# Networks, scheduling and assignment - Test 1

10 questions | 58 marks | 65 minutes

A balanced first paper covering project scans, critical paths, assignment reductions and sensible recommendations.

Equivalent correct methods earn the corresponding marks.

**1.** Use the display-project precedence table. [6 marks]

A school display project. Times are in days.

| Activity | Duration | Immediate predecessors |
|---|---|---|
| A | 4 | None |
| B | 3 | None |
| C | 5 | A |
| D | 4 | A |
| E | 2 | B and D |
| F | 3 | C and E |

**(a)** Name the activities that can begin immediately. [2 marks]

Both have no predecessors.

**Answer:** A and B.

**(b)** State the immediate predecessors of F, then give one indirect predecessor. [2 marks]

F waits for C and E.

Earlier tasks reach F through those tasks.

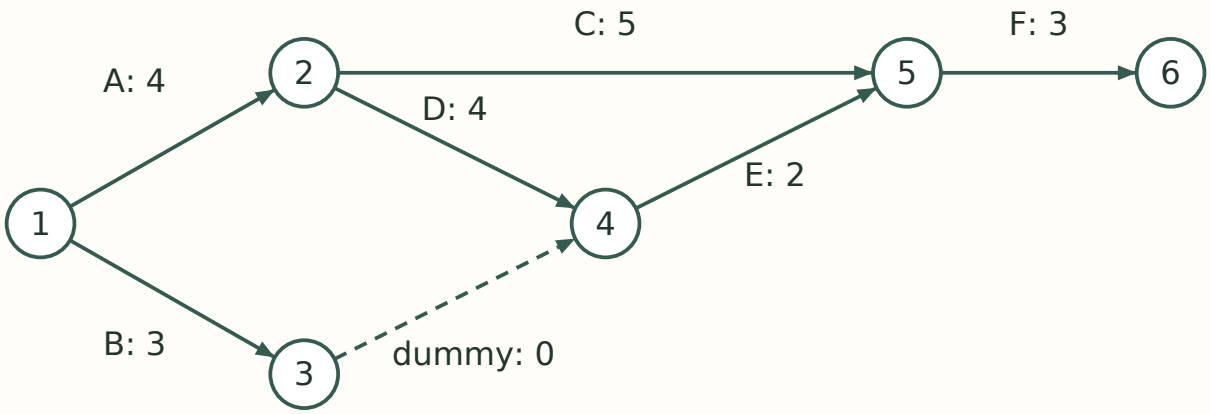
**Answer:** C and E are immediate; A, B or D is indirect.

**(c)** Explain why a single chain A-B-C-D-E-F would not represent this project. [2 marks]

A and B may start together; C and D are separate branches after A.

**Answer:** It adds unstated dependencies and prevents permitted parallel work.

**2.** Use this activity-on-arrow network. Durations are in days. [6 marks]




Activity-on-arrow network; durations are in days.

**(a)** Complete the forward scan for events 1-6. [4 marks]

$E_1 = 0;\ E_2 = 4;\ E_3 = 3.$

$E_4 = \max(8, 3) = 8;\ E_5 = \max(9, 10) = 10;\ E_6 = 13.$

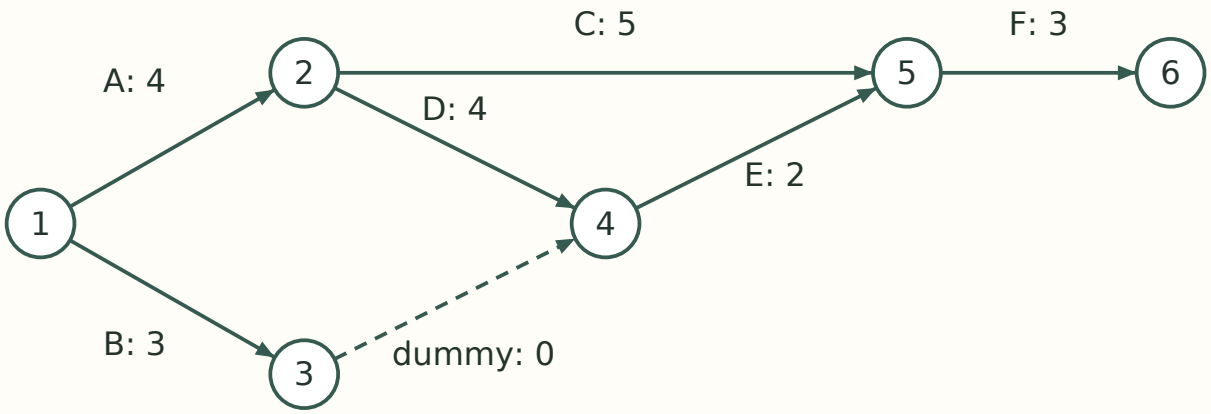
**Answer:** 0,4,3,8,10,13.

**(b)** State the earliest completion and explain the max calculation at event 5. [2 marks]

Choosing 9 would allow F to start before E finishes.

**Answer:** 13 days; event 5 must wait for both C and E, so $\max(9, 10) = 10$.

**3.** Use the same displayed network, reproduced here. [6 marks]




Activity-on-arrow network; durations are in days.

**(a)** Carry out a backward scan for a day-13 finish. [4 marks]

Work backwards:13,10,8,8.

$L_2 = \min(10-5, 8-4) = 4;\ L_1 = \min(4-4, 8-3) = 0.$

**Answer:** $L_1 = 0,\ L_2 = 4,\ L_3 = 8,\ L_4 = 8,\ L_5 = 10,\ L_6 = 13.$

**(b)** Find the latest start and total float of B. [2 marks]

B has duration 3 and latest finish 8.

$\mathrm{LS} = 8 - 3 = 5;\ \mathrm{ES} = 0.$

**Answer:** $\mathrm{LS} = 5,\ \mathrm{float} = 5$ days.

**4.** Consider changes to the display project; each change is made separately. [5 marks]

A school display project. Times are in days.

| Activity | Duration | Immediate predecessors |
|---|---|---|
| A | 4 | None |
| B | 3 | None |
| C | 5 | A |
| D | 4 | A |
| E | 2 | B and D |
| F | 3 | C and E |

**(a)** Find its critical path before any change. [2 marks]

$4+4+2+3=13$; $\mathrm{A}-\mathrm{C}-\mathrm{F}=12$.

**Answer:** A-D-E-F, 13 days.

**(b)** Reduce D from 4 to 1 day. Find the new completion and explain why the saving is not 3 days. [3 marks]

D route becomes 10, but C route remains 12.

Overall saving is only $13-12=1$.

**Answer:** 12 days; the A-C-F route controls.

**5.** Two independent tasks P and Q take 5 and 8 hours. R takes 2 hours and follows both. [5 marks]

**(a)** Find total task-hours and the minimum elapsed duration with separate workers. [3 marks]

$\text{Sum work} = 5 + 8 + 2 = 15.$

$\text{Parallel branch time} = \max(5, 8) = 8$; add R: 2.

**Answer:** 15 task-hours;10 elapsed hours.

**(b)** Find the duration if the same sole worker must do P and Q before R. [2 marks]

P and Q cannot overlap, so $5 + 8 + 2 = 15.$

**Answer:** 15 hours.

**6.** Use the technician cost table. [6 marks]

Cost ($) of assigning one technician to each job.

| Technician | Job 1 | Job 2 | Job 3 |
|---|---|---|---|
| Ali | 9 | 2 | 7 |
| Bea | 6 | 4 | 3 |
| Chen | 5 | 8 | 1 |

**(a)** Calculate the total for Ali→3, Bea→2, Chen→1. [2 marks]

$7 + 4 + 5 = 16.$

**Answer:** $16.

**(b)** Find a minimum complete assignment and justify its minimum by comparing all six totals. [4 marks]

The six totals are 14,20,9,10,21,16.

The smallest is 9.

**Answer:** Ali→2, Bea→1, Chen→3;$9.

**7.** The time table below is to be minimised. [7 marks]

Times in hours for one person to perform one task.

| Person | X | Y | Z |
|---|---|---|---|
| Amy | 4 | 1 | 3 |
| Ben | 2 | 0 | 5 |
| Cal | 3 | 2 | 2 |

**(a)** Show row reduction followed by column reduction. [3 marks]

Row minima 1,0,2; column minima 1,0,0 after row reduction.

**Answer:** After rows: $\begin{bmatrix} 3 & 0 & 2 \\ 2 & 0 & 5 \\ 1 & 0 & 0 \end{bmatrix}$; after columns: $\begin{bmatrix} 2 & 0 & 2 \\ 1 & 0 & 5 \\ 0 & 0 & 0 \end{bmatrix}$.

**(b)** Cover column Y and row Cal, adjust by the smallest uncovered value, then state the optimum. [4 marks]

Smallest uncovered is 1.

Original total $1+2+2=5$.

**Answer:** Adjusted: $\begin{bmatrix} 1 & 0 & 1 \\ 0 & 0 & 4 \\ 0 & 1 & 0 \end{bmatrix}$. Amy→Y, Ben→X, Cal→Z;5 hours.

**8.** Use the team profit table; table units are \$100. [6 marks]

Profit (\$100 units) from assigning each team to one distinct contract.

| Team | Contract 1 | Contract 2 | Contract 3 |
|---|---|---|---|
| P | 18 | 14 | 13 |
| Q | 15 | 17 | 12 |
| R | 16 | 11 | 19 |

**(a)** Form the opportunity-loss matrix with $K = 19$. [3 marks]

Subtract every profit from 19.

**Answer:** $\begin{bmatrix} 1 & 5 & 6 \\ 4 & 2 & 7 \\ 3 & 8 & 0 \end{bmatrix}$.

**(b)** State a maximum-profit assignment and the profit in dollars. [3 marks]

The feasible row maxima sum $18 + 17 + 19 = 54$.

$54 \times 100 = 5{,}400$.

**Answer:** P→1, Q→2, R→3;\$5,400.

**9.** Four workers cover three jobs; idling is free. [6 marks]

Costs ($) for four workers and three required jobs. A worker may remain idle at no cost.

| Worker | Job 1 | Job 2 | Job 3 |
|---|---|---|---|
| A | 4 | 8 | 7 |
| B | 6 | 3 | 8 |
| C | 5 | 7 | 2 |
| D | 9 | 4 | 6 |

**(a)** Describe the dummy entries needed. [2 marks]

One of the four workers must be idle.

**Answer:** Add one all-zero dummy-job column.

**(b)** Find the cheapest assignment, identify the idle worker and give a lower-bound justification. [4 marks]

Real-job column minima are 4,3,2 and are feasible together.

Their sum 9 is attained, so it is optimal.

**Answer:** A→1, B→2, C→3, D idle;$9.

**10.** The display-project model predicts 13 days. A manager wants a promise of completion in 13 days. [5 marks]

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**(a)** State two assumptions needed before making that promise. [2 marks]

The network alone does not reserve staff or allow for uncertain supplies.

**Answer:** For example reliable durations and enough resources for the parallel tasks.

**(b)** B is revised from 3 to 9 days. Find the new project finish and controlling sequence. [3 marks]

E now starts at $\max(9, 8) = 9$, ends 11; F ends 14.

**Answer:** 14 days; B-E-F.