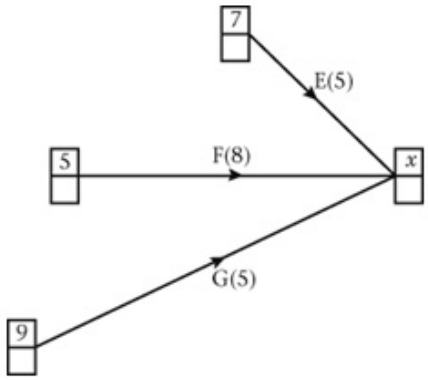
Exercise C, Question 1

Question:

The diagram shows part of an activity network.
Calculate the value of x.



Solution:

x is the largest of $7 + 5 = 12$, $5 + 8 = 13$ and $9 + 5 = 14$.
$x = 14$

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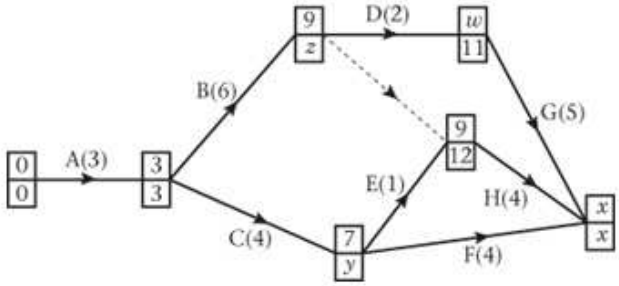
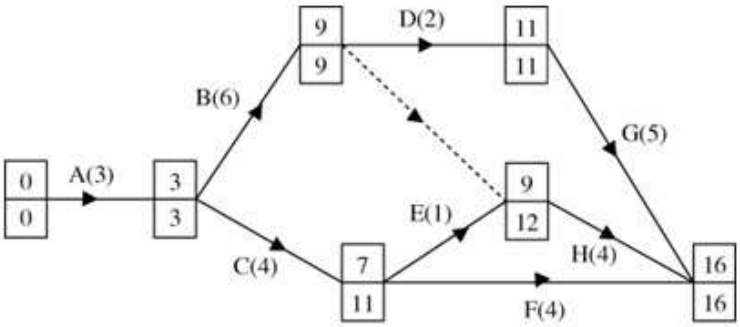
Exercise C, Question 2

Question:

The activity network for a project is given opposite.
The time in hours needed to complete each activity is shown in brackets.
Early and late times are shown at each vertex.
Calculate the values of w, x, y and z.



Solution:



$w = 11, x = 16, y = 11, z = 9$

w and x are found using a forward scan.
y and z are found using a backward scan.

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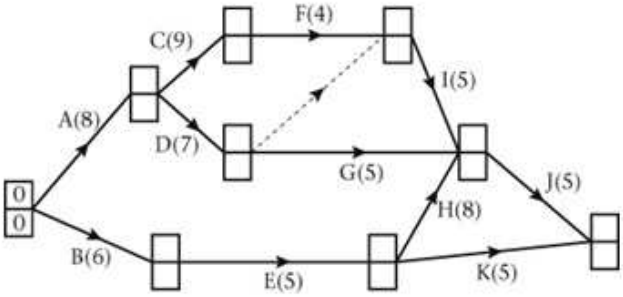
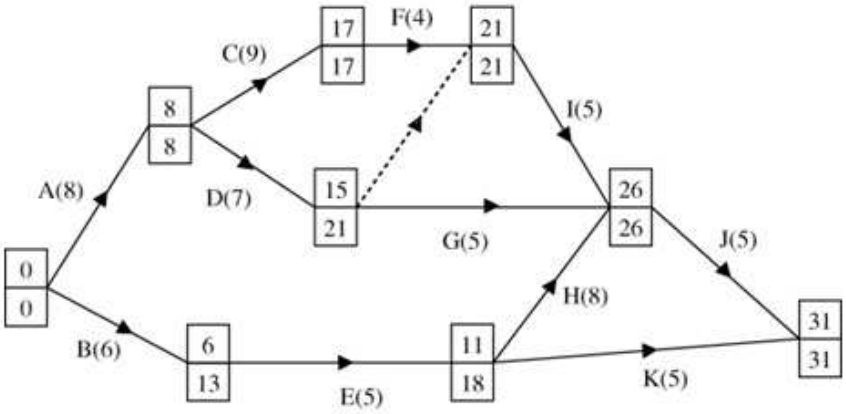
Exercise C, Question 3

Question:

The activity network for a project is given opposite.
The time in days needed to complete each activity is shown in brackets.
Calculate the early and late times at each vertex.



Solution:



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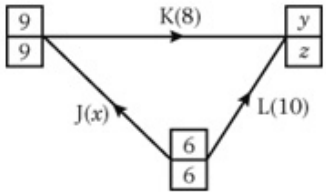
Exercise D, Question 1

Question:

Part of an activity network is shown opposite including the early and late event times given in hours.
Activities J and K are critical.
Find the values of x, y and z.



Solution:

$x = 3, y = 17, z = 17$

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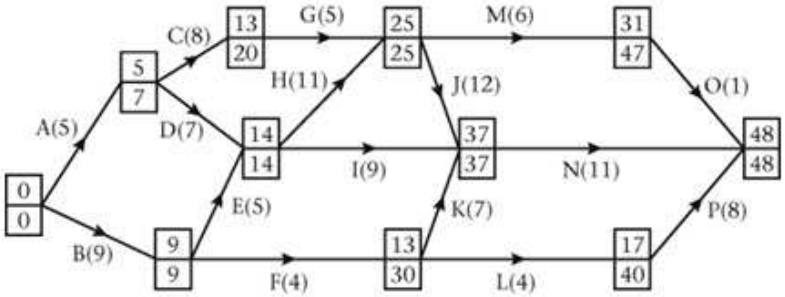
Exercise D, Question 2

Question:

The diagram shows an activity network with early and late event times, in hours, shown at the vertices.

a Identify the critical activities.

b Name an activity that links two critical events but is not critical.



Solution:

a The critical activities are B, E, H, J and N

b I

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Exercise D, Question 3

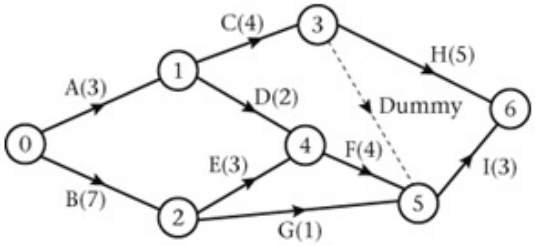
Question:

The activity network for a project is shown below. Activity times are given in days and are shown in brackets.

a Copy and complete the activity network to show the early and late event times.

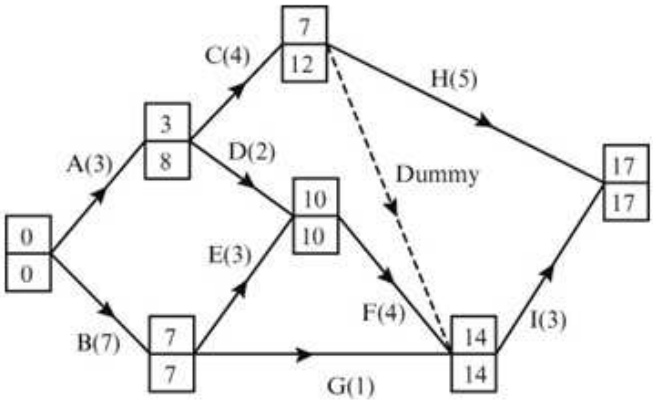
b Is G a critical activity?
Explain your answer.

c Describe the critical path.



Solution:

a



b No. $7+1 \neq 14$

c The critical path is B–E–F–I.

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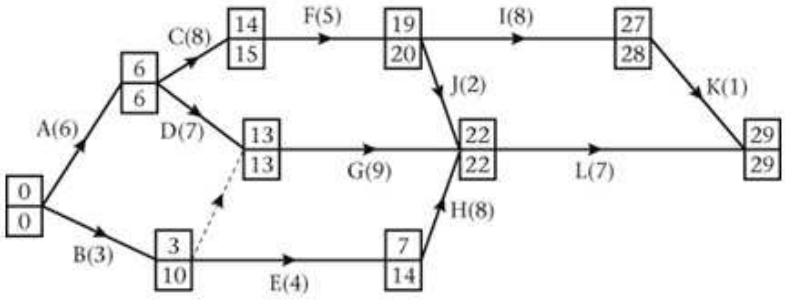
Exercise E, Question 1

Question:

Determine the total float of each activity in this activity network.



Solution:

Activity	Total float
A	0
B	$10-3-0=7$
C	$15-8-6=1$
D	0
E	$14-4-3=7$
F	$20-5-14=1$
G	0
H	$22-8-7=7$
I	$28-8-19=1$
J	$22-2-19=1$
K	$29-1-27=1$
L	0

Solutionbank D1

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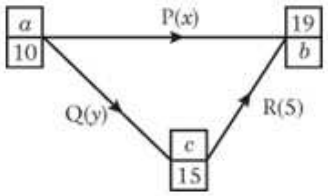
Exercise E, Question 2

Question:

The diagram shows part of an activity network with activity times measured in hours.



P is a critical activity.
Q has a total float of 3 hours.

a Work out the values of a, b, x and y.

b What is the minimum possible value of c?

c What is the maximum possible value of the total float of R?

Solution:

a $a = 10$ $b = 19$ $x = 19 - 10 = 9$

Total float $= 3 = 15 - y - a$

$y = 15 - 3 - 10$

$y = 2$

b Minimum value of $c = 10 + 2 = 12$

c Minimum value of total float of R $= 19 - 5 - 12$

$= 2$

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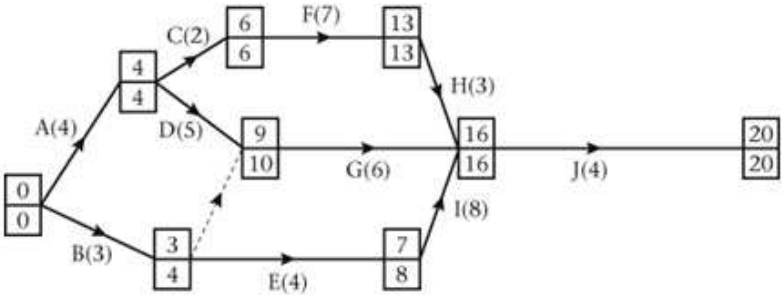
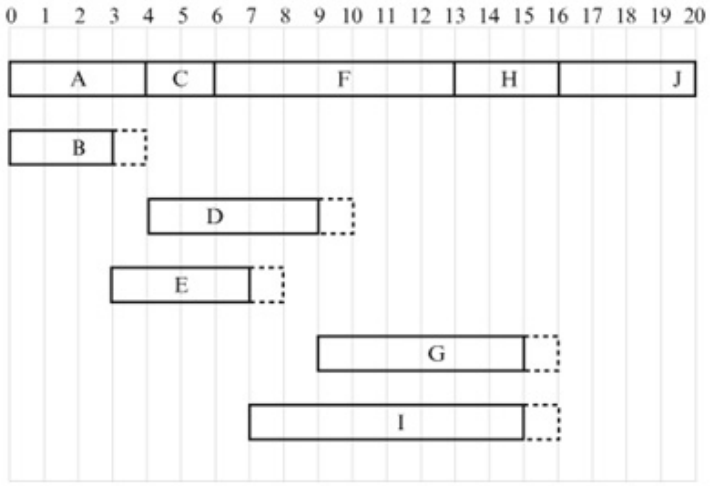
Exercise F, Question 1

Question:

The diagram shows an activity network for a project. Early and late event times are shown in days at the nodes. Draw a Gantt chart to represent the project.



Solution:



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Exercise F, Question 2

Question:

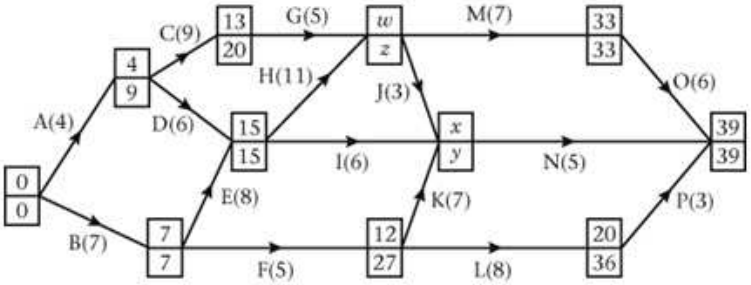
An activity network for a project is shown below.

a Calculate the values of w, x, y and z.

b List the critical activities.

c Calculate the total float for activities G and N.

d Draw a Gantt chart to represent the project.



Solution:

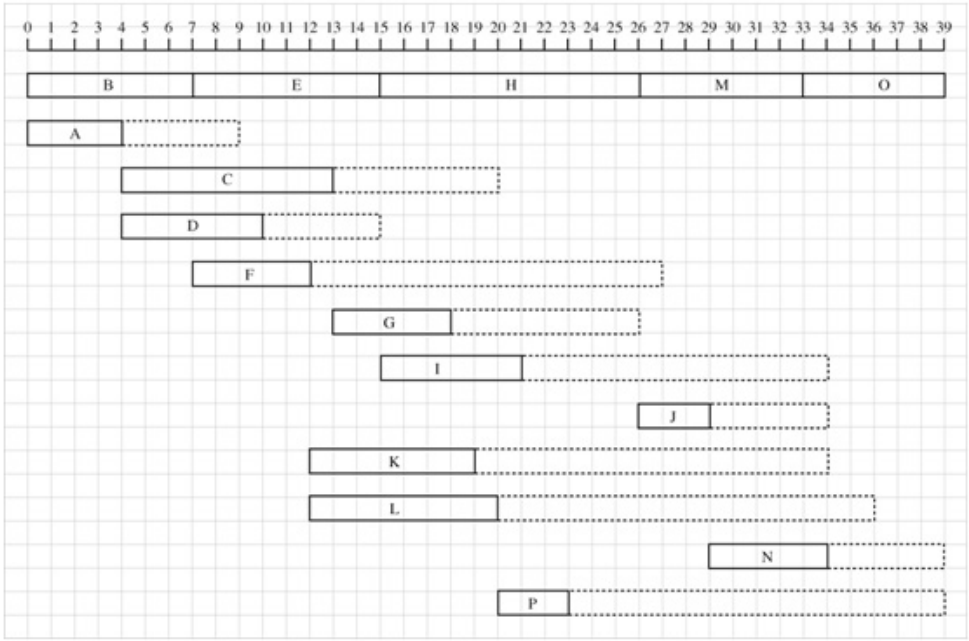
a $w = 26$ $x = 29$ $y = 34$ $z = 26$

b Critical activities: B, E, H, M, O

c Total float for E $= 26 - 5 - 13 = 8$

Total float for N $= 39 - 5 - 29 = 5$

d



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Exercise G, Question 1

Question:

Refer to the Gantt chart shown in Example 12 for this question.

a Which activities *must* be happening at midday on day 8?

b Which activities *must* be happening at midday on day 21?

c Which activities *may* be happening at midday on day 22?

Solution:

a A, E

b G, H

c F, H

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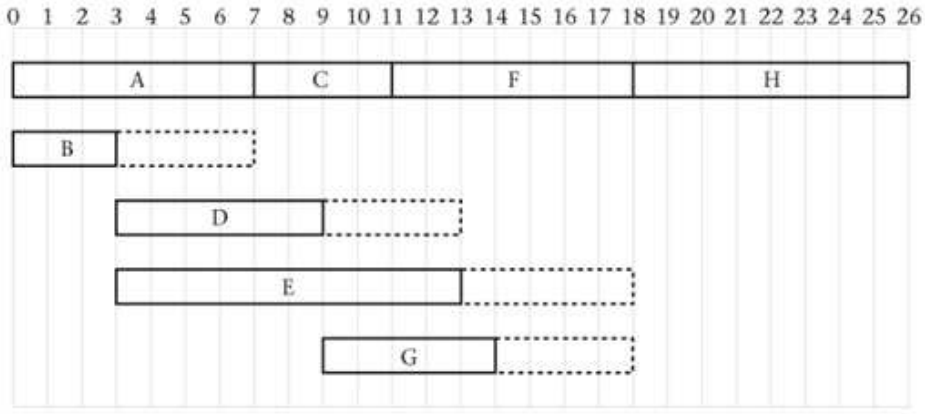
Exercise G, Question 2

Question:

The Gantt chart below represents an engineering project. An engineer decides to carry out some spot checks on the progress of the project.

a Which activities *must* be happening at 12 noon on day 8?

b Which activities *may* be happening at 12 noon on day 15?



Solution:

a C, D

b E, G

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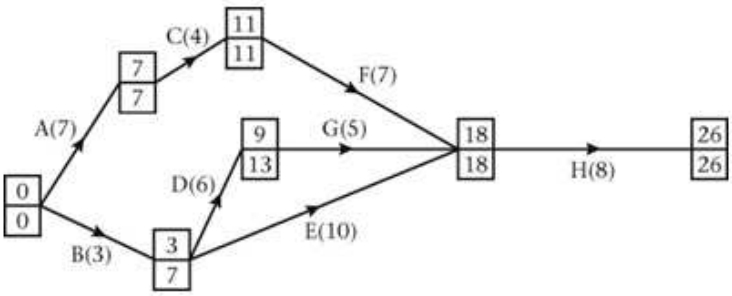
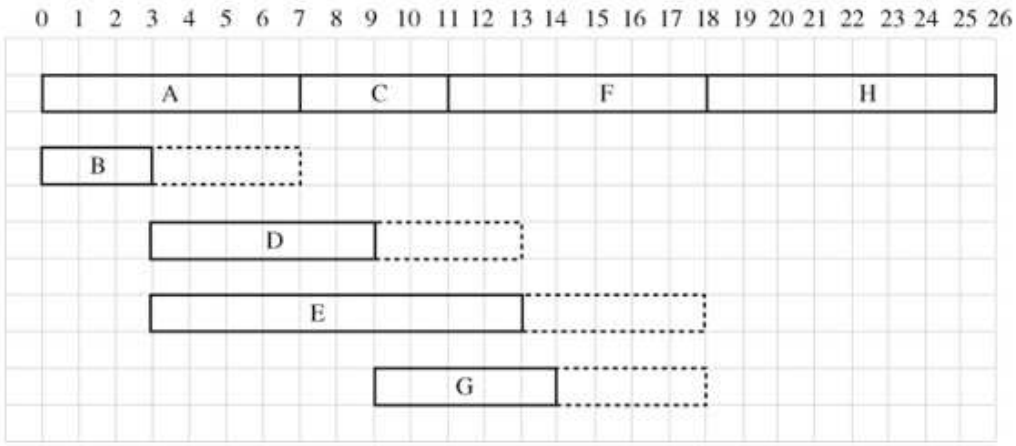
Exercise G, Question 3

Question:

Draw a Gantt chart to represent the activity network below.
Use your chart to determine:
a which activities *may* be happening at midday on day 5,
b which activities *must* be happening at midday on day 7.



Solution:



a B, D and E may be happening at midday on day 5,
b Only A must be happening at midday on day 7.

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Exercise H, Question 1

Question:

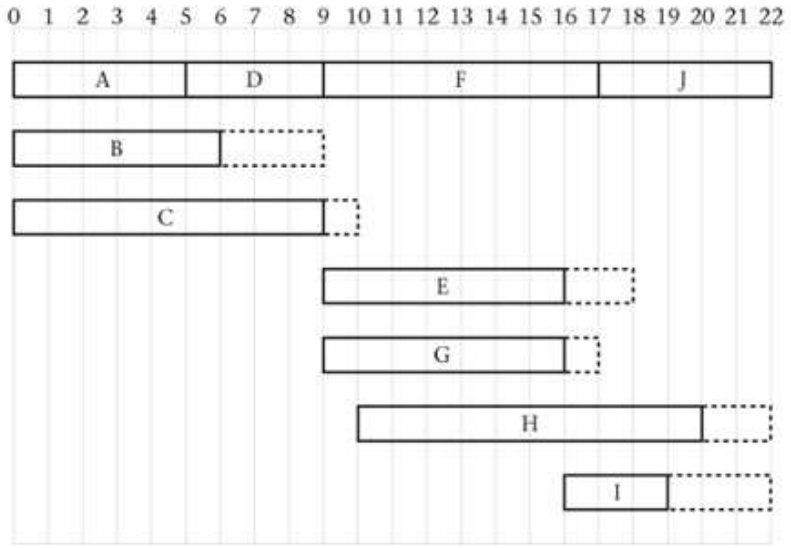
The cascade chart below represents a project with a critical time of 22 hours.

a Given that the total duration of all of the activities is 64 hours calculate a lower bound for the number of workers needed to complete the project in the minimum time.

b An unforeseen problem means that Activity B cannot be started until 2 hours into the project. Does this mean that the time for the whole project is delayed?

c Which activity *must* be happening 17 hours into the project?

d Complete a scheduling diagram to complete the project in 22 hours. State the number of workers required.



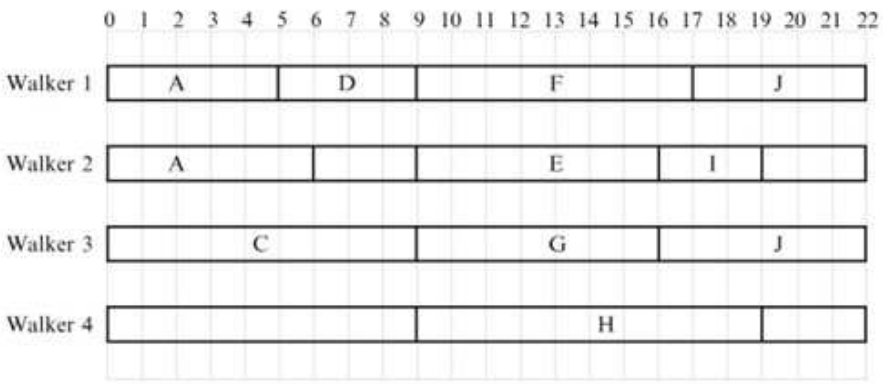
Solution:

a $\frac{64}{22} = 2.9\ldots$ so, lower bound $= 3$

b No. 2 hours is less than the total float for activity B (3 hours).

c Activity H

d



4 workers are needed to complete the project in 22 hours.

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Exercise H, Question 2

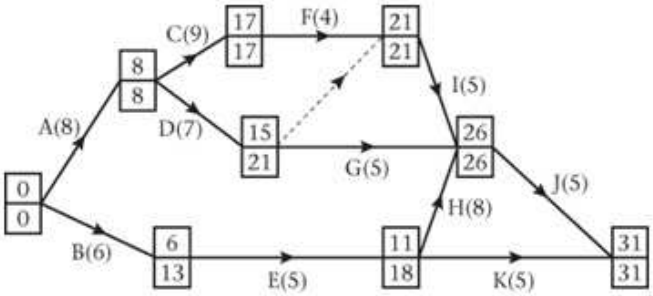
Question:

The activity network used in Example 14 is shown again here.

a Draw a Gantt chart to represent the project.

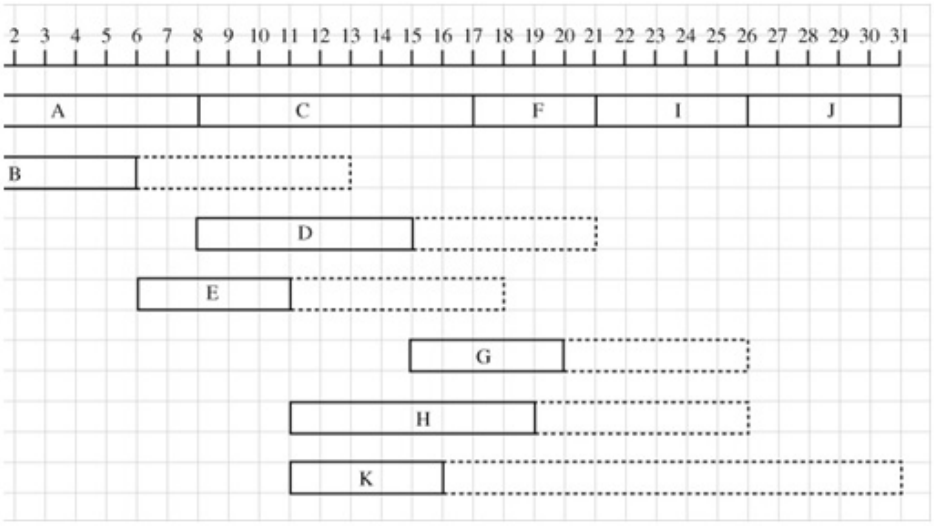
b Schedule the project to be completed by the minimum number of workers in the critical time.

State the number of workers required.

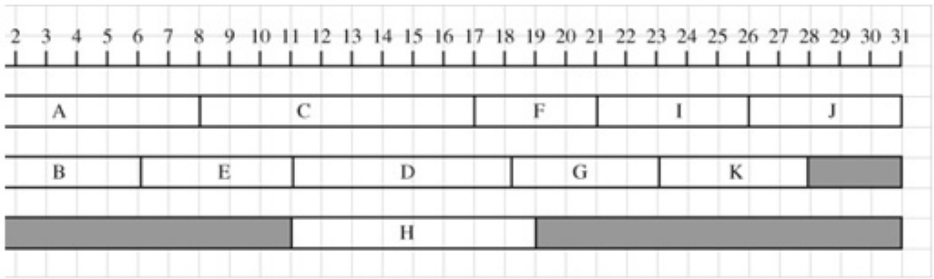


Solution:

a



b



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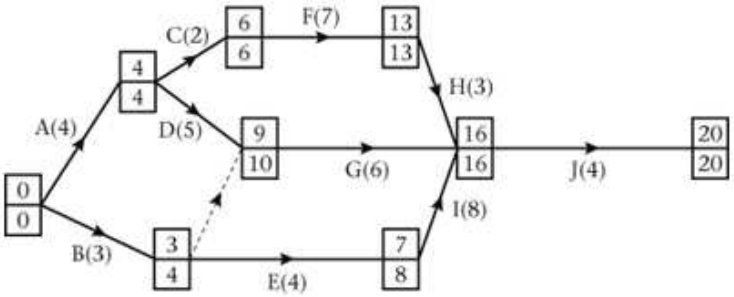
Exercise H, Question 3

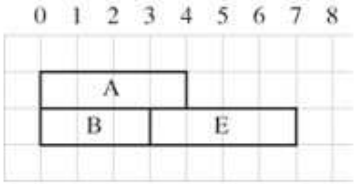
Question:

Construct a scheduling diagram based on the activity network below, given that only two workers are available.

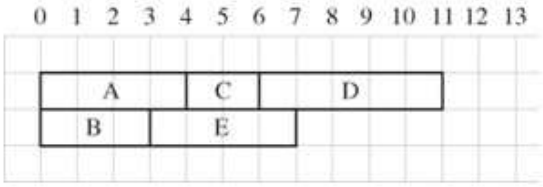
Find the new minimum time for completion of the project.



Solution:



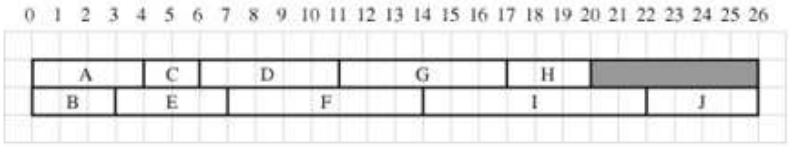
When worker 2 completes activity B, only activity E may be started.

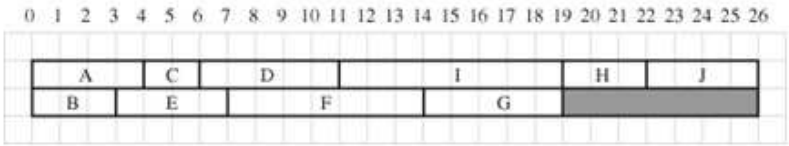


When worker 1 completes activity A, the next activity to start is either C or D. Activity C is chosen because it has the lower value for its latest finish time.

At this stage, worker 1 has a choice between activity G and activity I. Activity H may not be started until activity F has been completed.

There are two possible ways to complete the schedule so that the project is completed in the minimum possible time.





Solutionbank D1

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Exercise I, Question 1

Question:

The precedence table for activities involved in producing a computer game is shown opposite. An activity on arc network is to be drawn to model this production process.

Activity	Must be preceded by
A	—
B	—
C	B
D	A, C
E	A
F	E
G	E
H	G
I	D, F
J	G, I
K	G, I
L	H, K

a Explain why it is necessary to use at least two dummies when drawing the activity network.

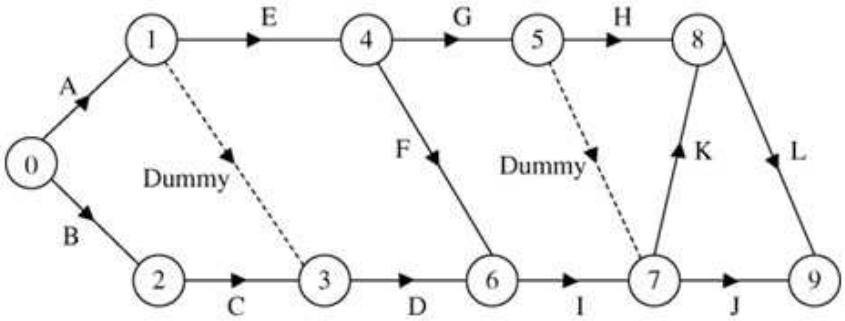
b Draw the activity network using exactly two dummies.

Solution:

a Activity D depends on activities A and C, whereas activity E depends only on activity A. This shows that a dummy is required.

Activity J depends on activities G and I, whereas activity H depends only on activity G. This shows that a second dummy is required.

b



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Exercise I, Question 2

Question:

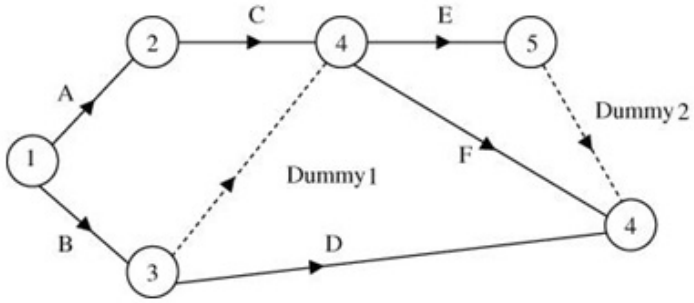
a Draw the activity network described in this precedence table, using activity on arc and exactly two dummies.

Activity	Immediately preceding activities
A	–
B	–
C	A
D	B
E	B, C
F	B, C

b Explain why each of the two dummies is necessary.

Solution:

a



b Dummy1 is needed to show *dependency*.
E and F depend on C and B, but D depends on B only.

Dummy2 is needed so that each activity can be *uniquely* represented in terms of its event.

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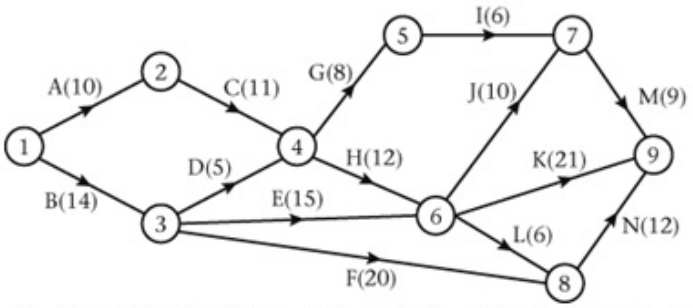
Exercise I, Question 3

Question:



An engineering project is modelled by the activity network shown above. The activities are represented by the arcs. The number in brackets on each arc gives the time, in days, to complete the activity. Each activity requires one worker. The project is to be completed in the shortest time.

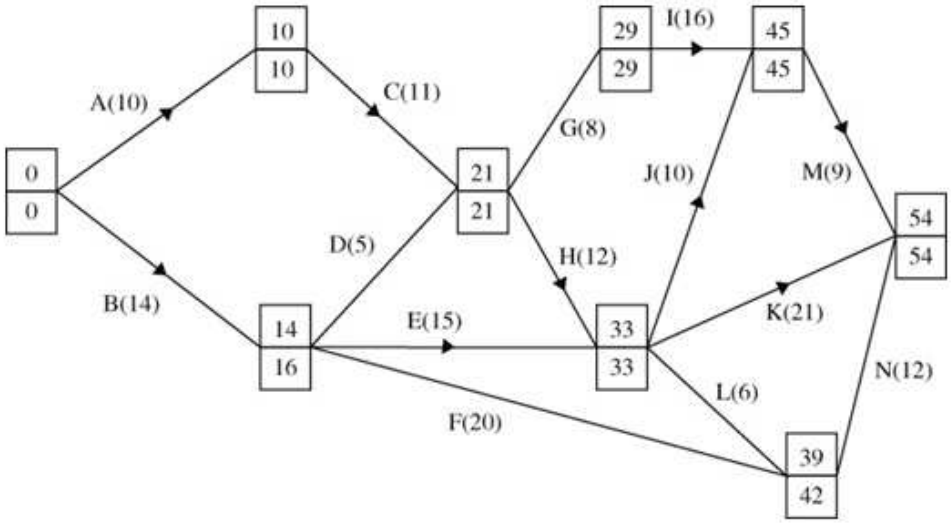
a Calculate the early time and late time for each event.
b State the critical activities.
c Find the total float on activities D and F. You must show your working.
d Draw a cascade (Gantt) chart for this project.

The chief engineer visits the project on day 15 and day 25 to check the progress of the work. Given that the project is on schedule,

e which activities *must* be happening on each of these two days? ***E***

Solution:

a

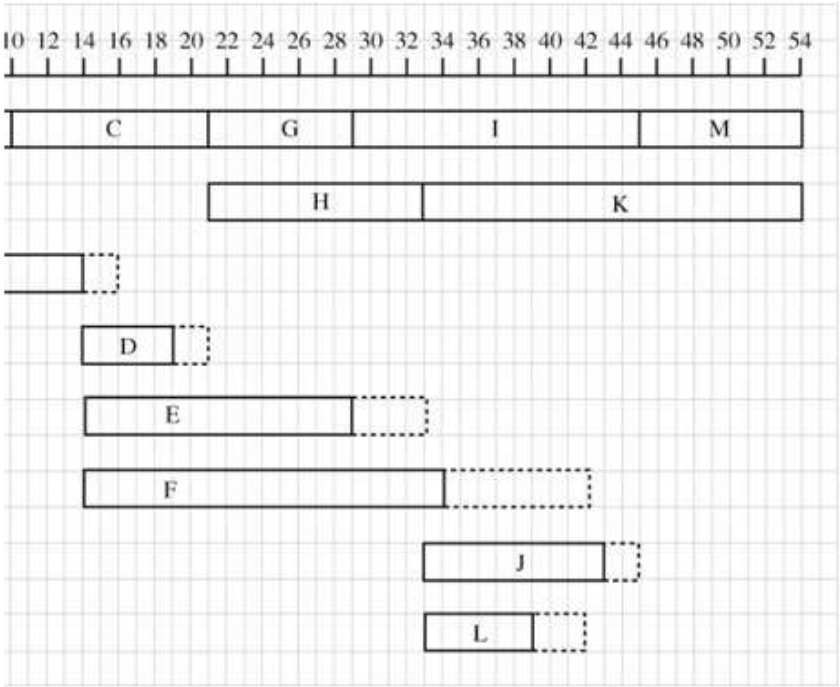


b There are *two* critical paths:
A–C–G–I–M and A–C–H–K

The critical activities are A, C, G, H, I, K

c Total float on D is 21 – 5 – 14 = 2
Total float on F is 42 – 20 – 14 = 8

d



e Day 15 : C
Day 25: G, H, E, F

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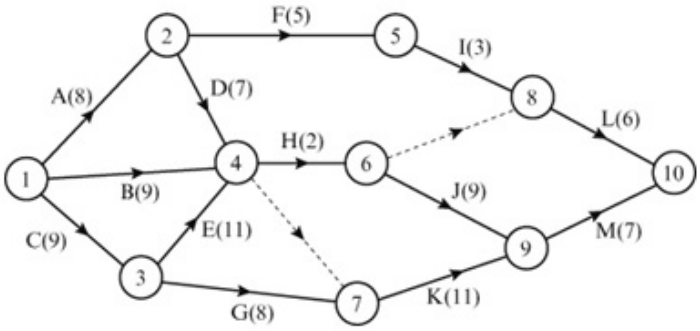
Exercise I, Question 4

Question:



A project is modelled by the activity network shown above. The activities are represented by the arcs. The number in brackets on each arc gives the time, in days, to complete the activity. The numbers in circles are the event numbers. Each activity requires one worker.

a Explain the purpose of the dotted line from event 6 to event 8.

b Calculate the early time and late time for each event.

c Calculate the total float on activities D, E and F.

d Determine the critical activities.

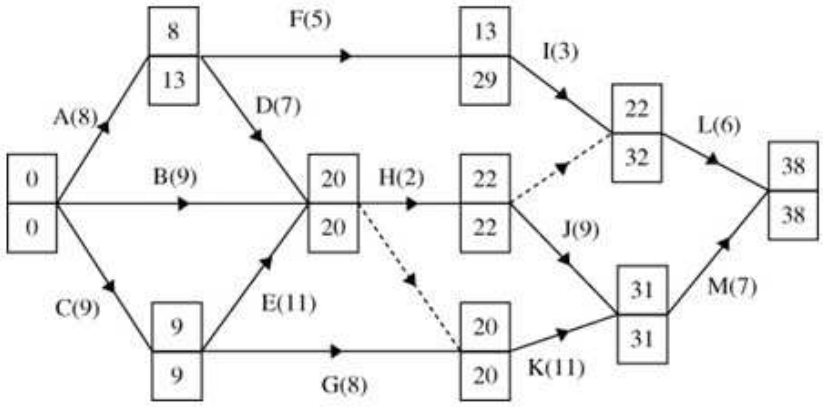
e Given that the sum of all the times of the activities is 95 hours, calculate a lower bound for the number of workers needed to complete the project in the minimum time. You must show your working.

f Given that workers may not share an activity, schedule the activities so that the process is completed in the shortest time using the minimum number of workers. ***E***

Solution:

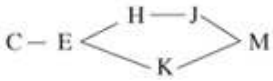
a J depends on H alone, but L depends on H and I.

b



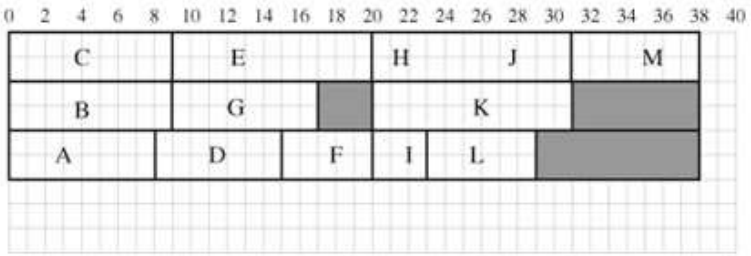
c Total float on D = 20 – 7 – 8 = 5
Total float on E = 20 – 11 – 9 = 0
Total float on F = 29 – 5 – 8 = 16

d



e $\frac{95}{38} = 2.5$ so 3 workers

f For example



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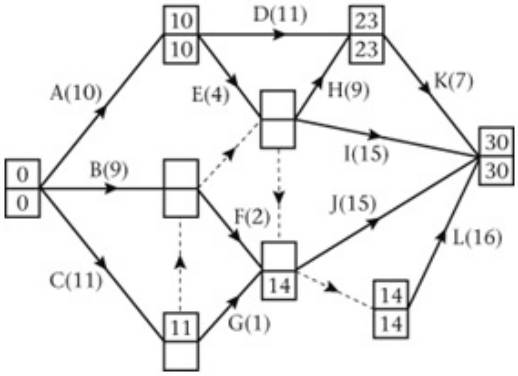
Exercise I, Question 5

Question:



The network shows the activities that need to be undertaken to complete a project. Each activity is represented by an arc. The number in brackets is the duration of the activity in days. The early and late event times are to be shown at each vertex and some have been completed for you.

a Calculate the missing early time and late times.

b List the two critical paths for this network.

c Explain what is meant by a critical path.

The sum of all the activity times is 110 days and each activity requires just one worker. The project must be completed in the minimum time.

d Calculate a lower bound for the number of workers needed to complete the project in the minimum time. You must show your working.

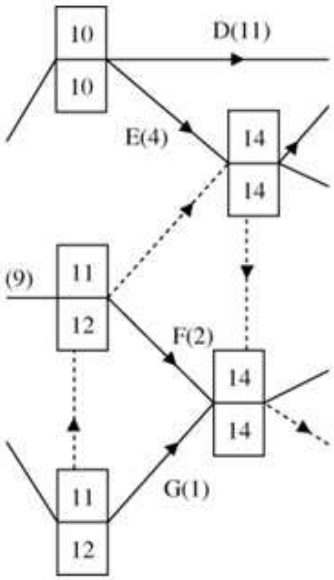
e List the activities that must be happening on day 20.

f Comment on your answer to part **e** with regard to the lower bound you found in part **d**.

g Schedule the activities, using the minimum number of workers, so that the project is completed in 30 days. ***E***

Solution:

a



b The critical paths are: A–E–H–K and A–E–L.

c A critical path is a continuous path from the source node to the sink node such that a delay in any activity results in a corresponding delay in the whole project.

d

$$\frac{\text{Sum of all of the activity times}}{\text{critical time of the project}} = \frac{110}{30}$$

Lower bound for number of workers is 4.

e D, H, I, J, L

f The answers to part **e** show that 5 workers are needed on day 20 in order to complete the project in the minimum time.

g