Y1 Workbook - useful for As level physics

Physical Science (University of East London)

A-level Physics

Y1 Workbook

100’s of A-level Physics exam questions, with mark schemes, covering Year 1 topics

Physics Tutor Online

MECHANICS (57 MARKS)

Q1. (a) State what is meant by a vector quantity.

....

....

(1)

(b) Give **one** example of a vector quantity.

....

(1)
(Total 2 marks)

Q2. A canoeist can paddle at a speed of 3.8 ms^{-1} in still water.
She encounters a current which opposes her motion. The current has a velocity of 1.5 ms^{-1} at 30° to her original direction of travel as shown in the figure below.

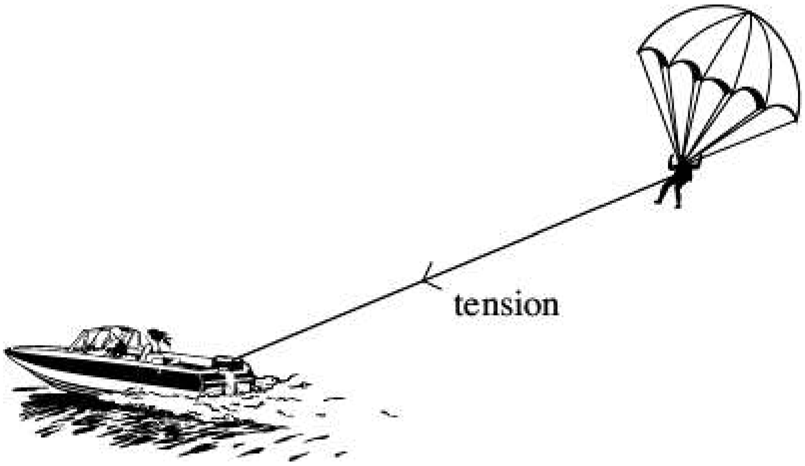
By drawing a scale diagram determine the magnitude of the canoeist's resultant velocity.

magnitude of velocity .... ms^{-1}

(Total 3 marks)

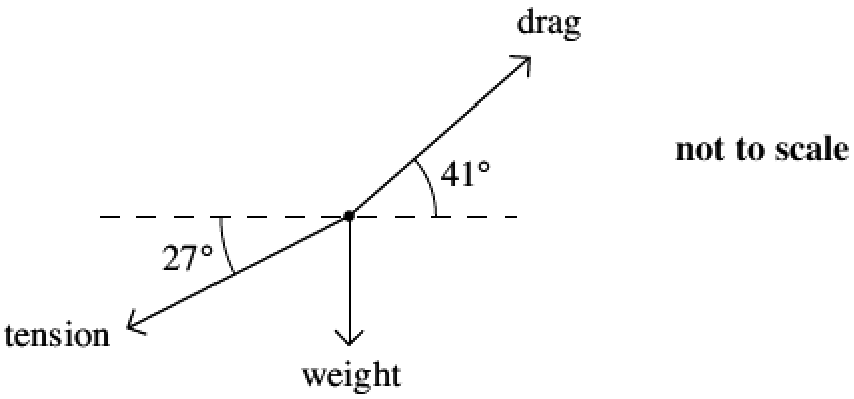
Q3. **Figure 1** shows a parascender being towed at a constant velocity.

Figure 1



The forces acting on the parascender are shown in the free-body diagram in **Figure 2**.

Figure 2

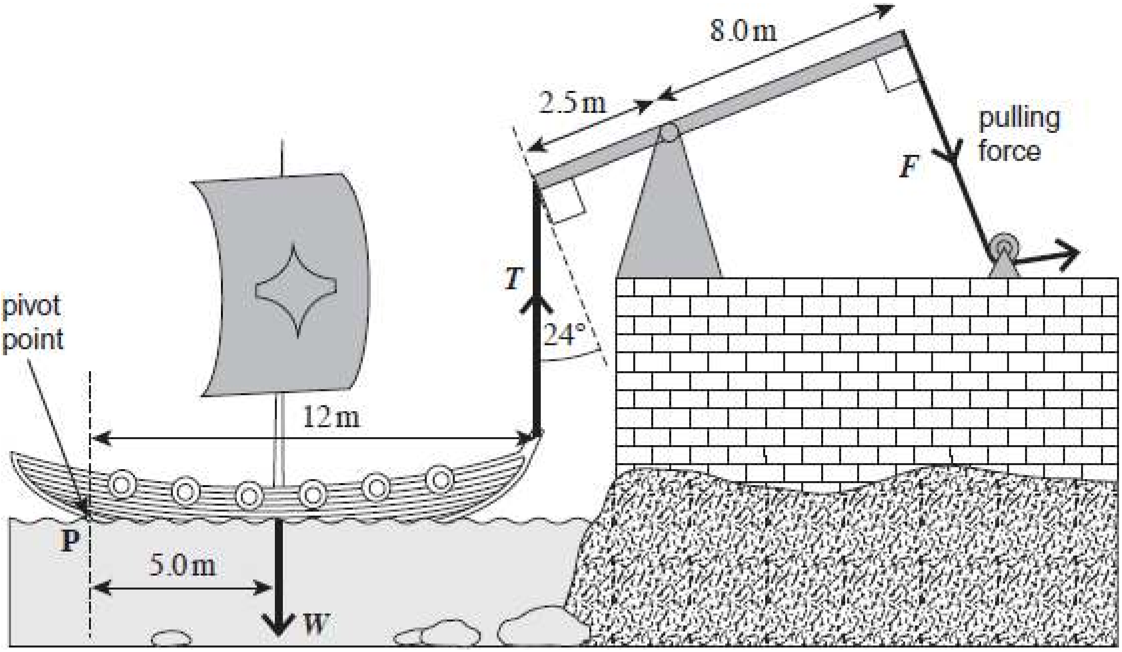


The rope towing the parascender makes an angle of 27° with the horizontal and has a tension of 2.2 kN. The drag force of 2.6 kN acts at an angle of 41° to the horizontal. Calculate the weight of the parascender.

weight .... N

(Total 3 marks)

Q4. It is said that Archimedes used huge levers to sink Roman ships invading the city of Syracuse. A possible system is shown in the following figure where a rope is hooked on to the front of the ship and the lever is pulled by several men.



(a) (i) Calculate the mass of the ship if its weight was 3.4×10^4 N.

mass .... kg

(1)

(ii) Calculate the moment of the ship's weight about point **P**. State an appropriate unit for your answer.

moment .... unit ....

(2)

(iii) Calculate the minimum vertical force, T, required to start to raise the front of the ship.
Assume the ship pivots about point **P**.

minimum vertical force .... N

(2

(iv) Calculate the minimum force, F, that must be exerted to start to raise the front of the ship.

force .... N

(3)

(Total 8 marks)

Q5. A car of mass 1300 kg is stopped by a constant horizontal braking force of 6.2 kN.

(a) Show that the deceleration of the car is about 5 m s^{-2}.

....

....

....

....

....

(3)

(b) The initial speed of the car is 27 m s^{-1}.

Calculate the distance travelled by the car as it decelerates to rest.

....

....

....

....

....

....

distance travelled .... m

(3)
(Total 6 marks)

Q6. A supertanker of mass 4.0×10^8 kg, cruising at an initial speed of 4.5 m s^{-1}, takes one hour to come to rest.

(a) Assuming that the force slowing the tanker down is constant, calculate

(i) the deceleration of the tanker,

....

....

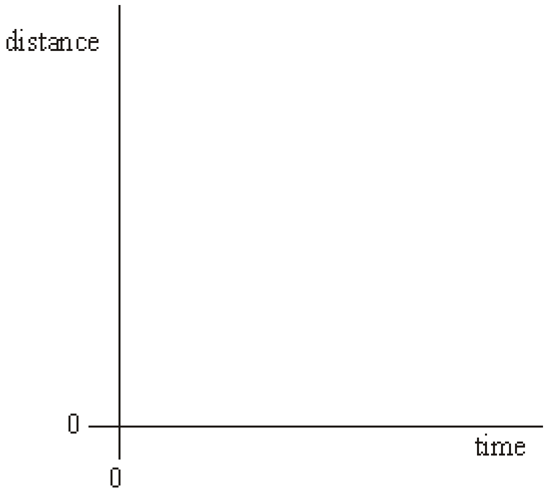
(ii) the distance travelled by the tanker while slowing to a stop.

....

....

(4)

(b) Sketch, using the axes below, a distance-time graph representing the motion of the tanker until it stops.



(2)

(c) Explain the shape of the graph you have sketched in part (b).

....

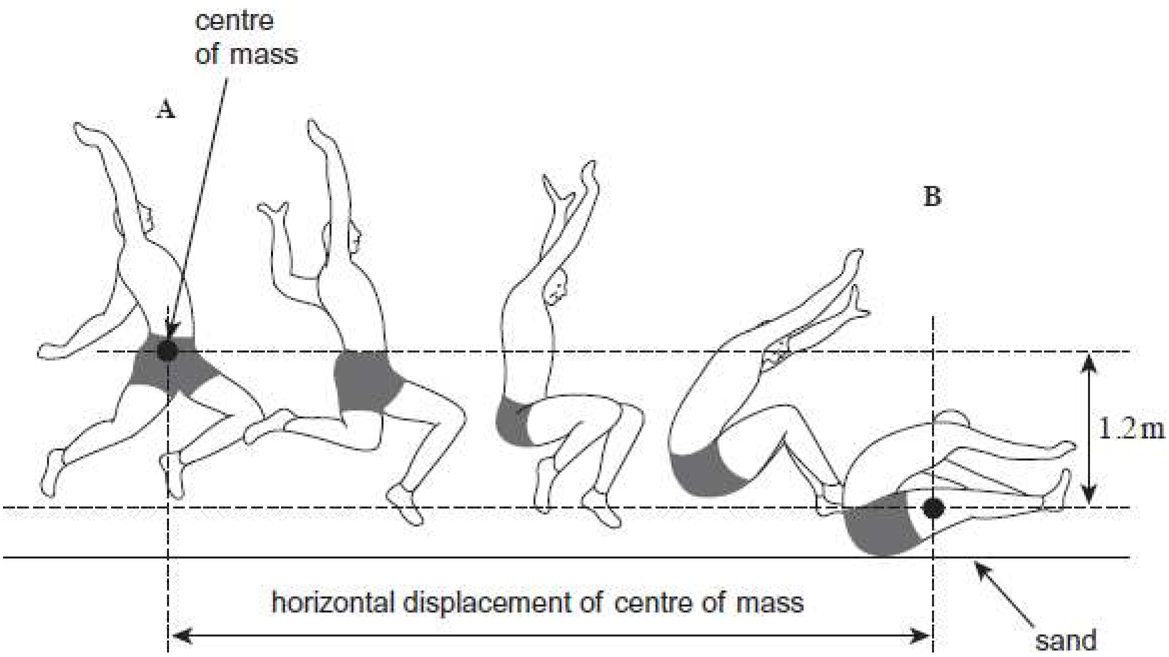
....

....

....

(2)
(Total 8 marks)

Q7. The motion of a long jumper during a jump is similar to that of a projectile moving under gravity. The figure below shows the path of an athlete above the ground during a long jump from half-way through the jump at position **A**, to position **B** at which contact is made with sand on the ground. The athlete is travelling horizontally at **A**.



(a) During this part of the jump, the centre of mass of the athlete falls 1.2 m.

(i) Calculate the time between positions **A** and **B**.

time .... s

(3)

(ii) The athlete is moving horizontally at **A** with a velocity of 8.5 m s^{-1}. Assume there is noair resistance. Calculate the horizontal displacement of the centre of mass from **A** to **B**.

horizontal displacement .... m

(2)

(b) (i) The athlete in the image above slides horizontally through the sand a distance of 0.35 m before stopping.

Calculate the time taken for the athlete to stop. Assume the horizontal component of the resistive force from the sand is constant.

time .... s

(2)

(ii) The athlete has a mass of 75 kg. Calculate the horizontal component of the resistive force from the sand.

horizontal component of resistive force .... N

(3)

(Total 10 marks)

Q8. **Figure 1** shows a skier being pulled by rope up a hill of incline 12° at a steady speed. The total mass of the skier is 85 kg. Two of the forces acting on the skier are already shown.

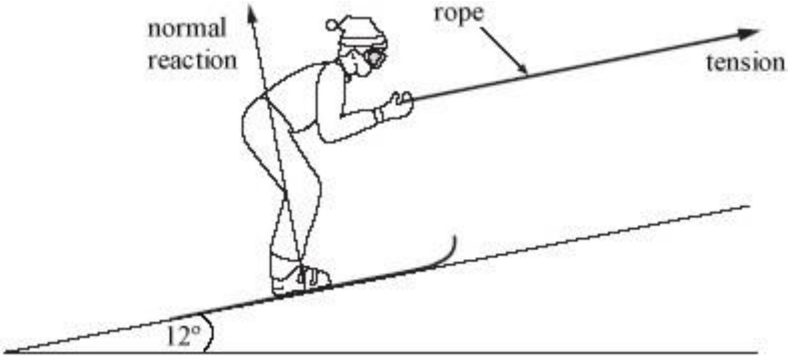


Figure 1

(a) Mark with arrows and label on **Figure 1** a further two forces that are acting on the skier.

(2)

(b) Calculate the magnitude of the normal reaction on the skier.
gravitational field strength, $g = 9.8\ \text{N kg}^{-1}$

Normal reaction = ...

(3)

(c) Explain why the resultant force on the skier must be zero.

....

....

(1)
(Total 6 marks)

Q9. The world record for a high dive into deep water is 54 m.

(a) Calculate the loss in gravitational potential energy (gpe) of a diver of mass 65 kg falling through 54 m.

loss in gpe = ... J

(2)

(b) Calculate the vertical velocity of the diver the instant before he enters the water. Ignore the effects of air resistance.

velocity = ... ms^{-1}

(2)

(c) Calculate the time taken for the diver to fall 54 m. Ignore the effects of air resistance.

time = ... s

(2)

(d) Explain, with reference to energy, why the velocity of the diver is independent of his mass if air resistance is insignificant.

....
.

....

.

....
.

....
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....
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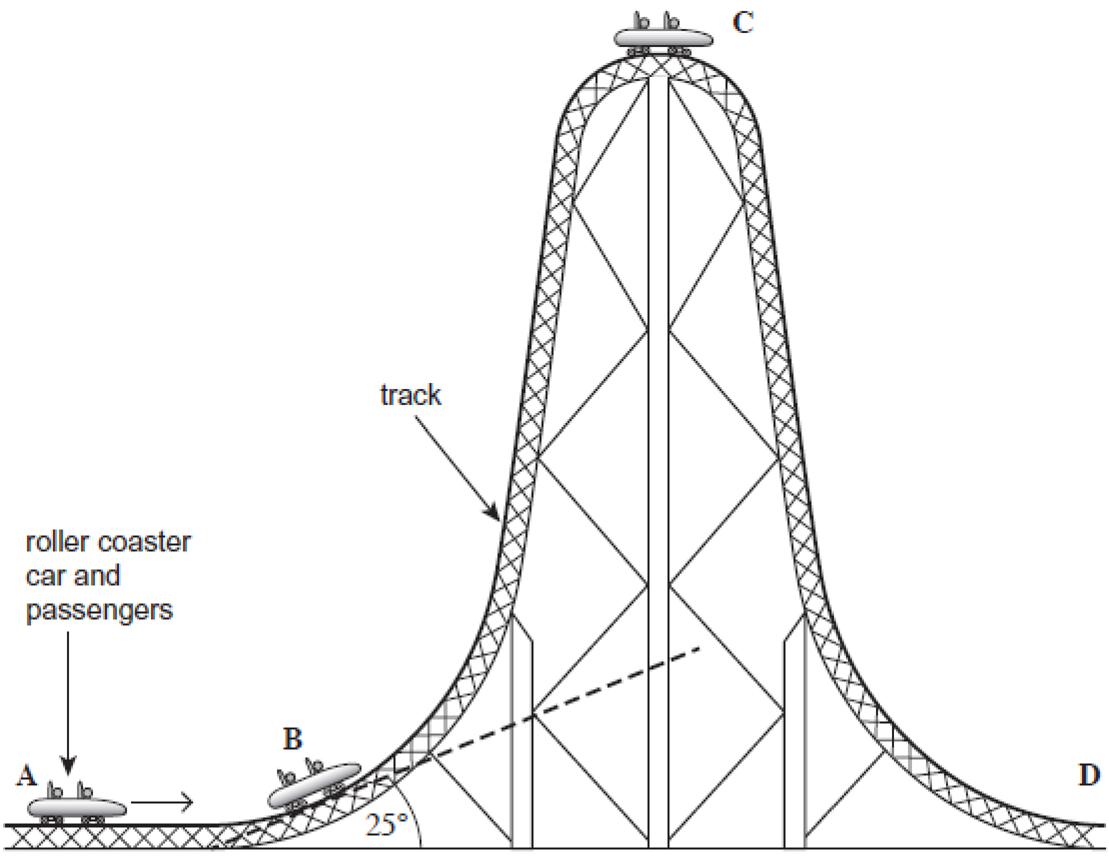
....
.

(3)
(Total 9 marks)

Q10. The following figure shows a roller coaster car which is accelerated from rest to a speed of 56 m s^{-1} on a horizontal track, **A**, before ascending the steep part of the track. The roller coaster car then becomes stationary at **C**, the highest point of the track. The total mass of the car and passengers is 8300 kg.



(a) The angle of the track at **B** is 25° to the horizontal. Calculate the component of the weight of the car and passengers acting along the slope when the car and passengers are in position **B** as shown in the image above.

component of weight .... N

(2)

(b) (i) Calculate the kinetic energy of the car including the passengers when travelling at 56 m s^{-1}.

kinetic energy .... J

(2)

(ii) Calculate the maximum height above **A** that would be reached by the car and passengers if all the kinetic energy could be transferred to gravitational potential energy.

maximum height .... m

(2)

(c) The car does not reach the height calculated in part (b).

(i) Explain the main reason why the car does not reach this height.

....

....

....

....

(2)

(ii) The car reaches point **C** which is at a height of 140 m above **A**. Calculate the speed that the car would reach when it descends from rest at **C** to its original height from the ground at **D** if 87% of its energy at **C** is converted to kinetic energy.

speed .... m s^{-1}

(2)
(Total 10 marks)

MECHANICS MARK SCHEME

M1. (a) (quantity that has both) magnitude and direction

B1

1

(b) any vector quantity eg velocity, force, acceleration

B1

1

[2]

M2. scale <1cm to 1 m s^{-1} stated or obvious from calculation (allow × 3, 7 etc. here)

B1

allow 2 max for correct calculation

correct resultant direction by eye (needs arrow if not clear from parallelogram
or triangle)

B1

allow 1 max for

2.6±0.2 (m s^{-1})

B1

correct method of calculation but with error(s)

3

[3]

M3. statement that forces up = forces down/correctly resolved vertical component of either drag or tension

C1

2600 *sin* 41 = *W* + 2200 *sin* 27 seen (or equivalent kN)

C1

1705.8 = W + 998.8 (condone power 10 error)

707/710 (N)

A1

3

[3]

M4.(a) (i) $m = W / g)$

(3.4 × 10^4 / 9.81 =) 3500 (3466 kg) ✓

Allow use of g = 10

1

(ii) (moment = 34 000 × 5.0) = 1.7 × 10^5 ✓ (Nm)

Nm ✓ do not allow NM \ nM etc

allow in words

2

(iii) 170 000 = T x 12 OR T = 170 000 / 12 ✓ ecf aii

= 1.4(167) × 10^4 ✓ (N)

2

(iv) (component of T perpendicular to lever) = T cos 24 **OR** 14 167 × 0.9135 **OR** 12942 (N) ✓ ecf aiii allow 2.5cos24 × T

(12942) × 2.5 = **F** × 8.0

OR F = ((12942) × 2.5) / 8.0 ✓ ecf for incorrect component of T or T on its own

F = 4000 (N) ✓ (4044) ecf for incorrect component of T or T on its own

allow 4100 for use of 14 200 (4054)

Some working required for full marks. Correct answer only gets 2

Failure to find component of T is max 2 (4400 N)

3

[8]

M5. (a) a force/1300 (condone power of ten error)

C1

6200 ÷ 1300

C1

4.77 (m s^{-2})

A1

3

(b) use of suitable kinematic equation

C1

eg distance = $27^2/(2 \times 4.8)$ correct sub

C1

76/76.4 m/72.9 from a = 5/75.9 from a = 4.8

A1

3

[6]

M6. (a) (i) (use of $a = \frac{\Delta v}{\Delta t}$ gives) $a = \frac{4.5}{3600}$ **(1)**

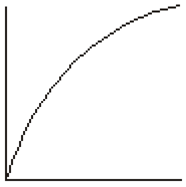
$= 1.25 \times 10^{-3}$ ms^{-2} **(1)**

(ii) (use of $v^2 = u^2 + 2as$ gives) $0 = 4.5^2 - 2 \times 1.25 \times 10^{-3} \times s$ **(1)**

$s\left(= \frac{20.25}{2.5 \times 10^{-3}}\right) = 8.1 \times 10^3$ m **(1)**

4

(b) increasing curve **(1)**
correct curve **(1)**



1

(c) gradient (slope) of graph represents speed **(1)**
hence graph has decreasing gradient **(1)**

2

[8]

M7.(a) (i) use of $\left(s = \frac{1}{2}gt^2\right)$ OR $t^2 = 2s / g$ ✓

$t = \sqrt{\frac{2 \times 1.2}{9.81}}$ ✓

= 0.49 (0.4946 s) ✓ allow 0.5 do not allow 0.50

Some working required for full marks. Correct answer only gets 2

3

(ii) ($s = vt$)
= 8.5 × 0.4946 ✓ ecf ai
= 4.2 m ✓ (4.20) ecf from ai

2

(b) (i) $\left(s = \frac{1}{2}(u + v)\, t\right)$

$t = \frac{2s}{u(+v)}$ or correct sub into equation above ✓

$= \frac{2 \times 0.35}{8.5}$ = 8.2 × 10^{-2} (s) ✓ (0.0824) allow 0.08 but not 0.080 or 0.1

Allow alternative correct approaches

2

(ii) $a = (v - u) / t$ OR correct substitution OR a = 103 ✓
(= −8.5) / 8.24 × 10^{-2} = 103.2)

($F = ma =$) 75 × (103.2) ✓ ecf from bi for incorrect acceleration due to arithmetic error only, not a physics error (e.g. do not allow a = 8.5. Use of g gets zero for the question.

= 7700 N ✓ (7741) ecf (see above)

Or from loss of KE

Some working required for full marks. Correct answer only gets 2

3

[10]

M8. (a) air resistance (drag) /friction with correct arrow from or towards body

B1

weight (force of gravity/ 838 N) not *gravity* with correct arrow from somewhere on skier or ski -vertically downwards

B1

(b) clear attempt to resolve weight (not mass) or equate normal reaction with component of weight (condone sin θ)

C1

$Mg\cos\theta$ or substituted values

C1

815 (or 810 or 820) N

A1

3

(c) constant speed/velocity or zero acceleration

B1

1

[6]

M9.(a) *(Ep = mgΔh)*

$= 65 \times 9.81 \times 54$ ✓

$= 3.44 \times 10^4 = 3.4 \times 10^4$ (J) ✓ (34433)

max 1 if g =10 used (35100 J)

Correct answer gains both marks

2

(b) $v = \sqrt{\frac{2\,Ep}{m}}$ OR $v = \sqrt{\frac{2 \times 34433}{65}}$ ✓ $= 33$ (32.55 ms^{-1}) ✓ ecf 1(a)

allow 32 (32.3) for the use of 34000

allow 32.6

OR correct use of $v^2 = 2\,g\,s$

don't penalise g = 10 (32.863)

2

(c) (s =1 / 2 gt^2 or other kinematics equation)

$t = \sqrt{\frac{2s}{g}}$ OR $t = \sqrt{\frac{2 \times 54}{9.81}}$ ✓ $= 3.318 = 3.3$ (s) ✓

With use of g= 9.8 or 9.81 or 10 and / or various suvat equations, expect range 3.2 to 3.4 s.

No penalty for using g= 10 here.

ecf from 1(b) if speed used

2

(d) (all G)PE (lost) is transferred to KE

no (GP)E transferred to 'heat' / 'thermal' / internal energy

OR ✓

Must imply that all GPE is transferred to KE. E.g. accept 'loss of GPE is gain in KE' but not: 'loses GPE and gains KE'.

(therefore) $mg\Delta h \; \frac{1}{2}mv^2$ ✓

mass cancels. ✓

Accept 'm's crossed out

3

[9]

M10.(a) 8300 × 9.81 OR = 81423 ✓
(8300 × 9.81 sin 25)
= 3.4 × 10^4 (N) ✓ (34 411 N) ecf from first line unless g not used

msin25 gets zero

Penalize use of g = 10 <u>here only</u>
(35 077 N)
Allow 9.8 in any question
Correct answer only, gets both marks for all two mark questions

2

(b) (i) (E_k = ½mv^2)
= ½ × 8300 × 56^2 ✓
= 1.3 × 10^7 (J) ✓ (13 014 400) allow use of 8300 only

In general: Penalise transcription errors and rounding errors in answers

2

(ii) *mgh* = KE (13 014 400) for *mgh* allow GPE or E_p
OR 13 014 400 / 81 423 ✓
h = 160 (m) ✓ (159.8) ecf 1bi

Allow use of suvat approach

2

(c) (i) (work done) by friction \ drag \ air resistance \ resistive forces ✓
(energy converted) to internal \ thermal energy ✓

Allow 'heat'

2

(ii) 0.87 x (8300 x 9.81 x 140 = 9 917 000) OR $v = \sqrt{\left[\frac{2 \times (9\ 917\ 000)}{8300}\right]}$ ✓
= 49 (= 48.88 ms^{-1}) ✓

87% of energy for 140m or 160m only for first mark.
Use of 160 (52.26) and / or incorrect or no % (52.4) gets max 1 provided working is shown
Do not credit suvat approaches here

2

[10]

ELECTRIC CIRCUITS (55 marks)

Q1. (a) State what is meant by a superconducting material.

....

....

....

....

(2)

(b) State an application of a superconductor and explain why it is useful in this application.

....

....

....

....

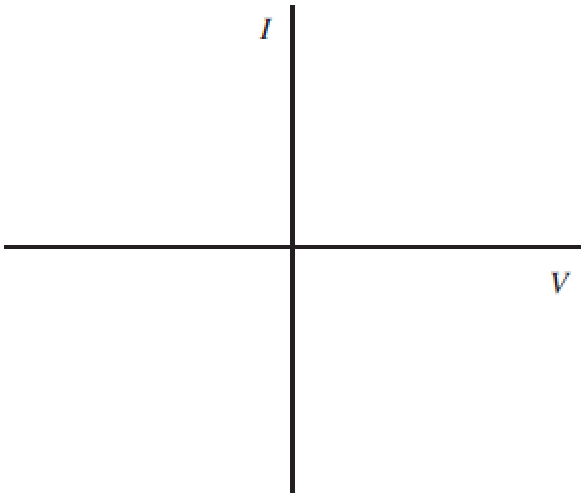
(2)

(Total 4 marks)

Q2.(a) Sketch, on **Figure 1**, the current−voltage (IV) characteristic for a filament lamp for currents up to its working power.

Figure 1

Physics Tutor Online



(2)

(b) (i) State what happens to the resistance of the filament lamp as the current increases.

....
.

(1)

(ii) State and explain whether a filament lamp is an ohmic or non−ohmic conductor up to its working power.

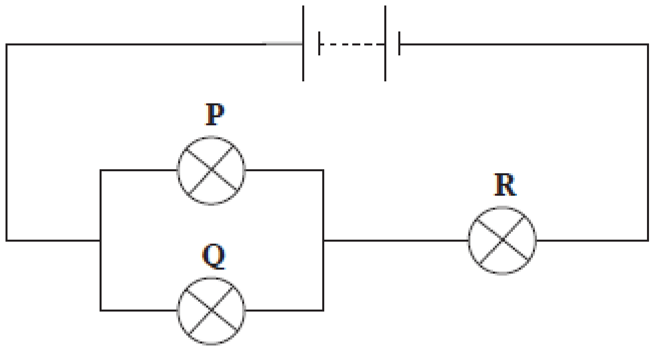
....
.

....
.

(1)

(c) Three identical filament lamps, **P**, **Q** and **R** are connected in the circuit shown in **Figure 2**.

Figure 2.



The filament in lamp **Q** melts so that it no longer conducts. Explain why lamp **P** becomes brighter and lamp **R** becomes dimmer.

....

....

....

....

....

....

(2)

(d) A filament lamp, **X**, is rated at 60 W 230 V. Another type of lamp, **Y**, described as 'energy saving' has the same light intensity output but is rated at 11 W 230 V.

(i) Calculate the electrical energy converted by each lamp if both are on for 4 hours a day for a period of 30 days.

electrical energy converted by **X** = ... J

electrical energy converted by **Y** = ... J

(2)

(ii) Suggest why the two lamps can have different power ratings but have the same light intensity output.

....
.

....
.

....
.

....
.

....
.

(2)

(Total 10 marks)

Q3. A battery in a laptop computer has an electromotive force (emf) of 14.8 V and can store a maximum charge of 15.5×10^3 C. The battery has negligible internal resistance.

(a) Calculate the maximum amount of energy this battery can deliver.

energy .... J

(2)

(b) The average power consumption of the laptop is 30 W.

Estimate how long the laptop can be operated from the fully charged battery. Give your answer in hours.

time .... hours

(2)

(Total 4 marks)

Q4. The critical temperature of tin is −269 °C. The resistivity of tin increases as its temperature rises from −269 °C.

(a) (i) Define resistivity.

....

....

....

....

(2)

(ii) State the significance of the critical temperature of a material.

....

....

....

....

(2)

(b) A sample of tin in the form of a cylinder of diameter 1.0 mm and length 4.8 m has a resistance of 0.70 Ω.

Use these data to calculate a value of the resistivity of tin.

State an appropriate unit for your answer.

resistivity .... unit ....

(4)

(Total 8 marks)

Q5. A copper connecting wire is 0.75 m long and has a cross-sectional area of 1.3×10^{-7} m^2.

(a) Calculate the resistance of the wire.

resistivity of copper = 1.7×10^{-7} Ωm

resistance = ... Ω

(2)

(b) A 12 V 25 W lamp is connected to a power supply of negligible internal resistance using two of the connecting wires. The lamp is operating at its rated power.

(i) Calculate the current flowing in the lamp.

current = ... A

(1)

(ii) Calculate the pd across each of the wires.

pd = ... V

(1)

(iii) Calculate the emf (electromotive force) of the power supply.

emf = ... V

(2)

(c) The lamp used in part (b) is connected by the same two wires to a power supply of the same emf but whose internal resistance is not negligible.

State and explain what happens to the brightness of the lamp when compared to its brightness in part (b).

....
.

....
.

....
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....
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....
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....
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(2)

(Total 8 marks)

Q6. A student investigates how the power dissipated in a variable resistor, Y, varies as the resistance is altered.

Figure 1 shows the circuit the student uses. Y is connected to a battery of emf ε and internal resistance r.

Figure 1

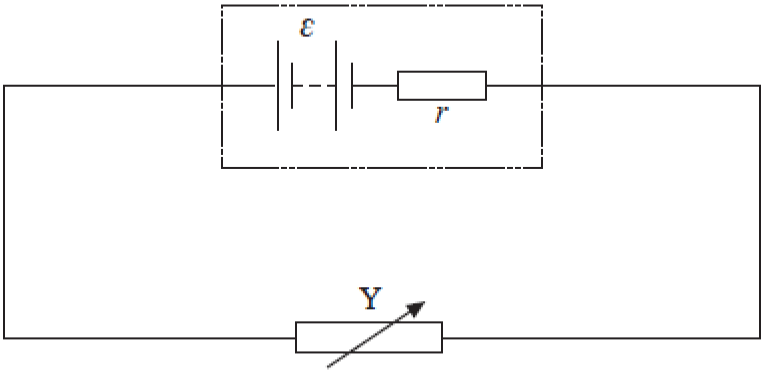
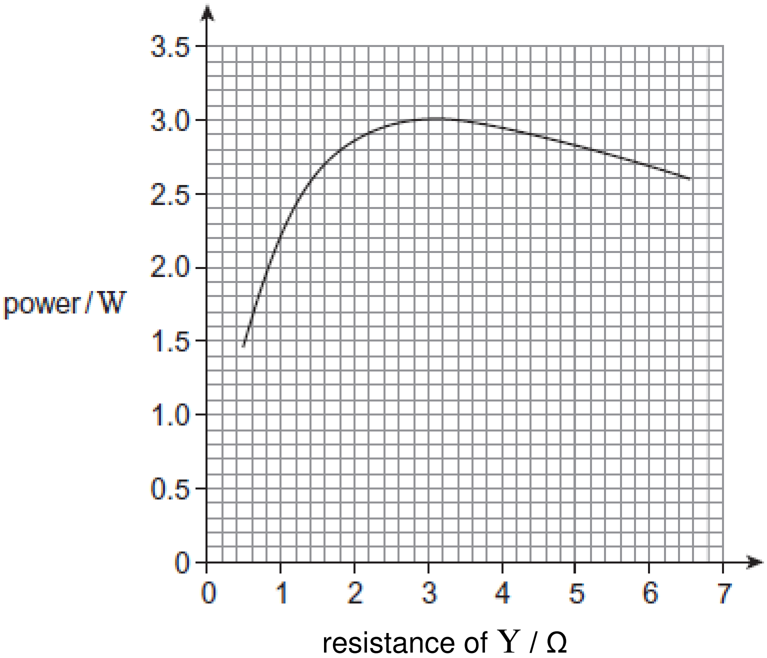


Figure 2 shows the results obtained by the student as the resistance of Y is varied from 0.5 Ω to 6.5 Ω.

Figure 2



(a) Describe how the power dissipated in Y varies as its resistance is increased from 0.5 Ω to 6.5 Ω.

....
.

....
.

....
.

....
.

....
.

(2)

(b) The emf of the battery is 6.0 V and the resistance of Y is set at 0.80 Ω.

(i) Use data from **Figure 2** to calculate the current through the battery.

current .... A

(3)

(ii) Calculate the voltage across Y.

voltage V

(2)

(iii) Calculate the internal resistance of the battery.

internal resistance .... Ω

(2)

(c) The student repeats the experiment with a battery of the same emf but negligible internal resistance. State and explain how you would now expect the power dissipated in Y to vary as the resistance of Y is increased from 0.5 Ω to 6.5 Ω.

....

....

....

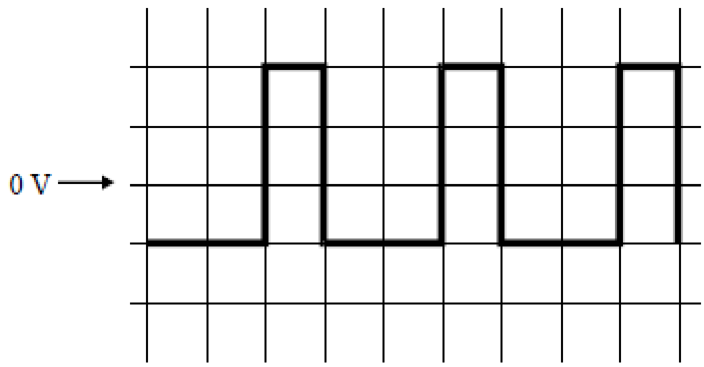
....

....

(3)

(Total 12 marks)

Q7. The diagram shows a trace on the screen of an oscilloscope. The Y-sensitivity of the oscilloscope is set at 5.0 V per division and the time base is set at 0.50 ms per division.



(a) For the trace, determine

(i) the maximum positive value of potential difference,

....

(ii) the maximum negative value of potential difference,

....

(iii) the frequency of the signal.

....

(4)

(b) The trace shows the variation in the potential difference across a 100 Ω resistor. Calculate the energy dissipated in the resistor

(i) for the first 1.00 ms,

....

....

(ii) between 1.00 ms and 1.50 ms,

....

....

(iii) in one cycle,

....
.

(iv) in one second.

....
.

(5)

(Total 9 marks)

ELECTRIC CIRCUITS MARK SCHEME

M1. (a) no resistance

M1

(at or) below critical temperature

A1

alternative:

allow a labelled diagram which indicates features, allow T_c for transition temp in diagram

2

(b) **Use**

eg mri scanner, transformer, generator, maglev train, particle accelerators, microchips, computers, energy storage with detail

B1

Reason

eg **strong** magnetic field, no energy dissipation (mri scanner / maglev / particle accelerator)
higher (processing) speeds, smaller, no energy dissipation

(microchip / computer)

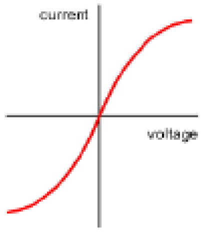
B1

smaller, no energy dissipation, no fire risk (transformer / generator)
no energy dissipation (power transmission / energy storage with detail)

2

[4]

M2.

(a) 

✓ ✓

first mark for linear at origin and decreasing gradient in either quadrant (linear region can be very small)

second mark for symmetry plus no dip at end or extended horizontal section at end

straight line scores zero

2

(b) (i) resistance (of filament lamp) increases✓

1

(ii) filament lamp is a non-ohmic conductor as current is not (directly) proportional to voltage / resistance is not constant✓

proportionality can be shown using graph

1

(c) either
circuit / total resistance increases✓
(hence) current decreases and pd / voltage across R decreases✓
OR
resistance of PQ combination increases✓
(hence) greater share of pd / voltage across lamp P✓

implication that current is different in different parts

of series circuits scores 0
implication that new total current is greater scores zero
voltage flowing loses second mark

2

(d) (i) (use of *energy* = *VIt*)
(energy converted by X = 60 × 120 × 3600 =) 2.59 × 10^7 J ✓
(energy converted by Y = 11 × 120 × 3600 =) 4.75 × 10^6 J ✓

Accept answers to 1 sig. fig.

2

(ii) in lamps energy is wasted as heat / thermal energy ✓
specific lamp considered e.g. in lamp, X / filament lamp more energy is wasted OR in X / filament lamp less energy is converted to light / luminosity ✓

2

[10]

M3. (a) use of $\varepsilon = E / V$ condone power 10 errors in sub
allow rearrangement to $E = \varepsilon V$
14.8 × 15.5 × 10^3 seen

C1

2.29 × 10^5 (J) / 2.3 × 10^5 (J)

A1

2

(b) use of $P = \Delta W / \Delta t$ condone power 10 errors in sub
Allow rearrangement to $\Delta t = \Delta W / P$
2.3 × 10^5 / 30 or 7647 seen

C1

2.12 (hours) cao

A1

2

[4]

M4.(a) (i) resistivity is defined as

$\rho = \frac{RA}{l}$

where R is the resistance of the material of length l ✓
and <u>cross-sectional</u> area A ✓

2

(ii) <u>below</u> the critical temperature / maximum temperature which resistivity / resistance ✓
is zero / becomes superconductor ✓

Any reference to negligible / small / very low resistance loses second mark

2

(b) (*use of* $\rho = \frac{RA}{l}$)

$\rho = 0.70 \times \pi \times 0.0005^2 / 4.8$ ✓ $= 1.1(5) \times 10^{-7}$ (1.1 – 1.2) ✓ ✓ Ω m ✓

First mark for substitution R and l
Lose 1 mark if diameter used as radius and answer is 4 times too big (4.4 – 4.8) OR if power of ten error

4

[8]

M5.(a) (use of ρ=RA / l)

$R = 1.7 \times 10^{-7} \times 0.75 / 1.3 \times 10^{-7}$ ✓

$R = 0.98\ \Omega$ ✓

First mark for sub. and rearranging of equation.
Bald 0.98 gets both marks
Final answer correct to 2 or more sig. figs.

2

(b) (i) *(use of P=VI) I*= 2.08 A

1

(ii) V=2.08 × 0.98 = 2.04 V

C.E. from (a) and (b)(i)

1

(iii) emf = 12 + 2 ✓ × 2.04 = 16.1 V ✓

C.E. from (b)(ii)
If only use one wire then C.E. for second mark

2

(c) lamp would be less bright ✓
as energy / power now wasted in internal resistance / battery
OR terminal pd less
OR current lower (due to greater resistance) ✓

No C.E. from first mark

2

[8]

M6.(a) power increases to a maximum / (up) to 3.0 (2.8 -3.4) Ω / / (up)to 3.0 W ✓
then decreases ✓

2

(b) (i) (*use of* $P = I^2R$)
when R = 0.8 Ω power = 1.95 W ✓
$1.9 = I^2 \times 0.8$ ✓
$I = \sqrt{2.375} = 1.5(4)$ (A) ✓

Range
1.9 - 2.0 W for power (first mark)
Current 1.5 – 1.6 A

3

(ii) (*use of* $V = IR$)
$V = 1.54 \times 0.8$ ✓
$V = 1.2$ V ✓

CE from part (i)

2

(iii) (*use of* $\varepsilon = V + Ir$)
$6.0 = 1.2 + 1.54 \times r$ ✓
$r = (6.0 – 1.2) / 1.54 = 3.1$ (2.9 – 3.2)(Ω) ✓
use of maximum power theorem (quoted) as alternative method can get both marks i.e. read peak maximum from graph

CE from part (ii)

2

(c) power would decrease (as R increased) ✓
pd / voltage across R is now constant / equal to emf ✓
and so power proportional to 1 / R / inversely proportional to R OR

can quote $P = V^2 / R$ but only if scored second mark ✓

3

[12]

M7.(a) (i) 10(V) **(1)**

(ii) 5.0(V) **(1)**

(iii) T = 150 V (ms) **(1)** $f = \frac{1}{T}$ = 667 Hz **(1)**

4

(b) (i) I = $\frac{V}{R}$ = 0.050(A) **(1)** [or substitute in $P = \frac{V^2}{R}$ **(1)**]

$E_1 = VIt = 25 \times 10^{-4}$ J **(1)**

(ii) I = 0.10(A) **(1)** $E_2 = 5.0 \times 10^{-4}$ J **(1)** [or substitute in $P = \frac{V^2}{R}$ **(1)**]

(iii) $E_t = 7.5 \times 10^{-4}$ J **(1)**

(iv) P = 667 **(1)** × 7.5×10^{-4} = 0.50Js^{-1} **(1)** (accept J)

max 5

[9]

MATERIALS (54 MARKS)

Q1. (a) Define the *density* of a material.

....

.... **(1)**

(b) Brass, an alloy of copper and zinc, consists of 70% **by volume** of copper and 30% **by volume** of zinc.

density of copper $= 8.9 \times 10^3$ kg m^{-3}
density of zinc $= 7.1 \times 10^3$ kg m^{-3}

(i) Determine the mass of copper and the mass of zinc required to make a rod of brass of volume 0.80×10^{-3} m^3.

....

....

....

....

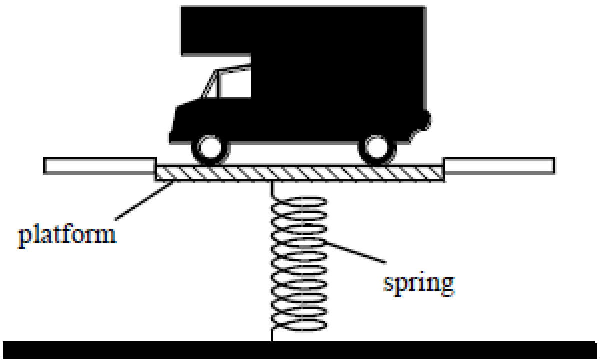
(ii) Calculate the density of brass.

....

.... **(4)**

(Total 5 marks)

Q2. The diagram below shows a lorry of mass 1.2×10^3 kg parked on a platform used to weigh vehicles. The lorry compresses the spring that supports the platform by 0.030 m.



Calculate the energy stored in the spring.

gravitational field strength g = 9.8 N kg^{-1}

Energy stored = ...

(Total 3 marks)

Q3.(a) The Young modulus is defined as the ratio of *tensile stress* to *tensile strain*. Explain what is meant by each of the terms in italics.

tensile stress ....

....

....

tensile strain ....

....

(3)

(b) A long wire is suspended vertically and a load of 10 N is attached to its lower end. The extension of the wire is measured accurately. In order to obtain a value for the Young modulus of the material of the wire, two more quantities must be measured. State what these are and in each case indicate how an accurate measurement might be made.

quantity 1 ....

method of measurement ....

....
.

quantity 2
....

method of measurement
....

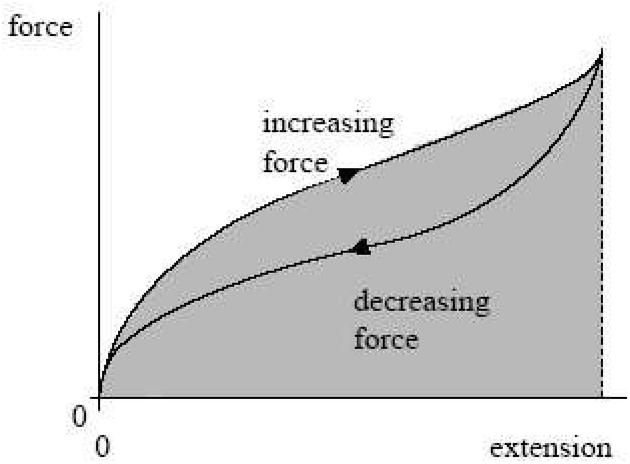
....
.

(4)

(c) Sketch below a graph showing how stress and strain are related for a ductile substance and label important features.

(2)
(Total 9 marks)

Q4. A student investigated how the extension of a rubber cord varied with the force used to extend it. She measured the extension for successive increases of the force and then for successive decreases. The diagram below shows a graph of her results.



(a) (i) Give a reason why the graph shows the rubber cord does not obey Hooke's law.

....

.... **(1)**

(ii) Give a reason why the graph shows the rubber cord does not exhibit plastic behaviour.

....

.... **(1)**

(iii) What physical quantity is represented by the area shaded on the graph between the loading curve and the extension axis?

....

.... **(1)**

(b) Describe, with the aid of a diagram, the procedure and the measurements you would make to carry out this investigation.

The quality of your written answer will be assessed in this question.

....

....

....

....

....

....

....

....

....

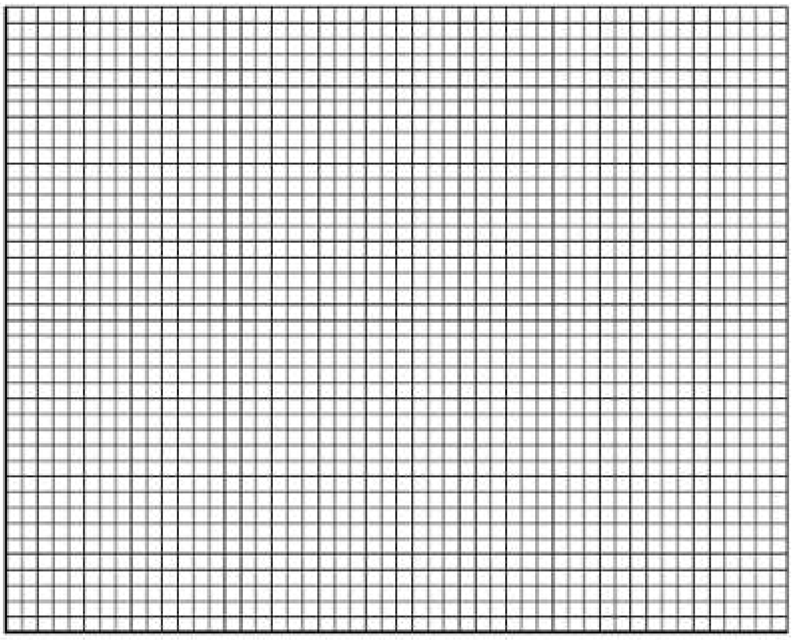
....

(6)
(Total 9 marks)

Q4. The table below shows the results of an experiment where a force was applied to a sample of metal.

(a) On the axes below, plot a graph of stress against strain using the data in the table.

Strain / 10^{-3}	0	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
Stress /10^8 Pa	0	0.90	2.15	3.15	3.35	3.20	3.30	3.50	3.60	3.60	3.50



stress / 10^8 Pa

strain / 10^{-3}

(3)

(b) Use your graph to find the Young modulus of the metal.

answer = ... Pa

(2)

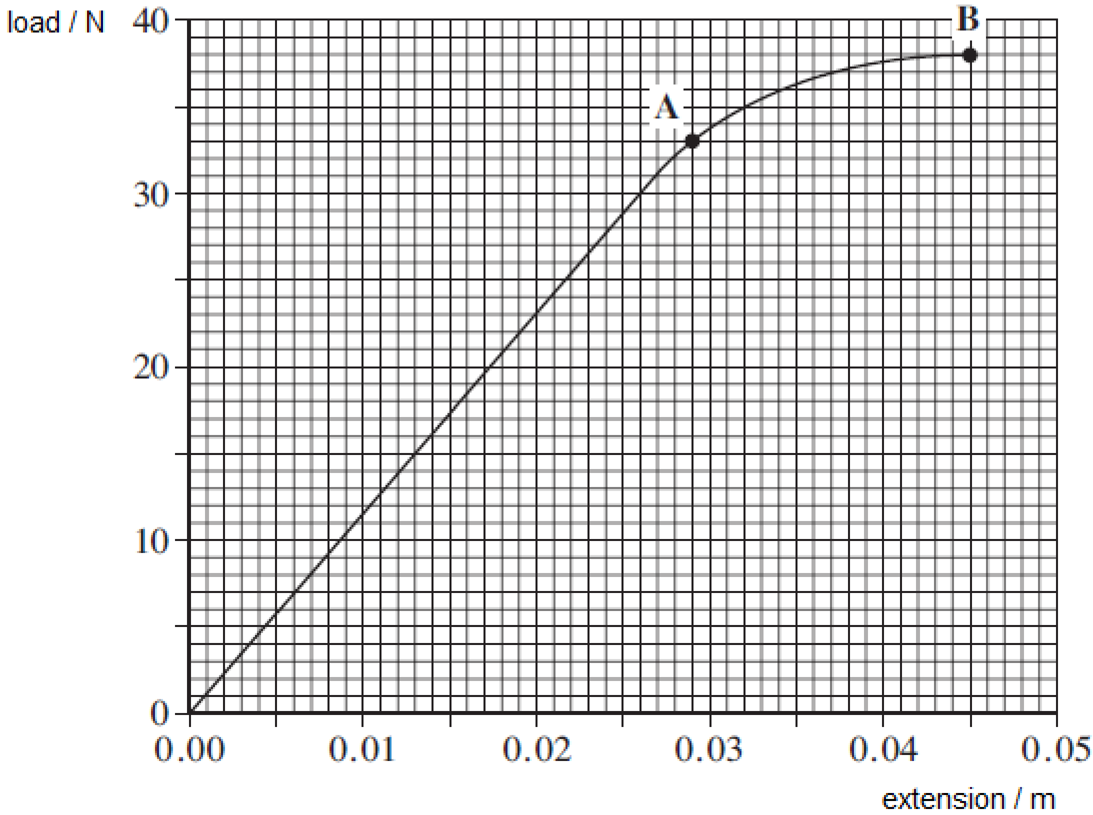
(c) A 3.0 m length of steel rod is going to be used in the construction of a bridge. The tension in the rod will be 10 kN and the rod must extend by no more than 1.0mm. Calculate the minimum cross-sectional area required for the rod.

Young modulus of steel = 1.90×10^{11} Pa

answer = ... m^2

(3)
(Total 8 marks)

Q6. A manufacturer of springs tests the properties of a spring by measuring the load applied each time the extension is increased. The graph of load against extension is shown below.



(a) State Hooke's law.

....

....

....

(2)

(b) Calculate the spring constant, *k*, for the spring. State an appropriate unit.

spring constant .... unit ....

(3)

(c) Use the graph to find the work done in extending the spring up to point **B**.

work done .... J

(3)

(d) Beyond point **A** the spring undergoes *plastic deformation*.

Explain the meaning of the term plastic deformation.

....
.

....
.

(1)

(e) When the spring reaches an extension of 0.045 m, the load on it is gradually reduced to zero. On the graph above sketch how the extension of the spring will vary with load as the load is reduced to zero.

(2)

(f) Without further calculation, compare the total work done by the spring when the load is removed with the work that was done by the load in producing the extension of 0.045 m.

....
.

....
.

....
.

(1)
(Total 12 marks)

Q7. An aerospace engineer has built two differently designed wings. One wing is made from an aluminium alloy and the other is made from a carbon fibre composite.

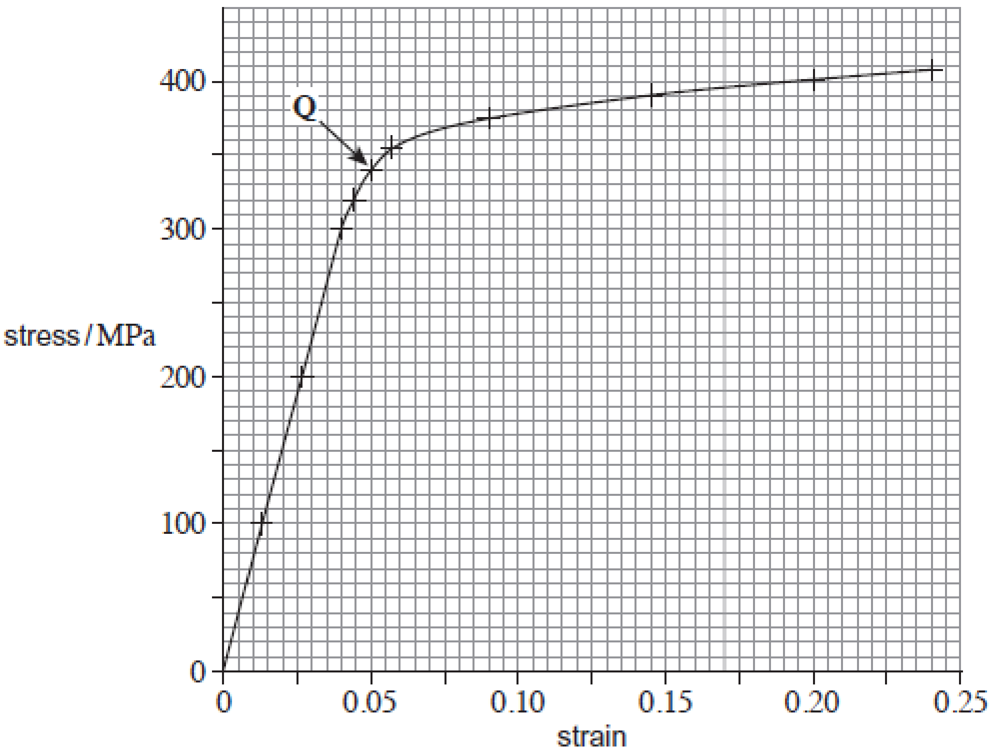
The engineer tests a sample of each material by applying a varying stress.

(a) Tick (✓) **two** of the boxes in the table below to indicate which are properties of the material from which the wing is made.

breaking stress	
stiffness constant, k	
tensile strain	
tensile stress	
Young modulus	

(1)

(b) Below is the stress−strain graph that the engineer obtains for the aluminium alloy.



(i) The engineer has labelled a point **Q** on the graph. This is a point beyond which the behaviour of the material changes irreversibly.
State the name for this point.

....
.

(1)

(ii) Use the graph to determine the Young modulus of the aluminium alloy.
Show your working.

Young modulus = ... Pa

(2)

(c) The engineer who carried out the experiment to obtain the stress−strain graph decided to stretch another sample to a strain of 0.10. She then gradually reduced the stress to zero.

Show by drawing on the graph how you would expect the stress to vary with strain as the stress is reduced.

(2)

(d) Calculate the volume of 25.0 kg of the aluminium alloy.

density of aluminium alloy = 2.78×10^3 kg m^{-3}.

volume = ... m^3

(1)

(e) 1.28% of the aluminium alloy's volume is copper.
Calculate the mass of pure aluminium needed to make 25.0 kg of the aluminium alloy.

density of pure aluminium = 2.70×10^3 kg m^{-3}.

mass of pure aluminium = ... kg

(2)

(Total 9 marks)

M1. (a) density = $\frac{\text{mass}}{\text{volume}}$ **(1)**

1

(b) (i) volume of copper = $\frac{70}{100} \times 0.8 \times 10^{-3}$ (= 0.56×10^{-3} m^3)

(volume of zinc = 0.24×10^{-3} m^3)

m_c (= $\rho_c V_c$) = $8.9 \times 10^3 \times 0.56 \times 10^{-3}$ = 5.0 kg **(1)** (4.98 kg)

$m_z = \frac{30}{100} \times 0.8 \times 10^{-3} \times 7.1 \times 10^3$ = 1.7 (kg) **(1)**

(allow C.E. for incorrect volumes)

(ii) m_b (= 5.0 +1.7) = 6.7 (kg) **(1)**
(allow C.E. for values of m_c and m_z)

$\rho_b = \frac{6.7}{0.8 \times 10^{-3}}$ = 8.4×10^3 kg m^{-3} **(1)**

(allow C.E. for value of m_b)
[or ρ_b = (0.7 × 8900) + (0.3 × 7100) **(1)** = 8.4×10^3 kg m^{-3} **(1)**]

max 4

[5]

M2. use of mg with g = 9.8[use of g 10 – 1]

B1

energy = ½ $F\,l$ = ½ (1200 × 9.8) × 0.03

M1

= 180 J [176] [omission of g will score only 1]

A1

[3]

M3.(a) tensile stress = $\dfrac{\text{(tensile) force}}{\text{cross - sectional area}}$ **(1)**

tensile strain = $\dfrac{\text{extension}}{\text{original length}}$ **(1)**

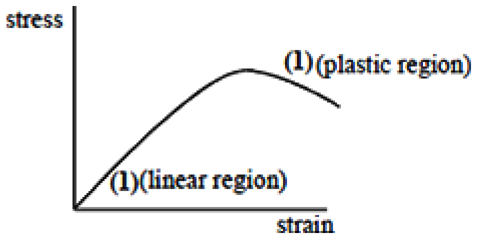
mention of tensile **and** original **(1)**

(3)

(b) diameter of wire **(1)**
in several *places* [or repeated] **(1)**
using a micrometer **(1)**
(original) length of wire **(1)**
using a metre rule (or tape measure) **(1)**

(max 4)

(c)



(2)

[9]

M4. (a) (i) the lines are not straight (owtte) **(1)**

(ii) there is no permanent extension **(1)**
(or the overall/final extension is zero or the unloading curve returns to zero extension)

(iii) (area represents) **work done** (on or energy transfer to the rubber cord) or **energy** (stored) **(1)** not heat/thermal energy

3

(b) the mark scheme for this part of the question includes an overall assessment for the Quality of Written Communication

QWC	descriptor	mark range
good-excellent	The candidate provides a comprehensive and coherent description which includes nearly all the necessary procedures and measurements in a logical order. The descriptions should show awareness of how to apply a variable force. They should know that measurements are to be made as the force is increased then **as it is decreased**. In addition, they should know how to calculate/measure the extension of the cord. **At least five different masses/'large number' of masses are used. Minimum 7 masses to reach 6 marks**. The diagram should be detailed.	**5-6**
modest-adequate	The description should include most of the necessary procedures including **how to apply a variable force** and should include the necessary measurements. They may not have described the procedures in a logical order. They may not appreciate that measurements are also to be made as the cord is unloaded. They should know **that the extension** of the cord must be found and name a **suitable measuring instrument (or seen in diagram – label need not be seen)**/**how to calculate**. The diagram may lack some detail.	**3-4**
poor-limited	The candidate knows that the **extension or cord length** is to be measured for **different forces –** may be apparent from the diagram. They may not appreciate that measurements are also to be made as the cord is unloaded. They may not state how to calculate the extension of the cord. The diagram may not have been drawn.	**1-2**
incorrect, inappropriate or no response	No answer at all or answer refers to unrelated, incorrect or inappropriate physics.	**0**

The explanation expected in a competent answer should include a coherent selection of the following physics ideas.

diagram showing rubber cord fixed at one end supporting a weight at the other end or pulled by a force **(1)**

means of applying variable force drawn or described (eg use of standard masses or a newtonmeter) **(1)**

means of measuring cord drawn or described **(1)**

procedure

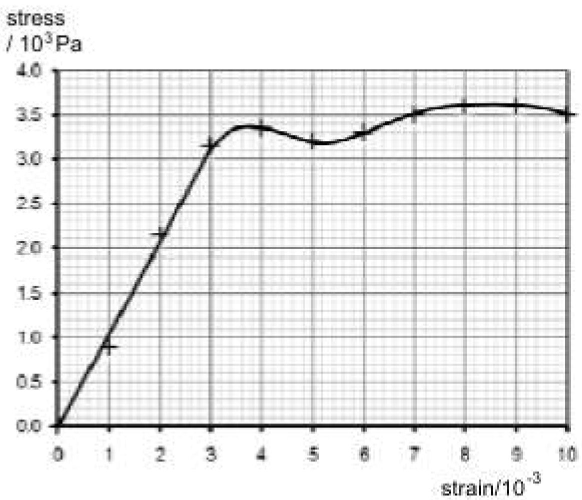
measured force applied (or known weights used) **(1)** cord extension measured or calculated **(1)**

repeat for increasing then decreasing length (or force/weight) **(1)**

extension calculated from cord length – initial length **(1)**

[9]

M5. (a)



Suitable scale on both axes (eg not going up in 3s) **and** > ½ space used ✔

≥ points correct (within half a small square) ✔

line is straight up to at least stress = 2.5 × 10^8 **and** curve
is smooth beyond straight section ✔

3

(b) understanding that E = gradient (= $\Delta y/\Delta x$) ✔

allow y/x if line passes through origin

= 1.05 × 10^{11} (Pa) (allow 0.90 to 1.1) **ecf** from their line in (a)
if answer outside this range **and** uses a y value ≥ 2 ✔

when values used from table;

- two marks can be scored only if candidates line passes through them

- one mark only can be scored if these points are not on their line

2

(c) correct rearrangement of symbols or numbers ignoring incorrect powers of ten, eg $A = \frac{FL}{E\Delta L}$ ✓

correct substitution in any correct form of the equation,

eg = $\frac{10(000) \times 3.0}{1.90(\times 10^{11}) \times 1.0(\times 10^{-3})}$ ✓

allow incorrect powers of ten for this mark

= 1.6×10^{-4} ✓ (1.5789) (m^2)

3

[8]

M6.(a) Force proportional to extension ✓

up to the limit of proportionality (accept elastic limit) ✓ dependent upon award of first mark

Symbols must be defined
Accept word equation
allow 'F=kΔL (or F ∝ ΔL) up to the limit of proportionality ' ***for the second mark only***
allow stress ∝ strain up to the limit of proportionality' ***for the second mark only***

2

(b) Gradient clearly attempted / use of $k=F / \Delta L$ ✓

k = 30 / 0.026 = 1154
or 31 / 0.027 = 1148

correct values used to calculate gradient with appropriate 2sf answer given (1100 or 1200)

1100 or 1200 with no other working gets 1 out of 2

OR <u>1154 ± 6</u> seen

Do not allow 32/0.0280 or 33/0.0290 (point A) for second mark.

AND load used >= 15 ✓ (= 1100 or 1200 (2sf))

32 / 0.028 is outside tolerance. 32/0.0277 is just inside.

Nm^{-1} / N / m (newtons per metre) ✓ (not n / m, n / M, N / M)

3

(c) any area calculated or link energy with area / use of 1 / 2FΔL ✓

(or 0.001 Nm for little squares)

35 whole squares, 16 part gives 43 ± 1.0
OR equivalent correct method to find whole area ✓

0.025 Nm per (1cm) square × candidates number of squares and correctly evaluated
OR (= 1.075) = 1.1 (J) (1.05 to 1.10 if not rounded) ✓

3

(d) permanent deformation / permanent extension ✓

*Allow: 'doesn't return to original length'; correct reference to 'yield' e.g. allow '**extension beyond the yield point**'*
do not accept: 'does not obey Hooke's law' or 'ceases to obey Hooke's law',

1

(e) any line from B to a point on the x axis from 0.005 to 0.020 ✓

straight line from B to x axis (and no further) that reaches x axis for 0.010<=ΔL<= 0.014 ✓

2

(f) work done by spring < work done by the load

Accept 'less work' or 'it is less' (we assume they are referring to the work done by spring)

1

[12]

M7.(a)

breaking stress	✓
stiffness constant, k	
tensile strain	
tensile stress	
Young modulus	✓

1

(b) (i) elastic limit ✓

only one attempt at the answer is allowed

1

(ii) ($E = 300 \times 10^6 / 4 \times 10^{-2} = 7.5 \times 10^9$)

7.5 (Pa) ✓ allow 7.4 to 7.6 (Pa)

$\times 10^9$ ✓

first mark is for most significant digits ignoring the power of 10. E.g. 7500 gains mark

2

(c) <u>straight line</u> beginning on existing line at a strain of 0.10 and hitting the strain axis at a lower non-zero value ✓

line that ends on the x -axis with strain between 0.045 and 0.055 ✓(only allow if first mark is given)

ie accuracy required ± one division

2

(d) 8.99×10^{-3} (m^3) ✓ condone 1 sig fig

allow 9.00×10^{-3}

1

(e) $0.9872 \times 8.99 \times 10^{-3}$ or $= 8.8749 \times 10^{-3}$ (m^3) ✓

allow CE from 4d

($m = \rho V$)= 2700 × 8.8749 × 10^{-3} = 24 (kg) ✓ (23.962 kg)
allow CE from first part, e.g. if 1.28% was used gives 0.311 kg

V =0.9872 × (d)

m = 2.665 × (d)

1.28% of vol = 1.15 × 10^{-4} m^3

2

[9]

WAVES QUESTIONS (57 MARKS)

Q1. Which of the following is correct for a stationary wave?

A	Between two nodes the amplitude of the wave is constant.	◯
B	The two waves producing the stationary wave must always be 180° out of phase.	◯
C	The separation of the nodes for the second harmonic is double the separation of nodes for the first harmonic.	◯
D	Between two nodes all parts of the wave vibrate in phase.	◯

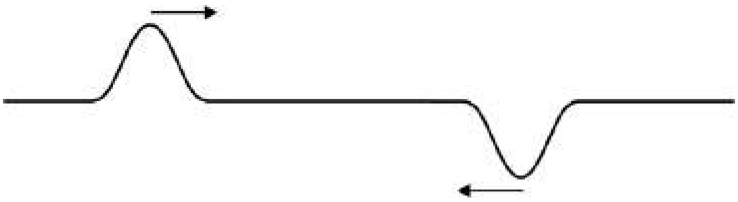
(Total 1 mark)

Q2. Sound waves cross a boundary between two media X and Y. The frequency of the waves in X is 400 Hz. The speed of the waves in X is 330 m s^{-1} and the speed of the waves in Y is 1320 m s^{-1}. What are the correct frequency and wavelength in Y?

	Frequency / Hz	**Wavelength / m**	
A	100	0.82	◯
B	400	0.82	◯
C	400	3.3	◯
D	1600	3.3	◯

(Total 1 mark)

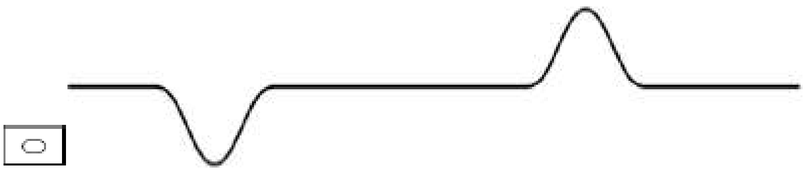
Q3. The diagram shows two pulses on a string travelling towards each other.

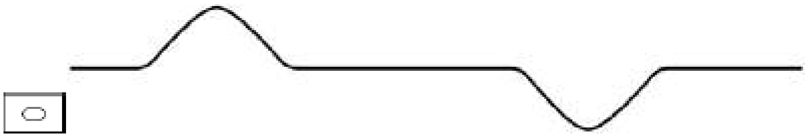


Which of the following diagrams shows the shape of the string when the pulses have passed through each other?

A 

B 

C 

D 

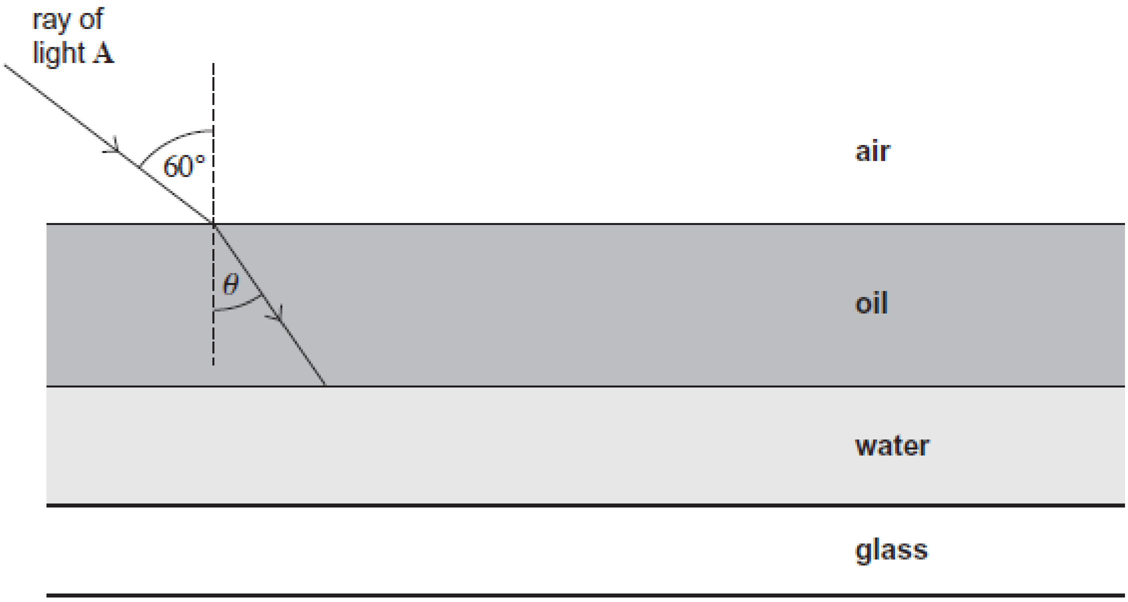
(Total 1 mark)

Q4.Figure 1 shows a ray of light **A** incident at an angle of 60° to the surface of a layer of oil that is floating on water.

refractive index of oil = 1.47

refractive index of water = 1.33

Figure 1



(a) (i) Calculate the angle of refraction θ in **Figure 1**.

angle .... degrees

(2)

(ii) Calculate the critical angle for a ray of light travelling from oil to water.

angle .... degrees

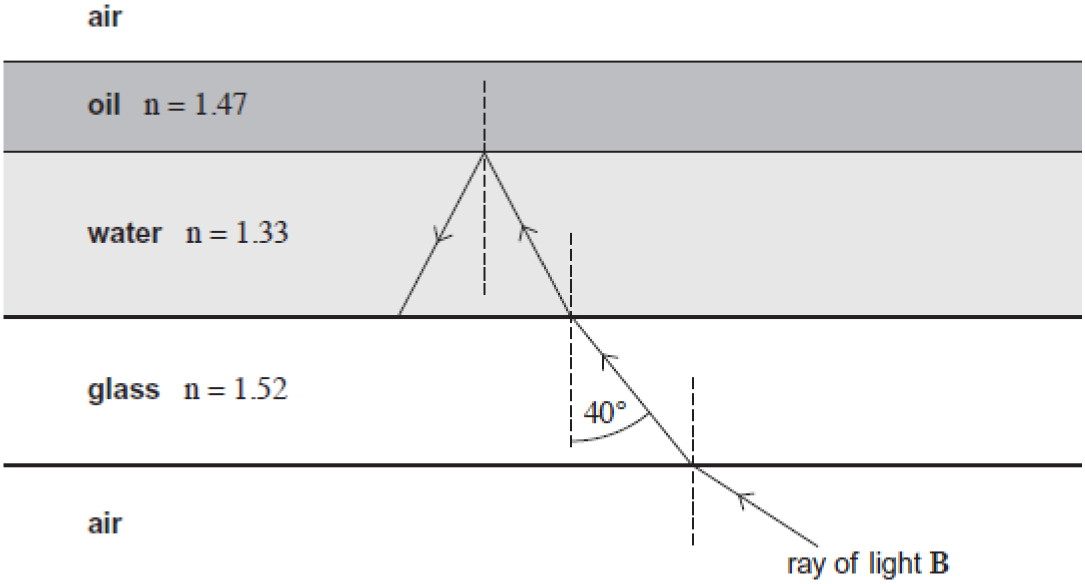
(2)

(iii) On **Figure 1** continue the path of the ray of light **A** immediately after it strikes the boundary between the oil and the water.

(2)

(b) In **Figure 2** a student has incorrectly drawn a ray of light **B** entering the glass and then entering the water before totally internally reflecting from the water–oil boundary.

Figure 2



The refractive index of the glass is 1.52 and the critical angle for the glass–water boundary is about 60°.

Give **two** reasons why the ray of light **B** would **not** behave in this way. Explain your answers.

reason 1 ....

....
.

explanation
....

....
.

....
.

reason 2 ....

....
.

explanation
....

....
.

....
.

(4)

(Total 10 marks)

Q5. An optical fibre consists of a core, cladding and an outer sheath.

(a) State the purpose of the outer sheath in an optical fibre.

....
.

....
.

(1)

(b) For one fibre, the speed of monochromatic light in the core is 1.97×10^8 m s^{-1} and the speed in the cladding is 2.03×10^8 m s^{-1}.

Calculate the critical angle for this light at the interface between the core and the cladding.

critical angle .... degrees

(2)

(Total 3 marks)

Q6.(a) Musical **concert pitch** has a frequency of 440 Hz.
A correctly tuned A-string on a guitar has a first harmonic (fundamental frequency) two octaves below concert pitch.

Determine the first harmonic of the correctly tuned A-string.

frequency.. Hz

(1)

(b) Describe how a note of frequency 440 Hz can be produced using the correctly tuned A-string of a guitar.

....

....

(1)

(c) Describe the effect heard when notes of frequency 440 Hz and 430 Hz of similar amplitude are sounded together.

....

....

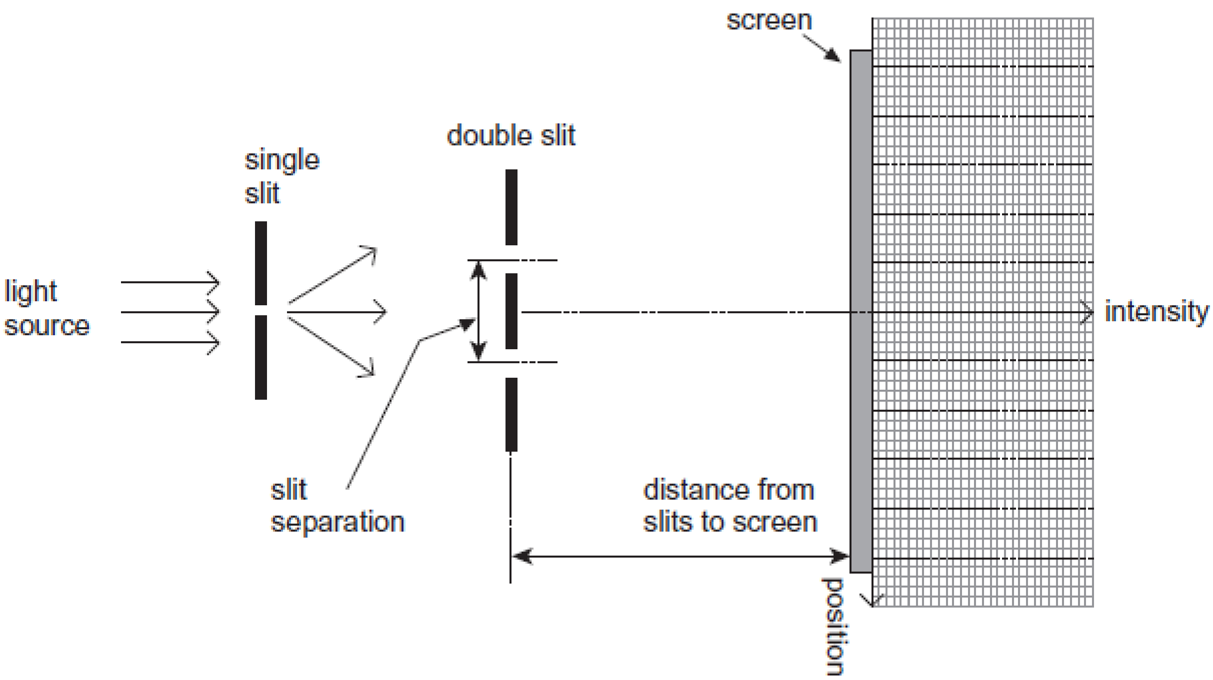
....

....
.

(2)

(Total 4 marks)

Q7. The diagram shows Young's double-slit experiment performed with a tungsten filament lamp as the light source.



not to scale

(a) On the axes in the diagram above, sketch a graph to show how the intensity varies with position for a **monochromatic** light source.

(2)

(b) (i) For an interference pattern to be observed the light has to be emitted by two **coherent sources**.
Explain what is meant by coherent sources.

....

....

....

....

(1)

(ii) Explain how the use of the single slit in the arrangement above makes the light from the two slits sufficiently coherent for fringes to be observed.

....

....

....

....

(1)

(iii) In this experiment light behaves as a wave.
Explain how the bright fringes are formed.

....
.

....
.

....
.

....
.

....
.

....
.

....
.

....
.

(3)

(c) (i) A scientist carries out the Young double-slit experiment using a laser that emits violet light of wavelength 405 nm. The separation of the slits is 5.00×10^{-5} m.

Using a metre ruler the scientist measures the separation of two adjacent bright fringes in the central region of the pattern to be 4 mm.

Calculate the distance between the double slits and the screen.

distance = ... m

(2)

(ii) Describe the change to the pattern seen on the screen when the violet laser is replaced by a green laser. Assume the brightness of the central maximum is the same for both lasers.

....

.

....
.

....
.

(1)

(iii) The scientist uses the same apparatus to measure the wavelength of visible electromagnetic radiation emitted by another laser.
Describe how he should change the way the apparatus is arranged and used in order to obtain an **accurate** value for the wavelength.

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(3)

(Total 13 marks)

Q8. A student has a diffraction grating that is marked 3.5×10^3 lines per m.

(a) Calculate the percentage uncertainty in the number of lines per metre suggested by this marking.

percentage uncertainty = ... %

(1)

(b) Determine the grating spacing.

grating spacing = ... mm

(2)

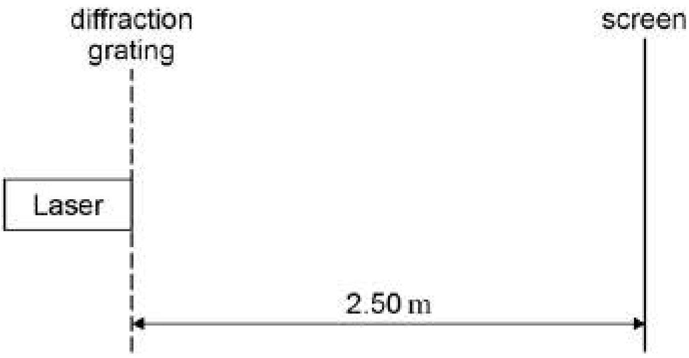
(c) State the absolute uncertainty in the value of the spacing.

absolute uncertainty = ... mm

(1)

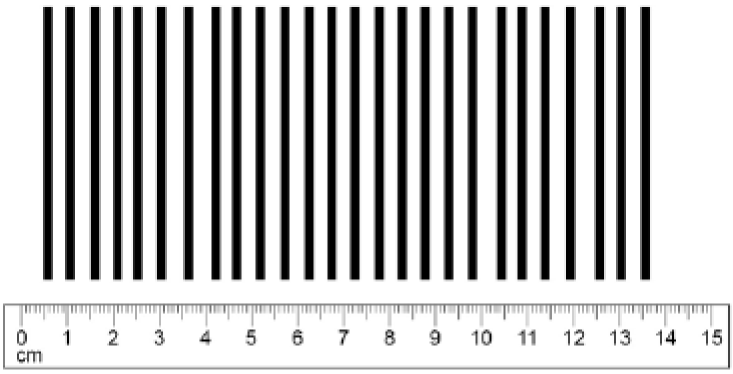
(d) The student sets up the apparatus shown in **Figure 1** in an experiment to confirm the value marked on the diffraction grating.

Figure 1



The laser has a wavelength of 628 nm. **Figure 2** shows part of the interference pattern that appears on the screen. A ruler gives the scale.

Figure 2



Use **Figure 2** to determine the spacing between two adjacent maxima in the interference pattern. Show all your working clearly.

spacing = ... mm

(1)

(e) Calculate the number of lines per metre on the grating.

number of lines = ...

(2)

(f) State and explain whether the value for the number of lines per m obtained in part (e) is in agreement with the value stated on the grating.

....

....

....

(2)

(g) State **one** safety precaution that you would take if you were to carry out the experiment that was performed by the student.

....

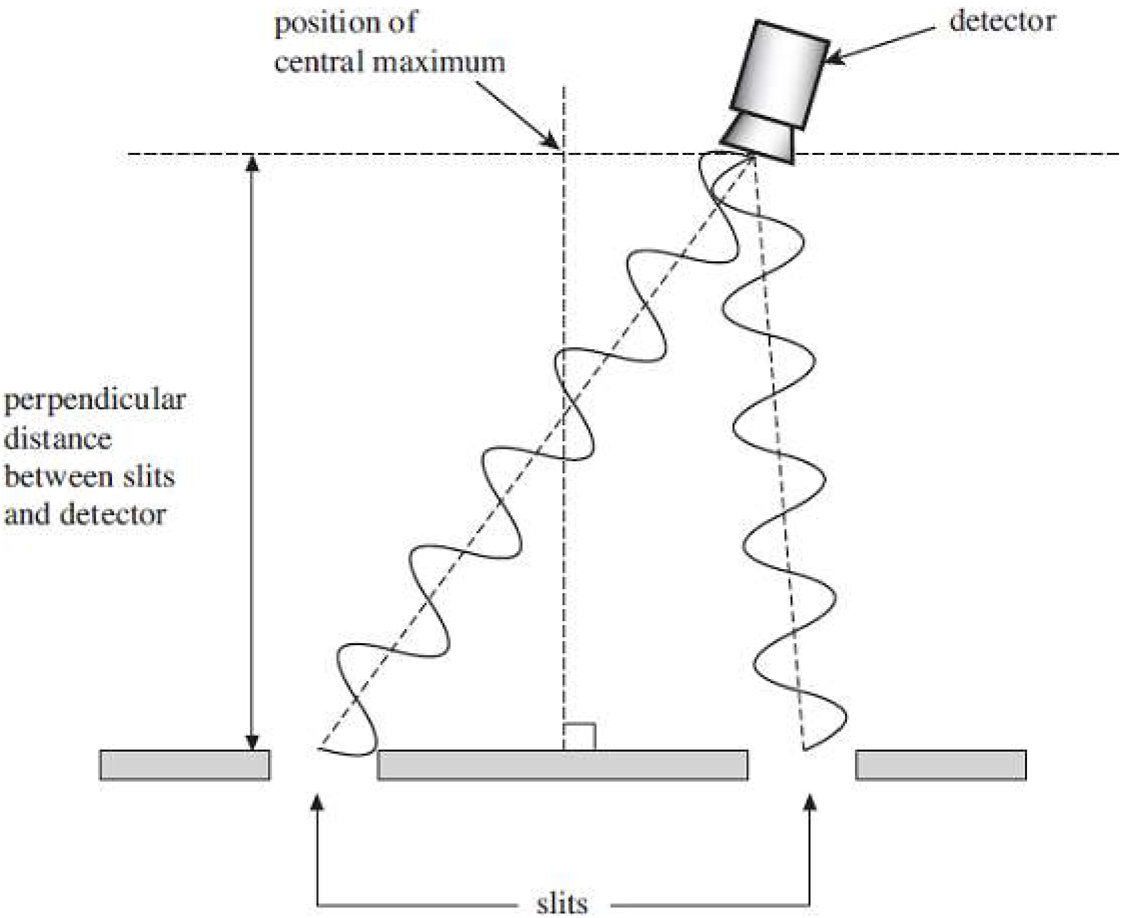
....

....

(1)

(Total 10 marks)

Q9. The diagram below shows the paths of microwaves from two narrow slits, acting as coherent sources, through a vacuum to a detector.



(a) Explain what is meant by *coherent sources.*

....
.

....

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.

....
.

....
.

(2)

(b) (i) The frequency of the microwaves is 9.4 GHz.

Calculate the wavelength of the waves.

wavelength = ... m

(2)

(ii) Using the diagram above and your answer to part (b)(i), calculate the path difference between the two waves arriving at the detector.

path difference = ... m

(1)

(c) State and explain whether a maximum or minimum is detected at the position shown in the diagram above.

....
.

....
.

....
.

....
.

(3)

(d) The experiment is now rearranged so that the perpendicular distance from the slits to the detector is 0.42 m. The interference fringe spacing changes to 0.11 m.

Calculate the slit separation. Give your answer to an appropriate number of significant figures.

slit separation = ... m

(3)

(e) With the detector at the position of a maximum, the frequency of the microwaves is now doubled. State and explain what would now be detected by the detector in the same position.

....
.

....
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....
.

....
.

(3)

(Total 14 marks)

WAVES MARK SCHEME

M1. D

[1]

M2. C

[1]

M3. C

[1]

M4. **M4** (a) (i) sin 60 = 1.47sin θ **OR** sin θ = sin 60 / 1.47 ✓
($\sin^{-1}$ 0.5891) = 36 (°) ✓ (36.0955°) (allow 36.2)

Allow 36.0

2

(ii) sin θ_c = 1.33 / 1.47 OR sin θ_c = 0.9(048) ✓
($\sin^{-1}$ 0.9048) = 65 (°) ✓ (64.79)

Allow 64 for use of 0.9 and 66 for use of 0.91

2

(iii) answer consistent with previous answers, e.g.

if aii >ai:
ray refracts at the boundary AND goes to the right of the normal ✓
Angle of refraction > angle of incidence ✓ **this mark depends on the first**

if aii
TIR ✓
angle of reflection = angle of incidence ✓

ignore the path of the ray beyond water / glass boundary

Approx. equal angles (continuation of the line must touch 'Figure 1' label)

2

(b) for Reason or Explanation:
the angle of refraction should be > angle of incidence when <u>entering the water</u> ✓
water has a lower refractive index than glass \ light is faster in water than in glass ✓

TIR could not happen \ there is no critical angle, when ray travels from water to oil ✓
TIR only occurs when ray travels from higher to lower refractive index \ water has a lower refractive index than oil ✓

Allow 'ray doesn't bend towards normal' (at glass / water)

Allow <u>optical</u> density

Boundary in question must be clearly implied

4

[10]

M5.(a) Prevents (physical) damage to fibre / strengthen the fibre / protect the fibre

Allow named physical damage e.g. scratching

B1

Prevent crosstalk

1

(b) (Relative) refractive index = 1.03
or
Use of sin$c$ = n_2 / n_1

Calculating the refractive indices and rounding before dividing gives 76.8

C1

76.0° or 76.8°

A1

2

[3]

M6.(a) 110 Hz

B1

1

(b) (Use finger on the fret so that) a ¼ length of the string is used to sound the note or hold string down on 24th fret

B1

1

(c) Mention or description of beats or description of rising and falling amplitude / louder and quieter

Regular rising and falling of loudness owtte

B1

B1

Beat frequency 10(.0Hz) Allow beat frequency = 430 - 420

2

[4]

M7.(a) uniform width peaks ✓ (accurate to within ± one division)

peaks need to be rounded ie not triangular

the minima do not need to be exactly zero

a collection of peaks of constant amplitude or amplitude decreasing away from central peak ✓

pattern must look symmetrical by eye

condone errors towards the edge of the pattern

double width centre peak total mark = 0

2

(b) (i) constant / fixed / same phase relationship / difference (and same frequency / wavelength) ✓

in phase is not enough for the mark

1

(ii) single slit acts as a point / single source diffracting / spreading light to <u>both slits</u> ✓
OR
the path lengths between the single slit and the double slits are constant / the same / fixed ✓

1

(iii) <u>superposition</u> of waves from two slits ✓

phrase 'constructive superposition' = 2 marks

diffraction (patterns) from both slits overlap (and interfere constructively) ✓ (this mark may come from a diagram)

constructive interference / reinforcement (at bright fringe)
peaks meet peaks / troughs meet troughs ✓ (any reference to antinode will lose this mark)

waves from each slit meet in phase
OR path difference = $n\lambda$ ✓

4 max 3

(c) (i) $D = \frac{ws}{\lambda} = \frac{0.004 \times 5.0 10^{-5}}{405 \times 10^{-9}}$ ✓ **do not penalise any incorrect powers of ten for this mark**

= 0.5 (m) ✓ (0.4938 m)

numbers can be substituted into the equation using any form

note 0.50 m is wrong because of a rounding error

full marks available for answer only

2

(ii) fringes further apart or fringe / pattern has a greater width / is wider ✓

ignore any incorrect reasoning

changes to green is not enough for mark

1

(iii) increase *D* ✓
measure across more than 2 maxima ✓

several / few implies more than two

added detail which includes ✓
explaining that when *D* is increased then *w* increases
Or
repeat the reading with a changed distance *D* or using different numbers of fringes or measuring across different pairs of (adjacent) fringes
Or
explaining how either of the first two points improves / reduces

the percentage error.

no mark for darkened room

3

[13]

M8.(a) 2.9% ✓

Allow 3%

1

(b) $\frac{1}{3.5 \times 10^3}$ seen ✓

1

0.29 mm or 2.9 x 10^{-4} m✓ must see 2 sf **only**

1

(c) ± 0.01 mm ✓

1

(d) Clear indication that at least 10 spaces have been measured to give a spacing = 5.24 mm✓

spacing from at least 10 spaces
Allow answer within range ±0.05

1

(e) Substitution in $d\ sin\theta = n\lambda$✓

The 25 spaces could appear here as n with sin θ as

0.135 / 2.5

1

d = 0.300 x 10^{-3} m so
number of lines = 3.34 x10^{3}✓

Condone error in powers of 10 in substitution

Allow ecf from 1-4 value of spacing

1

(f) Calculates % difference (4.6%) ✓

1

and makes judgement concerning agreement ✓

Allow ecf from 1-5 value

1

(g) care not to look directly into the laser beam✓
OR
care to avoid possibility of reflected laser beam ✓
OR
warning signs that laser is in use outside the laboratory✓
ANY ONE

1

[10]

M9.(a) same wavelength / frequency ✓

constant phase relationship ✓ allow 'constant phase difference' but not 'in phase'

2

(b) (i) ($\lambda = \frac{c}{f}$)

Use of speed of sound gets zero

$3.00 \times 10^8 = 9.4\ (10^9)\ \lambda$ OR $\frac{3.00\times10^8}{9.4\times(10^9)}$ ✓

$= 3.2 \times 10^{-2}$ (3.19×10^{-2} m) ✓

Allow 0.03

2

(ii) 3.2×10^{-2} ✓ (m) ecf from bi

Don't allow '1 wavelength', 1λ, etc
Do not accept: zero, 2π, 360 °

1

(c) maximum (at position shown) ✓

allow constructive superposition.
'Addition' is not enough

constructive interference / reinforcement ✓

ecf for 'minimum' or for reference to wrong maximum

(the waves meet) 'in step' / peak meets peak / trough meets trough / path difference is (n) λ / in phase ✓

3

(d) $s = \frac{\lambda D}{w}$

Don't allow use of the diagram shown as a scale diagram

$= \frac{0.0319 \times 0.42}{0.11}$ ✓ ecf bi

Do not penalise s and w symbols wrong way round in working if answer is correct.

= 0.12 (0.1218 m) ✓

Correct answer gains first two marks.

= **any <u>2sf</u>** number ✓

*Independent sf mark for **any** 2 sf number*

3

(e) a maximum ✓

Candidates stating ' minimum ' can get second mark only

(f × 2 results in) $\lambda/2$ ✓

path difference is an even number of multiples of the new wavelength ($2n\lambda_{new}$) ✓

allow 'path difference is $n\lambda$' / any even number of multiples of the new λ quoted e.g. 'path difference is now 2 λ'

3

[14]