AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level PHYSICS

Paper 1

Monday 20 May 2019 Afternoon Time allowed: 2 hours

Materials

For this paper you must have:
- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8–32	
TOTAL	

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 85.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

Do not write outside the box

Section A

Answer **all** questions in this section.

0 1 . 1 Two isotopes of iodine are $^{125}_{53}\mathrm{I}$ and $^{131}_{53}\mathrm{I}$.

nucleon no. (p+n)

proton (p) no.

Determine, for these two isotopes, the difference between the constituents of the nuclei.

[1 mark]

$^{131}_{53}\mathrm{I}$ has 6 more neutrons than $^{125}_{53}\mathrm{I}$

0 1 . 2 A $^{131}_{53}\mathrm{I}$ nuclide undergoes beta (β^-) decay to form a xenon nuclide.

State the nucleon number of the xenon nuclide.

[1 mark]

131

0 1 . 3 A $^{125}_{53}\mathrm{I}$ nuclide decays by electron capture to form a tellurium nuclide.

State **two** differences between the constituents of the iodine nucleus and the tellurium nucleus it decays into.

[2 marks]

Electron capture: proton absorbs electron, neutron is formed

- Tellurium nuclide has 1 more neutron ✓
- Tellurium nuclide has 1 fewer proton ✓

Do not write outside the box

0 1 . 4 Internal conversion is a process in which a nucleus in an excited state can release its excess energy. In internal conversion all of the excess energy is transferred from the nucleus to an orbital electron through the electromagnetic force. This orbital electron is ejected from the atom.

The tellurium nucleus formed in question **01.3** is in an excited state and can undergo internal conversion.

Discuss **three** differences between internal conversion and beta (β^-) decay.

[3 marks]

1 In beta decay, the proton and neutron numbers change, whereas in internal conversion they do not ✓

2 Discrete energy values for internal conversion but not beta decay ✓

3 Beta⁻: ${}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + {}^{0}_{0}\bar{\nu}$

Anti-neutrino released in beta decay but not internal conversion ✓

4: Internal conversion deals with electrons in outer shells, whereas beta decay involves the nucleus only ✓

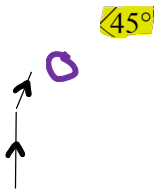
5: Internal conversion involves the electromagnetic force, whereas beta decay involves the weak interaction ✓

7

Do not write outside the box

0 2 Some cars are fitted with a water sensor designed to switch on windscreen wipers automatically when it rains. **Figure 1** shows a simplified diagram of the sensor.

Figure 1



A light ray travels from the light-emitting diode (LED) through the first prism and into the windscreen. The ray reflects off the surfaces of the windscreen at **A**, **B** and **C** and then passes through the second prism into the detector.

0 2 . 1 Suggest how the design ensures that there is no deviation of the ray as it enters the first prism.

[1 mark]

Light from the LED is entering the glass at a normal to the surface; no refraction.

0 2 . 2 Suggest **two** features of the design that ensure that there is no deviation of the ray as it leaves the first prism and enters the windscreen glass.

[2 marks]

1 The prism and the windscreen glass have the same refractive index, i.e. same optical density ✓

2 No gaps in the boundary (as air bubbles cause refraction and possibly total internal reflection) ✓

Snell's Law:

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Do not write outside the box

0 2 . 3 The refractive index of the windscreen glass is 1.52

Explain why the ray follows the path shown inside the windscreen glass in **Figure 1**. Support your answer with a suitable calculation.

[2 marks]

Critical angle equation: $n = \frac{1}{\sin(C)}$

(n: refractive index; C: critical angle)

$C = \sin^{-1}\left(\frac{1}{n}\right) = \sin^{-1}\left(\frac{1}{1.52}\right) = 41.1^\circ < 45^\circ$ ✓

The angle of incidence is larger than the critical angle, so total internal reflection occurs ✓

Question 2 continues on the next page

Do not write outside the box

0 2 . 4 When it starts to rain, water droplets form on the outside of the windscreen as shown in **Figure 2**.

Figure 2

Snell's Law

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

glass water

The refractive index of water is 1.33

Explain why the presence of water at **A** causes the intensity of the light at the detector to decrease.

Support your answer with a suitable calculation.

[2 marks]

$1.52 \sin(C) = 1.33 \sin(90°)$

$C = \sin^{-1}\left(\frac{1.33}{1.52}\sin(90°)\right) = \sin^{-1}\left(\frac{1.33}{1.52}\right) = 61.0°$ ✓

Some light refracts out as the angle of incidence is smaller than the critical angle; total internal reflection no longer occurs. ✓

Do not write outside the box

0 2 . 5 The refractive index of the windscreen glass can vary by a few per cent across the thickness of the glass.

Discuss how this variation may affect the path of the ray through the windscreen glass.

[2 marks]

- Light only travels straight when refractive indices are the same (or at normal to a boundary) ✓

- n only varies by a few percent, so the path will not be affected greatly. ✓

0 2 . 6 A different design has the LED and the detector further apart. The ray undergoes more reflections inside the windscreen glass before reaching the detector.

Discuss **two** ways in which this different design affects the sensitivity of the sensor to the presence of water droplets.

[2 marks]

	More Sensitive	Less Sensitive
1	 • More likely to reach a water drop ✓	• More likely to reach dirt/scratches on glass ✓
2	• Light travels further, so its intensity decreases by more. More sensitivity to rain. ✓	• Screen absorbs light; without water, received intensity of light is much lower ✓ • Windscreen is curved; light less likely to reach detector ✓

11

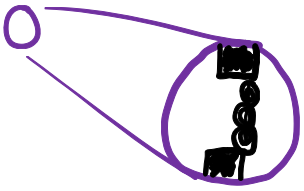
Turn over ►

Do not write outside the box

0 3 **Figure 3** shows an arrangement to investigate diffraction. White light is incident on a single slit. After leaving the slit, the diffracted light passes through a green filter to reach the screen.

Huygens' principle: A wavefront can be considered as a line of point sources

Figure 3



0 3 . 1 Describe the pattern produced on the screen.

[2 marks]

- Maximum at the centre, with lower intensity maxima on either side ✓
- Central maximum is double the width of the other maxima ✓

0 3 . 2 The green filter is replaced with a red filter.

Describe the change in the pattern produced on the screen.

[2 marks]

Diffraction grating: $n\lambda = d\sin\theta$

Red light has a longer wavelength than green light

- Maxima will be further apart ✓
- Central maximum is wider ✓

Do not write outside the box

0 3 . 3 A diffraction grating is placed between the red filter and the screen. The diffraction grating has 500 lines per millimetre. Light is incident normally on the grating. **Figure 4** shows the arrangement.

Figure 4

The wavelength of the red light is 650 nm.

Calculate the angle θ between a first-order maximum and the central maximum.

[2 marks]

$n\lambda = d\sin\theta$

$\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right)$

$= \sin^{-1}\left(\frac{1 \times 6.5 \times 10^{-7}}{2 \times 10^{-6}}\right)$

$= 19°$

500 lines per mm

$\left(\frac{1}{500}\right)$ mm per line

$\left(\frac{1}{500} \times 10^{-3}\right)$ m per line

$= 2 \times 10^{-6}$ m per line ✓

$\theta =$ 19 ✓ degrees

Question 3 continues on the next page

Turn over ►

Do not write outside the box

0 3 . 4 In practice, the filter transmits red light with wavelengths in the range 600 nm to 700 nm.

Suggest how this affects the appearance of the maxima.

[2 marks]

- Each maximum has a broader appearance/range of angles ✓
- Larger order maxima will be broader ✓
- $\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right) = \sin^{-1}\left(\frac{3 \times 7 \times 10^{-7}}{2 \times 10^{-6}}\right) = ?$

  So third order maximum cut off at larger wavelengths ✓
- Central maximum does not change width ✓

8

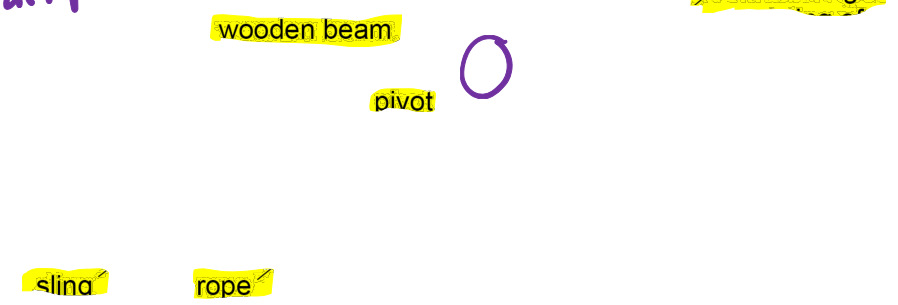
Do not write outside the box

0 4 **Figure 5** shows a simplified catapult used to hurl projectiles a long way.

Anti-clockwise moment:
- Weight of projectile
- Vertical component of tension in rope

Clockwise moment:
- Weight of stones

Figure 5



The counterweight is a wooden box full of stones attached to one end of the beam.
The projectile, usually a large rock, is in a sling hanging vertically from the other end of the beam. The weight of the sling is negligible.
The beam is held horizontal by a rope attached to the frame.

0 4 . 1 The catapult is designed so that the weight of the beam and the weight of the **empty** wooden box have no effect on the tension in the rope.

Suggest how the pivot position achieves this.

The point at which all mass is concentrated

[2 marks]

- The centre of mass of the beam-box combination is at the pivot. ✓
- Net moment about the pivot is equal to zero. ✓

Question 4 continues on the next page

Turn over ►

Do not write outside the box

0 4 . 2 The stones in the counterweight have a total mass of 610 kg and the projectile weighs 250 N.

Calculate the tension in the rope.

[5 marks]

clockwise moment = anticlockwise moment ✓

$W_{stones} \times d_{stones} = (W_{pro} + T_v) \times L_{arm}$

$610 \times 9.81 \times 1.5$ ✓ $= (250 + T\sin(50)) \times 4.0$ ✓

$250 + T\sin(50) = \frac{610 \times 9.81 \times 1.5}{4.0}$ ✓

$T\sin(50) = \frac{610 \times 9.81 \times 1.5}{4.0} - 250$

$T = \frac{\left(\frac{610 \times 9.81 \times 1.5}{4.0} - 250\right)}{\sin(50)} = 2600$ ✓

tension = 2600 N

0 4 . 3 When the rope is cut, the counterweight rotates clockwise. When the beam is vertical it is prevented from rotating further. The projectile is then released horizontally with a velocity of 18 m s^{-1}, as shown in **Figure 6**.

The projectile is released at a height of 7.5 m above ground level.

Figure 6

Do not write outside the box

The range of the catapult is the horizontal distance between the point where the projectile is released to the point where it lands.

Calculate the range.
Ignore air resistance.

[2 marks]

Vertically

$s = ut + \frac{1}{2}at^2 = \frac{1}{2}at^2 \Rightarrow t = \sqrt{\frac{2s}{a}}$ ✓

(s: displacement, u: initial velocity, t: time, a: acceleration)

$= \sqrt{\frac{2 \times 7.5}{9.81}}$

$= 1.2\text{s}$

Horizontally

$v = \frac{d}{t} \Rightarrow d = vt = 18 \times 1.2 = 22\text{m}$

range = 22 ✓ m

0 4 . 4 In another release, the sling is adjusted so that a projectile of the same mass is released just before the wooden beam is vertical. The projectile is not released horizontally.

Discuss the effect this change has on the range of the catapult.

[3 marks]

Increase	Decrease
• Vertical component of velocity is non-zero. ✓	• Counterweight doesn't fall as far. ✓
• Time of flight is greater. ✓	• Less gravitational potential energy converted to kinetic energy of the rock. ✓
• Therefore larger range. ✓	• Rock has a lower initial speed ($KE = \frac{1}{2}mv^2$) ✓
	• Therefore lower range ✓

Turn over ►

Do not write outside the box

0 5 Safety barriers are used on UK motorways to prevent vehicles crossing from one carriageway to the other carriageway. The barriers also absorb some of the kinetic energy of a vehicle and deflect vehicles along the barrier.

The standard test of a safety barrier uses a vehicle that contains dummies. The total mass of the vehicle and its contents is 1.5×10^3 kg and its initial speed is 110 km h^{-1}.

0 5 . 1 Show that the initial kinetic energy of the test vehicle is 700 kJ.

[2 marks]

$110\,\text{km h}^{-1} = 110{,}000\,\text{m h}^{-1} = \left(\frac{110{,}000}{3600}\right)\text{m s}^{-1} = 31\,\text{m s}^{-1}$ ✓

$KE = \frac{1}{2}mv^2$ (kinetic energy, mass, speed)

$= \frac{1}{2} \times 1.5 \times 10^3 \times 31^2$ ✓

$= 7.2 \times 10^5\,\text{J}$

$\simeq 700\,\text{kJ}$

0 5 . 2 The test vehicle hits a steel safety barrier at an angle of 20°, as shown in **Figure 7**.

Figure 7

$1.5 \times 10^3 \times 31$

p

$\{p = mv\}$ (momentum, mass, velocity)

Calculate the component of the momentum of the test vehicle in a direction along the line of the safety barrier.
Give an appropriate unit for your answer.

Unit: kg m s^{-1}

[3 marks]

SOH CAH TOA

$\cos\theta = \frac{A}{H}$

$\cos(20) = \frac{p}{1.5 \times 10^3 \times 31}$ ✓

$p = 1.5 \times 10^3 \times 31 \times \cos(20)$

$= 4.4 \times 10^4\,\text{kg m s}^{-1}$

momentum = 4.4×10^4 ✓ unit kg m s^{-1} ✓

Do not write outside the box

0 5 . 3 Immediately after the collision, the test vehicle moves along the safety barrier with no change in its momentum in this direction.

Show that the kinetic energy lost in the collision is about 80 kJ.

[3 marks]

Initial KE = 700kJ

Final momentum = $p = 4.4\times10^{4}\ \text{kgms}^{-1} = mv$

$v = \frac{p}{m} = \frac{4.4\times10^{4}}{1.5\times10^{3}} = 31\cos 20$

$= 28.7\ \text{ms}^{-1}$ ✓

Final KE = $\frac{1}{2}mv^2 = 0.5\times1.5\times10^{3}\times 28.7^2 = 618{,}000\text{J}$ ✓

$700{,}000 - 618{,}000$ ✓ $= 82{,}000\text{J} \simeq 80\text{kJ}$

0 5 . 4 The steel safety barrier deforms during the collision. For the barrier to pass the test, the test vehicle should not move more than 1.5 m towards the other carriageway.

The barrier can apply an average force of 60 kN at right angles to the carriageway.

Deduce whether the safety barrier will pass the test.

[3 marks]

Work done = force × distance moved in the direction of the force

$\text{Force} = \frac{\text{work done}}{\text{distance}}$ ✓ $= \frac{82{,}000}{1.5} = 5.5\times10^{4}\text{N}$ ✓

55kN < 60kN

⇒ It will pass the test } ✓

Question 5 continues on the next page

Do not write outside the box

0 5 . 5 A different safety barrier uses a solid concrete wall which does not deform. The same standard test is carried out on a concrete wall.

Discuss which type of barrier would cause less damage to the dummies in the test.

[2 marks]

Impulse = Ft = change in momentum

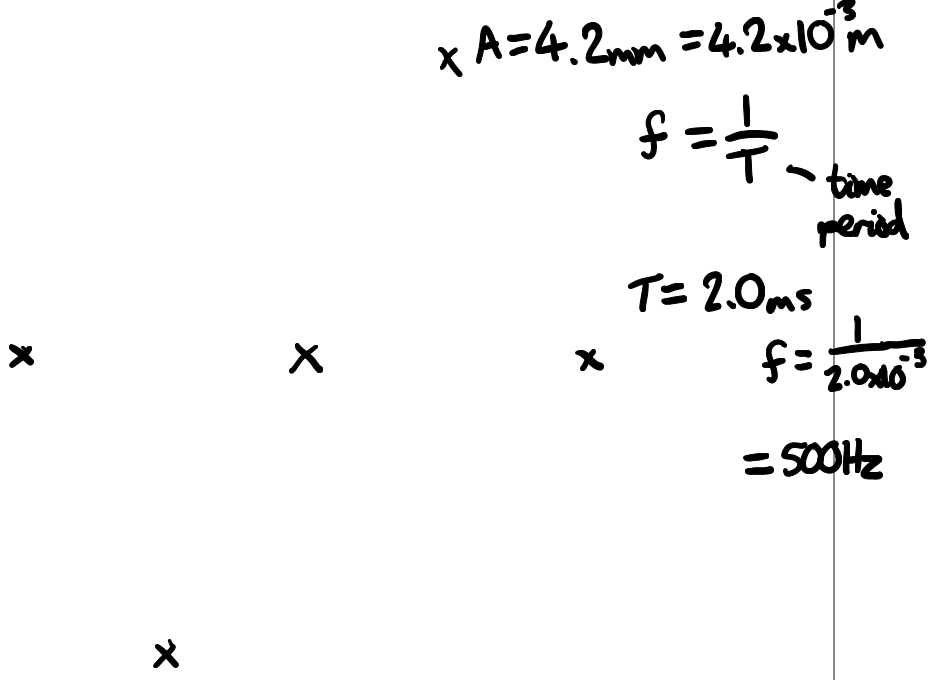
- Time of contact is smaller ✓
- For a constant impulse, force is larger ✓
  (∴ steel is better)

13

Do not write outside the box

0 6 A loudspeaker cone is driven by a signal generator (oscillator).
Figure 8 shows the variation of displacement with time t for a point **P** at the centre of the cone. **P** is oscillating with simple harmonic motion.

Figure 8



0 6 . 1 State the time, in milliseconds, when **P** is moving at its maximum positive velocity.
[1 mark]

On a displacement-time graph, velocity is the gradient

time = 1.5 ms

0 6 . 2 Calculate the maximum acceleration of **P**.
[3 marks]

T = 2.0 ms ✓

$a = -\omega^2 x$ (a = acceleration, ω = angular frequency, x = displacement)

$\omega = 2\pi f$ (f = frequency)

$a_{max} = -(2\pi f)^2 A$

$A = 4.2 \times 10^{-3}$ m ✓

$f = 500\text{ Hz} = \frac{1}{T}$

acceleration = 4.1×10^4 ✓ m s^{-2}

$a_{max} = (2\pi \times 500)^2 \times 4.2 \times 10^{-3}$

$= 4.15 \times 10^4\ \text{m s}^{-2}$

41,452 m s^{-2}

Do not write outside the box

0 6 . 3 The loudspeaker creates variations in pressure and produces a sound wave in the air around it.

→ Longitudinal or transverse?

State the type of wave produced and describe the motion of the particles in this type of wave.

[1 mark]

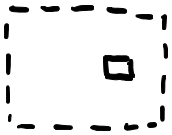
- Longitudinal
- Oscillations are parallel to direction of energy transfer (or direction of wave travel)

5

Do not write outside the box

0 7 **Figure 9** shows a practical circuit in which a variable resistor is used to control the brightness of a lamp. The voltmeter reading is monitored as the variable resistor is adjusted to make the lamp brighter.

Figure 9



$V = IR$ — resistance

potential difference — current

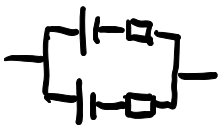
0 7 . 1 Explain why the reading on the voltmeter decreases as the brightness of the lamp increases.

[2 marks]

- If the lamp is brighter, the current is higher ✓
- The potential difference across the internal resistance is greater, so the overall potential difference across the cell (e.m.f. minus p.d.) is lower. ✓

0 7 . 2 The variable resistor is adjusted so that the lamp is at its brightest. The reading V_1 on the voltmeter is noted. A second identical cell is then connected in parallel with the cell in **Figure 9**. The new reading V_2 on the voltmeter is noted.

Explain why V_2 is greater than V_1.



[2 marks]

- When two cells are placed in parallel, overall e.m.f. remains the same as one cell but the overall internal resistance is half of that of one cell. ✓
- Fewer volts lost across the internal resistance (as $V = IR$), so the p.d. across the new system of cells is higher. ✓

4

Do not write outside the box

Section B

Each of Questions **8** to **32** is followed by four responses, **A**, **B**, **C** and **D**.

For each question select the best response.

Only **one** answer per question is allowed.
For each question completely fill in the circle alongside the appropriate answer.

CORRECT METHOD  WRONG METHODS 

If you want to change your answer you must cross out your original answer as shown. 

If you wish to return to an answer previously crossed out, ring the answer you now wish to select as shown. 

You may do your working in the blank space around each question but this will not be marked.
Do **not** use additional sheets for this working.

0 8 The process of beta plus (β^+) decay can be represented by

- W must be positive to conserve charge
- X must produce a matter neutrino to balance lepton number

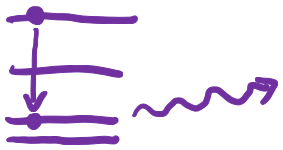
Which row identifies particles **X** and **Y**? **[1 mark]**

	X	Y	
A	W^+	ν_e	●
B	W^+	$\overline{\nu_e}$	○
C	W^-	ν_e	○
D	W^-	$\overline{\nu_e}$	○

Do not write outside the box

0 9 An electron collides with an isolated atom and raises an orbiting electron to a higher energy level.

Which statement is correct?



[1 mark]

A The colliding electron is captured by the nucleus of the atom. ○

Nucleus is not involved

B A photon is emitted when the electron rises to the higher energy level. ○

Doesn't obey conservation of energy (see diagram)

C An electron is emitted when the excited electron returns to the ground state. ○

Where does the extra electron come from?

D Energy is transferred from the colliding electron to the orbiting electron. ●

1 0 Light of frequency 2.0×10^{15} Hz is incident on a metal surface. The work function of the metal is 4.6×10^{-19} J.

$hf = \phi + KE_{max}$ — max. kinetic energy

Planck constant, frequency, work function

Which statement is correct?

[1 mark]

A No photoelectrons are released. ○

$hf = 6.63\times10^{-34} \times 2\times10^{15} = 1.33\times10^{-18}$ J

B Photoelectrons are released with a maximum kinetic energy of 3.1×10^{-19} J. ○

$(1.33\times10^{-18}) - (4.6\times10^{-19}) = 8.7\times10^{-19}$ J

C Photoelectrons are released with a maximum kinetic energy of 8.7×10^{-19} J. ●

D Photoelectrons are released with a maximum kinetic energy of 18×10^{-19} J. ○

1 1 A photon of ultraviolet radiation has a frequency of 1.5×10^{15} Hz.

What is the momentum of the photon?

$p = \frac{h}{\lambda} = \frac{hf}{c}$

$c = f\lambda$

$= \frac{1}{\lambda} = \frac{f}{c}$

[1 mark]

A 3.3×10^{-41} kg m s^{-1} ○

$\frac{6.63\times10^{-34} \times 1.5\times10^{15}}{3\times10^{8}}$

B 1.3×10^{-40} kg m s^{-1} ○

C 3.3×10^{-27} kg m s^{-1} ●

$= 3.315\times10^{-27}$ kgms^{-1}

D 1.3×10^{-26} kg m s^{-1} ○

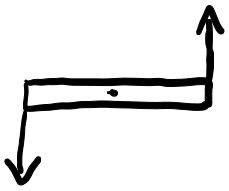
$\simeq 3.3\times10^{-27}$ kgms^{-1}

Turn over ►

Do not write outside the box

1 2 Which statement about a couple is **not** true?

[1 mark]



A It must consist of coplanar forces. ○

Rotation is in one plane

B It can produce rotational motion. ○

Couples always produce rotation

C It can produce translational motion. ●

Translation is in a straight line (Cartesian)

D It has a moment with units N m. ○

Force x distance

1 3 Two cars **P** and **Q** leave from the same point and travel in the same direction.
Q leaves at time $t = 0$ and **P** leaves one second later.
The figure shows the velocity–time graph for **P** and **Q**.

What is the distance between **Q** and **P** when $t = 8$ s?

[1 mark]

$\frac{1}{2} \times 8 \times 40$
$= 160\text{m}$

$\left(\frac{1}{2} \times 2 \times 20\right) + (5 \times 20)$
$= 120\text{m}$

$160 - 120$
$= 40\text{m}$

A 40 m ●

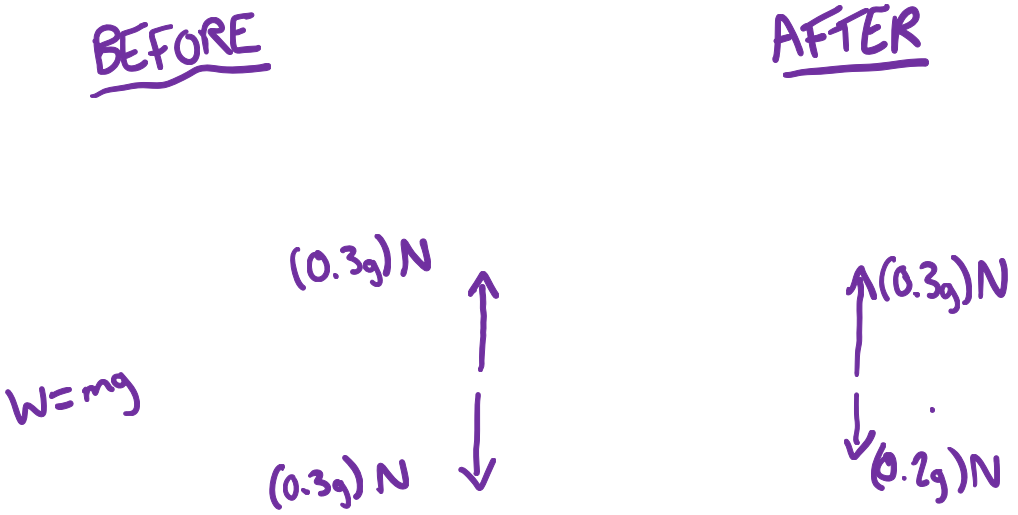
B 80 m ○

C 160 m ○

D 180 m ○

Do not write outside the box

1 4 A 0.20 kg mass is suspended from a spring. A 0.10 kg mass is suspended from the 0.20 kg mass using a thread of negligible mass.
The system is in equilibrium and the thread is then cut.



What is the upward acceleration of the 0.20 kg mass at the instant that the thread is cut?

[1 mark]

$F = ma = (0.3g) - (0.2g)$
$= (0.1g)N$
$a = \frac{F}{m} = \frac{0.1g}{0.2} = 0.5g$
$\{g = 9.8 ms^{-2}\}$ $= 4.9 ms^{-2}$

A 3.3 m s^{-2} ○

B 4.9 m s^{-2} ●

C 6.5 m s^{-2} ○

D 9.8 m s^{-2} ○

1 5 A lift of mass M is suspended from a cable. The lift descends with a downward acceleration, a. A frictional force F acts on the lift.

What is the tension T in the cable?

[1 mark]

A $T = Ma + F$ ○

B $T = Ma - F$ ○

C $T = M(g + a) - F$ ○

D $T = M(g - a) - F$ ●

$R = W - (F + T) = ma$
$T = W - F - ma = mg - F - ma$
$\{M = m\}$ $= M(g - a) - F$

Do not write outside the box

1 6 A body of constant mass falls freely due to gravity.

The rate of change of momentum of the body is equal to its

[1 mark]

Newton's Second Law: The resultant force on a body is equal to its rate of change of momentum

A kinetic energy. $KE = \frac{1}{2}mv^2$ ○

B mass. ○

C gravitational potential energy. $\Delta GPE = mg\Delta h$ ○

D weight. $W = mg = F = ma = m\frac{\Delta v}{\Delta t} = \frac{\Delta(mv)}{\Delta t}$ ●

1 7 An electric vehicle is driven by a motor which produces a constant driving force.
The vehicle travels from rest along a straight horizontal road.
Friction and air resistance are negligible.

$\frac{W}{t} = \frac{Fd}{t}$

Which statement describes the variation with time of the power developed by the motor?

[1 mark]

Vehicle is accelerating. $P = Fv$

$F = ma$ (constant)

v increases linearly from zero

A It stays constant. ○

B It increases linearly from zero. ●

C It increases non-linearly from zero. ○

D It increases from zero to a maximum and then decreases. ○

1 8 Which is a correct statement about mechanical power?

[1 mark]

$P = \frac{E}{t}$ — scalar / scalar

A It is a vector quantity. ○

B It is measured in J. $1W = 1Js^{-1}$ ○

C In fundamental units, its unit is $\text{kg m}^2\text{ s}^{-3}$ ●

D It can be calculated from force × distance moved. = work done ○

$1W = 1Js^{-1}$ $(P = \frac{E}{t} = \frac{W}{t})$

$= 1Nms^{-1}$ $(W = Fd)$

$= 1kgms^{-2}s^{-1}$ $(F = ma)$

$= 1kgm^2s^{-3}$

Do not write outside the box

1 9 A load of 50 N is suspended from a wire that has an area of cross-section of 1 mm^2.

The stress in the wire, in Pa, is between

[1 mark]

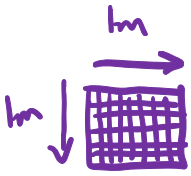
$\sigma = \frac{F}{A}$ — F: force, σ: stress, A: cross-sectional area

A 10^0 and 10^3 ○

B 10^3 and 10^6 ○

C 10^6 and 10^9 ●

D 10^9 and 10^{12} ○



$1\,mm^2 = 10^{-6}\,m^2$

$\frac{50}{10^{-6}} = 5 \times 10^7$

2 0 Which combination of properties would produce the smallest extension of a wire when the same tensile force is applied to the wire?

[1 mark]

$E = \frac{FL}{Ax}$ ⇒ $x = \frac{FL}{AE}$

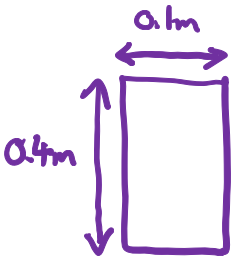
	Cross-sectional area	Length	Young modulus of material	
~~A~~	X	$3L$	E	○ $x_A = \frac{F(3L)}{XE}$
B	$2X$	L	E	○ $x_B = \frac{FL}{2XE}$
C	X	$3L$	$4E$	○ $x_C = \frac{F(3L)}{X(4E)}$
D	$2X$	L	$4E$	● $x_D = \frac{FL}{(2X)(4E)}$

Young modulus: $E = \frac{\sigma}{\varepsilon} = \frac{FL}{A\Delta x}$ — σ: stress, ε: strain

$\left\{\sigma = \frac{F}{A},\ \varepsilon = \frac{x}{L}\right\}$ — F: force, A: cross-sectional area, x: extension, L: original length

Do not write outside the box

2 1 A rubber belt in an electrostatic machine has a width of $0.1\ \text{m}$ and moves with speed $0.4\ \text{m s}^{-1}$.
Each square metre of the belt carries a charge Q coulomb. The charge is removed and transferred to a metal sphere.



0.1×0.4
$= 0.04\ \text{m}^2\text{s}^{-1}$
$0.04Q\text{s}^{-1}$

What is the charge collected by the sphere each second?

[1 mark]

A $0.016Q$ ○

B $0.04Q$ ●

C $0.25Q$ ○

D $4Q$ ○

Do not write outside the box

2 2 Charged plates **X** and **Y** have a potential difference 1.5 V between them.

$V = \frac{W}{Q}$ — W energy, Q charge; potential difference

One electronvolt (eV) is the energy gained by an electron when it is accelerated by a potential difference of one volt.

$Q = \frac{W}{V} = \frac{3.0}{1.5}$

Which particle gains 3.0 eV of kinetic energy when moving from **Y** to **X**?

$= 2e$

[1 mark]

A proton ○

B positron ○

C electron ○

D alpha particle ● — contains 2p, 2n ⇒ has a charge of 2e

Turn over for the next question

Do not write outside the box

2 3 The diagram shows part of a circuit and the currents in the circuit.

Kirchhoff's 1st Law
The sum of currents entering a junction is equal to the sum of currents leaving the junction.

potential difference
V = IR — resistance
current

V = 2×10
= 20V

V = 6×20
= 120V

20+120 = 140V

What is the potential difference between point **P** and earth?

[1 mark]

A 60 V ○

B 100 V ○

C 120 V ○

D 140 V ●

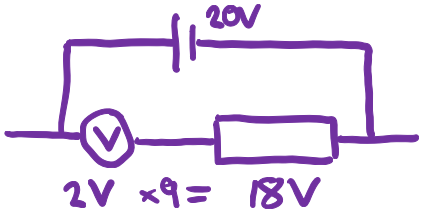
2 4 A voltmeter has a resistance of 4.0 kΩ and reads 1.0 V for every scale division on the meter.

A power supply of emf 20 V and negligible internal resistance is connected across this voltmeter and a resistor in series. The voltmeter reads two divisions. — 2.0V

What is the value of the resistor?

Kirchoff's 2nd Law
Σemf = Σpd in a closed loop

[1 mark]



2V ×9 = 18V

4.0kΩ ×9 = 36kΩ

A 44 kΩ ○

B 36 kΩ ●

C 4.4 kΩ ○

D 3.6 kΩ ○

Do not write outside the box

2 5 Two cylindrical wires **P** and **Q** are of equal length and made of the same material. The diameter of **P** is greater than that of **Q**.

P and **Q** are connected in series and the ends of this arrangement are connected to a power supply.

potential difference — $V = IR$ — resistance; current

$\rho = \frac{RA}{l}$ — resistance; cross-sectional area; length; resistivity

Which two quantities are the same for **P** and **Q**?

[1 mark]

A	potential difference across wire ✗	resistivity ✓	⬭
B	resistivity ✓	current ✓	⬬
C	current ✓	resistance ✗	⬭
D	resistance ✗	potential difference across wire ✗	⬭

Turn over for the next question

Do not write outside the box

2 6 In the circuit below, the initial voltmeter reading is zero.

$\frac{R_P}{R_Q} = \frac{R_R}{R_T}$

R decrease

The temperature of the negative temperature coefficient thermistor **T** is then increased.

Which change to the circuit could restore the voltmeter reading to zero?

[1 mark]

A Decreasing the resistance of **R**. This will keep $\frac{R_R}{R_T}$ the same, as R_T has increased already. ●

B Increasing the resistance of **R**. ○

C Decreasing the resistance of **P**. ○

D Increasing the resistance of **Q**. ○

2 7 An electric motor lifts a load of weight W through a vertical height h in time t. The potential difference across the motor is V and the current through it is I.

$P = \frac{E}{t}$

$P = VI \Rightarrow E = VIt = Pt$

What is the efficiency of the motor?

[1 mark]

efficiency = $\frac{\text{useful energy output}}{\text{total energy input}} = \frac{Wh}{VIt}$

A $\frac{Wht}{VI}$ ○

B $\frac{VI}{Wht}$ ○

C $\frac{Wh}{VIt}$ ●

D $\frac{VIt}{Wh}$ ○

$\Delta GPE = mg\Delta h = W\Delta h = Wh$

(ΔGPE: change in gravitational potential energy; m: mass; g: gravitational field strength; Δh: change in height; $W = mg$: weight)

Do not write outside the box

2 8 An object of mass m moves in a circle of radius r. It completes n revolutions every second.

What is the kinetic energy of the object?

[1 mark]

A $\frac{mn^2r^2}{8\pi^2}$ ⬭

B $\frac{mn^2r^2}{4\pi^2}$ ⬭

C $2m\pi^2n^2r^2$ ●

D $4m\pi^2n^2r^2$ ⬭

$KE = \frac{1}{2}mv^2$ (m: mass, v: speed)

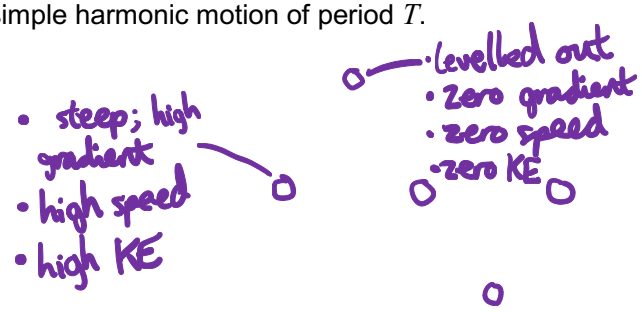
$n = \frac{\omega}{2\pi}$ = $\frac{v}{2\pi r}$ (ω: angular frequency; n: frequency; $v = \omega r$)

$v = 2\pi r n$

$= \frac{1}{2}m(2\pi r n)^2 = \frac{1}{2}m(4\pi^2r^2n^2) = 2m\pi^2n^2r^2$

Do not write outside the box

2 9 The graph shows the variation of displacement d with time t for a particle moving with simple harmonic motion of period T.



Which graph shows the variation of kinetic energy E_k of the particle with time?

[1 mark]

A

B

C

D

A ⬭

B ⬭

C ⬭

D ●

Do not write outside the box

3 0 Two pendulums **A** and **B** oscillate with simple harmonic motion.
The time period of **A** is 2.00 s and the time period of **B** is 1.98 s.

A and **B** are released in phase.

$2.00 - 1.98 = 0.02$s

What is the number of oscillations of **A** before **A** and **B** are next in phase?

[1 mark]

B has completed 100 swings

No. of swings (B)	How far ahead B is (s)
1	0.02
2	0.04
3	0.06
⋮	⋮

A 49 ○

B 50 ○

C 99 ●

D 100 ○

3 1 The frequency of oscillation of a vertical spring is f when the mass hanging from the spring is m.

What is the relationship between f and m?

[1 mark]

angular frequency

$\omega = \sqrt{\frac{k}{m}}$ — spring constant; mass

$= 2\pi f$

$\Rightarrow f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$= \frac{1}{2\pi}\frac{\sqrt{k}}{\sqrt{m}}$

$f \propto \frac{1}{\sqrt{m}}$

$f \propto m^{-\frac{1}{2}}$

A $f \propto m^{-\frac{1}{2}}$ ●

B $f \propto m^{-2}$ ○

C $f \propto m^{\frac{1}{2}}$ ○

D $f \propto m^{2}$ ○

Turn over ►

Do not write outside the box

3 2 A metal panel is driven to vibrate at different frequencies. The amplitude a of the vibration is measured at each frequency. The graph shows the variation of amplitude with driven frequency.

- Resonance peak at a lower amplitude
- Resonance peak is more spread out horizontally
- Peak occurs at a slightly lower frequency

The damping of the metal panel is increased without changing the mass of the panel.

Which graph on the opposite page shows the variation of a with frequency with increased damping?

[1 mark]

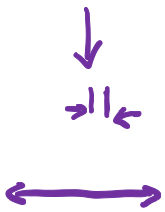
Do not write outside the box

A

B

C

D



A ⬭

B ⬭

C ⬭

D ⬬

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

Do not write outside the box

Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**