ENG1011 Engineering Methods

MONASH UNIVERSITY · LEVEL 1 · SEMESTER 2, 2026 · EXAM REVISION SHEET · SIDE 1 OF 2

Full guide + ask Sia about ENG1011

SIDE 1/2 DEFINITIONS → FORMULAS → DECISION RULES → CHECKS **FINAL ASSESSMENT 50%** v2 · 2026-10-25

1 · Exam map

COURSE.JSON · ASSESSMENTS

CT 15 | PP 8 | Prog | Per | Rpt 12 | FINAL 50

ASSESSMENT	WEIGHT
Workshop quizzes	0%
Content Test	15%
Project Presentation	8%
Project Progress #1, #2 and #3	10%
Project Performance Test	5%
Project Report	12%
Final Assessment (Examination)	**50%**

Permitted materials: not confirmed for this offering in the course materials we hold — check the exam instructions on the LMS.

2 · Units + resultants

C01 · WEEK 1

Dimensional homogeneity: every term added must describe the same physical quantity. Carry units through working; use N and mm when stress is wanted in MPa.

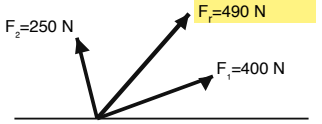
TWO FORCES / MANY FORCES

$F_r^2 = F_1^2 + F_2^2 + 2F_1F_2\cos\theta$

$R_x = \Sigma F\cos\theta \cdot R_y = \Sigma F\sin\theta$

$|R| = \sqrt{(R_x^2+R_y^2)} \cdot \alpha = \operatorname{atan2}(R_y, R_x)$

GIVEN	FAST ROUTE	CHECK
Exactly two + included angle	Cosine rule	Between $\lvert F_1-F_2\rvert$ and F_1+F_2
Three or more / direction needed	Components	Quadrant matches signs
Angles from mixed references	Convert first	Sketch axes



Guide figure, redrawn: two vectors give a 490 N resultant; the included angle belongs between the arrows.

CHECK *A moment term needs force × distance; a stress term needs force/area. If dimensions disagree, stop before substituting.*

UNIT STRIP

QUANTITY	COHERENT FORM	RESULT
Force	kg·m/s²	N
Moment	force × perpendicular length	N·m or N·mm
Stress	N/mm²	MPa
Stiffness / load intensity	force/length	N/m or kN/m

3 · Free-body diagrams

C02 · WEEK 1

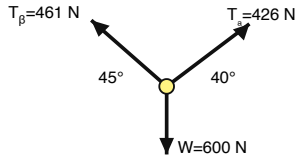
★ ***FBD*** = one isolated body, with geometry/dimensions, coordinate axes, every external load/moment and each removed support replaced by its reactions. Leave internal forces out unless a cut exposes them.

CHECKLIST	WHAT MUST BE VISIBLE
Geometry	Body alone; dimensions and angles used later
Supports	All reaction components the restraint can supply
Loads	Point, distributed and applied couples at correct positions
Unknowns	Assume directions; a negative answer reverses one

PARTICLE EQUILIBRIUM

$\Sigma F_x = 0 \cdot \Sigma F_y = 0$

weight W = mg; guide solutions use g = 9.8 m/s² unless the question states another value.



Guide figure, redrawn: draw cable forces pulling away from the ring, then resolve.

ANGLE SANITY CHECK

For a hanging load, the steeper cable usually carries the larger vertical share. A flatter cable needs more total tension to provide the same vertical component.

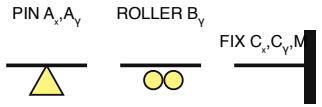
FAST SOLVE + MARKABLE TRAIL

1. Convert any mass to weight and write it on the diagram.
2. Write $\Sigma F_x=0$ first if it gives one tension in terms of the other.
3. Substitute into $\Sigma F_y=0$; keep signs attached to components.
4. Back-substitute and verify both equations numerically.

COMMON OMISSION	WHY IT BREAKS THE SOLUTION
Axes / angle reference	Sine and cosine become ambiguous

4 · Supports

C04 · WEEK 3



Guide figure, redrawn: pin = 2 reactions; roller = 1 normal reaction; fixed = 2 forces + moment.

5 · Rigid-body equilibrium

C04 · WEEK 3

THREE EQUATIONS

$\Sigma F_x = 0 \cdot \Sigma F_y = 0 \cdot \Sigma M^O = 0$

$M^O = Fd\perp$; anticlockwise positive in the guide.

1. Draw the complete FBD and choose an assumed reaction direction.
2. Take moments about the point where the most unknowns meet.
3. Use force balance for the remaining reactions.
4. Check with moments about another point.

OBJECT	MOMENT BEHAVIOUR
Force through O	Zero moment about O
Applied couple	Same moment about every point; no force term
Fixed support	Reaction moment cancels applied resultant moment
Negative reaction	True direction is opposite the arrow assumed

TRAP ***If asked for the reaction moment, do not report the loads' resultant moment: equal size, opposite sign.***

STABILITY BEFORE ARITHMETIC

A planar rigid body must be restrained against translation in x, translation in y and rotation. Three reaction unknowns do not automatically guarantee stability: reactions that are all parallel or all concurrent can leave a motion unrestrained. Predict whether an overhang can reverse one support reaction before solving.

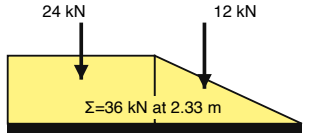
IF THE QUESTION GIVES	BEST FIRST EQUATION
Pin + roller beam	Moments about the pin, eliminating A_x and A_y
Cantilever	Force balances, then moment at fixed end; report reaction sign
Inclined point load	Resolve it before moment and force sums
Applied couple	Insert its signed value directly in ΣM

6 · Distributed loads

C05 · WEEK 3

For **external reactions**, replace a distribution by its area acting at the area's centroid. Keep the actual distribution when finding internal shear and moment.

SHAPE OVER L	EQUIVALENT F	POSITION
Uniform w	wL	L/2



Guide figure, redrawn: split the trapezoid; resultant lies between part centroids, nearer the 24 kN part.

7 · Springs + pulleys

C03 · WEEK 2

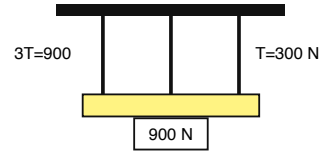
SPRING RULES

$F = k\delta$

parallel: $k_e = \Sigma k_i$ (same stretch)

series: $1/k_e = \Sigma(1/k_i)$ (same force)

Reduce the innermost group, redraw, repeat. A parallel group is stiffer than its stiffest spring; a series chain is softer than its softest spring.



Guide figure, redrawn: count only rope segments supporting the moving block; one ideal rope has one tension.

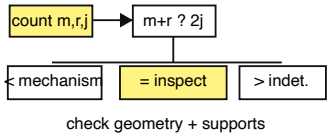
IF YOU SEE	DO THIS
Fixed pulley	Redirect tension only; no mechanical gain
Moving block	Cut the supporting segments: nT = W
Spring + pulley	Find rope force first, then δ = F/k
Bracket load	Vector-sum rope tensions on the fixed support

Geometry cost of gain: if n segments support a moving block, each shortens as the block rises. The free end therefore moves n times the block distance in the ideal system. Force is reduced, displacement is increased.

Network checks: forces in a parallel group add to the applied load; extensions in a series chain add to total extension. Keep k symbolic when springs are multiples of k, then substitute once.

8 · Truss decision rules

C06–C07 · WEEK 4



Guide determinacy figure, redrawn: equality is necessary, not sufficient—inspect geometry and supports.

Count meanings: each joint provides two scalar equations; the unknowns are m axial member forces plus r support reactions. A pin contributes two reactions, a roller one. Replacing a roller by a second pin raises r by one and can make an otherwise determinate truss indeterminate.

Loading idealisation: truss loads act at joints; members are straight and pinned. If a member carries a load between its pins, it is not behaving as the ideal two-force member assumed by the method of joints.

9 · Truss analysis

C06–C07 · WEEK 4

METHOD	USE WHEN	FIRST MOVE
Joints	Many member forces	Reactions, then a joint with ≤2 unknowns
Sections	One/few interior members	Cut ≤3 unknowns; moment about intersection of two
Inspection	Unloaded joint pattern	Mark zero-force members before equations

Method of joints: every member is a two-force member. Draw unknown forces pulling away from each joint (tension positive). Negative result = compression. Resolve along member axes; exploit exact geometry such as 3–4–5.

ZERO-FORCE INSPECTION

Unloaded joint + 2 non-collinear members → both zero.
Unloaded joint + 3 members, 2 collinear → third zero.
Never apply at a load or support reaction.

Method of sections: take one side of the cut as a rigid body. Choose a moment point where two cut forces intersect so both vanish, leaving the third. Chord force often equals section moment ÷ truss depth.

FINAL CHECKS	MEANING
Last joint balances	Confirms the force chain
Symmetric load/geometry	Reactions and mirrored members match
Force lies along member	Required for a two-force member
Zero member retained	May brace buckling or carry another load case

10 · Stress + strain

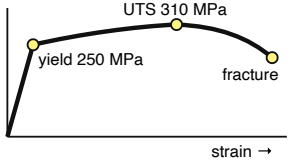
C08 · WEEK 5

TENSILE-TEST TOOLS

$\sigma = F/A_0 \cdot \varepsilon = \Delta L/L_0 \cdot E = \Delta\sigma/\Delta\varepsilon$ (linear)

Fmax = UTS × A_0

$\varepsilon_{plastic} = \varepsilon_{total} - \sigma/E \cdot L_{final} = L_0(1+\varepsilon_{plastic})$



Guide figure, redrawn: modulus is the initial slope; yield begins permanent strain; UTS is the peak.

READ FROM CURVE	MEANING / CALCULATION
Elastic modulus E	Slope of straight initial region only
Yield strength	Permanent deformation begins; 0.2% offset if knee is gradual
UTS	Highest engineering stress; Fmax=UTS×A_0

11 · Materials + processing

C08–C09 · W5–6

CHOICE / PROCESS	STRUCTURE → PROPERTY CONSEQUENCE
Thermoplastic	Secondary bonds between chains; softens and can be remelted
Thermoset	Cross-linked covalent network; does not melt on reheating
Cold work	More tangled dislocations → strength ↑, ductility ↓
Anneal	Recovery/recrystallisation → ductility restored
FDM printing	No part-specific tooling; suits custom parts/prototypes; visible layers
Injection moulding	Tooling needed; suits high volume and smoother surfaces

THERMAL STRAIN

$\varepsilon_{thermal} = \alpha\Delta T \cdot L_{final} = L_{initial}(1+\alpha\Delta T)$

Read true/false statements word by word: *increase/decrease*, *always/never*, surface finish, tooling and production volume are the deciding cues.

12 · Axial-member design

C10 · WEEK 7

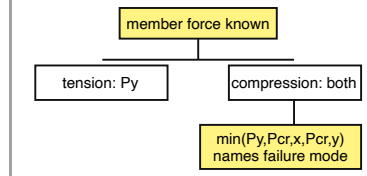
CAPACITY EQUATIONS

$P_y = \sigma_y A$

$P_{cr} = \pi^2 EI/(kL)^2$

rectangle: $I = bd^3/12$

capacity = min(Py, Pcr,x, Pcr,y)



New decision figure: compression must pass yielding and buckling about every relevant axis.

CUE	CONSEQUENCE
Longer member	Pcr falls with $1/L^2$
Both ends restrained, k=0.5	Half effective length; Pcr becomes 4× pinned k=1
Rectangular strip	Buckles about smaller I unless braced
Tube vs solid at similar area	Material farther from axis gives larger I

13 · Beams, frames, machines

C11–C13 · W8–11

BEAM + MACHINE CORE

$dV/dx = -w \cdot dM/dx = V \cdot \Delta M$ = area under V

$\sigma = My/I \cdot$ flexural rigidity = EI

MA = output/input = effort arm/load arm

AskSia

FORWARD THIS TO YOUR TUTORIAL GROUP · V2 · 2026-10-25

Check your exam instructions on the LMS for what you may bring; use this sheet to revise and self-test. Monash Semester 2 final assessment period, 2–18 November 2026 (check your personal exam timetable).

ENG1011 Engineering Methods · self-test drills

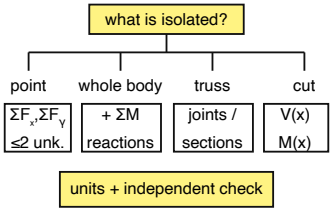
MONASH UNIVERSITY · LEVEL 1 · SEMESTER 2, 2026 · EXAM REVISION SHEET · SIDE 2 OF 2

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SIDE 2/2 5 WORKED MINI-EXAMPLES · IF X → Y · TRAPS · EXAM-MORNING PLAN — **ANSWER PATH BEFORE ANSWER** — v2 · 2026-10-25

14 · Method chooser

PRACTICE · ROUTING CHART



New routing figure: the isolated object determines the first equilibrium equations.

IF YOU SEE X	DO Y
Several forces at one point	Resolve components; $\Sigma F_x=\Sigma F_y=0$
Beam reactions	Equivalent loads; moment about best support
One interior truss member	Section through ≤3 unknowns
Compression member	Compute squash + Euler about both axes
Beam design	Reactions → Mmax → σ → deflection
Frame	Split at pins; equal/opposite shared forces

ONE-LINE JUDGEMENT CARDS

If a sign is negative → keep it through the working, then state the reversed physical direction or compression. **If symmetry appears →** use it for reactions, then confirm at the centre joint. **If a value is read from a graph →** record axis units before arithmetic. **If two design limits appear →** calculate both and name the smaller.

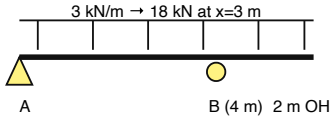
UNIVERSAL CHECK SENTENCE

```
The result has the expected sign, units and order of magnitude; substituting it into an independent equilibrium equation gives zero.
```

15 · Worked 1: overhang

COURSE WORKED EXAMPLE

Given: 6 m beam; pin A at 0, roller B at 4 m; 3 kN/m over all 6 m.



Keep the distribution on the FBD; use its resultant only in the reaction equations.

1. Resultant = 3×6 = 18 kN at 3 m from A.
2. ΣM^A: $4B_y - 18\times3 = 0$ → **B_y=13.5 kN ↑**.
3. ΣF_y: $A_y+13.5-18=0$ → **A_y=4.5 kN ↑**; $A_x=0$.
4. Check at B: 18×1−4.5×4=0.

16 · Worked 2: forces

C01 WORKED EXAMPLE

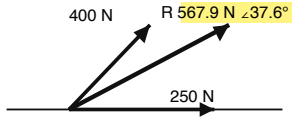
Given: 250 N along +x; 400 N at 60° above +x.

MAGNITUDE

```
F_r² = 250²+400²+2(250)(400)cos60° = 322,500
F_r = 567.9 N
```

DIRECTION CHECK

```
R_x=250+400cos60°=450 N
R_y=400sin60°=346.4 N
θ=tan⁻¹(346.4/450)=37.6° above +x
```



Same guide example, redrawn: components independently verify the cosine-rule answer.

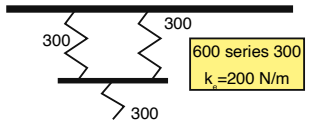
TRAP *With arrows tail-to-tail, use their included angle with the plus-sign cosine rule.*

SELF-CHECK	HERE
Magnitude bounds	150 N < 567.9 N < 650 N
Direction	Both components positive → first quadrant
Dominant force	Resultant lies nearer the 400 N direction

17 · Cable + spring/pulley drills

C02–C03

PROMPT	ANSWER PATH
1000 N; cables 30° right and 60° left	$T_1\cos30=T_2\cos60$ → $T_2=1.732T_1$; vertical: $.5T_1+.866T_2=1000$ → **T_1=500 N, T_2=866 N**
Two 300 N/m springs parallel; third 300 N/m in series; load 60 N	kI=600; $1/k_e=1/600+1/300$ → **k_e=200 N/m**; δ=60/200=**0.30 m**
900 N block, three supporting segments	3T=900 → **T=300 N**



Reduce one group at a time; the final series stiffness must be below 300 N/m.

THERMAL SHRINKAGE MINI-DRILL

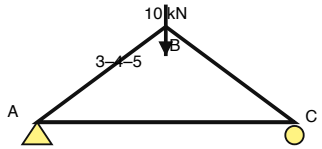
Given: α=70×10⁻⁶/°C; solidifies at 180°C; finished length 80.00 mm at 20°C. ΔT=20−180=−160°C; ε=αΔT=−0.0112. Since 80.00=Lmould(1−0.0112), **Lmould=80.91 mm**. The starting dimension is the mould length, so divide by the cooled length factor.

PROCESS CUE	VERDICT
Custom prototype, no tooling	FDM is suitable

18 · Worked 3: truss

C06 WORKED EXAMPLE

Given: triangle A(0,0), B(4,3), C(8,0); pin A, roller C; 10 kN ↓ at B.



Symmetric three-member truss: exact 3–4–5 components avoid rounded angles.

1. m=3, r=3, j=3 → m+r=6=2j; triangulated and stable → determinate.
2. Symmetry: $A_y=C_y=5$ kN ↑.
3. Joint A: $5+F^{AB}(3/5)=0$ → $F^{AB}=-8.33$ kN → **8.33 kN compression**.
4. Horizontal: $F^{Ac}+F^{AB}(4/5)=0$ → **F^{Ac}=6.67 kN tension**.

CHECK *Finish the last joint; every known force must balance without a new unknown.*

ZERO-FORCE INSPECTION DRILL

JOINT SEEN	IMMEDIATE CONCLUSION
Unloaded; two non-collinear members	Both forces are zero
Unloaded; three members, two collinear	The third member is zero
External load or support reaction present	No inspection shortcut; write equilibrium

Section alternative: if only a middle chord is asked, cut through it and at most two other unknown members. Keep the side with fewer loads. Take moments about the intersection of the other two cut forces, so the desired member is the only cut-force term left.

PUBLISHED SECTION DRILL

```
10 kN reaction × 3 m = Fchord × 1.5 m
Fchord = 20 kN tension
```

19 · Worked 4: tensile rod

C08 WORKED EXAMPLE

Given: steel rod d=10 mm, L=2 m, F=5 kN, E=200 GPa.

N–MM–MPA ROUTE

```
A=π10²/4=78.5 mm²
σ=5000/78.5=63.7 MPa
ε=63.7/200,000=0.000318
ΔL=0.000318×2000=0.64 mm
```

QUANTITY	USE	UNIT CHECK
Area	Original section	mm^2
Stress	N/mm^2	MPa
Modulus	200 GPa	200,000 MPa
Length	2 m	2000 mm

UNLOAD AFTER YIELD

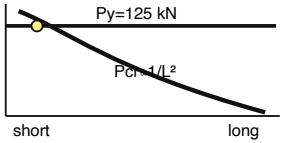
20 · Worked 5: strut

C10 WORKED EXAMPLE

Given: 25×25 mm aluminium strut, L=1500 mm, pinned ends, E=70,000 MPa, σ_Y=200 MPa.

BOTH LIMITS

```
A=625 mm² → Py=200×625=125,000 N
I=25⁴/12=32,552 mm⁴
Pcr=π²(70,000)(32,552)/1500²=9,995 N
≈10.0 kN
capacity=min(125,9.995) kN →
buckling governs
```



Guide capacity plot, redrawn: squash is length-independent; Euler capacity falls with $1/L^2$.

ANSWER PATH *section A and I → effective length kL → all capacities → smallest value + named mode.*

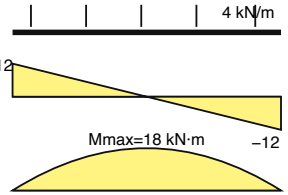
CHANGE	EFFECT ON EULER LOAD
Double L	Pcr becomes one quarter
k: 1.0 → 0.5	Pcr becomes four times larger
Increase weak-axis I	Pcr rises in direct proportion
Increase yield strength only	Raises Py; does not change elastic Pcr

Orientation judgement: for a rectangular section $I=bd^3/12$, so the dimension cubed is the depth perpendicular to the bending axis. The smaller I defines the easy buckling direction unless bracing prevents it.

21 · SFD/BMD drill

C11 · WEEK 8

Given: simply supported L=6 m with w=4 kN/m. Symmetry gives $A_y=B_y=wL/2=12$ kN.



Guide figure, redrawn: uniform load → linear shear → parabolic moment; maximum where V=0.

```
V(x)=12-4x → V=0 at x=3 m
Mmax=wL²/8=4×6²/8=18 kN·m
```

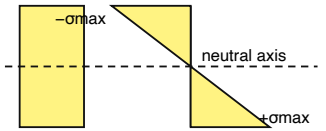
LOAD EVENT	SHEAR DIAGRAM	MOMENT DIAGRAM
No distributed load	Horizontal	Straight, slope=V
Uniform load	Straight slope	Parabola
Triangular load	Parabola	Cubic curve

22 · Bending stress drill

C12 WORKED EXAMPLE

Given: b=100 mm, d=200 mm, Mmax=20 kN·m.

```
I=bd³/12=100×200³/12=66.7×10⁶ mm⁴
ymax=100 mm · M=20×10⁶ N·mm
σmax=My/I=30 MPa
```



Guide figure, redrawn: sagging puts the top in compression, bottom in tension; stress is zero at the neutral axis.

TRAP *Convert kN·m to N·mm by ×10⁶ before using mm section dimensions.*

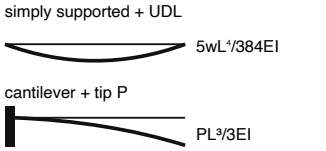
FIBRE LOCATION + ORIENTATION

Stress varies linearly with y. For the guide's 50×150 mm beam under M=2.25 kN·m with $I=14.06\times10^6$ mm^4, the stress 30 mm above the neutral axis is $2.25\times10^6\times30/(14.06\times10^6)$=**4.8 MPa compression**. It is 30/75 of the 12.0 MPa extreme value.

SECTION MOVE	CONSEQUENCE
Increase depth d	I grows with d^3; stress falls because section modulus grows with d^2
Turn 50×150 on its side	I falls to one ninth; peak stress triples
Move toward neutral axis	|σ| falls linearly to zero

23 · Deflection + limit states

C12 · WEEK 9



Guide figure, redrawn: choose the stated load/support case; maximum occurs at midspan or the free end.

CHECK	PASS CONDITION	IF IT FAILS
ULS strength	|σmax| ≤ allowable stress	Increase section modulus / reduce M
SLS deflection	|δmax| ≤ stated limit	Increase EI / reduce span or load

Use N, mm, MPa, mm^4 and N/mm throughout. A beam can pass strength and fail deflection, or the reverse; state both verdicts and the governing one.

DEFLECTION SUBSTITUTION AUDIT

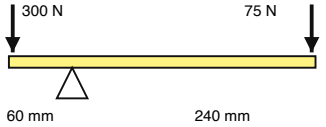
SYMBOL	BEFORE SUBSTITUTING
w	Convert kN/m to N/mm; numerical value is the same
P	Convert kN to N
L	Convert metres to millimetres before powers
E	Convert GPa to MPa=N/mm^2

24 · Frames + machines

C13 · W10–11

MEMBER	FORCE INFORMATION
Two-force	Only two pin forces; equal, opposite and collinear with member
Multi-force	Three or more force points / distributed load; forces need not follow axis
Shared pin	C_x,C_y on one member; $-C_x$,$-C_y$ on the other

1. Identify two-force members; their force direction is already known.
2. Separate every multi-force member and draw shared pin forces equal/opposite.
3. Take moments about a pin to remove its unknown components.
4. Use force balance; check the whole frame last.



Guide figure, redrawn: 300×60 = effort×240 → effort 75 N; MA=300/75=4.

GUIDE LEVER EXAMPLE

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500 N at 0.2 m; effort arm 1.0 m
E(1.0)=500(0.2) → E=100 N
MA=500/100=1.0/0.2=5
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25 · Classic traps

FAQ + PRACTICE SOLUTIONS

TRAP	REPAIR
Reaction moment vs resultant moment	Equal magnitude, opposite sign; answer the named quantity
Wrong centroid end	Triangle acts L/3 from tall end
m+r=2j declared sufficient	Also inspect triangulation and reaction layout
Zero-force rule at loaded/support joint	Rules apply only to unloaded joints
Mixed m/mm or GPa/MPa	Convert once at the top of the working
Only squash or only buckling	Compute both axes and take the smallest
Missed applied couple in BMD	Couple gives moment jump; shear unchanged
Strength checked, deflection ignored	Give separate ULS and SLS verdicts

26 · Exam-morning plan

STUDY STRATEGY

1. Confirm timetable and the LMS exam instructions, including permitted items.
2. From memory, draw pin/roller/fixed reactions; write ΣF_x, ΣF_y, ΣM.
3. Write spring, distributed-load, truss-count, stress/strain, Euler and bending formulas once.
4. Recite: FBD → equation name → units → independent check → governing limit.
5. Warm up with one mixed recognition drill; do not learn a new method.