Module 11 · PERT, CPM, crashing P16 · 11.0

SM pp. 600–625 (exercise 626–635). The most frequent Q6–Q7 sum: **a whole 14-mark Q7 in J24, D24, J25**, a 7-mark half in D23 and J26, none in D25; MCQs on floats, variance, crash days. Module 11 per paper: **J26-7 · D25-0 · J25-16 · D24-18 · J24-16 · D23-9** (J23-10). PERT has come in every June.

Paper	Network question	MCQ
Dec'23	Q7(a): a fire after day 15 — new duration, critical path, probability	independent float
Jun'24	Q7 (14): a / m / b network, paths, SD, P(3 weeks early / late), P(miss 18 weeks)	activity variance
Dec'24	Q7 (14): **crashing** — critical path, % cost increase for 21 days	variance · crash days
Jun'25	Q7 (14): predecessors table, P(54 days), revised extreme estimates	SD of the critical path
Jun'26	Q7(b): EST / LST, critical path, P(38 weeks), 95% duration (MQP Q7(b) times)	–

HOW IT IS ASKED · DEC'26

- One of the four Q6–Q7 halves; Decembers had the fire (D23) and crashing (D24) — **crashing or a PERT probability** is the likely form.
- Every PERT answer: te and variance table → network → all paths → critical path → σ → Z → probability (use only the Z values printed with the question).

A Formula sheet — when to use

Formula	When to use · notes	SM
t_e = (a + 4m + b) ÷ 6; SD = (b − a) ÷ 6; variance = SD^2	Activity times follow a beta distribution; the project time is taken as normal.	[SM 612]
Project σ = √ Σ variances on the critical path	Two critical paths: take the larger variance.	[SM 613]
Z = (scheduled time − T_E) ÷ σ; duration for p% = $T_E + Z_p \times \sigma$	95%: Z = 1.645 (the question may print 1.65).	[SM 613]
Slack = L − E of an event; **total float** = $L_j - E_i - t$	Zero float = critical activity.	[SM 606]
Free float = total float − head slack; **independent float = free float − tail slack**	Independent ≤ free ≤ total (D23 MCQ).	[SM 607]
Cost slope = (crash cost − normal cost) ÷ (normal − crash time)	Crash the cheapest critical activity first; crash parallel paths together.	[SM 616–618]

B PERT probability · Q7 11.0

PROBLEMS BOX · PERT (RECOMPUTED BY SCRIPT m11_patterns.py)

WORKED PATTERN · SM ILLUSTRATION 4 (95% DURATION → BID)

Critical path 1-2-3-5-7-9 = **77.49 days**; variance 3.36 + 1.36 + 4 + 0 + 17.36 = 26.08 → σ = **5.11**; (t_s − 77.49) ÷ 5.11 = 1.645 → **86 days**; bid = 8 lakh + 86 × 9,000 = **₹15,74,000**. [SM 614–615]

JUN'26 Q7(b) (OUR WORKING)

Path	Weeks
1-2-6-7 (7 + 11 + 18) **critical**	**36**
1-3-6-7 (6 + 7 + 18) · 1-4-7 (14 + 11) · 1-2-5-7 (7 + 5 + 4)	31 · 25 · 16

JUN'24 Q7 JOBSON (OUR WORKING)

Paths 1-3-5-6 = 4 + 6 + 7 = **17** (critical), 1-2-5-6 = 10, 1-4-6 = 8; σ = √(1 + 4 + 4) = **3**. P(≤ 14) = 0.5 − 0.3413 = **15.87%**; P(≤ 20) = **84.13%**; P(miss 18) = 0.5 − 0.1293 = **37.07%**.

DEC'23 Q7(a) FIRE AFTER DAY 15 (OUR WORKING)

Original critical 1-2-5-6 = **37 days**. Restart 2-4, 2-5, 3-6 at day 15; 5-6 now 20: 2-5-6 ends 15 + 13 + 20 = **48** (critical), 2-4-6 36, 3-6 32. σ = √($1.33^2 + 0.47^2$) = 1.41 → Z(46) = −1.42 → **7.78%**.

MCQ ONE-LINERS

- Variance from a and b: $((b - a) \div 6)^2$ (D24); from t_e, m, b: first find a = $6t_e - 4m - b$ (J24).

Variance 4 + 4 + 16 = 24 → σ 4.899. P(38): Z = 0.41 → 0.5 + 0.1591 = **65.91%**. 95%: 36 + 1.65 × 4.899 = **44.08 weeks**. Event times E / L: 1 0/0 · 2 7/7 · 3 6/11 · 4 14/25 · 5 12/32 · 6 18/18 · 7 36/36.

JUN'25 Q7 SIMCON (OUR WORKING)

t_e: A 5, B 12, C 6, D 3, E 2, F 5, G 14, H 22. Paths ADH 30, BDH 37, BEH 36, **BGH 48**, CGH 42, CF 11. σ^2 = 1.778 + 1.778 + 7.111 = 10.667 → Z(54) = 1.84 → **96.67%**. Wider estimates (B, G, H): σ^2 17.889 → Z 1.42 → **92.22%** (t_e unchanged).

- SD of a path: √ of the sum of variances, never the sum of SDs (J25).
- Independent float = free float − tail slack (D23).

PRACTISE THESE

J26, J25, J24 Q7, D23 Q7(a) · **MQP Q7(b) (= J26's times)**, PTP Q7(b), postal Q10(b) · SM Illus. 1–4 (SM 608–615), exercise sums 1–5 (SM 633–635) · MCQ bank Q125–Q147, Q207, Q211, Q222, Q224, Q226, Q228, Q261, Q272, Q273, Q282.

C Crashing · Q7 (D24) 11.0

WORKED PATTERN · SM ILLUSTRATION 5

- Normal 22 days, critical 1-2-4-6-7; direct ₹4,700 + indirect 22 × 100 = **₹6,900**. [SM 618–619]
- Stage 1: crash 1-2 (slope ₹200) by 1 → 21 days, **₹7,000**; 1-3-4-6-7 also critical. [SM 619]
- Then 6-7 (350), 4-6 (550 × 4) → 16 days **₹9,050**; 1-2 + 3-4 together (750) → 15 days **₹9,700**. [SM 620–621]

Every slope here exceeds the ₹100 a day of indirect cost, so total cost rises with each crash: the cheapest total is the normal 22 days.

Dec'24 Q7 Rontech (our working): paths A-B-E-G 24, **A-C-E-G 25**, A-C-F-G 23, A-D-F-G 24; normal cost ₹4,500. Slopes A 200, D 100, E 100, F 200, G 400 (B's crash time exceeds its normal time and C has none — say so). To 21 days: E by 1 (100) → two paths at 24; then A by 2 (200 a day) and E + D by 1 (200) → **extra ₹700** → ₹5,200 = **+15.56%**.

TRAPS

- List **every** path with its length — the marks for "indicate all paths" are separate.
- Crash only critical activities; when two paths are critical, cut both (a common activity or one on each).
- Never crash an activity below its crash time or beyond what keeps the path critical.
- A dummy carries zero time and zero variance but counts in the path.