PHYS1003 Physics 1 (Technological)

THE UNIVERSITY OF SYDNEY · FIRST-YEAR UNDERGRADUATE

EXAM REVISION SHEET
Semester 2, 2026
SIDE 1 OF 2

Full guide + ask Sia about PHYS1003

SIDE 1/2 DEFINITIONS → FORMULAS → DECISION RULES → CHECKS | **FINAL EXAMINATION · 40% · COMPULSORY** | v2 · 2026-10-25

01 · Exam map

2026 S2 OUTLINE

FINAL 40 | MI | LAB 25 | MID 25 | EN

COMPONENT	WT	FORMAT / CONTROL
Final examination	40%	Pen-and-paper; compulsory
Tutorial discussion	0%	Two discussions; completion control
Mastering Physics	4%	Six; best five count
Laboratory competencies	0%	All listed required for laboratory component
Week 3 quiz	1%	Early feedback task
Lab test	25%	Practical + written laboratory skills
Mid-semester test	25%	Pen-and-paper lecture material
Tutorial + lecture engagement	5%	Weekly participation and timely engagement

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

02 · Universal solution spine

COURSE OVERVIEW

1. **Diagram + assumptions.** Mark axes, directions, surfaces, nodes, streamlines or boundaries.
2. **Governing relation.** Name why it applies before substituting.
3. **Symbolic rearrangement.** Preserve vector signs and carry units.
4. **Independent check.** Conservation, symmetry, limiting case or boundary condition.

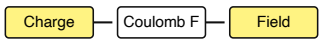
IF THE PROMPT CHANGES…	FIRST QUESTION
geometry / direction	Which component or orientation changes?
inside ↔ outside	What enclosed amount or boundary changes?
connection / constraint	Which quantity is fixed?
ideal ↔ dissipative	Which conservation statement survives?

EXAM TIP *A plausible magnitude cannot repair a reversed cross product, inconsistent sign or violated assumption.*

02A · What a finished answer contains

STUDY STRATEGY

LINE	VISIBLE EVIDENCE
Model	The named physical system, relevant objects and idealisations.
Mechanism	The equation is connected to the changed fact by an active explanation.
Calculation	Symbols first; directions, signs and units remain auditable.



Start with signed charge; resolve force directions before vector superposition.

03 · Charge, force, field

CH 1

Electric charge is a conserved signed property. *Electric field* is force per unit positive test charge at a position.

CORE RELATIONS

$F_C \propto q_1 q_2 / r^2$ (point-charge model)

$E = F/q$; $F_{net} = \Sigma F_i$ (vector sum)

STEP	WHAT EARNS THE LINE
1	Draw each source-to-field-point direction.
2	Choose axes; assign signs to components.
3	Add components, not force magnitudes.
4	Check reflection: the corresponding component reverses.

Boundary: use the point-charge expression directly only when source size and charge distribution can be idealised at the separation scale.

04 · Flux + Gauss

CH 2

Electric flux is the oriented surface integral of field. A *Gaussian* is imaginary and chosen to connect symmetry with enclosed charge.

CLOSED-SURFACE TEST

$\Phi_E = \oint E \cdot dA$; $\oint E \cdot dA = Q_{encl}/\varepsilon$

USE GAUSS TO FIND E?	DECISION
Field direction fixed on surface?	If no, law remains true but does not isolate E simply.
Magnitude constant on useful pieces?	Pull E outside only on those pieces.
Observation point moved inside?	Replace total charge by the charge enclosed at that radius.

EXAM TIP *State the symmetry before simplifying the integral. "Gauss's law applies" is not the same as "Gauss's law makes E easy".*

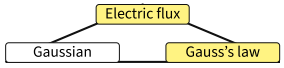
04A · Field quantities kept separate

CH 1–3

QUANTITY	OBJECT	OPERATION
Force F	Interaction on a specified charge	Vector superposition
Field E	Force per unit positive test charge at a point	Vector; independent of chosen test charge
Flux Φ_E	Oriented field through a surface	Surface integral; signs depend on normal
Potential V	Potential energy per charge	Scalar; only differences are reference-independent

GAUSSIAN-SURFACE DESIGN

- Enclose the charge relevant to the observation point; distinguish inside from outside.



Law is general; symmetry is what turns it into a field method.

05 · Potential + equipotentials

CH 3

Electric potential is potential energy per unit charge relative to a chosen reference. *Potential difference* is the negative line integral of field.

SCALAR ROUTE

$V = U/q$; $\Delta V_{A\to B} = -\int_A^B E \cdot dl$

$\Delta U = q\Delta V$; along equipotential: $\Delta V = 0$, $W = 0$

CHANGE	CONSEQUENCE
Reverse A→B to B→A	ΔV changes sign; the field itself does not.
Shift zero reference	V values shift; potential differences do not.
Move along equipotential	No electrostatic work along the surface.

Do not confuse V with U: the test charge is the bridge, and units expose the mistake.

Potential V	Difference ΔV
V: reference set	Delta V: fixed

Only potential differences are reference-independent.

06 · Capacitance + dielectric

CH 4

Capacitance is stored charge magnitude divided by potential difference. A dielectric polarises and changes field, charge and voltage relations according to the constraint.

CAPACITOR SET

$C = Q/\Delta V$; $U_C = \tfrac{1}{2}C(\Delta V)^2 = Q^2/(2C)$

AFTER DIELECTRIC INSERTION	FIXED	REASON FIRST
Source remains connected	ΔV	Source controls potential difference.
Source removed after charging	Q	Isolated plates retain charge.

Decision rule: write the constraint before choosing an energy expression. The same rise in C gives different voltage, charge and energy changes.

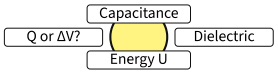
06A · Capacitor networks

CH 4 TOPIC MAP

EQUIVALENT CAPACITANCE

parallel: $C_{eq} = \Sigma C_i$; series: $1/C_{eq} = \Sigma(1/C_i)$

CONNECTION	SHARED QUANTITY	AUDIT
Parallel	Same potential difference across branches	Total charge is the sum of branch charges.
Series	Same charge magnitude on ideal series capacitors	Potential differences add to the applied value.



Constraint first; energy conclusion second.

07 · DC circuits

CH 5

Current is rate of charge crossing a selected surface. *Resistance* is ΔV/I for an ohmic element under specified conditions. Kirchhoff rules encode charge conservation and loop energy consistency.

CIRCUIT AUDIT

$I = dQ/dt$; $R = \Delta V/I$

junction: $\Sigma I = 0$; loop: $\Sigma \Delta V = 0$

1. Mark node potentials and assume a direction for every branch current.
2. Use one junction equation to reduce unknown currents.
3. Declare each loop orientation; keep potential-rise/drop signs consistent.
4. Solve symbolically. Negative I means actual flow is opposite the assumed arrow.
5. Check every node and loop; compare source power with resistor dissipation.

Boundary: Ohm's law is an element model, not the definition of every device's current–voltage behaviour.

07A · Reduction, power, RC

CH 5 TOPIC MAP

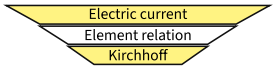
RESISTIVE REFERENCES

series: $R_{eq} = \Sigma R_i$; parallel: $1/R_{eq} = \Sigma(1/R_i)$

$P = I\Delta V$; $\tau = RC$

STRUCTURE	SHARED / ADDED
Series resistors	Same current; potential drops add.
Parallel resistors	Same potential difference; branch currents add.
RC behaviour	Identify the switching state and relevant resistance before using the time constant.

Use reduction only where the topology truly is series or parallel. In a multi-loop network, premature reduction can erase the shared branch that requires Kirchhoff equations.



Assumed arrows → equations → signed solution → conservation audit.

08 · Magnetic force + motion

CH 6

Magnetic field contributes a velocity-dependent force. Lorentz force combines electric and magnetic forces; cyclotron radius describes transverse circular motion.

DIRECTION BEFORE MAGNITUDE

$F = q(E + v \times B)$; $|F_B| = |q|vB\sin\theta$

$r = mv_\perp/(|q|B)$



Tilt v toward B: $v_\perp$ and curvature shrink; $v_\parallel$ survives.

09 · Induction + direction

CH 7

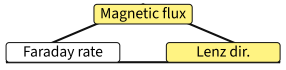
Magnetic flux is the oriented surface integral of B. Faraday links induced emf to flux-linkage change; Lenz chooses the direction that opposes the *change* producing it.

SIGNED SEQUENCE

$\Phi_B = \int B \cdot dA$; $\varepsilon = -d(N\Phi_B)/dt$

1. Declare loop orientation and corresponding surface normal.
2. Determine the sign of Φ_B and whether it is increasing or decreasing.
3. Apply the minus sign: induced circulation resists that change.
4. Check energy consistency; do not merely oppose the existing field.

FLUX CHANGE	INDUCED RESPONSE
Outward flux increasing	Creates inward contribution.
Outward flux decreasing	Creates outward contribution.
Reverse normal	All signed flux/emf labels reverse consistently.



Orientation → signed flux change → induced direction.

10 · Fluid statics

CH 8

Pressure is normal force per unit area. Hydrostatic balance is the pressure gradient balancing fluid weight at rest. Buoyant force equals displaced-fluid weight under the usual Archimedean conditions.

STATICS SET

$P = F_\perp/A$; $\Delta P = \rho g \Delta h$

$F_B = \rho_{fluid} g V_{displaced}$

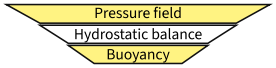
OBJECT	VOLUME IN BUOYANCY
Fully submerged	Submerged object volume.
Floating at equilibrium	Only displaced/submerged volume; F_B balances weight.

Boundary: simple hydrostatics assumes fluid at rest and density treated consistently over the height interval.

10A · Static-force audit

CH 8

QUESTION	REQUIRED DISTINCTION
Pressure at depth?	Use a pressure difference and a consistent vertical coordinate.
Force on a patch?	Pressure acts normal to area; direction matters.
Buoyancy?	Integrate the pressure effect conceptually; use displaced-fluid volume.



Pressure varies with depth; the surface forces combine to buoyancy.

11 · Flow: continuity or Bernoulli?

CH 9

Volume flow rate is volume crossing a section per time. Continuity is mass conservation; Bernoulli is a mechanical-energy balance for steady ideal flow.

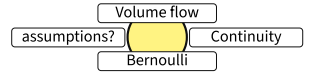
FLOW SET

$Q_v = dV/dt = Av$; $\rho Av = \text{constant}$

$P + \tfrac{1}{2}\rho v^2 + \rho g y = \text{constant}$ (stated assumptions)

QUESTION	USE
How does speed change with area?	Continuity; for incompressible flow, $A_1v_1 = A_2v_2$.
How do pressure, speed, height trade?	Bernoulli only after assumptions pass.
Pump, viscosity, turbulence, loss?	Simple Bernoulli is incomplete; identify energy transfer/loss.

Narrow pipe: mass conservation survives viscous loss; the simplest energy balance does not.



Continuity first; ideal-flow energy check second.

12 · Quantum formula chain

CH 10–12

PHOTON + MATTER WAVE

$E_\gamma = hf$; $K_{max} = hf - \varphi$; $f_\theta = \varphi/h$

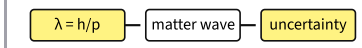
$\lambda = h/p$; $\Delta x \Delta p \geq \hbar/2$

STATE + PROBABILITY

probability density $= |\psi|^2$; $\int |\psi|^2 dx = 1$

stationary state: energy eigenstate; $|\psi|^2$ time independent

CHANGE	PREDICT
Intensity ↑ below threshold	No emission; photon energy still below φ.
Frequency ↑ above threshold	K_{max} rises; threshold crossed.
Localise packet more tightly	Momentum-space spread must increase.
Change infinite-well boundary	Allowed wavelengths and energy spacing change.



Momentum sets wavelength; state localisation constrains momentum spread.

13 · Fast definitions

GLOSSARY

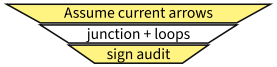
TERM	RECITE
Work function	Minimum energy to release an electron from a specified surface.
Photoelectric threshold	Frequency where photon energy just equals work function.
Normalisation	Total probability over allowed domain equals one.

Semester 2 formal examination period, from 16 November 2026 (the Exams Office publishes the exact date).
Check your exam instructions on the LMS for what you may bring; use this sheet to revise and self-test.

14 · Worked drill: two-loop circuit

COURSE WORKED EXAMPLE

Prompt [12-mark guide drill]. A source drives shared and unshared resistive branches. Choose current directions, write independent junction and loop equations, then interpret a negative solved current.



Keep assumed arrows fixed so the sign retains meaning.

1. **Draw.** Label branches, node potentials, current arrows and source polarity.
2. **Reduce.** Charge conservation at a node removes one independent current.
3. **Traverse.** Pick loop orientation once; record every potential rise/drop consistently.
4. **Solve symbolically.** A negative current means actual direction is opposite the arrow.
5. **Verify.** Reconstruct each node and loop sum; source power and resistor dissipation must be consistent.

ANSWER SKELETON

$\Sigma I_{node}=0$ → independent loop $\Sigma\Delta V=0$ → solve → interpret sign → power/conservation check

CLASSIC TRAP	REPAIR
Changing arrows after seeing a negative value	Keep arrows; state "opposite assumed direction".
Writing every possible loop	Use independent loops only.
Mixing sign conventions mid-loop	Write orientation beside the loop before equations.

SELF-TEST *Can you explain why a negative current is physical information, not a failed equation?*

15 · Circuit judgement cards

CH 5

IF YOU SEE...	DO THIS
junction	Apply charge conservation.
complete loop	Sum signed potential changes to zero.
device not specified ohmic	Do not impose ΔV=IR automatically.
negative solved I	Reverse the physical interpretation, not the algebra.

15A · Closed-note circuit audit

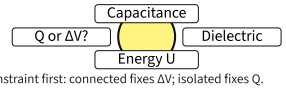
CH 5 FAQ

1. Sketch a two-loop network from memory with one shared branch.
2. Assign all current arrows before writing any equation.
3. Write one independent node equation and identify the minimum independent loop set.
4. For each resistor crossing, connect the sign of ΔV to traversal versus assumed current.

16 · Worked drill: dielectric constraint

CH 4 WORKED EXAMPLE

Prompt. Insert a dielectric first while the source remains connected, then after the source is removed. Compare the quantities held fixed and propagate the change to stored energy.



Constraint first: connected fixes ΔV; isolated fixes Q.

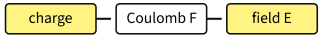
CASE	START	THEN TRACK
Connected	ΔV fixed	C changes → Q=CΔV and $U=\frac{1}{2}C(\Delta V)^2$ follow.
Isolated	Q fixed	C changes → ΔV=Q/C and $U=Q^2/(2C)$ follow.

Answer path. Name the constraint; state that dielectric polarisation changes the capacitance relation; use the matching energy form; compare direction of change. Do not memorise one universal "dielectric makes energy rise/fall" sentence.

17 · Changed field cases

CH 1–3 DRILLS

CHANGED CASE	ANSWER PATH
Reflect one source charge across field point	Redraw geometry → predict which component reverses → recalculate vector sum.
Move point outside → inside spherical distribution	Keep surface symmetry → replace enclosed-charge expression → solve only if E is controlled on surface.
Reverse A→B integration path	ΔV reverses sign; E field does not.



Redraw geometry first; then trace charge → force → field.

TRAP *Flux through a surface and field at a point are not interchangeable quantities.*

17A · Field trap cards

CH 1–3

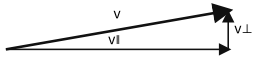
TEMPTING MOVE	WHY IT FAILS / REPAIR
Add force magnitudes	Superposition is vectorial; resolve components first.
Pull E outside every flux integral	Do so only where symmetry controls magnitude and direction.
Use total charge for an interior Gaussian point	Use only charge enclosed by that surface.
Treat zero flux as zero field	Dot products may cancel or vanish while local E remains non-zero.
Call V and U the same quantity	Restore the test charge: U=qV.
Forget path reversal	Exchange integration limits; ΔV changes sign.

ONE-MINUTE VERBAL DRILL

18 · Worked drill: magnetic trajectory

CH 6 WORKED EXAMPLE

Prompt. Tilt incoming velocity from perpendicular toward parallel to B. Track force magnitude and the resulting trajectory.



Only $v_\perp$ contributes to magnetic-force magnitude and cyclotron radius.

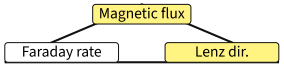
1. Decompose v into $v_\parallel$ and $v_\perp$.
2. Use $|F_B|=|q|v_\perp B$: tilting toward parallel reduces the force.
3. Use $r=mv_\perp/(|q|B)$: the transverse curvature scale changes with $v_\perp$.
4. $v_\parallel$ persists; magnetic force alone does not change speed.
5. Use charge sign to reverse the right-hand-rule direction where required.

Judgement: parallel does not mean "moves in a circle of infinite radius"; it means the magnetic force is zero for that component.

19 · Worked drill: induction reversal

CH 7 WORKED EXAMPLE

Prompt. Change increasing outward flux to decreasing outward flux. Determine which induced circulation reverses.



Flux sign and rate lead to the induced direction.

ANSWER PATH

choose normal → sign Φ_B → sign $d\Phi_B/dt$ → apply minus sign → translate emf sign to circulation

TRAP	CORRECTION
"Induced field opposes B"	It opposes the change in flux.
No declared normal	Signed emf cannot be audited.
Direction from memory	Use energy consistency as independent check.

19A · Magnetic decision cards

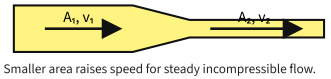
CH 6–7

IF YOU SEE...	DO THIS
v at an angle to B	Split v into parallel and perpendicular components.
charged-particle curvature	Use $v_\perp$ in magnetic force and radius; preserve charge sign for direction.
magnetic force only	Check that speed is unchanged while direction changes.
changing B, area or angle	Calculate the resulting signed flux change, not merely the field change.
increasing ↔ decreasing flux	Redo Lenz direction from the chosen normal.

20 · Worked drill: narrow pipe

CH 9 WORKED EXAMPLE

Prompt. Narrow a pipe first neglecting and then including viscous loss. Compare which conservation statement survives unchanged.



Smaller area raises speed for steady incompressible flow.

1. Check steady flow and mass conservation. For incompressible flow, $A_1v_1=A_2v_2$, so narrowing raises speed.
2. For the ideal case, test steady, incompressible, nonviscous, same-streamline conditions and unmodelled energy transfer.
3. Only then relate pressure, speed and height using Bernoulli.
4. When viscous loss is introduced, continuity survives; the simplest Bernoulli equality does not account for the dissipated energy.

Answer: conservation of mass is unchanged; the ideal mechanical-energy relation needs a loss/transfer treatment.

21 · Fluid statics changed case

CH 8 WORKED EXAMPLE

Prompt. Replace a fully submerged object with one floating at equilibrium. Decide which volume enters buoyancy.

Pressure	Hydrostatic balance
Buoyant force	displaced volume

Use the volume that actually displaces fluid in the stated state.

CASE	REASON
Fully submerged	Displaced volume equals submerged object volume.
Floating equilibrium	Submerged volume adjusts until buoyancy balances weight.

TRAP *Pressure itself is not buoyant force; buoyancy is the resultant of pressure forces over the surface.*

21A · Fluid assumptions checklist

CH 8–9

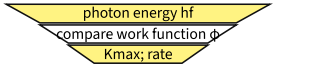
CLAIM	WHAT MUST BE STATED
Hydrostatic ΔP	Fluid at rest; density handled consistently; vertical height interval identified.
Continuity simplification	Steady flow and whether density is constant.
Bernoulli equality	Steady, incompressible, nonviscous, appropriate streamline, no unmodelled transfer.
Buoyancy	Actual displaced-fluid volume and equilibrium state.

CHANGED-CASE STRESS TEST

22 · Worked drill: photoelectric changes

CH 10 WORKED EXAMPLE

Prompt. Increase intensity below threshold, then increase frequency above threshold. Distinguish emission rate from maximum electron energy.



Frequency sets photon energy; threshold compares hf with ϕ.

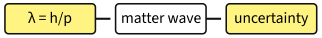
CHANGE	RESULT	WHY
Intensity ↑ while $f<f_0$	No emission in elementary model	Each photon remains below ϕ.
f rises above f_0	Emission possible; $K_{max}=hf-\phi$	Single-photon energy exceeds work function.
Intensity ↑ with $f>f_0$	Emission rate may rise	Do not confuse rate with K_{max}.

Boundary: the elementary equation treats one photon transferring energy to one electron and requires the material work function.

23 · Worked drill: localisation

CH 11 WORKED EXAMPLE

Prompt. Localise a wave packet more tightly and predict the required change in momentum-space spread.



Localisation is a state-spread trade-off, not apparatus carelessness.

ANSWER PATH

Δx decreases → Δp lower bound rises because $\Delta x\Delta p \geq \hbar/2$ → momentum-space distribution must broaden

Do not call this measurement carelessness. The relation concerns statistical spreads of a state, not a paired error bar on each individual position measurement.

23A · Quantum trap cards

CH 10–12

TRAP	REPAIR
More light intensity always raises K_{max}	Use photon frequency for energy; intensity changes photon supply.
Below-threshold intensity eventually emits	In the elementary model, each photon still has $hf<\phi$.
Uncertainty is poor apparatus	Describe intrinsic statistical state spreads.
ψ is probability	Use $|\psi|^2$ and normalise over the allowed domain.
Any solution of the differential equation is physical	Impose the potential's boundary conditions and normalisation.

THIRTY-SECOND CHAIN

24 · Worked drill: infinite-well boundary

CH 12 WORKED EXAMPLE

Prompt. Change an infinite-well boundary while keeping the potential shape. Predict the effect on allowed wavelength and energy spacing.



Change the boundary → allowed wavelengths and energy spacing change.

1. State the potential and boundary conditions; the differential equation alone does not select physical states.
2. Enforce the boundary on ψ; only compatible standing-wave states remain.
3. Normalise: total probability over the allowed domain equals one.
4. Translate the changed well boundary into changed allowed wavelengths, then changed energy spacing.
5. For a stationary state under a time-independent Hamiltonian, measurable $|\psi|^2$ is time independent.

Trap: ψ may be negative or complex; probability density is $|\psi|^2$.

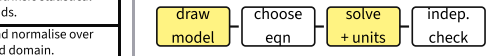
25 · Method chooser

ALL CHAPTERS

IF YOU SEE X...	DO Y
Several point sources	Resolve and superpose vectors.
High symmetry + closed surface	State symmetry; use Gauss.
Endpoints / work / equipotential	Use scalar potential difference.
Capacitor changed constraint	Decide fixed Q or fixed ΔV first.
Nodes + loops	Kirchhoff with declared arrows/orientation.
Charge moving in B	Cross product; isolate $v_\perp$.
Changing magnetic flux	Orientation → Faraday → Lenz.
Fluid at rest	Hydrostatic balance / displaced volume.
Steady flow	Continuity; then test Bernoulli assumptions.
Threshold / emitted electron	Compare hf with ϕ.
Localisation	Use uncertainty as spread relation.
Bound quantum state	Potential + boundaries + normalisation.

26 · Exam-morning plan

STUDY STRATEGY



Rehearse the same four-line skeleton across mixed topics.

- Recite one definition, governing relation, boundary and trap from each chapter family.
- Mix field, circuit, fluid and quantum prompts so the heading does not choose the model.