ETC2520 Probability and Statistical Inference for Economics and Business

MONASH UNIVERSITY · SEMESTER 2, 2026

Full guide + ask Sia about ETC2520

SIDE 1 · DECIDE + JUSTIFY

CLOSED-BOOK MEMORY SHEET · FORMULA SHEET PROVIDED

REVISION ONLY

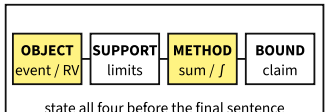
1 · Exam Map

COURSE FACTS

MST 30%	QUIZ	FINAL 60%
Mid Semester Test	30%	in-person pen-and-paper · Week 9
Mini Quizzes	10%	weekly Moodle quizzes
Final Exam	60%	electronic · eExam platform

"A: No, both will be closed-book." *ETC2520 2026 S2 unit FAQs + Moodle "Four Sheets Provided in MST and Exam" page.*

Use this side to recall what a supplied sheet cannot decide: object → support → conditioning information → method → assumptions → interpretation → inferential boundary.



Guide synthesis: the reusable probability-answer workflow.

2 · Probability Object First

CH 1

OBJECT	WHAT MUST BE EXPLICIT
Experiment	random mechanism and level of detail
Sample space Ω	all elementary outcomes used later
Event A	A ⊆ Ω; exact condition defining membership
Probability	assigned only after outcomes/events are fixed

Make Ω fine enough to distinguish every event later used. If two needed events collapse into the same outcome description, rebuild the sample space before calculating.

COUNTING ROUTE — ONLY IF EQUALLY LIKELY

```
P(A) = number of outcomes in A ÷ number in Ω
First justify equal likelihood; counting alone does not.
```

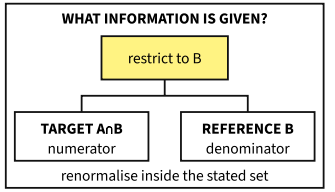
PROBABILITY CONTROL	CONSEQUENCE
non-negativity	P(A)≥0 for every event A
normalisation	P(Ω)=1 and P(∅)=0
disjoint additivity	add event probabilities when overlap is empty
complement	$P(A^c)=1-P(A)$

Counting checklist: decide whether order matters, whether repetition is possible, and whether the counted outcomes are equally likely. The count is a denominator only after those modelling choices agree with the experiment.

EXAM BITE *A clean calculation built on an underspecified Ω cannot support the requested event. Repair the probability object first.*

3 · Condition, Partition, Update

CH 1



New decision figure: "given B" changes numerator and denominator.

CONDITIONING + PRODUCT

```
P(A|B) = P(A∩B)/P(B), provided P(B)>0
P(A∩B) = P(A|B)P(B) = P(B|A)P(A)
```

TOTAL PROBABILITY + BAYES

```
For a partition {Bᵢ}:
P(A)=Σᵢ P(A|Bᵢ)P(Bᵢ)
P(Bⱼ|A)=P(A|Bⱼ)P(Bⱼ)/P(A)
```

CUE	MOVE	EXAM BOUNDARY
"given / among / after learning"	restrict reference set	P(given event)>0
reverse a condition	Bayes; include base rate	do not swap P(A|B)
several source groups	partition + total probability	groups disjoint and exhaustive
new population	rebuild priors/base rates	do not transport unchanged

EXAM BITE *Bayes updates probabilities inside the stated partition. It does not prove causation, and changed base rates change the posterior.*

4 · Independence ≠ Disjointness

CH 1

THREE EQUIVALENT CHECKS

```
A ⊥ B ⇔ P(A|B)=P(A) ⇔ P(B|A)=P(B)
⇔ P(A∩B)=P(A)P(B)
```

RELATION	LEARNING B DOES...	CAN COEXIST?
independent	not change P(A)	yes, usually overlap
disjoint	forces A not to occur	positive-probability events cannot be independent

EVENT COMBINATION

```
P(A∪B)=P(A)+P(B)-P(A∩B)
If A and B are disjoint, the intersection term is zero.
```

Fast diagnosis: "cannot occur together" is disjointness; "knowing one changes nothing about the other" is independence. If both event probabilities are positive, the first statement rules out the second.

5 · RV → PMF / PDF → CDF

CH 2 · FIG 1



support travels with every formula

Guide figure redrawn: a random variable maps outcomes to supported values.

Random variable X is a function assigning a numerical value to every outcome. The distribution belongs to X; always write its support beside the rule.

	DISCRETE: PMF P(X)	CONTINUOUS: PDF F(X)
validity	p(x)≥0; Σp(x)=1	f(x)≥0; ∫f(x)dx=1
point	P(X=x)=p(x)	P(X=x)=0
interval	sum masses	integrate density
meaning	mass is probability	height is not probability

CDF — UNIVERSAL INTERFACE

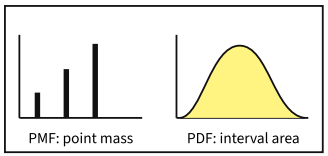
```
F(x)=P(X≤x)
discrete: F(x)=Σ_{u≤x} p(u) · jumps at mass
continuous: F(x)=∫_{-∞}^{x} f(u)du
```

CDF checks: non-decreasing, right-continuous, approaches 0 on the far left and 1 on the far right. For continuous X, interval probability is area/difference of CDF values, never the density at one point.

TARGET	CDF MOVE
P(X≤b)	F(b)
P(X>b)	1−F(b)
P(a<X≤b)	F(b)−F(a)
point mass at x	size of the jump at x

Validation: sum/integrate only over the declared support, and confirm total probability one. Any expression outside the support is zero even when the algebraic formula returns a positive number there.

Discrete endpoint care: when a strict inequality excludes a mass point, subtract that jump. For continuous variables the endpoint choice does not alter the probability, but the interval must still lie inside the support.

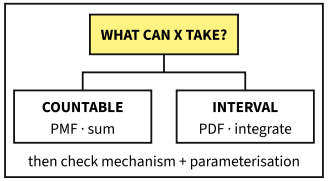


Guide comparison redrawn: sum bars; integrate under the curve.

6 · Choose a Distribution Model

CH 2

QUESTION TO ASK FIRST	WHAT IT CONTROLS
What produces the observation?	candidate family / mechanism
Count or measurement?	PMF versus PDF
Which values are possible?	support and integration/sum limits
What do parameters mean?	interpretation and valid changes
Does the family fit?	separate empirical question



New decision figure: support determines the mathematical operation.

Do not choose by visual resemblance to a memorised formula. A fitted family supplies probabilities only under its generating mechanism, parameterisation and support; goodness of fit and sampling design remain separate.

INTERVAL DISCIPLINE

```
P(a<X≤b) = Σ or ∫ over the actual support only
For continuous X: F(b)-F(a);
endpoint inclusion does not change probability.
```

Changed-case test: change one mechanism, parameter or support condition while holding the others fixed. Retrace the first quantity affected; do not import the old probability after the generating assumptions have changed.

BEFORE CALCULATING	AFTER CALCULATING
name variable + support	probability lies in [0,1]
identify mass/density/CDF	units and event match question
state parameter meaning	limit conclusion to fitted family

7 · Transformations

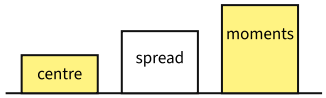
CH 2, 4

1. State Y=g(X) and the original support of X.
2. Map that support through g to find the support of Y.
3. Choose a route: CDF/event inversion, or a density transformation.
4. Check non-negativity and total probability one.

IF G IS...	SAFE REASONING MOVE
one-to-one on support	invert and carry the transformed support
not one-to-one	split into all relevant inverse branches

8 · Expectation, LOTUS, Variance

CH 3 · FIG 1



Guide figure redrawn: three related objects, three different jobs.

EXPECTATION

```
Discrete: E[g(X)] = Σ g(x)p(x)
Continuous: E[g(X)] = ∫ g(x)f(x)dx
Use the original support; require the relevant sum/integral to exist.
```

LOTUS is exactly this transformed-expectation rule. It finds E[g(X)] without first deriving the distribution of Y=g(X). Use it when the expectation is requested and transformation algebra would add work.

LINEARITY — NO INDEPENDENCE REQUIRED

```
E[aX+bY+c] = aE[X]+bE[Y]+c
```

VARIANCE ROUTES

```
Var(X)=E[(X-E[X])²]=E[X²]-(E[X])²
Var(aX+b)=a²Var(X)
```

QUANTITY	INTERPRETATION	EXISTENCE CHECK
E[X]	probability-weighted long-run centre	first moment
Var(X)	expected squared distance; squared units	first + second moments
SD(X)	spread in X's units	finite variance

Shortcut trap: $E[X^2]-(E[X])^2$ is computationally convenient but still needs the relevant moments to be finite. Do not interpret a symbol that is undefined.

MOMENT LANGUAGE	OBJECT
rth raw moment	$E[X^r]$
rth central moment	$E[(X-E[X])^r]$
second central moment	Var(X)

Sanity checks: variance cannot be negative; shifting X by a constant shifts the mean but not the variance; multiplying X by a scales the mean by a and the variance by a^2.

9 · Sums Carry Covariance

CH 3, 5

TWO VARIABLES

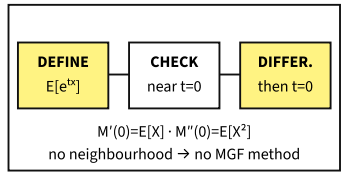
```
Var(X+Y)=Var(X)+Var(Y)+2Cov(X,Y)
Var(aX+bY)=a²Var(X)+b²Var(Y)+2abCov(X,Y)
```

Independence is not needed for means. It matters for variance because it can remove covariance terms when the needed moments exist.

Longer sums: add every component variance and every pairwise covariance contribution. Dropping all cross-terms silently asserts a dependence condition the question may not give.

10 · MGF: Use, Check, Stop

CH 3



Guide method redrawn: existence comes before differentiation.

DEFINITION + RAW MOMENTS

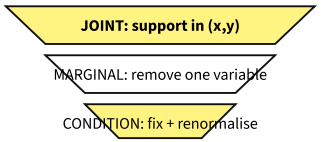
```
M_X(t)=E[e^{tX}]
M_X^(r)(0)=E[X^r], if M_X exists on an open interval containing 0
```

TASK	MGF MOVE	STOP CONDITION
identify moments	differentiate, evaluate at 0	existence not established
sum variables	factor expectation only with independence	dependence remains
transformed expectation	prefer LOTUS if direct	MGF adds no value

Boundary: failure of an MGF to exist does *not* imply that the distribution lacks moments. It only blocks this method. Return to summation/integration and check the particular moment.

11 · Joint → Marginal → Conditional

CH 4 · FIG 1



Guide funnel redrawn: marginalising and conditioning are different operations.

CONTINUOUS FORM; DISCRETE REPLACES ∫ WITH Σ

```
f_X(x)=∫ f_{X,Y}(x,y)dy over valid y for that x
f_Y(y)=∫ f_{X,Y}(x,y)dx over valid x for that y
f_{X|Y}(x|y)=f_{X,Y}(x,y)/f_Y(y), where f_Y(y)>0
```

Draw the joint support first. Rectangular support may allow constant bounds; triangular or otherwise constrained support needs bounds that change with the retained variable.

OPERATION	WHAT HAPPENS TO THE OTHER VARIABLE?
marginalise	sum/integrate it out
condition	fix its value and renormalise
transform	map support; include all inverse branches

Forward this to your tutorial group

SHARED BY _____

Your exam is closed book with a formula sheet provided: nothing of your own goes in. Use this to revise, not to carry.

Monash Semester 2 final assessment period, 2–18 November 2026 (check your personal exam timetable).

ETC2520 Self-test Drills · Judgement Cards · Fast Recall

PROBABILITY AND STATISTICAL INFERENCE FOR ECONOMICS AND BUSINESS

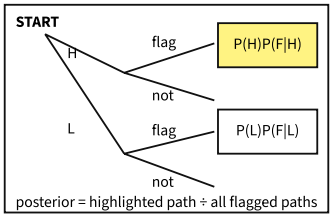
Full guide + ask Sia about ETC2520

SIDE 2 · RETRIEVE + CHECK — CLOSED-BOOK MEMORY SHEET · FORMULA SHEET PROVIDED — SELF-TEST

13 · Worked Drill 1 – Bayes Tree

CH 1 WORKED

Prompt from the guide: a screening system flags transactions from two customer groups with different base rates. Find the probability that a flagged transaction came from the higher-risk group.



Worked symbolic tree: multiply along paths, add competing flagged paths.

1. **Define events:** H/L = group; F = flagged. Confirm H and L form the stated partition.
2. **Numerator:** higher-risk and flagged = P(H)P(F|H).
3. **Denominator:** every flagged route = P(H)P(F|H)+P(L)P(F|L).
4. **Finish:** divide and state "among flagged transactions, the probability of H is …", inside these base rates.

ANSWER SCAFFOLD

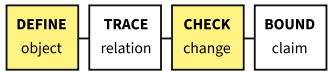
$$P(H|F) = P(H)P(F|H) \div [P(H)P(F|H)+P(L)P(F|L)]$$

CHANGED FACT	FIRST CONSEQUENCE
P(H) changes	both numerator and denominator change
flag rate in L changes	competing flagged path changes
group partition incomplete	denominator misses valid paths

TRAP *High P(F|H) does not by itself imply high P(H|F); the base rate and other flagged paths remain.*

14 · Exam-Morning Plan

STUDY STRATEGY



support · assumptions · inferential reach

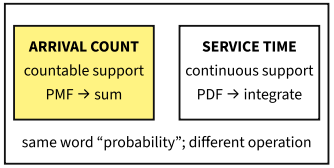
Guide study strategy redrawn: retrieve, apply, vary one fact, limit the claim.

1. **Recite:** Ω/event; conditional/Bayes; independence; PMF/PDF/CDF; support; expectation/variance/LOTUS; MGF; joint/marginal/conditional; covariance/correlation.
2. **Draw:** Bayes tree, PMF versus PDF, triangular support, independence implication.

15 · Worked Drill 2 – Count vs Time

CH 2 WORKED

Prompt from the guide: customer arrivals are modelled by a count distribution while service time is continuous. Choose suitable models, compute interval probabilities and explain why a density value is not itself a probability.



Guide relation redrawn: classify the variable before choosing the calculation.

1. **Name variables:** N = arrivals; T = service time. Write the support of each.
2. **Match object:** N needs a PMF; T needs a PDF. Select a named family only from its mechanism and parameter meaning.
3. **Compute:** add p(n) for admissible counts; integrate f(t) across the stated time interval.
4. **Interpret:** p(n) is point probability; f(t) is density per unit of t, so $f(t_0)$ alone is not $P(T=t_0)$.

INTERVAL TEMPLATES

$$P(a \le N \le b) = \Sigma_n \; p(n), \text{ for admissible integers } n$$

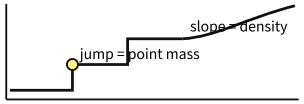
$$P(a < T \le b) = \int_a^b f(t)dt = F(b)-F(a)$$

CHECK	COUNT	TIME
normalise	$\Sigma p(n)=1$	$\int f(t)dt=1$
outside support	$p(n)=0$	$f(t)=0$
single point	may be positive	probability zero

CHANGED CASE *If recorded time is rounded into bins, the data may be discrete even though the underlying duration is continuous; state which variable is being modelled.*

16 · CDF Decoder

CH 2



CDF handles discrete, continuous and mixed X

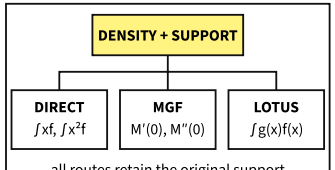
Guide CDF relation redrawn: jumps reveal mass; slope reflects density where smooth.

Translate language: "no greater than x" → F(x); "greater than x" → 1−F(x); interval → difference, with endpoint care for a discrete variable.

17 · Worked Drill 3 – Moments Three Ways

CH 3 WORKED

Prompt from the guide: a random payoff has a simple density on a bounded interval. Compute its first two moments directly, verify them from the generating function and find the expected value of a transformed payoff using LOTUS.



Guide method redrawn: direct moments, MGF check and LOTUS serve distinct tasks.

1. **Validate density:** f(x)≥0 on its bounded support and $\int f(x)dx=1$.
2. **Direct:** $\mu=\int xf(x)dx$; $m_2=\int x^2 f(x)dx$; $Var(X)=m_2-\mu^2$.
3. **MGF:** form $M_x(t)=\int e^{tx}f(x)dx$ on the support; establish existence near zero; verify $M'(0)=\mu$ and $M''(0)=m_2$.
4. **LOTUS:** $E[g(X)]=\int g(x)f(x)dx$; do not derive a new PDF unless it is separately requested.

MISMATCH	DIAGNOSTIC
$M'(0) \neq$ direct mean	differentiate/integrate again; check constant
negative variance	$E[X^2]$ or square of E[X] is wrong
transformed answer outside possible range	support or g(x) was mishandled

Interpretation line: report the mean in payoff units, variance in squared payoff units and the transformed expectation in the units created by g. A matching symbolic form from two routes is stronger evidence than two decimal approximations.

Counter-case: if the support becomes unbounded, redo the existence checks before reusing the bounded-support argument; convergence is part of the method, not an afterthought.

EXAM BITE *A second method is a check only when it could expose an error; repeat algebra with the same mistake is not corroboration.*

18 · MGF Judgement Card

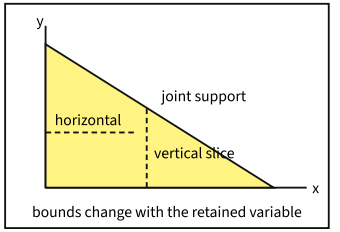
CH 3

CLAIM	VERDICT	WHY
MGF differentiable at zero	not enough	needs existence on an open interval around zero
MGF fails	method fails	individual moments may still exist
means add	yes	linearity needs no independence

19 · Worked Drill 4 – Triangular Joint Support

CH 4–5 WORKED

Prompt from the guide: two business outcomes have a joint density on a triangular support. Verify the normalising constant, derive both marginals, calculate a conditional density and decide what covariance permits you to infer.



New support figure: marginal limits must follow the triangle, not a rectangle.

1. **Sketch support:** rewrite every inequality so each vertical and horizontal slice is visible.
2. **Normalise:** solve $1=\iint_{support} c\cdot h(x,y)\,dxdy$. Keep the constant symbolic until the integral is evaluated.
3. **Marginals:** $f_x(x)=\int$ along the valid y-slice; $f_y(y)=\int$ along the valid x-slice. State each marginal's support.
4. **Conditional:** divide joint by the relevant marginal and state values where the denominator is positive.
5. **Dependence:** compute E[XY] and Cov(X,Y)=E[XY]−E[X]E[Y]. Interpret only linear co-movement.

VERIFICATION STACK

$$\iint f_{x,y}=1 \;\cdot\; \int f_x=1 \;\cdot\; \int f_y=1$$

For fixed y: $\int f_{x|y}(x|y)dx=1$ over conditional support

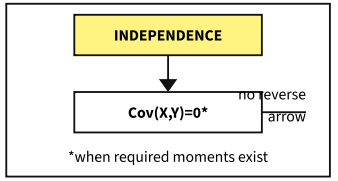
WRONG MOVE	REPAIR
constant rectangle bounds	derive slice bounds from geometry
marginal = plug in y	integrate/sum y out
conditional denominator omitted	divide by marginal; renormalise
Cov=0 therefore independent	not generally valid

Order check: either order of integration must cover the same support. If switching order changes the region, the bounds were translated incorrectly. Marginals and conditionals must remain nonnegative and normalised on their own supports.

FINISH *State what covariance permits: direction and scale of linear co-movement. Do not promote it to independence or causation.*

20 · Dependence: What Can You Say?

CH 5



Guide rule visualised: independence is stronger than zero covariance.

LINEAR DEPENDENCE

$$Cov(X,Y)=E[(X-E[X])(Y-E[Y])]$$
$$=E[XY]-E[X]E[Y]$$
$$Corr(X,Y)=Cov(X,Y)/(SD(X)SD(Y))$$

RESULT	LICENSED CONCLUSION	NOT LICENSED
Cov>0	positive linear co-movement in model	causal effect
Cov<0	negative linear co-movement	perfect relation
Cov=0	uncorrelated	general independence
|Corr| near 1	strong linear relation	valid transport beyond model

Scale distinction: covariance changes with units; correlation standardises by both SDs and is between −1 and 1 when defined. Neither supplies a causal explanation.

Interpret in context: name the two outcomes and say "linear co-movement". A nonlinear relationship may remain even when correlation is zero, so pair the numerical summary with the model structure.

21 · Iterated Expectation

CH 5



E[E[X|Y]]=E[X]

Guide relation redrawn: average conditional means over the conditioning variable.

Use when the problem is naturally staged. First derive the conditional expectation using the information fixed at that stage; then average it over the distribution of the conditioning variable.

21b · Event Algebra Recall

CH 1

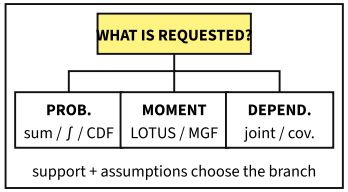
complement	$P(A^c)=1-P(A)$
union	$P(A \cup B)=P(A)+P(B)-P(A \cap B)$
disjoint union	intersection term is zero

Oral check: explain why "disjoint" removes the overlap term yet does not normally establish independence.

22 · Method Chooser

CH 1–5

IF ASKED FOR…	USE / SHOW	GUARDRAIL
event from equally likely outcomes	count favourable ÷ total	justify equal likelihood
probability after information	conditional probability	new denominator
source given result	Bayes + total probability	base rates + full partition
event independence	product or unchanged-condition test	not disjointness
discrete point/interval	PMF; sum	integer/support filter
continuous interval	PDF integral / CDF difference	point probability zero
transformed expectation	LOTUS	integrability + original support
first/second raw moments	direct or MGF derivatives	MGF exists near zero
variance of a sum	carry covariance	drop only with justification
one variable from joint	marginalise	geometry controls bounds
distribution given another	joint ÷ marginal	positive denominator
linear dependence	covariance/correlation	not causation or independence



New decision figure: the requested object selects the operation.

23 · Classic Traps

ALL CHAPTERS

WRONG MOVE	REPAIR
formula before sample space	define outcomes/events first
naive ratio without equal likelihood	justify or use probability law
P(A|B)=P(B|A)	reverse via Bayes
density height called probability	integrate over an interval
distribution without support	write support on same line
variance sums automatically	include covariance terms
marginal and conditional conflated	remove versus fix + renormalise
zero covariance = independence	state only uncorrelated

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