MGMT90280 Managerial Decision Analytics

UNIVERSITY OF MELBOURNE · POSTGRADUATE COURSEWORK · SEMESTER 2, 2026

Full guide + ask Sia about MGMT90280

SIDE 1/2 · EXAM MAP · METHOD SELECTOR · FORMULAS · DECISION RULES · OPEN-BOOK EXAM SHEET · Final exam 50% · 2 h writing + 30 min reading · 100 marks

0 · Exam Map

COURSE.JSON · BRIEF

A1 20% | A2 25% | FINAL 50%

ASSESSMENT	WEIGHT · FORMAT
Assignment 1	20% · timed Respondus quiz, semi-open-book
Assignment 2	25% · group analytics report/project
Class presentation	5% · group oral presentation of A2
Final exam	**50%** · individual; 5 compulsory short/long-answer questions

"Unlimited printed or handwritten resources (No digital resources permitted)" *(MGMT90280 exam permitted-materials list, 2026 subject materials)*. Paper notes are allowed: print this sheet and bring it.

Pace: 120 writing minutes ÷ 100 marks = 1.2 min/mark; a 20-mark question ≈ 24 min. Use reading time to label the method, inputs, requested decision and units.

2 · Linear Programming

CH1 · OPTIMISATION

Use when objective and constraints are linear and variables may be continuous. Define units; then:

GENERAL FORM

$$\text{Max/Min } Z = \sum c_j x_j$$
$$\text{s.t. } \sum a_{ij} x_j \ \{\le, =, \ge\}\ b_i;\ x_j \ge 0$$

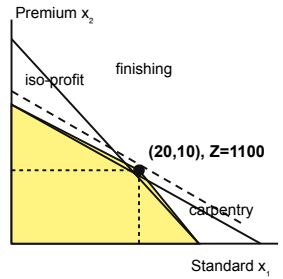
Four marked parts: decision variables; objective; one row per constraint; non-negativity. In Solver use Simplex LP.

LINEARISE PERCENTAGE RULES

For non-negative totals, multiply out before Solver. Example:

$$A \ge 0.40(A + B)$$
$$A - 0.40A - 0.40B \ge 0$$
$$0.60A - 0.40B \ge 0$$

Corner rule: a linear objective over a polygon reaches an optimum at a feasible vertex; evaluate all corners for a two-variable hand solve.



Guide Fig 1.1 redraw: feasible polygon; best corner (20,10).

3 · Integer & Binary LP

CH2 · OPTIMISATION

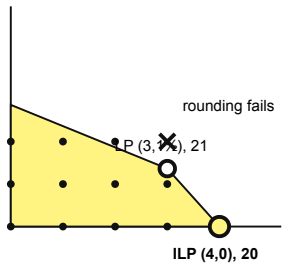
Use when decisions must be whole units or yes/no. Pure ILP: all integer; MILP: some; binary: $x_j \in \{0,1\}$. Use Simplex LP with integer/binary constraints and Integer Optimality 0%.

RELAXATION BOUND

$$\text{Max: } z^*_{LP} \ge z^*_{ILP} \text{ (upper bound)}$$
$$\text{Min: } z^*_{LP} \le z^*_{ILP} \text{ (lower bound)}$$

Never round a fractional relaxation: rounding may violate a row or miss a better integer point. If relaxation is already integral, it also solves the ILP.

ENGLISH RULE	BINARY ROW
At most k	$\Sigma x_j \le k$
At least / exactly k	$\Sigma x_j \ge k$ / $= k$
j only if i	$x_j \le x_i$
Not both i,j	$x_i + x_j \le 1$
Both or neither	$x_i = x_j$



Guide ILP redraw: the relaxation is a bound, not a rounded answer.

3b · ILP Finish

CH2

Translate *one sentence* → *one row*, test each row with 0/1 substitution, then state chosen projects and unused budget. Standard LP sensitivity does not apply cleanly after integrality: discrete changes can jump the solution, so re-solve.

3c · Binary Formulation Checklist

CH2 · MARKS

Capital budgeting: let $x_j = 1$ when project j is funded. Maximise total NPV $\Sigma NPV_j x_j$ subject to $\Sigma Cost_j x_j \le$ budget, then add every logical rule separately. Keep dollar units consistent—if inputs are in $000, the objective and budget are also in $000.

Truth-test "j only if i": $x_j \le x_i$ permits (i,j)=(0,0),(1,0),(1,1) but forbids (0,1). Reversing the row encodes the reverse implication. For "at least one", use $\Sigma x \ge 1$; "exactly one", $\Sigma x = 1$; "at most one", $\Sigma x \le 1$.

4 · Nonlinear Programming

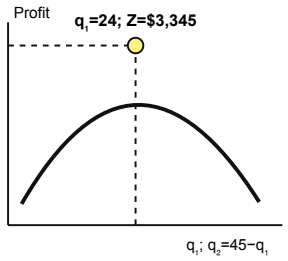
CH3 · FINAL Q1

Cue: squares, products or ratios in objective/constraints. Profit questions begin with Profit = Revenue − Cost. Use GRG Nonlinear for smooth models.

BY-HAND WORKFLOW

1 Write Z and constraints
2 Solve $\partial Z/\partial q_1 = 0$
3 Check feasibility
4 If infeasible, bind the active row, substitute, re-optimise
5 Check $d^2Z/dq^2 < 0$ / concavity; state plan + profit

GRG is a hill-climber: on non-concave surfaces try several starts. A concave objective over a convex region has one peak, so its local maximum is global.



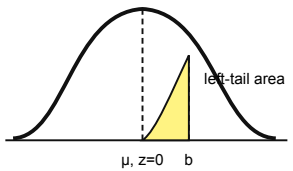
Guide Fig 3.2 redraw: bind $q_1+q_2=45$, then optimise the parabola.

5 · Probability Chooser

CH4

MODEL	SIGNATURE · CORE FACTS
Binomial(n,p)	n independent trials, constant p; E=np; Var=np(1−p)
Poisson(μ)	Count per interval, constant rate; E=Var=μ
Uniform(a,b)	Equal density; E=(a + b)/2; Var=(b−a)²/12
Normal(μ,σ)	Bell; z=(x−μ)/σ
Exponential	Time between events; mean μ, Excel rate=1/μ

```
BINOM.DIST(x,n,p,FALSE)=P(X=x)
TRUE=P(X≤x); upper tail=1-cdf
NORM.INV(probability,μ,σ)=percentile
```



Guide Fig 4.3 redraw: standardise, then read area or invert it.

6 · Monte Carlo Simulation

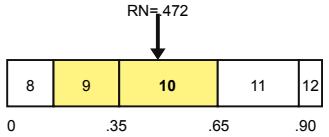
CH5 · FINAL Q2

Use when uncertain inputs drive an output distribution. Loop: model → assign distributions → sample → recalculate → repeat → report risk and decision. Use ≥1,000 iterations for a stable estimate.

INVERSE TRANSFORM

```
RN = RAND() ~ Uniform(0,1)
Uniform: x=a + (b-a)RN
Normal: x=NORM.INV(RN,μ,σ)
Discrete: RN∈[F(x_{k-1}),F(x_k)) → x_k
```

Intervals are cumulative and half-open: the lower bound belongs; the upper bound moves to the next outcome. Simulation enables risk analysis but does **not** guarantee an optimum.



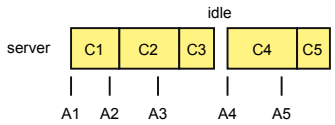
Guide discrete sampler redraw: .472 maps to demand 10.

6b · Single-Server Queue

CH5

```
Arrival_i = cumulative IAT_i
Start_i = max(Arrival_i, Departure_{i-1})
Departure_i = Start_i + Service_i
Wait_i = Start_i - Arrival_i
Idle_i = max(0,
Arrival_i-Departure_{i-1})
```

IAT ≠ arrival time: cumulate first. A customer either waits or the server is idle, never both. Compare mean wait or risk of exceeding threshold with the stated staffing rule.



Guide queue redraw: one server; waits and idle gaps are visible.

6c · Simulation Output → Decision

CH5

Monte Carlo produces an output distribution. Report mean, spread and the tail probability tied to the threshold, e.g. P(wait>4). More runs reduce sampling noise, not model error.

7 · Clustering

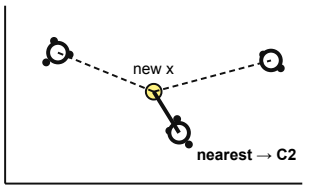
CH6 · DESCRIPTIVE MINING

Unsupervised: no outcome label; group similar records. Standardise numeric features before distances so units do not dominate.

$$z = (x - x)/s \quad \cdot \quad d(u,v) = \sqrt{\Sigma (u_j - v_j)^2}$$

METHOD	RULE
Matching	(1–1 + 0–0 matches)/all binary fields
Jaccard	1–1 / (1–1 + mismatches); ignores joint 0–0
Single linkage	Minimum pairwise distance
Complete linkage	Maximum pairwise distance
k-means	Assign nearest centroid → recompute means → repeat

Cut a dendrogram horizontally: lines crossed = clusters. For a new record, use the same training means/SDs, then assign the nearest centroid.



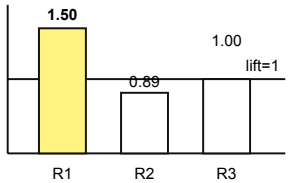
Guide Fig 6.1 redraw: standardise, compare distances, assign nearest.

8 · Association Rules

CH7

```
Support(A→C)=count(AuC)/N
Confidence=count(AuC)/count(A)=P(C|A)
Lift=Confidence ÷ [count(C)/N]
```

Decision: lift >1 useful positive association; =1 independent; <1 worse than random. Confidence is directional; lift is symmetric. A common consequent can create high confidence but weak lift—check lift last.



Guide Fig 7.1 redraw: lift 1 is the useful/not-useful line.

NEAREST-CENTROID CHECK *For x=(0.5,−0.2), c1=(−0.6,0.9), c2=(0.8,−0.5): squared distances are 2.42 and 0.18. Pick c2; √0.18=0.42. Compare squared distances first; use training means/SDs.*

9 · Regression

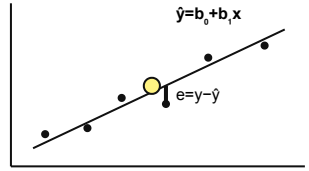
CH8 · FINAL ANALYTICS

$$\hat{y} = b_0 + b_1 x_1 + \ldots + b_p x_p;\ e = y - \hat{y}$$
$$b_1 = \Sigma(x-\bar{x})(y-\bar{y})/\Sigma(x-\bar{x})^2;\ b_0 = \bar{y} - b_1\bar{x}$$
$$SST = SSR + SSE;\ R^2 = SSR/SST$$
$$\text{Adj } R^2 = 1-(1-R^2)(n-1)/(n-p-1)$$

Slope: expected change in mean y for +1 x, holding other predictors fixed. Compare models with adjusted R^2, not raw R^2.

QUESTION	TEST AND DECISION
Any predictor useful?	Overall F=MSR/MSE; df (p,n−p−1); upper-tail
One β_k useful?	$t = b_k/SE(b_k)$; df n−p−1; two-tail
Reject	p-value < α; 95% CI excluding 0 agrees

k categories need **k−1 dummies**; omitted category is baseline. Interaction means one predictor's effect depends on another. Predictor |r|>0.7 warns of multicollinearity: inflated SEs can give significant F but weak individual t-tests.



Guide Fig 8.1 redraw: least squares minimises vertical e^2.

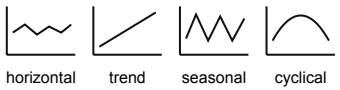
10 · Forecasting

CH9

PATTERN	METHOD
Horizontal	Moving average or exponential smoothing
Trend	Regression with time t
Seasonal	k−1 seasonal dummies
Cyclical	Multi-year, no fixed period; hardest

$$e_t = y_t - \hat{y}_t;\ MAE = \Sigma|e|/(n-k);\ MSE = \Sigma e^2/(n-k)$$
$$MAPE = \Sigma|e/y|/(n-k)\times 100;\ MFE = \Sigma e/(n-k)$$
$$F_{t+1} = \alpha y_t + (1-\alpha)F_t;\ \text{set } F_2 = y_1$$

MFE is bias, not accuracy: negative = over-forecast. Pick lower error, significant trend and higher adjusted R^2.



plot first → pattern chooses method

Guide Fig 9.1 redraw: pattern before formula.

11 · Classification

CH10 · FINAL Q5

Train builds; **validation** tunes/prunes; **test** gives one final unbiased score. Low train error with higher validation error = overfitting.

MGMT90280 Managerial Decision Analytics · Worked Drills

UNIVERSITY OF MELBOURNE · SOURCE-NUMBERED CALCULATIONS · TRAPS · FAST RECALL

Full guide + ask Sia about MGMT90280

SIDE 2/2 FIVE WORKED DRILLS · ERROR CHECKS · METHOD CHOOSER **SHOW WORKING + DECIDE** Write formula → substitute → check → interpret

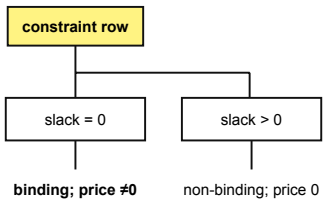
12 · Drill 1 – LP Product Mix

CH1 · WE1 · 8 MARKS

Given: Standard x_1 profit $30 uses (1 carpentry,1 finishing); Premium x_2 profit $50 uses (2,1). Capacities: 40 carpentry, 30 finishing.

Max $Z=30x_1+50x_2$
$x_1+2x_2\le40;\ x_1+x_2\le30;\ x_1,x_2\ge0$

1. Binding lines: $x_1+2x_2=40$ and $x_1+x_2=30 \rightarrow x_2=10$, $x_1=20$.
2. Corners: (20,10)→1100; (0,20)→1000; (30,0)→900; (0,0)→0.
3. Decision: make 20 Standard and 10 Premium; maximum profit $1,100.
4. Both rows bind: slack 0. Shadow prices: carpentry $20/h; finishing $10/h. Extra carpentry is worth more, within allowable RHS range 30–60 h.



Sensitivity retrieval: check slack before interpreting price.

13 · Optimisation Traps

CH1–3

TRAP	REPAIR
Undefined x	Name item and unit before equations.
Ratio left nonlinear	Multiply out using non-negative total.
Shadow price used forever	Quote allowable RHS range.
ILP relaxation rounded	Re-solve with int/bin row.
"only if" reversed	j only if i → $x_j \le x_i$; test 0/1.
Solver number only	State plan, unused capacity and objective.

CHECK *Feasible? integer? within range? units? explicit decision?*

13b · LP Mark-Banking Script

CH1–2

Formulate before solving: "Let x_1=… units and x_2=… units"; "Maximise/Minimise Z=…"; list every capacity, balance, minimum and non-negativity row. If a percentage is present, show the fraction, multiply out, then show the linear row.

Sensitivity sentence: "The [resource] row is binding (slack 0). Its shadow price is $s per unit, so one extra RHS unit changes optimal Z by $s, provided the RHS remains within [lower,upper]." For x_j=0, describe reduced cost as the coefficient improvement needed for entry—not a resource value.

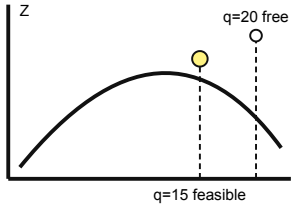
14 · Drill 2 – Binding NLP

CH3 · WE · 8 MARKS

Given: p=100−2q; cost=20q+80; q≤15.

Revenue=$(100-2q)q=100q-2q^2$
Z=Revenue−Cost=$-2q^2+80q-80$

1. $dZ/dq=-4q+80=0 \rightarrow$ free q=20. $d^2Z/dq^2=-4<0$: concave maximum.
2. q=20 violates capacity 15; reject the free point. Since Z rises to q=20, the feasible maximum is the binding boundary q=15.
3. At q=15: p=$70; revenue=70×15=$1,050; cost=20×15+80=$380.
4. Decision: produce 15; capacity binds; maximum profit=$670.



Guide boundary logic: free peak infeasible → bind q=15.

15 · Probability Fast Recall

CH4

WORDS	TRANSLATE
Exactly x	FALSE / pmf P(X=x)
At most x	TRUE / cdf P(X≤x)
Fewer than x	P(X≤x−1), discrete
More than x	1−P(X≤x)
Between a,b normal	cdf(b)−cdf(a)
Percentile	NORM.INV(prob,μ,σ)

Guide normal check: X~N(4,1.2). z at 6 =1.667; P(X<6)=0.9522, so a 95%-within-6-min target is met. P(X>5)=0.2023; 90th percentile=5.54 min.

15b · NLP + Probability Checks

CH3–4

NLP anatomy: identify the nonlinear term, expand Revenue−Cost cleanly, differentiate every decision variable, and solve the simultaneous first-order conditions. Then test every bound. If the free point fails, set the biting constraint to equality and substitute; do not merely "clip" a multivariable answer. A negative second derivative proves a one-variable maximum; concavity over a convex feasible region upgrades the local optimum to global.

DISTRIBUTION CLUE	ASSUMPTION / PARAMETER CHECK
Successes in n trials	Independent; constant p; X=0,…,n
Events per interval	Independent; constant mean μ; rescale interval
Equal values on [a,b]	Density 1/(b−a)

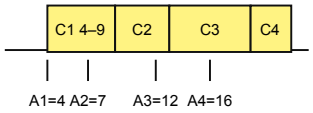
16 · Drill 3 – Queue

CH5 · WORKED EXAMPLE

Given: one teller; ST~Uniform(2,8), so ST=2+6RN. IATs 4,3,5,4; service RNs .500,.333,.667,.167. Add a teller only if average wait >3 min.

I	IAT	ARRIVE	ST	START	DEPART	WAIT
1	4	4	5	4	9	0
2	3	7	4	9	13	2
3	5	12	6	13	19	1
4	4	16	3	19	22	3

Average wait=(0+2+1+3)/4=1.5 min. Since 1.5<3, do not add a second teller on this run. Four customers illustrate the mechanics; base the real call on ≥1,000 iterations.



Queue drill: start=max(arrival, previous departure).

17 · Simulation Traps

CH5

- NORM.INV takes probability, mean, **SD**—not variance.
- Exponential Excel rate is 1/mean.
- Build discrete cutoffs from **cumulative** probabilities and use [L,U).
- Freeze or record random draws before explaining a run.
- Report mean, spread and relevant tail probability; then match the decision threshold.

DO NOT CLAIM *a simulation "optimises"; it estimates an output distribution under a specified policy.*

17b · Build the Simulation Table

CH5

Columns in order: iteration/customer; RN for each uncertain input; sampled value; state carried from the previous row; output; decision statistic. In a queue, compute IAT → cumulative arrival → service time → start → departure → wait → idle. Do not use an IAT directly as an arrival clock.

Uniform(a,b): a + (b-a)RN
Normal(μ,σ): NORM.INV(RN,μ,σ)
Discrete: first cumulative F(x) exceeding RN

Queue check: $idle_i=\max(0,arrival_i-departure_{i-1})$; $wait_i=\max(0,departure_{i-1}-arrival_i)$. At most one is positive. The max belongs in service start, not departure.

21 · Drill 4 – Regression

CH8 · WORKED EXAMPLE

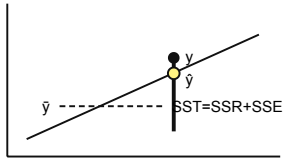
Data: (2,14),(4,18),(6,23),(8,25),(10,30); n=5. $\bar{x}=6$; $\bar{y}=22$; $\Sigma(x-\bar{x})(y-\bar{y})=78$; $\Sigma(x-\bar{x})^2=40$.

$b_1=78/40=1.95$; $b_0=22-1.95\times6=10.3$
$\hat{y}=10.3+1.95x$

SST=154; SSR=1.95×78=152.1; SSE=1.9. $R^2=152.1/154=.988$; adjusted $R^2=.984$.

MSE=1.9/(5-1-1)=.6333
F=152.1/.6333=240.2; df(1,3)
240.2>10.13 → reject H_0
SE(b_1)=√(.6333/40)=.1258
t=1.95/.1258=15.50; df3 → reject H_0
95% CI=1.95±3.182(.1258)=[1.55,2.35]

Decision: model and slope significant; each extra $1,000 advertising is associated with ≈1,950 more units sales. CI excludes 0; $t^2\approx F$.



Guide Fig 8.2 redraw: total = explained + residual variation.

22 · Inference Script

CH8–9

1. Write H_0 and H_a; identify upper- or two-tailed.
2. Compute statistic and degrees of freedom.
3. Compare p with α or statistic with critical value.
4. Say **reject** or **fail to reject**—never "accept H_0".
5. Translate into model/predictor decision with units.

OUTPUT PATTERN	DIAGNOSIS
F significant; t weak	Inspect multicollinearity.
R^2 rises; adjusted R^2 falls	Added predictor is weak.
CI contains 0	Fail to reject β_k=0.

22b · Regression Interpretation Bank

CH8

Slope stem: "Holding other predictors constant, +1 unit of x_k is associated with b_k units in mean y." The intercept is fitted y at numeric zeros and baseline dummies.

Dummy stem: k levels need k−1 indicators; each coefficient is a difference from the omitted baseline. An interaction makes one slope depend on another—interpret the combined marginal effect.

Overall: $H_0:\beta_1=\ldots=\beta_p=0$; H_a:at least one differs
Coefficient: $H_0:\beta_k=0$; $H_a:\beta_k\neq0$
CI: $b_k \pm t\alpha/2,n-p-1 \cdot SE(b_k)$

23 · Forecasting Recall Card

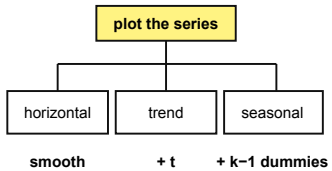
CH9 · METHOD

For quarterly seasonal + trend with Q4 baseline:

$\hat{y}=b_0+b_1Q1+b_2Q2+b_3Q3+b_4t$

QUARTER	Q1	Q2	Q3	TREND
Q1	1	0	0	future t
Q2	0	1	0	future t
Q3	0	0	1	future t
Q4 baseline	0	0	0	future t

Forecast by selecting the quarter's dummy pattern and inserting its future t. Test trend with H_0:βtrend=0, t=btrend/SE(btrend), df=n−p−1. Prefer the trend model when the term is significant, MSE is lower and adjusted R^2 is higher.



Forecast chooser: the plot decides smoothing versus regression.

24 · Forecast Error Traps

CH9

MEASURE	WHAT IT ANSWERS
MAE	Average absolute miss, original units.
MSE	Squares; punishes large misses.
MAPE	Unit-free percentage miss.
MFE	Signed bias; cancellation allowed.

Use n−k when first k periods lack forecasts. Larger moving-average k smooths more but reacts slower. Small α smooths; large α reacts. Moving averages cannot track trend or season. Future regression forecasts need both correct dummy and future t.

24b · Forecasting Mechanics

CH9

k-period MA: $F_{t+1}=(y_t+\ldots+y_{t-k+1})/k$
Exp smoothing: $F_{t+1}=\alpha y_t+(1-\alpha)F_t$; $F_2=y_1$

A moving average discards older observations and lags turns; larger k is smoother and slower. Exponential smoothing retains all history through the recursion; α near 1 reacts quickly, α near 0 smooths strongly. Choose α by minimum MSE, not visual preference.

Error table: calculate y_t, F_t, e_t, $|e_t|$, e_t^2 and $|e_t/y_t|$ for forecastable periods only. MFE<0 means over-forecasting; pair signed bias with MAE/MSE/MAPE.

25 · Drill 5 – Classifier

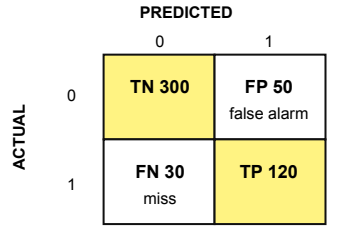
CH10 · WE · 7 MARKS

Validation N=500: TP=120, FN=30, FP=50, TN=300.

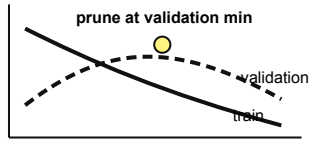
ACTUAL \ PRED.	0	1	TOTAL
0	TN 300	FP 50	350
1	FN 30	TP 120	150

Error=(30+50)/500=.16; Accuracy=.84
Class-1 error=30/150=.20
Class-0 error=50/350=.1429
Sensitivity=120/150=.80
Specificity=300/350=.8571
Precision=120/170=.7059
F1=240/(240+50+30)=.75

Training error 9% vs validation 16% = 7-point gap → overfitting; prune on validation. A missed default is an FN and is costlier here → optimise sensitivity.



Guide Fig 10.2 redraw: actual rows; predicted columns.



Guide overfitting redraw: training error cannot choose tree size.

26 · Final Method Chooser

ALL CHAPTERS

IF THE PROMPT SAYS…	REACH FOR…
Optimise linear resources	LP + sensitivity
Whole / yes-no choice	ILP + logic rows
Quadratic profit	NLP + derivatives + boundary
"Probability that"	Distribution + exact/cdf/tail
Uncertain repeated system	Monte Carlo + ≥1,000 runs
Group without label	Clustering
Basket if→then	Support/confidence/lift
Explain y	Regression + F then t
Forecast time-indexed y	Plot → smoothing or trend/season
Predict a class	Partition + confusion/ROC/tree

Semester 2 examination period, 2–20 November 2026.
Check your unit's exam rules for any limit on what may be brought in.