AMME1362 Introduction to Engineering Materials

UNIVERSITY OF SYDNEY · ENGINEERING · EXAM REVISION SHEET

Full guide + ask Sia about AMME1362

SIDE 1/2 PRIORITY MAP · DEFINITIONS · FORMULAS · DECISION RULES · COMPARISONS

S2 2026 · FINAL 45% · TWO HOURS · HURDLE 40%

recite → choose → calculate → check

1 · Exam map

COURSE JSON · BRIEF

TQ 10 | ILQ 20 | A 10 | Lab 15 | Final 45

ASSESSMENT	WEIGHT	COURSE DETAIL
Tutorial quizzes	10%	Six quizzes
In-lecture quiz	20%	Week 7 Thursday
Assignment	10%	Week 12 Friday
Laboratory report	15%	Attendance + submission compulsory
Final exam	**45%**	Whole course; minimum exam mark 40%

PERMISSION TRUTH

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

The supplied sources securely identify a **two-hour written final** in the examination period. Do not infer question count, sections or aid conditions from older material.

2 · Selection logic

GUIDE CH. 1

Service → Screen → Rank → Test

Selection order: service → pass/fail screens → objective → representative test.

STRUCTURE CHAIN

processing → structure → available motion/reaction → property → performance

FAMILY	QUALIFIED EXPECTATION	WATCH
Metal	Stiff; plasticity via dislocations	Corrosion, fatigue
Ceramic	Hard/heat resistant	Flaw-sensitive tension
Polymer	Low density; chain mobility	Time, T, moisture
Composite	Designed load path	Direction, interface

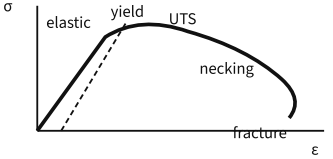
Specific stiffness = E/ρ, but an index ranks only its stated objective and geometry. A failed constraint cannot be rescued by a good ranking. Fix direction, temperature, rate and environment before comparing data.

PROMPT-TO-DECISION AUDIT

EXTRACT	TURN IT INTO	EVIDENCE NEEDED
Function + geometry	Load path and allowable shape change	Stiffness/strength in the named direction
Non-negotiable limit	Constraint and screening threshold	Compatible test condition and uncertainty
Quantity to improve	Objective such as mass or cost	Index with its geometry assumptions

3 · Tensile response

GUIDE CH. 2



Read the curve as specimen events, not as interchangeable property labels.

ENGINEERING DEFINITIONS

σ = F/A₀ · ε = (L - L₀)/L₀ = ΔL/L₀
E = Δσ/Δε in the stated linear elastic region

CURVE FEATURE	MEANING / EXAM CHECK
Slope	**Modulus**, not strength; compatible units
Offset yield	Specified parallel offset; permanent deformation criterion
Maximum σeng	Ultimate tensile strength; necking begins around localisation
Post-maximum fall	Load falls while original A_0 remains denominator
True stress	F/current area; increasingly differs as area changes

Presentation route: geometry → original dimensions → unit conversion → definition → substitution → result → curve-region check. N/mm² = MPa; strain is dimensionless. A secant through the origin gives E only if response is elastic and linear from zero.

EVIDENCE AUDIT

Record dimensions, direction, alignment, extension method, surface state and visible yielding/necking/fracture. Crosshead travel can include grip/frame deformation: ***machine compliance*** can distort strain and modulus.

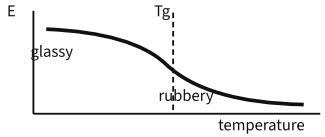
DUCTILITY MEASURES

% elongation = 100(Lf - L₀)/L₀
% reduction in area = 100(A₀ - Af)/A₀

OBSERVED ISSUE	EFFECT ON EVIDENCE	REPAIR
Area measured too small	Calculated engineering stress too high	Repeat dimensions; state section
Crosshead used as gauge extension	Frame/grip motion enters strain	Use extensometer or compliance correction
Misalignment	Bending contaminates nominal tension	Check grips/specimen symmetry
Short vs long gauge	Local neck occupies different fraction	Report gauge length with elongation
Gauge-length error	Strain and elongation comparisons shift	Verify and report L_0
After necking	Gauge-average strain hides local deformation	Use local/current geometry; state limit

5 · Ceramics + polymers

GUIDE CH. 4



Polymer properties are incomplete without temperature and loading time/rate.

IF TESTED...	MECHANISM → LIKELY RESPONSE
Polymer faster / colder	Less chain rearrangement → commonly stiffer, stronger, less ductile
Polymer slower / warmer	More segment motion → softer, more time-dependent
Ceramic in flexure	Known tensile surface; practical brittle comparison
Larger stressed volume	Greater chance of severe flaw → strength scatter

RECTANGULAR 3-POINT BEND

σfs = 3FfL/(2bd²) — locate tensile surface; keep geometry consistent.

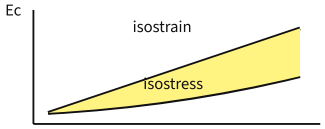
Ceramic strength belongs to specimen geometry, surface preparation and flaw population. Polymer comparison belongs to T, strain rate/time, crystallinity, topology and moisture history. ***Stress relaxation***: stress falls with time at fixed strain.

FAIR COMPARISON

Match test mode, geometry, finish, rate, T and environment. MPa does not make bend and tensile strengths interchangeable. Report brittle scatter/stressed volume and polymer transition proximity/timescale.

6 · Composite stiffness

GUIDE CH. 5



Aligned fibres give different ideal responses along and across the load path.

BOUNDS / DIRECTION

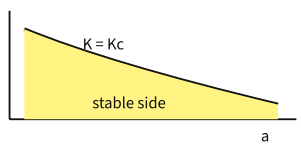
Vf + Vm = 1
EcL = EfVf + EmVm (equal strain; longitudinal)
1/EcT = Vf/Ef + Vm/Em (equal stress; lower bound)

COMPONENT	ROLE / FAILURE CLUE
Matrix	Binds, protects, transfers stress; may crack
Fibre	Axial stiffness/strength; may fracture or buckle

FOLLOW THE FAILURE SEQUENCE

7 · Fracture mechanics

GUIDE CH. 6



With Kc and geometry fixed, allowable stress varies as $1/\sqrt{a}$.

MODE I DECISION

K = Yσ√(πa)
failure screen: K ≥ Kc
σc = Kc/[Y√(πa)] · ac = (Kc/Yσ)²/π

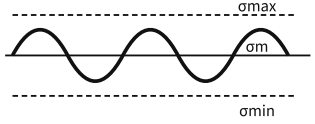
BEFORE SUBSTITUTING	WHY
Define a	Half/full crack convention changes result
Select Y	Crack/component geometry correction
Convert a to m	K units are MPa√m
Check constraint	Thickness affects plane-strain validity
Check environment	Resistance and growth may change

Fracture toughness is crack-growth resistance under defined geometry/constraint; it is not tensile toughness. Sharp cracks can cause failure below smooth-specimen yield. Thick sections suppress out-of-plane deformation and increase crack-tip constraint.

TREND *If a ×4 with Kc and Y fixed, σc ÷2.*

8 · Fatigue, creep, wear

GUIDE CH. 7



A cycle is not fully specified until maximum, minimum, mean and amplitude are known.

CYCLE ARITHMETIC

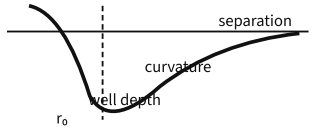
Δσ = σmax - σmin · σa = Δσ/2
σm = (σmax + σmin)/2 · R = σmin/σmax

MECHANISM	RECOGNISE → QUANTIFY → CONTROL
Fatigue	Cycles/notch → S–N with stated R/condition → reduce raisers, protect surface
Creep	Sustained hot load → steady secondary rate → lower stress/T, stabilise structure
Abrasive wear	Grooves/hard particles → loss/debris → filtration, sealing, supported hardness
Friction	System response → force ratio under stated conditions → lubrication/contact redesign

DATA-CONDITION MATCH

9 · Bonding → response

GUIDE CH. 8



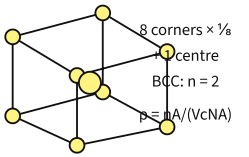
Local curvature near r_0 tracks stiffness; full well depth tracks separation energy.

BOND FEATURE	REASONING CONSEQUENCE
Steeper near r_0	More force for small spacing change → higher E tendency
Deeper well	More separation energy → higher melting tendency
Anharmonic well	Mean spacing shifts with vibration → thermal expansion
Nondirectional metallic	Mobile electrons + dislocation-mediated ductility
Secondary interactions	Strong influence on polymer chain mobility

Equilibrium occurs where attractive and repulsive forces balance. Real ceramics can have mixed ionic/covalent character: retain charge, coordination, directionality and crystal structure rather than using one label as the whole explanation.

10 · Unit cells + density

GUIDE CH. 9



Count shared atoms first; chemistry gives cell mass and geometry gives cell volume.

CRYSTAL CALCULATION

ρ = nA/(VcNA) · cubic Vc = a³
APF = n(4πr³/3)/Vc

SITE	CELL SHARE	CUBIC CONTACT
Corner	⅛	SC: edge
Face	½	FCC: face diagonal
Edge	¼	BCC: body diagonal
Interior	1	—

Length conversion is cubed. Measured density below theory can reflect porosity, vacancies, substitution, phases or conditions—not automatically algebra failure. APF alone does not determine strength; defects, grain size, solutes and T matter.

CERAMIC + POLYMER STRUCTURES

STRUCTURE	EXAM CHAIN
Ceramic	Charge neutrality first; radius ratio guides fit, not proof.
Polymer	Configuration needs bond breaking; conformation changes by rotation; cross-links block flow.

11 · Indexing + anisotropy

GUIDE CH. 10

DIRECTION [uvw]
head − tail
clear fractions

PLANE (hkl)
intercepts → 1/x
clear fractions

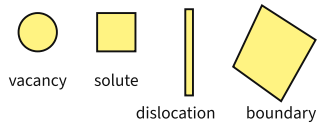
Directions subtract coordinates; planes invert intercepts. Preserve negative signs.

OBJECT	PROCEDURE / NOTATION
One direction	Translate vector if useful; Δ coordinates; smallest integers; [uvw]
One plane	Intercepts in lattice units; reciprocals; smallest integers; (hkl)
Parallel axis	Intercept ∞ → reciprocal 0
Slip system	Permitted slip plane + direction; resolved shear must reach resistance
Texture	Preferred grain orientations → bulk direction dependence

Same digits do not make a vector and a plane the same object. Negative index must survive subtraction or reciprocal construction. In sheet, compare rolling, transverse and thickness directions when texture is present.

12 · Defects + strengthening

GUIDE CH. 12



Point, line and interfacial defects enable motion and provide obstacles to motion.

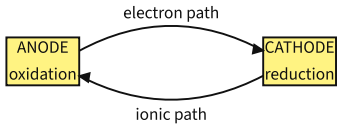
VACANCY POPULATION

Nv/N = exp[-Qv/(kT)] — use absolute T and compatible per-atom energy units.

METHOD	OBSTACLE → TRADE-OFF / STABILITY
Grain refinement	More boundaries interrupt slip → boundary stability matters at high T
Cold work	Dislocations interact → strength ↑, ductility ↓; recovery on heating
Solid solution	Solute strain fields obstruct motion → composition-dependent

13 · Corrosion cell

GUIDE CH. 13



Break any required cell link, then verify the predicted damage has slowed.

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v2 · 2026-10-25 · side 1/2

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SIDE 2/2 FIVE WORKED DRILLS · JUDGEMENT CARDS · CLASSIC TRAPS · EXAM-MORNING PLAN

SELF-TEST: COVER ANSWERS, SHOW PATH, THEN CHECK

units → assumptions → physical sense

14 · Worked 1: tensile point

GUIDE CH. 2 · COURSE FREE

Given: L_o = 50.0 mm, A_o = 80.0 mm², F = 12.0 kN, final gauge length 50.40 mm; point is elastic. Find engineering stress, strain and secant modulus.

ΔL	ε = ΔL/L_o	σ = F/A_o	E = σ/ε
0.40 mm	0.0080	150 MPa	18.75 GPa

Original dimensions control both engineering denominators.

ANSWER PATH

```
ΔL = 50.40 - 50.00 = 0.40 mm
ε = 0.40/50.0 = 0.0080
σ = 12,000/80.0 = 150 N/mm² = 150 MPa
E = 150/0.0080 = 18,750 MPa = 18.75 GPa
```

Interpretation: secant modulus is valid here only because the point is stated to remain elastic and linear from the origin.

SELF-CHECK *Did you use original area and original gauge length? Did you convert kN → N?*

15 · Curve-reading card

GUIDE CHS. 2–3

IF ASKED FOR…	READ / CALCULATE	DO NOT SAY
Stiffness	Linear elastic slope	Highest stress
Yield resistance	Stated yield convention	Fracture point
Ductility	Strain/elongation or area reduction to fracture	Curve slope
Resilience	Elastic area to yield	Total area
Toughness	Total area to fracture	Kc

Evidence sentence: "The curve shows ___ because ___ on the axes; under the stated test condition this implies ___ in service." Add what cannot be concluded if conditions or full curve are absent.

CLASSIC TRAPS

- Percentage strain entered as a whole number.
- Current area silently used for engineering stress.
- One point used for E outside the linear region.
- Hardness correlation treated as a complete tensile/fracture test.

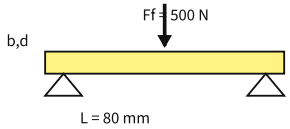
DIAGNOSE THE PROPOSED ANSWER

CLAIM	AUDIT QUESTION	CORRECTION
"Curve A is strongest"	Which stress feature is higher?	Name yield or UTS, not a vague curve impression
"Curve B is toughest"	Is the entire path to fracture shown?	Compare total area, not only peak or strain

16 · Worked 2: ceramic flexure

GUIDE CH. 4 BODY

Given: rectangular ceramic bar, b = 10 mm, d = 5 mm, support span L = 80 mm, centre fracture load Ff = 500 N.



The lower surface carries maximum tension in this central three-point bend.

ANSWER PATH

```
σfs = 3FfL/(2bd²)
= 3(500)(80)/[2(10)(5²)]
= 120,000/500 = 240 MPa
```

State the test geometry and tensile surface. This calculated extreme-fibre failure stress is comparative flexural strength; it remains tied to flaw population, surface condition and stressed volume.

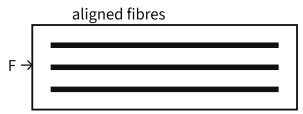
WRONG MOVE	WHY IT FAILS	VISIBLE REPAIR
Use d once	Section bending term contains d^2	Write geometry formula before values
Ignore surface	Tensile-side flaw can control fracture	Mark tensile face and preparation

TRAP *Thickness is squared. Do not compare flexural and tensile values as though test modes were identical.*

17 · Worked 3: composite E

GUIDE CH. 5 WORKED

Given: aligned fibres Ef = 200 GPa, Vf = 0.30; matrix Em = 4 GPa, Vm = 0.70. Load is along fibres under equal strain.



Parallel loading makes fibre and matrix extend by the same ideal axial strain.

ANSWER PATH

```
Ec∥ = EfVf + EmVm
= 200(0.30) + 4(0.70)
= 60 + 2.8 = 62.8 GPa
```

Check: Vf + Vm = 1; units match; conclusion says "ideal equal-strain longitudinal modulus". Misalignment, short fibres, voids, weak interface or nonlinear response can lower the real result.

LOAD	LIKELY CONTROLLING PATH	EARLY DAMAGE
Longitudinal tension	Fibres + interface transfer	Fibre fracture

BOUND-SELECTION SELF-TEST

18 · Worked 4: critical crack

GUIDE CH. 6 WORKED

Given: Kc = 30 MPa$\sqrt{m}$, σ = 150 MPa, Y = 1.0. Use K = Yσ$\sqrt{(\pi a)}$ to find critical a.

Kc/(Yσ) = 0.200 $\sqrt{m}$	square = 0.0400 m	÷ π = 0.0127 m

Keep the square root visible until Kc/(Yσ) has compatible $\sqrt{m}$ units.

ANSWER PATH

```
ac = (1/π)[Kc/(Yσ)]²
= (1/π)(30/150)²
= 0.0400/π = 0.0127 m = 12.7 mm
```

The result is for the stated ideal geometry and the a-definition in this equation. A defensible answer also checks that the toughness condition, thickness, crack orientation and environment are compatible.

CHANGE, OTHERS FIXED	CRITICAL RESPONSE
a ↑	K ↑ and allowable σ ↓
Y ↑	K ↑ and allowable σ ↓
Kc ↑	Larger allowable a or σ
Thickness/constraint ↑	May reduce apparent resistance toward plane strain

TRAP *Never drop Y or mix a full crack length with a half-length convention.*

DAMAGE-TOLERANCE LOGIC

Inspection must find relevant flaws below the allowable limit with margin for growth before the next interval.

SCREEN	QUESTION
Yield / fracture	Would nominal plasticity or Yσ$\sqrt{\pi a}$ control first?
Inspection / growth	Can the method see the flaw before service enlarges it?

19 · Fatigue / creep decoder

GUIDE CH. 7

cycles → fatigue	hot + held → creep	grooves → abrasive
transfer film → adhesive	pit + cycles → coupled	

Start with load history and surface evidence; interacting mechanisms are common.

IF YOU SEE…	DO THIS
σmax, σmin	Compute Δσ, σa, σm and R before using S–N data
Long steady creep stage	Use secondary slope as steady rate under stated σ,T

MECHANISM ANSWER STEMS

20 · Worked 5: crystal density

GUIDE CH. 9 WORKED

Given: cubic cell with n = 4 atoms, molar mass A = 60 g/mol, edge a = 0.400 nm. Find theoretical density.

cell mass nA/N_A	convert a 4e−8 cm	cube a 6.4e−23	mass/V 6.23 g/cm³

Separate atom count, molar conversion and cell-volume conversion.

ANSWER PATH

```
mcell = 4(60)/(6.022×10²³) =
3.985×10⁻²² g
a = 0.400 nm = 4.00×10⁻⁸ cm
Vc = a³ = 6.40×10⁻²³ cm³
ρ = mcell/Vc = 6.23 g/cm³
```

Check: n is the effective cell count, not the number drawn. Cube both the number and unit conversion. Explain measured–theoretical difference using specimen state: porosity, occupancy, composition, phases or defects.

CELL-ACCOUNTING AUDIT

LINE	WRITE EXPLICITLY	FAILURE CAUGHT
Geometry/contact	Site shares + contact line	Wrong n or radius–edge relation
Chemistry	n/formula units × molar mass	Wrong cell mass/occupancy
Volume/meaning	Converted a^3 + specimen state	Cubic error or false interpretation

Shares: corner ⅛, face ½, edge ¼, interior 1. Compounds use formula units × whole-formula mass; partial occupancy changes cell mass.

TRAP *Using nm in a cm³ answer creates a 10^{21} volume error.*

21 · Indexing drill

GUIDE CH. 10 WORKED

intercepts 1, ∞, ½	reciprocals 1, 0, 2	indices (102)

Zero records an axis parallel to the plane; it is not a missing index.

PROMPT	FIRST MOVE	FINAL CHECK
Vector endpoints	Head − tail	[uvw], smallest integers
Plane sketch/intercepts	Write axis intercepts	(hkl), reciprocals

ORIENTATION JUDGEMENT

22 · Structure judgement cards

GUIDE CHS. 8, 11, 12

feature observed	motion enabled?	property change	test / evidence

Mechanism answers need the middle link: what motion or reaction changes?

IF YOU SEE X…	→ DO Y
Deeper + steeper bond well	Separate local curvature (stiffness) from total depth (separation/melting tendency)
Cross-linked polymer heated	Network restricts whole-chain flow; expect degradation rather than melt-flow
Regular chains, slow cooling	More ordered packing likely; connect crystallinity to motion/property
Cold-worked metal	Dislocation density ↑ → interactions obstruct motion → strength ↑, ductility ↓
Annealing after cold work	Recovery → recrystallisation → grain growth; track strength, ductility, defects
Fine grains at room T	More boundaries interrupt slip; also test high-T stability/diffusion
Unknown micrograph contrast	Describe scale/signal/morphology first; propose alternatives and next measurement

POLYMER AVERAGES

M_n = ΣNiMi/ΣNi · degree of polymerisation = M_n/M_{repeat}

Mw normally ≥ M_n; say whether weighting is by molecules or mass.

Guide check: two chains of 10 kg/mol + three of 20 kg/mol → M_n = 80/5 = 16 kg/mol; with 0.100 kg/mol repeat unit, DP_n = 160. Use this as a recall check, not a sixth timed worked problem.

23 · Degradation judgement

GUIDE CHS. 7, 13

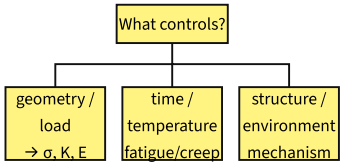
1 location wet/joint	2 cell A/C sites	3 mode local/bulk
4 control break link	5 verify measure	

A prevention label earns credit only when tied to a diagnosed cell or damage driver.

EVIDENCE	JUDGEMENT	VERIFICATION
Small coating defect coupled to broad cathode	Current concentrated on small anode	Local depth/current density
Deep pit; little mass loss	Local penetration controls consequence	Maximum pit depth

24 · Method chooser

GUIDE TOPIC MAPS + FAQ



Classify the controlling feature before selecting a formula or explanation chain.

PROMPT CUE	METHOD	MANDATORY CLOSE
Force + original geometry	Engineering σ, ε; E only in linear region	Units + curve event
Flaw + nominal stress	K = Yσ$\sqrt{\pi a}$	a/Y/constraint validity
Aligned phases + Vf	Directional composite bound	Compatibility + real architecture
Cell drawing + A,a	Count n → mass/cell → Vcell → ρ	Cubed conversion
Coordinates/intercepts	Direction subtraction / plane reciprocals	Brackets + signs
Processing change	Structure → obstacle/mobility → property	Trade-off + stability
Damage image/service history	Location → mechanism → control	Matched verification

UNIVERSAL ANSWER SPINE *Define → state assumptions → draw/label → substitute with units → calculate → interpret → test physical sense.*

25 · Trap register

GUIDE STUDY STRATEGIES

TRAP	REPAIR
Property slogan by material class	Qualify grade, process, direction, T, rate, environment
Strength called toughness	Stress level vs area/volume vs crack resistance
Static strength used for cyclic service	Compute cycle descriptors; use compatible life data

26 · Exam-morning plan

GUIDE EXAM STRATEGY · BRIEF

recall formula	redraw 5 figs	redo 1 setup	scan traps	check LMS

Short retrieval beats rereading: expose weak setup steps before the examination period.

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