Module 12 · Learning curve P16 · 12.0

SM pp. 638–652 (exercise 653–656). **MCQ (viii) in every paper**; a **7-mark pricing half in both Decembers that had one (D23, D25)** — due again. Module 12 per paper: **J26-2 · D25-9 · J25-2 · D24-2 · J24-2 · D23-9** (J23-8).

Paper	Asked
Dec'23	Q7(b) boats, 90%, price = VC + 20%: average for 4 and 8, 3rd and 4th boat · MCQ second set-up time (incremental model)
Jun'24	MCQ: time of the 200th unit, 85%
Dec'24	MCQ: learning rate from the first unit and 16-unit total
Jun'25	MCQ: time of the 16th unit, 85%
Dec'25	Q7(b) fire alarms, 80% table, 25% mark-up, two orders · MCQ cost of the 2nd unit, 90%
Jun'26	MCQ: learning rate from the first unit and 4-unit total

Rule	SM
Cumulative average time falls to r every time output doubles; ratio = average of 2n ÷ average of n	[SM 639]
$Y = aX^b$, b = log r ÷ log 2 (Y = cumulative average)	[SM 640]
Total for X units = X × aX^b; time of the Xth unit = total(X) − total(X − 1)	–

PROBLEMS BOX · LEARNING CURVE (RECOMPUTED BY SCRIPT m12_patterns.py)

WORKED PATTERNS · SM ILLUSTRATIONS 4 AND 5

- Illus. 4 (80%, first unit 10 h, ₹12 an hour): 8 units 5.12 × 8 = **40.96 h** = ₹491.52; 32 units 104.86 h → repeat order of 24 = **63.90 h = ₹766.80**. [SM 648]
- Illus. 5: rate ≈ 85%; b = log 0.85 ÷ log 2 = **−0.2344**; average of 30 = 46 × $30^{-0.2344}$ = **20.73** min; below 15 min after 119.179 → **120 units**. [SM 649]

> ⚠ **TWO MODELS**
> The SM defines the curve on the **cumulative average** (Wright), but its Example 1 (80%, 20 → 16 → 12.8 → 10.24 h) applies r to **each unit's own time** (incremental-unit model) — so did D23 MCQ (viii), which named that model. "Average" / "total" in the question → cumulative average; "time of the 2nd set-up" under the "incremental unit-time model" → unit × r.

MCQ TEMPLATES (OUR WORKING)

- Rate from the 1st unit and the 4-unit total: r = √(total ÷ 4 ÷ first) — e.g. 324 h ÷ 4 ÷ 100 → **90%** (J26, D24 with 16 units: 4th root).
- Cost of the 2nd unit, 90% average model: 2 × 0.9 × first − first = **0.8 × first** (D25).
- Time of the 16th unit (85%, first 100 h): 16 × 100 × 0.85^4 − 15 × 100 × $15^{-0.2345}$ ≈ **40.26 h** (J25, J24 type).

DEC'23 Q7(b) BOATS (OUR WORKING)

First boat: materials 8,000 (no learning) + labour 1,000 h × ₹4 + variable OH 200% of labour. Average hours 1,000 → 900 → 810 → 729. **4 boats**: 8,000 + 810 × 12 = 17,720 → **₹21,264** a boat; **8 boats**: 8,000 + 729 × 12 = 16,748 → **₹20,097.60**; 3rd and 4th: (3,240 − 1,800) ÷ 2 = 720 h → 16,640 → **₹19,968** each.

DEC'25 Q7(b) FIRE ALARMS (OUR WORKING)

Learning on Dept B (skilled) only — Dept A is highly automatic (state it). B: first 100 = 4,000 h; cumulative 160 at 86.1% = 5,510.4 h → order 1: 1,510.4 ÷ 60 = 25.17 h a unit; cumulative 200 at 80% = 6,400 h → order 2: 889.6 ÷ 40 = 22.24 h. Cost a unit = 500 + 200 + B labour × 15 + 20% VOH + A FOH 160 + B FOH × 5 → × 1.25: **order 1 ₹1,848.73**, **order 2 ₹1,764.40**.

PRACTISE THESE

D25, D23 Q7(b), J23 Q10(a) · MCQs every paper Q1(viii) + MQP / PTP Q1(viii) · SM Illus. 1–7 (SM 645–652), exercise MCQs (SM 653–654) · MCQ bank Q148–Q155, Q197, Q212, Q213, Q227, Q240, Q253, Q262, Q264, Q275, Q278.

Traps: materials do not learn; overheads charged on labour hours do; price on the order's own hours (total − earlier total), not the cumulative average.