ANDERSON JUNIOR COLLEGE

2017 JC2 Preliminary Examination

PHYSICS Higher 1 8866/01

Paper 1 Multiple Choice **Tuesday 19 September 2017**

1 hour

Additional Materials: Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

Write your name, class index number and PDG on the Answer Sheet in the spaces provided.
Shade and write your NRIC/FIN.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$

1 What is equivalent to 2000 picovolts?

A 0.002 μJ C **B** 0.02 GV **C** 0.2×10^4 TV **D** 2×10^{-15} MJ C^{-1}

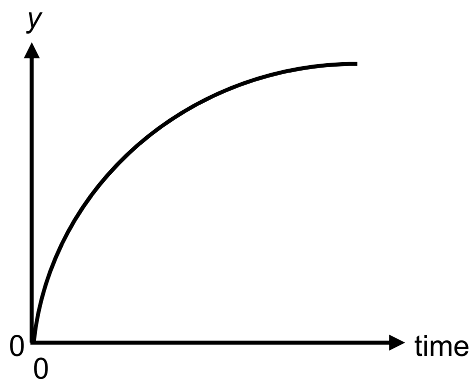
2 The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ of the liquid. The speed is given by the equation

$$v = k\left(\frac{\Delta P}{\rho}\right)^n$$

where k is a constant that has no units. What is the value of n?

A $\frac{1}{2}$ **B** 1 **C** $\frac{3}{2}$ **D** 2

3 The graph below relates to the motion of a falling body.



Which statement is a correct description of the graph?

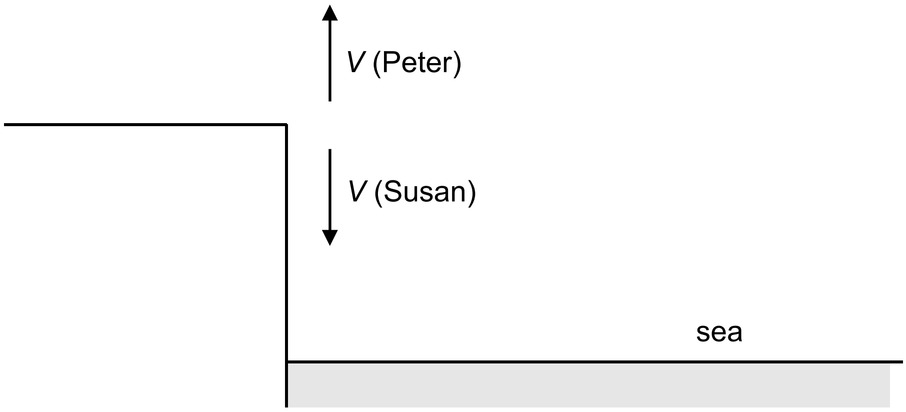
A y is distance and air resistance is negligible.

B y is distance and air resistance is not negligible.

C y is speed and air resistance is negligible.

D y is speed and air resistance is not negligible.

4 Peter and Susan both stand on the edge of a vertical cliff.



Susan throws a stone vertically downwards with speed V. At the same time, Peter throws a stone vertically upwards with the same speed V. Neglecting air resistance, which one of the following statements is true?

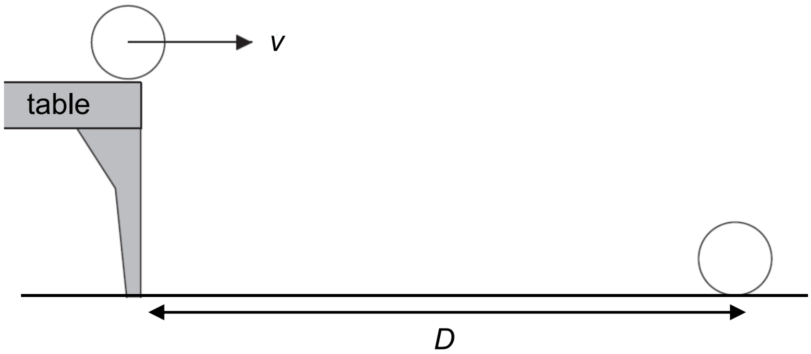
A The stone thrown by Susan will hit the sea first and with a greater speed than the stone thrown by Peter.

B Both stones will hit the sea with the same speed only when both stones have the same mass.

C The stone thrown by Susan will hit the sea first because it has a smaller displacement.

D Both stones will hit the sea with the same speed regardless of the height of the cliff.

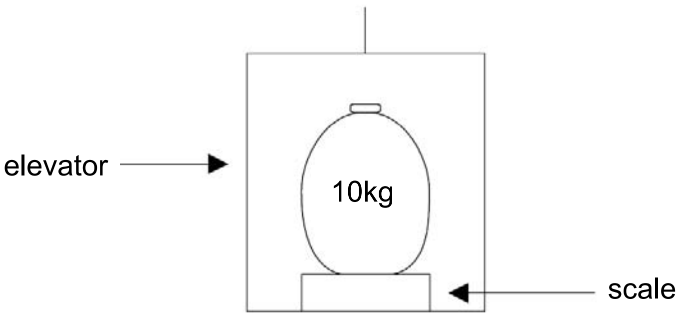
5 A ball rolls off a horizontally table with velocity *v*. It lands on the ground a time *T* later at a distance *D* from the foot of the table as shown in the diagram below. Air resistance is negligible.



A second heavier ball rolls off the table with velocity *v*. Which one of the following is correct for the heavier ball?

	Time to land	Distance from table
A	*T*	*D*
B	*T*	less than *D*
C	less than *T*	*D*
D	less than *T*	less than *D*

6 An elevator is used to either raise or lower sacks of potatoes. In the diagram, a sack of potatoes of mass 10 kg is resting on a scale that is resting on the floor of an accelerating elevator. The scale reads 12 kg.



Which of the following is the best estimate for the acceleration of the elevator?

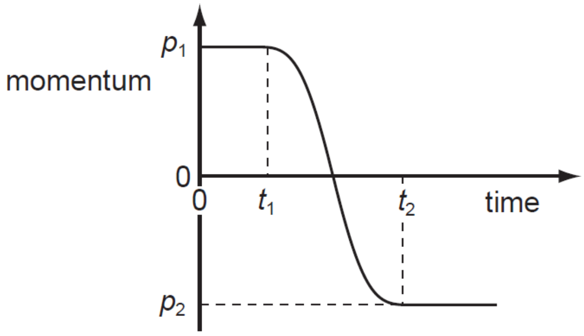
A 2.0 m s^{-2} downwards.

B 2.0 m s^{-2} upwards.

C 1.2 m s^{-2} downwards.

D 1.2 m s^{-2} upwards.

7 The graph shows the variation with time of the momentum of a ball as it is kicked in a straight line.



Initially, the momentum is p_1 at time t_1. At time t_2 the momentum is p_2.

What is the magnitude of the average force acting on the ball between times t_1 and t_2?

A $\dfrac{p_1 - p_2}{t_2}$ **B** $\dfrac{p_1 - p_2}{t_2 - t_1}$ **C** $\dfrac{p_1 + p_2}{t_2}$ **D** $\dfrac{p_1 + p_2}{t_2 - t_1}$

8 Two similar spheres, each of mass *m* and travelling with speed *v*, are moving towards each other.

The spheres have a head-on elastic collision.

Which statement is correct?

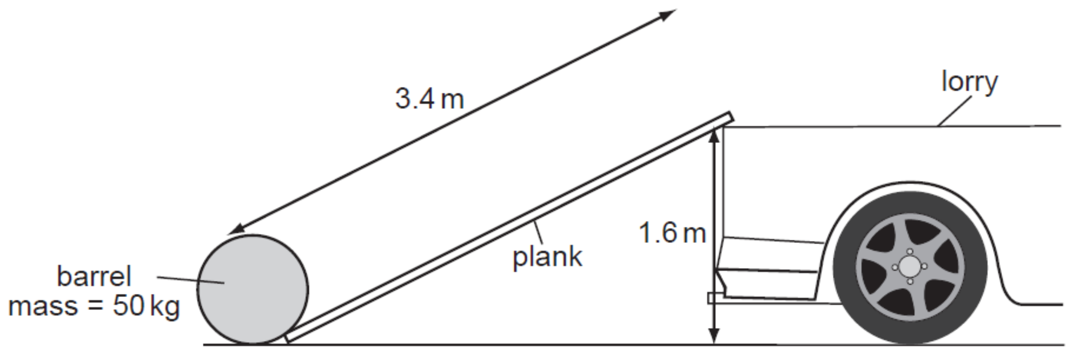
A The spheres stick together on impact.

B The total kinetic energy after impact is mv^2.

C The total kinetic energy during collision is mv^2.

D The total momentum before impact is $2mv$.

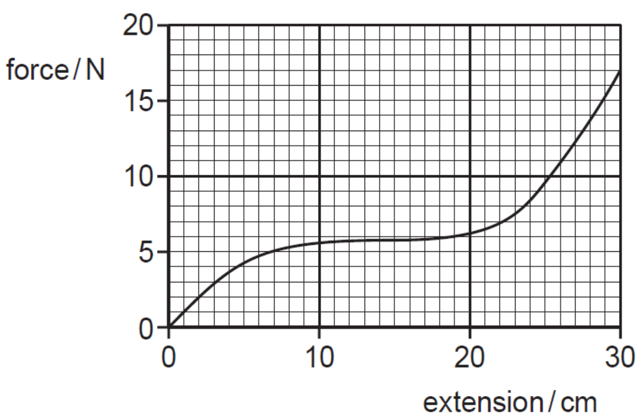
9 A barrel of mass 50 kg is loaded onto the back of a lorry 1.6 m high by pushing it up a smooth plank 3.4 m long.



What is the minimum work done?

A 80 J **B** 170 J **C** 780 J **D** 1700 J

10 A rubber band is stretched by hanging weights on it and the force-extension graph is plotted from the results.



What is the best estimate of the elastic potential energy stored in the rubber band when it is extended by 30 cm?

A 2.0 J **B** 2.6 J **C** 5.1 J **D** 200 J

11 Which of the following is not true about two forces that give rise to a couple?

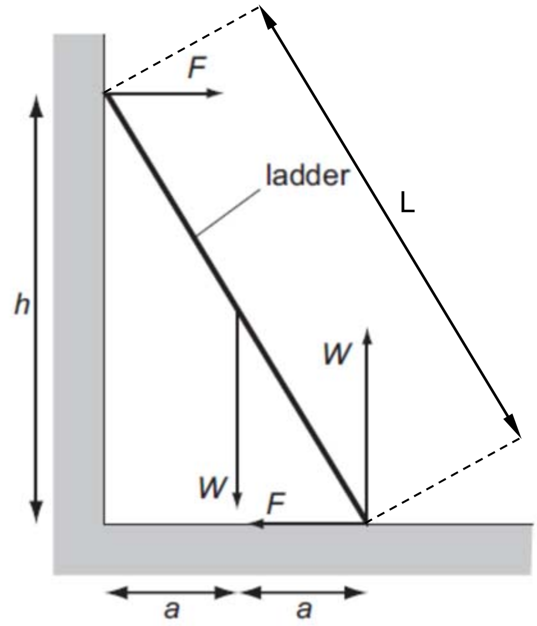
A They act in opposite directions.

B They both have the same magnitude.

C They both act on the same body.

D They both act at the same point.

12 A uniform ladder length *L* rests against a vertical wall where there is negligible friction. The bottom of the ladder rests on rough ground where there is friction. The top of the ladder is at a height *h* above the ground and the foot of the ladder is at a distance 2*a* from the wall. The diagram shows the forces that act on the ladder.



Which of the following equation is correct?

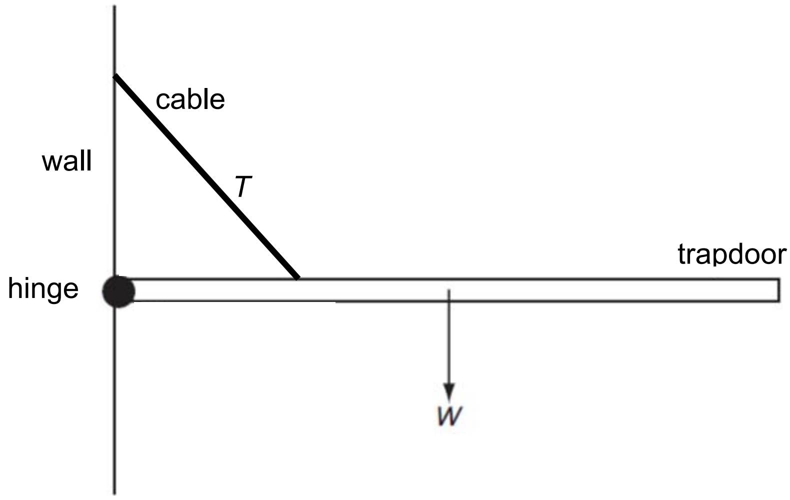
A ½ WL + FL = WL

B Wa + 2Wa = Fh

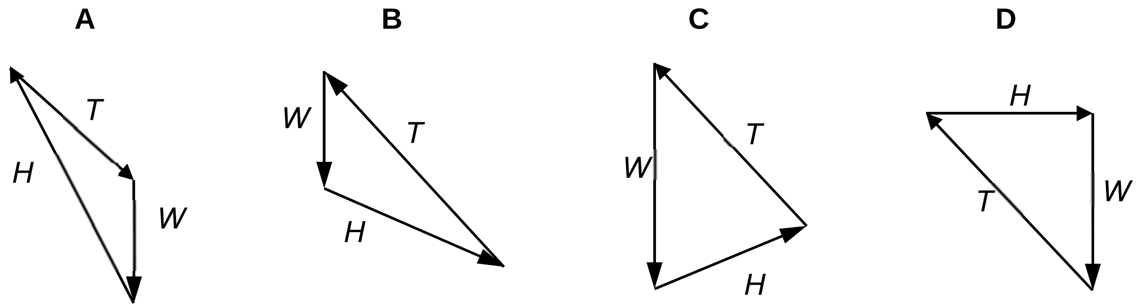
C Fh + Wa = 2Wa

D Wa = FL

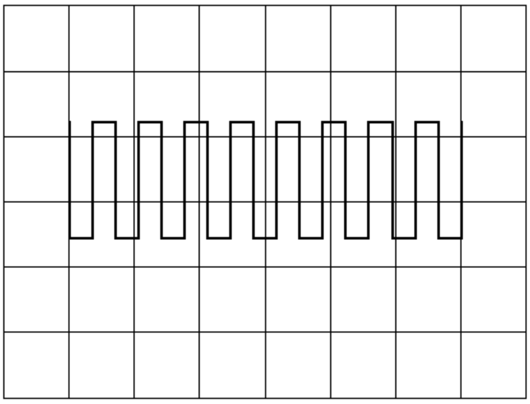
13 A hinged trapdoor is held closed in the horizontal position by a cable. Three forces act on the trapdoor: weight *W* of the door, tension *T* in the cable and a force *H* at the hinge.



Which vector triangle could represent the forces acting on the trapdoor?



14 The diagram shows a square-wave trace on the screen of a cathode-ray oscilloscope with the time-base set at 10 ms per division.



What is the approximate frequency of the wave?

A 70 Hz **B** 140 Hz **C** 280 Hz **D** 1400 Hz

15 M and N are two electromagnetic waves.

The ratio $\frac{\text{wavelength of M}}{\text{wavelength of N}} = 10^5$.

What could M and N be?

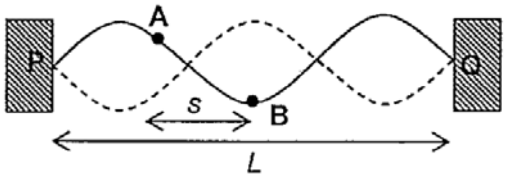
	M	N
A	microwaves	visible light
B	microwaves	γ-rays
C	γ-rays	microwaves
D	visible light	microwaves

16 A progressive wave is incident normally on a flat reflector. The reflected wave overlaps with the incident wave and a stationary wave is formed.

At an antinode, what could be the ratio $\frac{\text{displacement of the reflected wave}}{\text{displacement of the incident wave}}$ at any instant?

A -1 **B** 0 **C** 1 **D** 2

17 A guitar string of length L is stretched between two fixed points P and Q and made to vibrate transversely as shown.

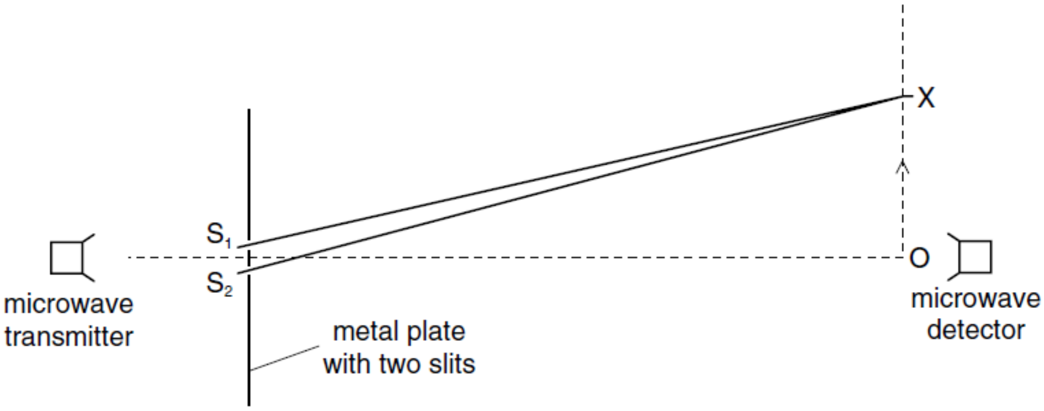


Two particles A and B on the string are separated by a distance s. The maximum kinetic energies of A and B are K_A and K_B respectively.

Which of the following gives the correct phase difference and maximum kinetic energies of the particles?

	Phase difference	Maximum kinetic energy
A	$\left(\frac{3s}{2L}\right)\times 360°$	$K_A < K_B$
B	$\left(\frac{3s}{2L}\right)\times 360°$	same
C	180°	$K_A < K_B$
D	180°	same

18 The diagram shows an experiment which has been set up to demonstrate two-source interference, using microwaves of wavelength λ.

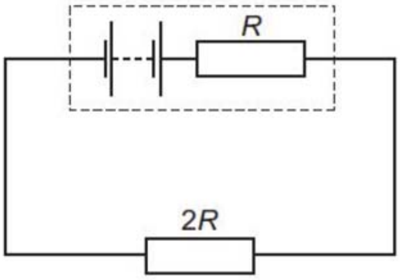


The detector is moved from O in the direction of the arrow. The signal detected decreases until the detector reaches the point X, and then starts to increase again as the detector moves beyond X.

Which equation correctly determines the position of X?

A OX = $\lambda/2$ **B** OX = λ **C** $S_2X - S_1X = \lambda$ **D** $S_2X - S_1X = \lambda/2$

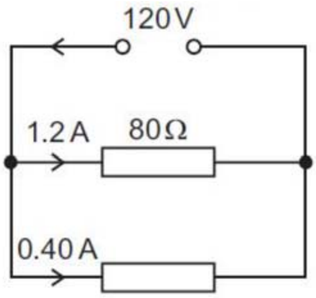
19 The diagram shows an electric circuit in which the resistance of the external resistor is $2R$ and the internal resistance of the source is R.



What is the ratio $\frac{\text{power in internal resistance}}{\text{power in external resistor}}$?

A $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** 2 **D** 4

20 The electromotive force of a power supply is 120 V. It delivers a current of 1.2 A to a resistor of resistance 80 Ω and a current of 0.40 A to another resistor, as shown.



What is the internal resistance of the power supply?

A 15 Ω **B** 20 Ω **C** 60 Ω **D** 75 Ω

21 There is a current in a resistor for an unknown time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

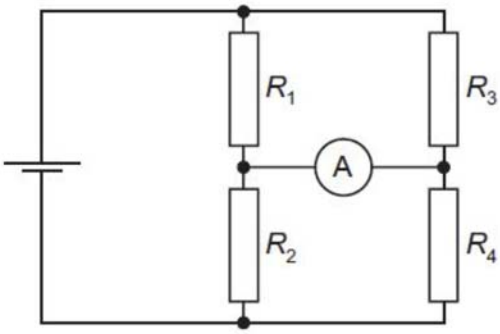
A The current in the resistor and the potential difference across the resistor.

B The resistance of the resistor and the current in the resistor.

C The total charge passing through the resistor and the resistance of the resistor.

D The total charge passing through the resistor and the potential difference across the resistor.

22 In the circuit shown, the reading on the ammeter is zero.



The four resistors have different resistances R_1, R_2, R_3 and R_4.

Which equation is correct?

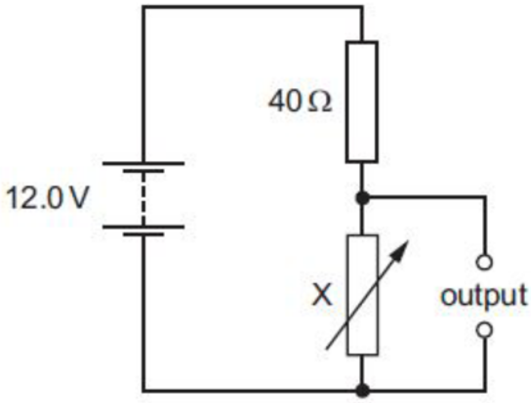
A $R_1 - R_3 = R_2 - R_4$

B $R_1 \times R_3 = R_2 \times R_4$

C $R_1 - R_4 = R_2 - R_3$

D $R_1 \times R_4 = R_2 \times R_3$

23 In the circuit shown, X is a variable resistor whose resistance can be changed from 5.0 Ω to 500 Ω. The e.m.f. of the battery is 12.0 V. It has negligible internal resistance.



What is the maximum range of values of potential difference across the output?

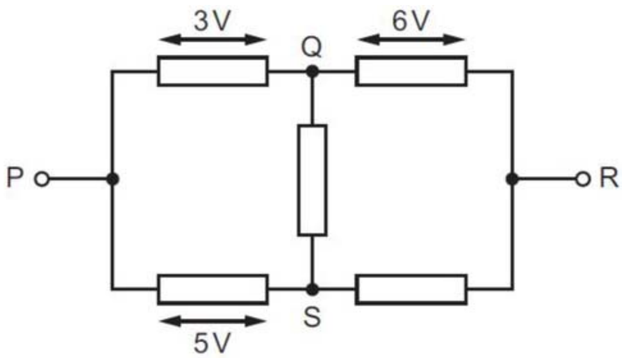
A 1.3 V to 11.1 V

B 1.3 V to 12.0 V

C 1.5 V to 11.1 V

D 1.5 V to 12.0 V

24 There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3 V.

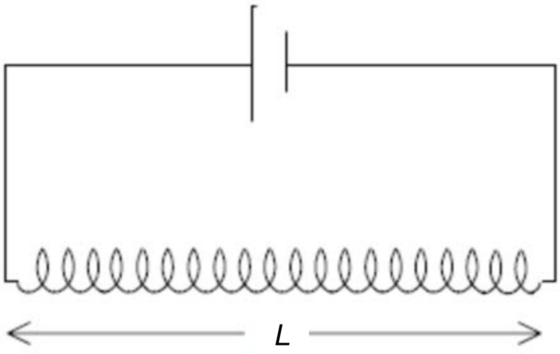
The p.d. between Q and R is 6 V.

The p.d. between P and S is 5 V.

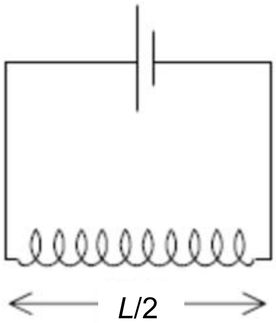
Which row in the table is correct?

	p.d. between Q and S	p.d. between S and R
A	2 V	4 V
B	2 V	10 V
C	3 V	4 V
D	3 V	10 V

25 The diagram shows a long solenoid of length L connected to a battery of negligible internal resistance. The magnetic field strength at the centre of the solenoid, B is given by $B = \mu_o nI$, where is μ_o is a constant known as the permeability of free space, n is the number of coils per unit length of solenoid, and I, the current through the solenoid.



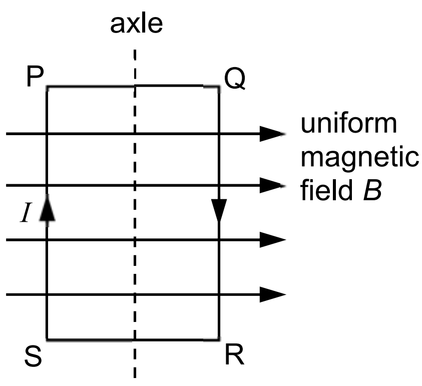
The solenoid is now disconnected from the battery and cut in half and one of the halves is reconnected to the battery as shown below.



What is the best estimate of the field strength at the centre of this solenoid?

A $0.5B$ **B** B **C** $2B$ **D** $4B$

26 A coil, mounted on an axle, has its plane parallel to the flux lines of a uniform magnetic field B, as shown. A current I flows through the coil.



Which of the following statement is correct for the position of the coil as shown above?

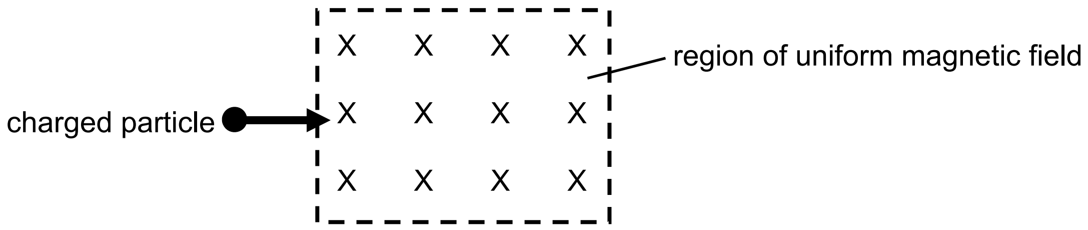
A Sides PQ and SR tend to attract each other.

B Sides SP and RQ tend to attract each other.

C There are no forces due to B on the sides PQ and SR.

D There are no forces due to B on the sides SP and RQ.

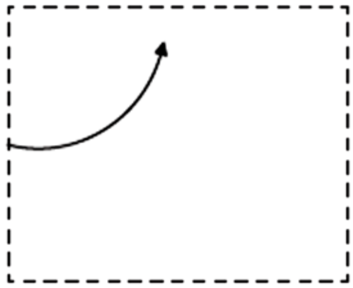
27 A negatively charged particle enters a region of uniform magnetic field. The direction of the magnetic field is into the plane of the paper as shown in the diagram below.



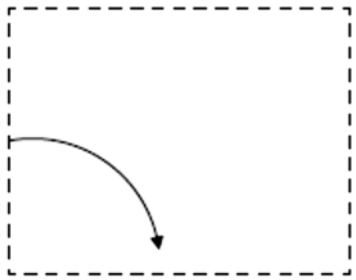
Which of the following diagrams correctly shows the path of the charged particle while in the region of magnetic field?

A

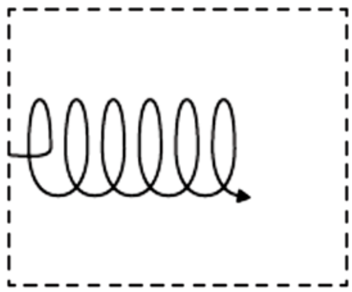
B



C

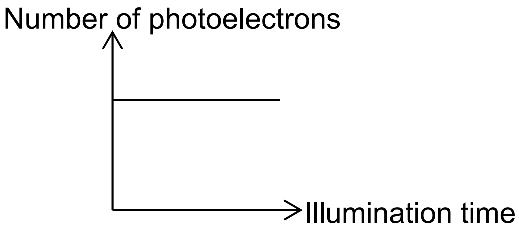


D

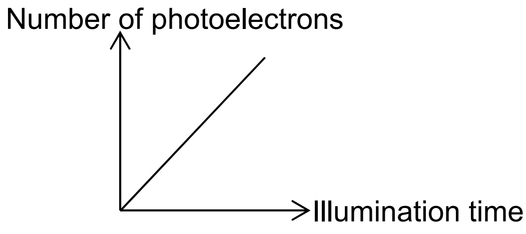


28 When electromagnetic radiation of frequency *f* falls on a particular metal surface, photoelectrons are emitted. Which graph is obtained when the intensity of the electromagnetic radiation is kept constant?

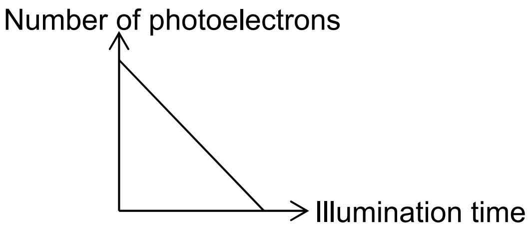
A



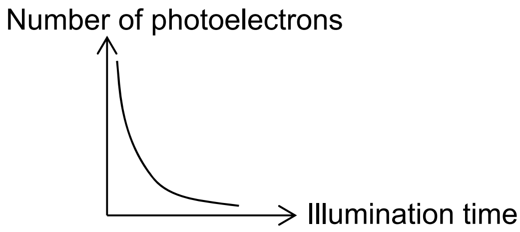
B



C



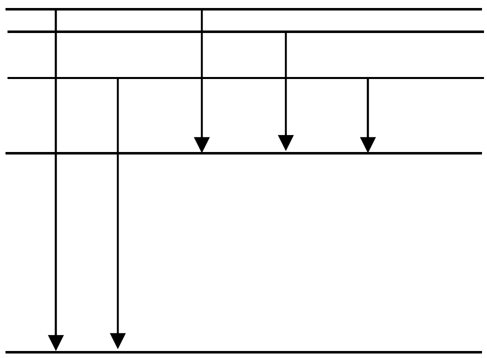
D



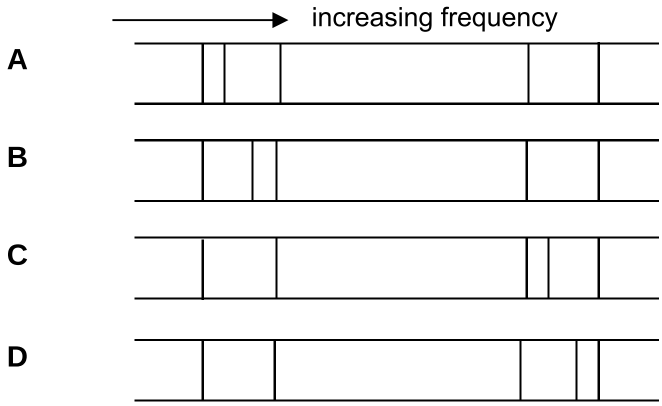
29 Let λ_0 be the de Broglie wavelength of an electron accelerated from rest through a potential difference of 10 V and let λ_1 be that of an electron accelerated from rest through a potential difference of 1000 V. What is the value of the ratio λ_0 / λ_1 ?

A 0.1 **B** 1 **C** 10 **D** 100

30 The figure below shows five energy level of an atom. Five transition lines are indicated, each of which produces photons of definite energy and frequency.



Which one of the spectra below best corresponds to the set of transitions indicated?



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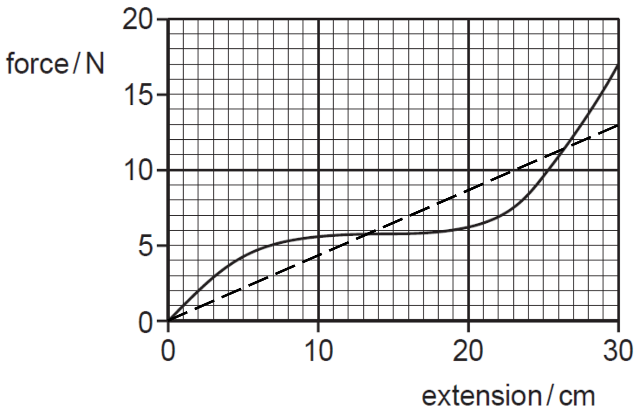
2017 AJC JC2 H1 Physics Prelim Solutions
Paper 1 (30 marks)

Answer

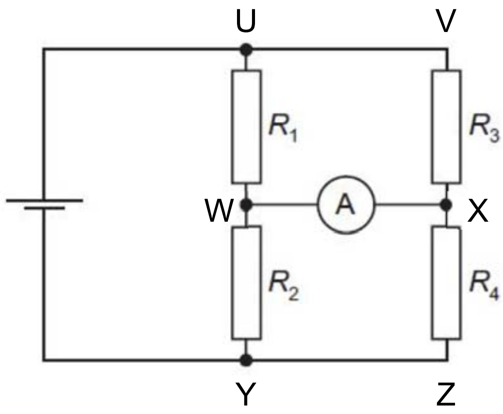
1	2	3	4	5	6	7	8	9	10
D	A	D	D	A	B	B	B	C	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
D	C	B	B	A	C	C	D	B	A
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
D	D	A	A	C	C	C	B	C	B

No	Answer & Solution
1	**Ans: D** 2000 pV = 2000 x 10^{-12} V = 2 x 10^{-9} V = 2 x 10^{-15} x 10^{6} V = 2 x 10^{-15} x M V p.d. = work done per unit charge, hence V is equivalent to J C^{-1}
2	**Ans: A** Unit of v = m s^{-1} Unit of $\frac{\Delta P}{\rho} = \frac{\text{kg m s}^{-2}\,\text{m}^{-2}}{\text{kg m}^{-3}} = \text{m}^2\,\text{s}^{-2}$ $\left(\text{m}^2\,\text{s}^{-2}\right)^n = \text{ms}^{-1}$ So n = $\frac{1}{2}$
3	**Ans : D** A falling object will continue to gain speed regardless of the effect of air resistance. Since speed is the gradient of distance-time graph, a distance-time graph of a falling object will have increasing gradient. With air resistance, gradient becomes constant at terminal velocity. Without air resistance, gradient will continue to increase. Hence quantity *y* cannot be distance, and Options A and B are wrong. Answer C is wrong because without air resistance, the body will be free-falling with constant acceleration = *g*. Speed will continue to increase at a constant rate. Answer D shows the speed increasing at a decreasing rate as air resistance increased. When air resistance is equal to weight, the body will fall with terminal velocity (speed).
4	**Ans : D** Let height of cliff be *h*. Both stones experience a downward acceleration of *g*. Taking upwards as positive. <u>Velocities when the stones hit the sea using $v^2 = u^2 + 2as$</u> For Peter's stone : $V_P^2 = (+V)^2 + 2(-g)(-h) = V^2 + 2gh$ For Susan's stone : $V_S^2 = (-V)^2 + 2(-g)(-h) = V^2 + 2gh$ Thus, both stones will hit the sea with the same speed regardless of the height and mass. Alternative method using COE : Total initial energy = Total final energy

	For Peter's stone : $\frac{1}{2} m_P V^2 + m_P gh = \frac{1}{2} m_P V_f^2$ For Susan's stone : $\frac{1}{2} m_S V^2 + m_s gh = \frac{1}{2} m_S V_f^2$ We can cancel the masses on both sides of the equation, and thus V_f will be independent of mass, both stones have the same final speed. <u>Time taken to hit the sea using v = u + at</u> For Peter's stone : $-V_P = (+V) + (-g)t_P$ $t_P = (V_P + V) / g$ For Susan's stone : $-V_S = (-V) + (-g)t_S$ $t_S = (V_S - V) / g$ Since $\|V_p\| = \|V_S\|$, $t_S < t_P$. No information about the mass or height of the cliff is required.
5	**Ans : A** For the projectile motion, horizontal speed is constant, *v*. Vertical speed is zero initially and acceleration is *g*, downwards. Let the height of the table be *h*. Using $s = ut + \frac{1}{2} at^2$ $h = 0 + \frac{1}{2} gT^2$ $T = \sqrt{\frac{2h}{g}}$ *T* is independent of mass. Range, $D = vT$. Since both *v and T* are independent of mass, *D* will remain the same.
6	**Ans : B** The scale reads the contact force between the sack and scale. Since the scale reading is larger than the mass, the upward contact force must be larger than the downward weight. The sack experiences a net force and acceleration upwards. $(12 – 10) \times 9.81 = 10 \times$ acceleration acceleration = 1.962 ≈ 2.0 m s^{-2}.
7	**Ans : B** Average force = $\Delta p / \Delta t = \frac{p_2 - p_1}{t_2 - t_1}$ For magnitude, $\left\|\frac{p_2 - p_1}{t_2 - t_1}\right\| = \left\|\frac{p_1 - p_2}{t_2 - t_1}\right\|$
8	**Ans : B** For elastic collision, total KE is conserved OR relative speed of approach equals to relative speed of separation. Total KE before impact = $\frac{1}{2} mv^2 + \frac{1}{2} mv^2 = mv^2$ Thus, total KE after impact = mv^2. Answer C is wrong because during collision, KE is not conserved. It is converted to elastic PE then back to KE. Answer D is wrong because total momentum before impact = mv + m(-v) = 0

	Answer A is wrong because when the spheres stick together, it is already a perfectly inelastic collision. Also note that relative speed of approach = $u_1 - u_2 = v - (-v) = 2v$ (non-zero). If the spheres stick together, they will share the same speed and relative speed of separation will be zero.
9	**Ans : C** Work done is minimum if the force applied is just enough to overcome the barrel's weight on its way up the plank, with no change in speed. The barrel gains GPE without any gain in KE. Minimum work = Gain in GPE = mgh = 50 x 9.81 x 1.6 = 784.8 J ≈ 780 J Alternative method : Work done = Force x distance = mg sin θ x d = 50 x 9.81 x (1.6/3.4) x 3.4 = 784. 8 J
10	**Ans : A** EPE = area under force-extension graph ≈ area under triangle under dotted line ≈ ½ x 0.3 x 13 = 1.95 J Alternative method by counting big squares : Total area = 2 big squares x area of 1 big square = 2 x 0.1 x 10 = 2.0 J 
11	**Ans: D** All options are correct description of a couple except option D. If the two forces act at the same point, there will not be any rotational effect about that point.
12	**Ans: C** Taking moment about the top of ladder: Clockwise moment = anticlockwise moment F h + W a = 2W a Note: distance must be perpendicular to the line of action of the force.
13	**Ans: B** For equilibrium, all three forces must meet at a common point, which is a point below trapdoor along the line of action of *W*. Hence option C and D is wrong as direction of *H* is wrong. Tension must act away from the door, hence direction of *T* is wrong. So option A is wrong.

14	**Ans: B** 8.5 periods = 6 squares = 60 ms T = 60 ms / 8.5 Frequency = 1 / T = 8.5 / (60 x 10^{-3}) = 141.6 ≈ 140 Hz
15	**Ans: A** Wavelength of M > Wavelength of N by 10^5. Wavelength of microwave (10^{-2} m or ~cm) > visible light (10^{-7} m or a few hundreds of nm) > γ – ray (<10^{-10} m)
16	**Ans: C** Reflected wave and incident wave have the same frequency and amplitude. At an antinode, displacement of reflected wave = displacement of incident wave at any instant.
17	**Ans: C** Since particles A and B are at two sides of a node of a stationary wave, they are anti-phase. Hence phase difference is 180° Maximum KE is proportional to amplitude. Since amplitude of A < amplitude of B, $K_A < K_B$
18	**Ans: D** First minimum occurs at X Hence path difference = $S_2X - S_1X = \lambda /2$
19	**Ans : B** Same current, I in series circuit. Use power, $P = I^2R$ ratio = $I^2R / I^2(2R)$ = ½
20	**Ans : A** Terminal p.d. = 1.2 x 80 = 96 V ---(1) Terminal p.d. = 120 – (1.2+0.40) r ---(2) Equating (1) and (2), r = 15 Ω <u>Alternative method:</u> Let r be the internal resistance of supply and X the resistance of the lower resistor. p.d. across 80 Ω resistor = p.d. across the lower resistor, $X = \frac{1.2 \text{ x } 80}{0.40} = 240\ \Omega$ total current = 1.2 + 0.40 = 1.6 A = supply voltage/total resistance $1.6 = \frac{120}{r + \left(\frac{80 \text{ x } 240}{80 + 240}\right)}$ $r = 15\ \Omega$

21	**Ans : D** Energy = QV
22	**Ans : D** U and V have the same potential. Y and Z have the same potential. When the reading on the ammeter is zero, W and X have the same potential, same current, I_1 through R_1 and R_2. Same current, I_3 through R_3 and R_4 p.d. across UW = p.d. across VX $I_1 R_1 = I_3 R_3$ p.d. across WY = p.d. across XZ $I_1 R_2 = I_3 R_4$ Hence, $\frac{R_1}{R_2} = \frac{R_3}{R_4} \Rightarrow R_1 \times R_4 = R_2 \times R_3$ 
23	**Ans : A** Method 1 – potential divider method $V_{output} = \left(\frac{V_X}{V_X + 40}\right) \times 12.0\text{ V}$ For min X = 5.0 Ω, V_{output} = 1.3 V For max X = 500 Ω, V_{output} = 11.1 V Method 2 – same series current method $I = \left(\frac{12.0}{X+40}\right)$, so $V_{output} = IX = \left(\frac{12.0}{X+40}\right)(X)$ For min X = 5.0 Ω, I = V_{output} = 1.3 V For max X = 500 Ω, V_{output} = 11.1 V Hence, V_{output} is between 1.3 V and 11.1 V
24	**Ans : A** Let V_R = 0 V. V_Q = 6 V $V_P - V_Q = 3\text{ V} \Rightarrow V_P = 9\text{ V}$ $V_P - V_S = 5\text{ V} \Rightarrow V_S = 4\text{ V}$ Hence, V_{QS} = 6 – 4 = 2 V and V_{SR} = 4 – 0 = 4 V
25	**Ans: C** As the number of coils is halved, solenoid length is also halved, hence *n* does not change. As $I = V/R$ where $R = \rho L/A$, since *L* is halved, *R* will be halved and I will be twice as before. Hence *B* will be twice.
26	**Ans: C** No forces acting on PQ and SR due to *B* as *B* is parallel to the current in PQ and SR.
27	**Ans: C** Using Fleming's Left Hand Rule, force on the negatively charged particle is downwards.
28	**Ans : B** The number of photoelectrons emitted per second ($\frac{N}{t}$) is directly proportional to the intensity of incident radiation. Since the intensity of radiation is constant, the number of photoelectrons varies proportional with time.

29	**Ans : C** $qV = KE$ $qV = p^2/2m$ $\Rightarrow \quad p = \sqrt{(2mqV)}$ $\lambda = h/p \quad = \quad h/\sqrt{(2qmV)}$ since m and q same, $\lambda \propto 1/\sqrt{V}$ $\lambda_0/ \lambda_1 = \sqrt{(1000/10)} = 10$
30	**Ans : B** $\Delta E = hf$ largest energy change ➔ largest frequency of radiation emitted

Name: ______________________________ (   )   PDG: ______/ 16

ANDERSON JUNIOR COLLEGE

2017 JC2 Preliminary Examination

PHYSICS Higher 1 — 8866/02

Paper 2 Structured Questions — **Thursday 14 September 2017**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Paper 1 (30 marks)	
Paper 2 (80 marks)	
1	
2	
3	
4	
5	
6	
7	
8	
Significant Figure	
Total (110 marks)	

This document consists of **22** printed pages and **0** blank page.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows a trolley of mass 0.80 kg, on a bench surface, connected to a mass *M* by a string. The mass *M* is released and the trolley moves along the surface. Fig. 1.2 shows the variation of the velocity *v* of the trolley with time *t* for the motion from A to B.

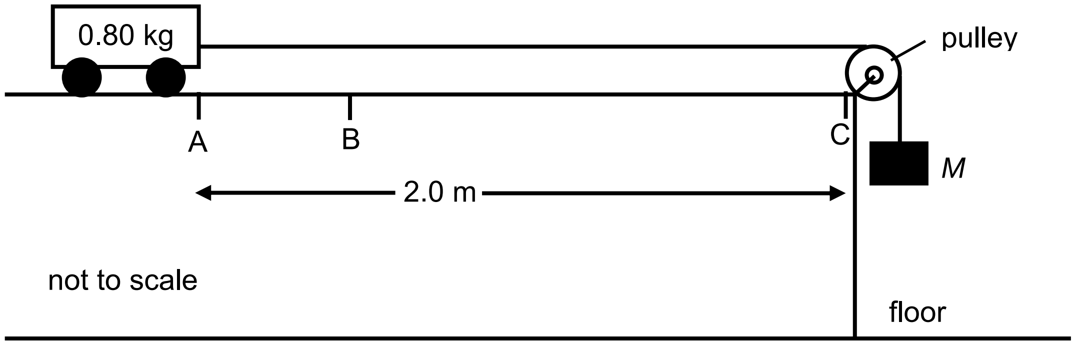


Fig. 1.1

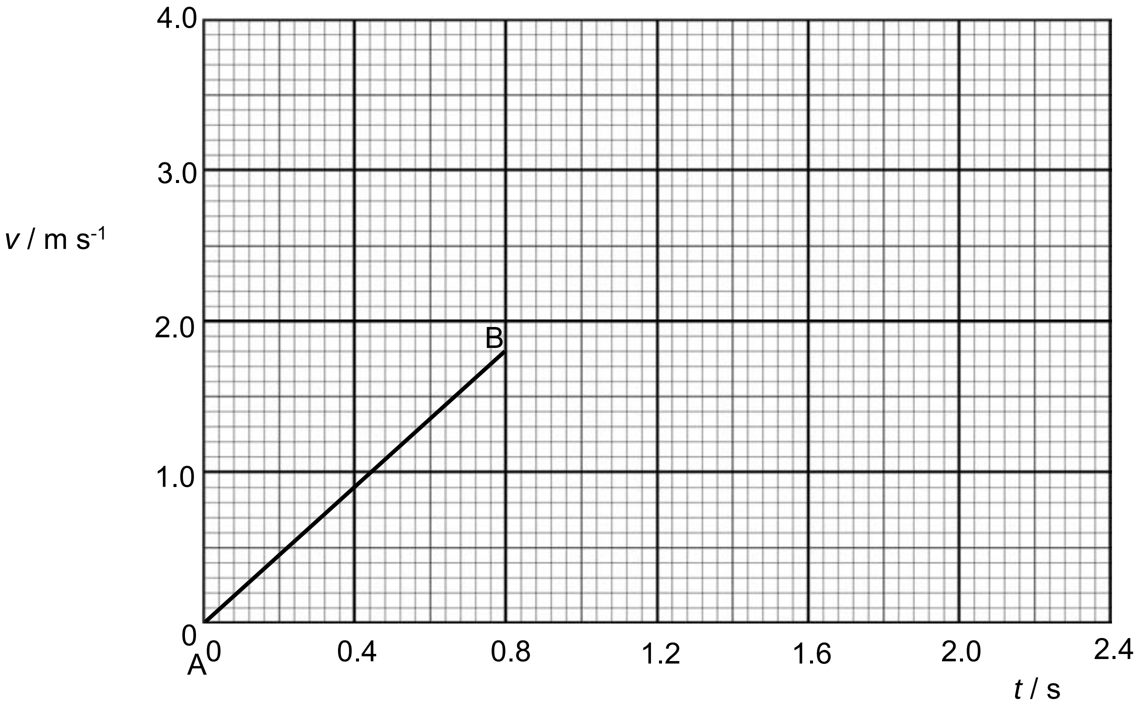


Fig. 1.2

(a) Calculate the acceleration of the trolley between A and B.

acceleration = ……………………………….m s^{-2} [1]

Turn Over

(b) Show that the distance from A to B is 0.72 m.

[1]

(c) When the trolley reaches B the mass *M* has just reached the floor.

(i) Ignoring any resistive forces, calculate the time it takes the trolley to travel from B to C.

time = …………………………………..s [2]

(ii) On Fig. 1.1, complete the graph for the trolley moving from B and coming to rest at the pulley at C. [2]

(iii) Using energy considerations, determine the mass *M*.

M = …………………………………..kg [2]

2 **(a)** Apparatus used to produce stationary waves on a stretched string is shown in Fig. 2.1.

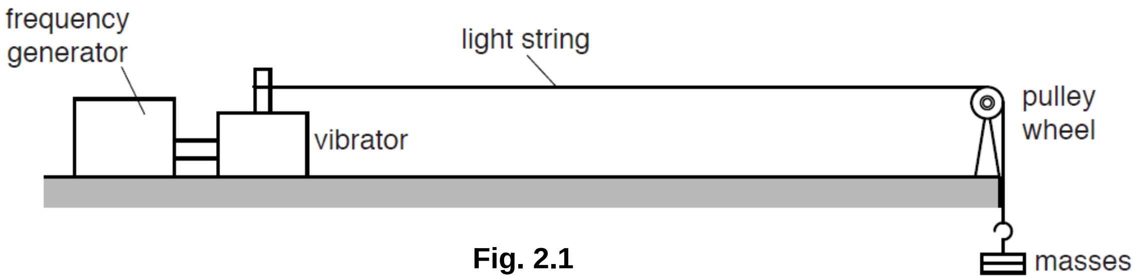


Fig. 2.1

The frequency generator is switched on.

(i) Describe two adjustments that can be made to the apparatus to produce stationary waves on the string.

1. …………………………………………………………………………………………..

…………………………………………………………………………………………..

2. …………………………………………………………………………………………..

………………………………………………………………………………………….. [2]

(ii) Describe the features that are seen on the stretched string that indicate stationary waves have been produced.

………………………………………………………………………………………….. [1]

(b) The variation with time *t* of the displacement *x* of a particle caused by a progressive wave R is shown in Fig. 2.2. For the same particle, the variation with time *t* of the displacement *x* caused by a second wave S is also shown in Fig. 2.2.

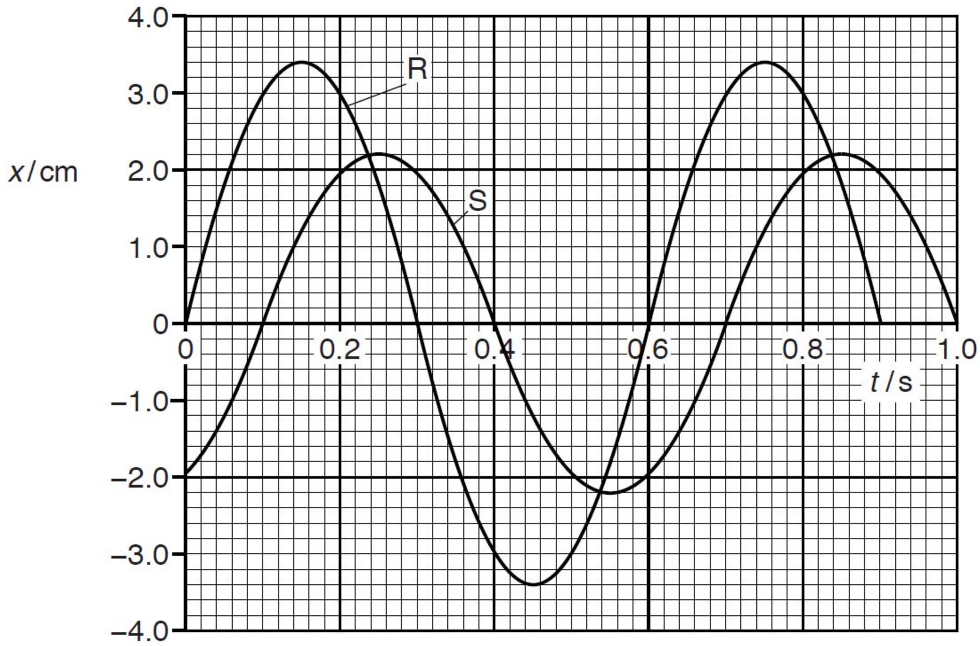


Fig 2.2

(i) Determine the phase difference between wave R and wave S. Include an appropriate unit.

phase difference = …………………………… [1]

(ii) Calculate the ratio

$$\frac{\text{intensity of wave R}}{\text{intensity of wave S}}.$$

ratio = …………………………… [2]

3 (a) State what is meant by the *diffraction* of a wave.

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(b) An arrangement for demonstrating the interference of light is shown in Fig. 3.1.

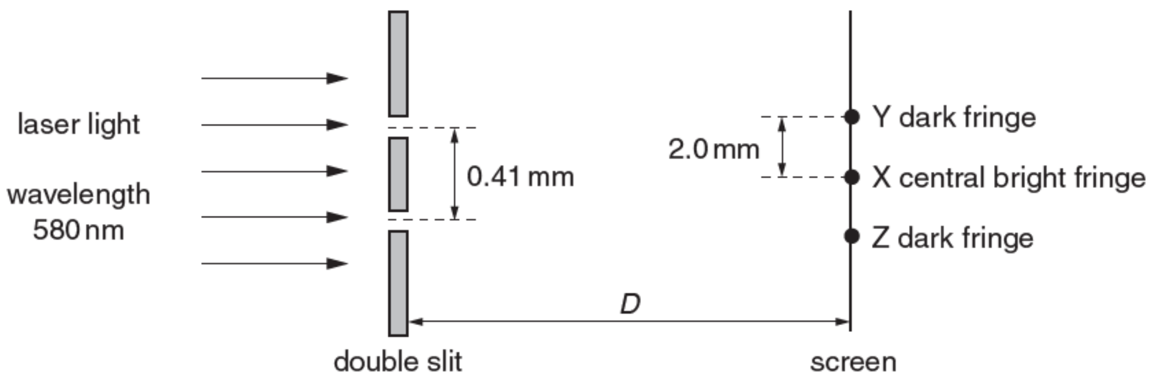


Fig. 3.1 (not to scale)

The wavelength of the light from the laser is 580 nm. The separation of the slits is 0.41 mm. The perpendicular distance between the double slit and the screen is *D*.

Coherent light emerges from the slits and an interference pattern is observed on the screen. The central bright fringe is produced at point X. The closest dark fringes to point X are produced at points Y and Z. The distance XY is 2.0 mm.

(i) Explain why a bright fringe is produced at point X.

…………………………………………………………………………………………..................

…………………………………………………………………………………………..................

…………………………………………………………………………………………..................

……………………………………………………………………………………………….... [2]

(ii) Calculate the distance *D*.

D = ……………………. m [2]

(iii) The intensity of the light passing through the two slits was initially the same. The intensity of the light through **one** of the slits is now reduced. Compare the appearance of the fringes before and after the change of intensity.

…………………………………………………………………………………………..................

…………………………………………………………………………………………..................

…………………………………………………………………………………………..................

……………………………………………………………………………………………….... [2]

4 A long, straight wire Z carrying a direct current of 2.0 A flows in the direction as shown in Fig. 4.1.

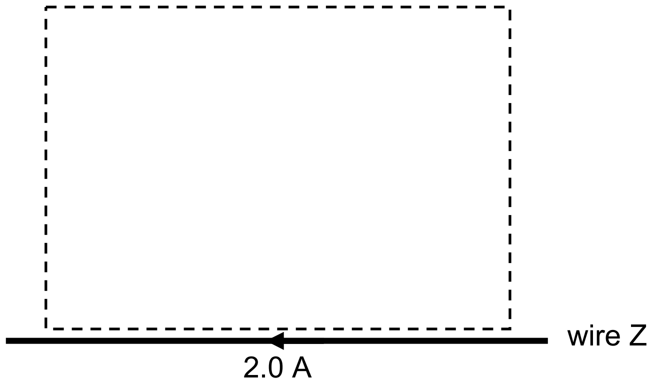


Fig. 4.1

(a) Using symbols X or ⊙ to represent the direction of magnetic field into or out of the paper respectively, draw on Fig. 4.1 the pattern of magnetic field produced by wire Z in the region indicated by the dotted box. [2]

(b) A similar wire Y is placed parallel to wire Z. The separation *d* between the two wires is 1.0 m. Wire Y is carrying a current of 1.0 A in the same direction as wire Z.

(i) Calculate the resultant magnetic flux density at the mid-point between the two wires. Given that the magnetic flux density *B* due to a long straight wire at a point is

$$B = \frac{\mu_0 I}{2\pi r}$$

where μ_0, the permeability of free space, is $4\pi \times 10^{-7}$ J s^2 C^{-2} m^{-1}, *r* is the perpendicular distance from the point to the wire and I is the current flowing through the wire.

magnetic flux density = …………………………….T [2]

(ii) Explain, with the aid of sketches, the direction of the forces which exist between the two wires.

……………………………………………………………………………………………………

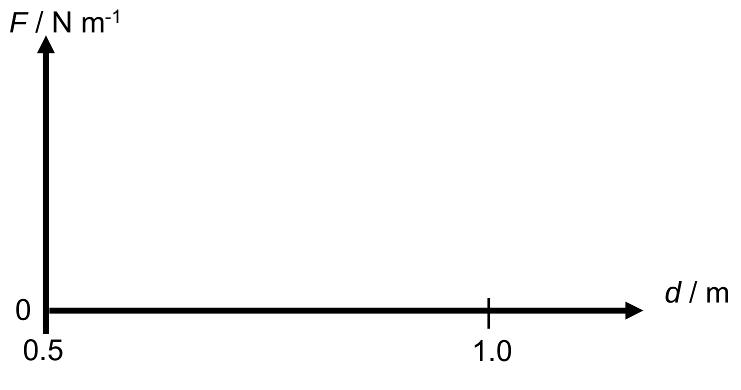
……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………..[3]

(iii) Wire Y moves towards wire Z such that the separation *d* of the two wires decreases from 1.0 m to 0.5 m. Wire Y is maintained parallel to wire Z throughout the motion. Sketch the variation with separation *d* of the force per unit length *F* experienced by wire Y due to the magnetic field of wire Z.



[2]

5 A mass *M* is moving at 5.00 m s^{-1} along a horizontal frictionless guide which bends into a vertical circle of radius r, as illustrated in Fig. 5.1.

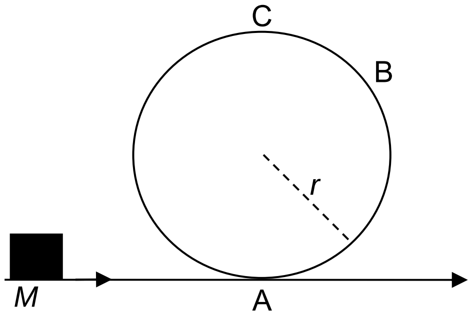


Fig. 5.1

Fig. 5.2 and Fig 5.3 show the velocity-time graphs for the vertical and horizontal components respectively of the velocity along the section ABC of the curve.

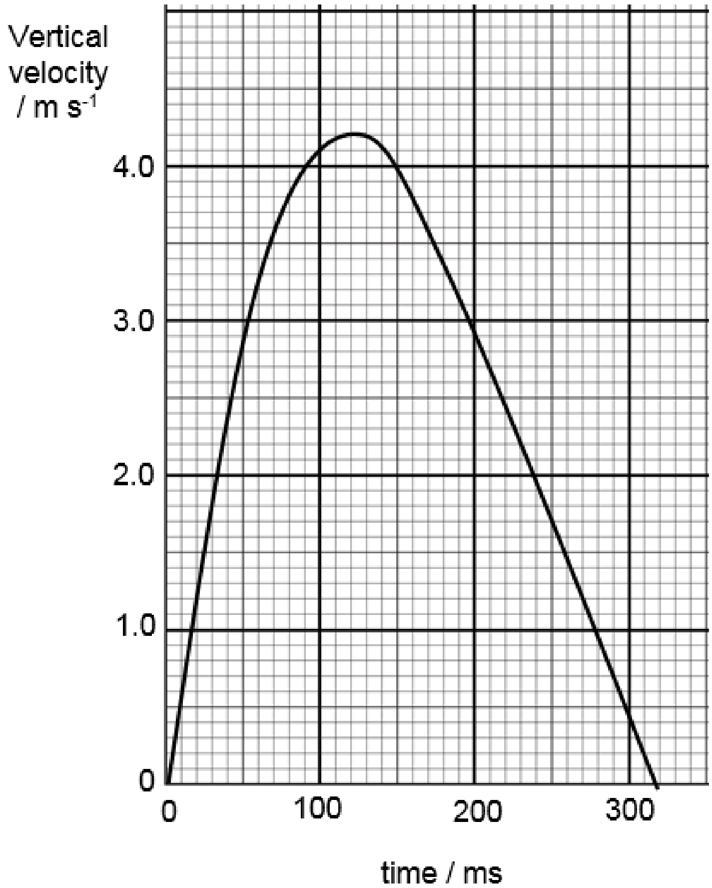


Fig. 5.2

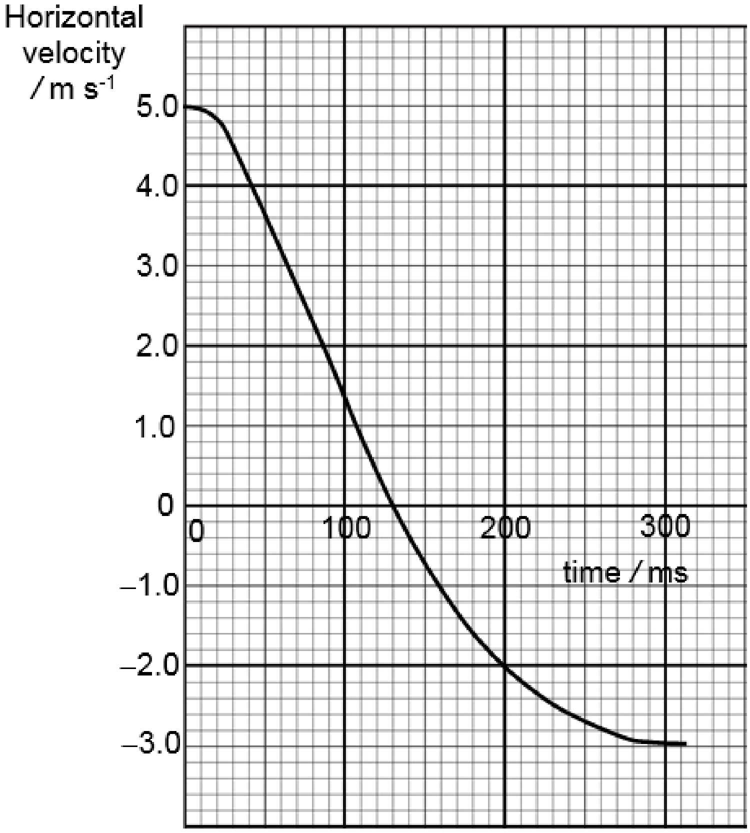


Fig. 5.3

(a) With the aid of Fig. 5.2, estimate the radius *r* of the vertical circle.

r = …………………….. m [3]

(b) (i) From Fig. 5.2 and Fig. 5.3, find the vertical and horizontal components of the acceleration of the mass *M* at B, 200 ms after it passes the point A.

vertical component of the acceleration = …..………. m s^{-2} [1]

horizontal component of the acceleration = ……..……. m s^{-2} [1]

(ii) Hence, find the magnitude and the direction of the resultant acceleration, made with the horizontal, of the mass *M* at B.

magnitude of acceleration = ……….……. m s^{-2} [1]

direction of acceleration = ………….………. ° [1]

(iii) On fig. 5.4, draw the resultant force acting on the mass *M* at B.

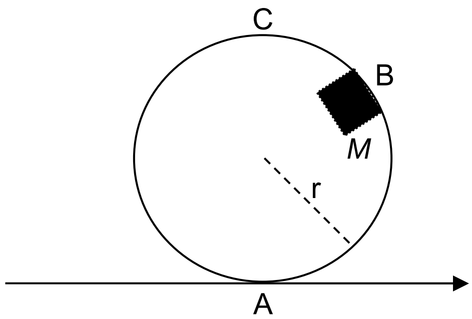


Fig. 5.4

[1]

(c) Without detailed mathematical calculation, deduce the area under the graph in Fig. 5.3. Explain your answer.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………..........[2]

Section B

Answer **two** of the questions from this section.

6 **(a)** Fig. 6.1 illustrates a model helicopter that is hovering in a stationary position.

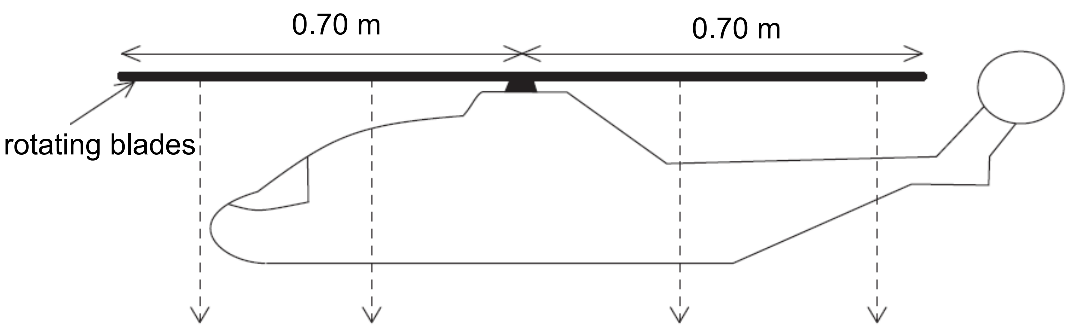


Fig. 6.1

(i) The rotating blades of the helicopter force a column of air to move downwards. Using Newton's Laws, explain how this may enable the helicopter to remain stationary.

....

....

....

....

....

.... [3]

(ii) The length of each blade of the helicopter is 0.70 m. Deduce that the area that the blades sweep out as they rotate is 1.5 m^2.

[1]

(iii) It is assumed that all the air beneath the blades is pushed vertically downwards with the same speed of 4.0 m s^{-1}. No other air is disturbed. The density of the air is 1.2 kg m^{-3}.

Calculate, for the air moved downwards by the rotating blades,

1. the mass per second.

mass per second = …………………. kg s^{-1} [2]

2. the rate of change of momentum.

rate of change of momentum = …………………. kg m s^{-2} [2]

(iv) Calculate the mass of the helicopter and its load.

mass of helicopter and its load =…………………. kg [2]

(b) A car and a truck are both travelling at the speed limit of 60 km h^{-1} but in opposite directions as shown in Fig. 6.2. The truck has twice the mass of the car.

Fig. 6.2

The vehicles collide head-on and become entangled together.

(i) Deduce and explain the final direction of the entangled vehicles after collision.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………….............[2]

(ii) Determine the speed of the combined wreck immediately after the collision.

speed = ……………………. km h^{-1} [2]

(iii) Explain whether the acceleration of the car is greater, equal or smaller than the acceleration of the truck during collision.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………..............[2]

(iv) Both the car and truck drivers are wearing seat belts. Explain which driver experiences a greater restraint by the seat belt. (Assume that the masses of both drivers are approximately equal).

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………..............[2]

(v) The total kinetic energy of the system decreases as a result of the collision. Explain whether the principle of conservation of energy is violated?

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………………………………………..............[2]

7 **(a)** Define

(i) resistance

....

.... [1]

(ii) the ohm

....

.... [1]

(b) Sketch the I–V characteristics of a metallic conductor at constant temperature on Fig. 7.1 and a filament lamp on Fig. 7.2. [2]

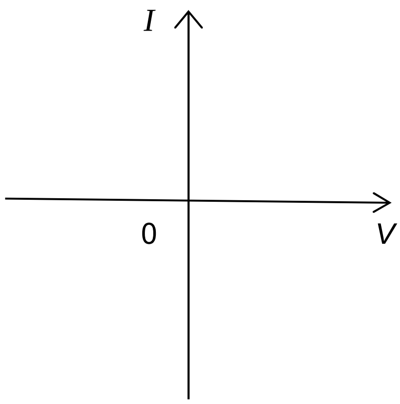


Fig. 7.1

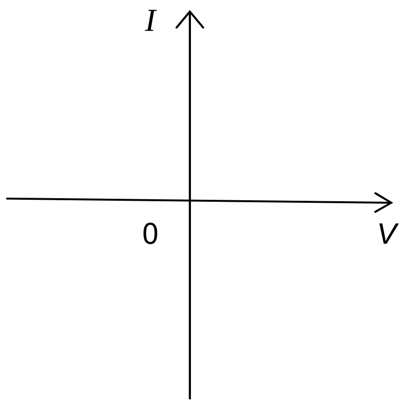


Fig. 7.2

(c) A copper wire of diameter 1.4 mm connects to the tungsten filament wire of a light bulb of diameter 0.020 mm. A current of 0.42 A flows through both of the wires. Copper has 8.0×10^{28} electrons per cubic metre and tungsten can be assumed to have 3.4×10^{28} electrons per cubic metre.

(i) The filament is 2.0 m long when uncoiled and has a resistivity of 5.5×10^{-8} Ωm.

For the filament bulb,

1. show that the resistance is 350 Ω,

[1]

2. calculate the power dissipated.

power dissipated = ………………………………W [1]

(ii) State **two** important properties of a conductor used to make heating elements.

………………………………………………………………………………………………... [2]

(d) A battery of electromotive force (e.m.f.) 14 V and negligible internal resistance is connected to a resistor network, as shown in Fig. 7.3.

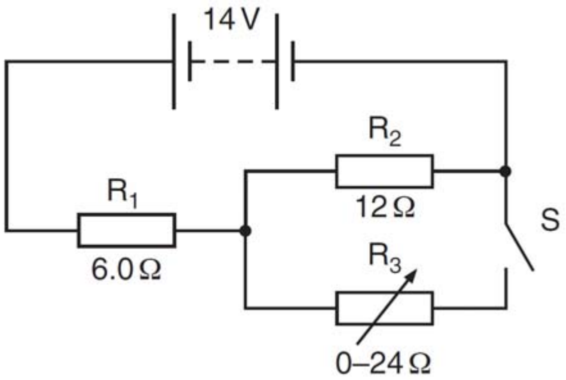


Fig. 7.3

R_1 and R_2 are fixed resistors of resistances 6.0 Ω and 12 Ω respectively. R_3 is a variable resistor.

Switch S is **closed**.

(i) Calculate the current in the battery when the resistance of R_3 is set

1. at zero,

current = ……………………………A [2]

2. at 24 Ω.

current = ……………………………A [2]

(ii) Use your answers in **(d)(i)** to calculate the change in the total power produced by the battery when the resistance of R_3 is changed from zero to 24 Ω.

change in power = ……………………………W [2]

(e) A thermistor has resistance 3900 Ω at 0 °C and resistance 1250 Ω at 30 °C. The thermistor is connected into the circuit of Fig. 7.4 in order to monitor temperature changes.

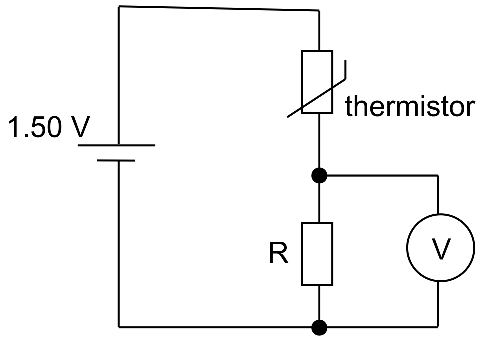


Fig. 7.4

The battery of e.m.f. 1.50 V has negligible resistance and the voltmeter has infinite resistance.

(i) The voltmeter is to read 1.00 V at 0 °C. Show that the resistance of resistor R is 7800 Ω.

[2]

(ii) The temperature of the thermistor is increased to 30 °C. Determine the reading on the voltmeter.

reading = ……………………………V [2]

(iii) The voltmeter in Fig. 7.4 is replaced with one having a resistance of 7800 Ω. Calculate the reading on this voltmeter for the thermistor at a temperature of 0 °C.

reading = ……………………………V [2]

8 **(a)** State and explain two relations in which the Planck constant h is the constant of proportionality.

1. ……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

2. ……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[4]

(b) Experiments are conducted to investigate the photoelectric effect.

(i) It is found that, on exposure of a metal surface to light, either electrons are emitted immediately or they are not emitted at all.

Suggest why this observation does not support a wave theory of light.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(ii) Data for the wavelength λ of the radiation incident on the metal surface and the maximum kinetic energy E_k of the emitted electrons are shown in Fig. 8.1.

λ /nm	E_k /10^{-19} J
650	-
240	4.44

Fig. 8.1

1. Without any calculation, suggest why no value is given for E_k for radiation of wavelength 650 nm.

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

2. Use data from Fig. 8.1 to determine the work function energy of the surface.

work function energy = ... J [2]

(iii) Radiation of wavelength 240 nm gives rise to a maximum photoelectric current I. The intensity of the incident radiation is maintained constant and the wavelength is now reduced.

State and explain the effect of this change on

1. the maximum kinetic energy of the photoelectrons,

....

....

.... [2]

2. the maximum photoelectric current I.

....

....

.... [2]

(c) Some electron energy levels in atomic hydrogen are illustrated in Fig. 8.2.

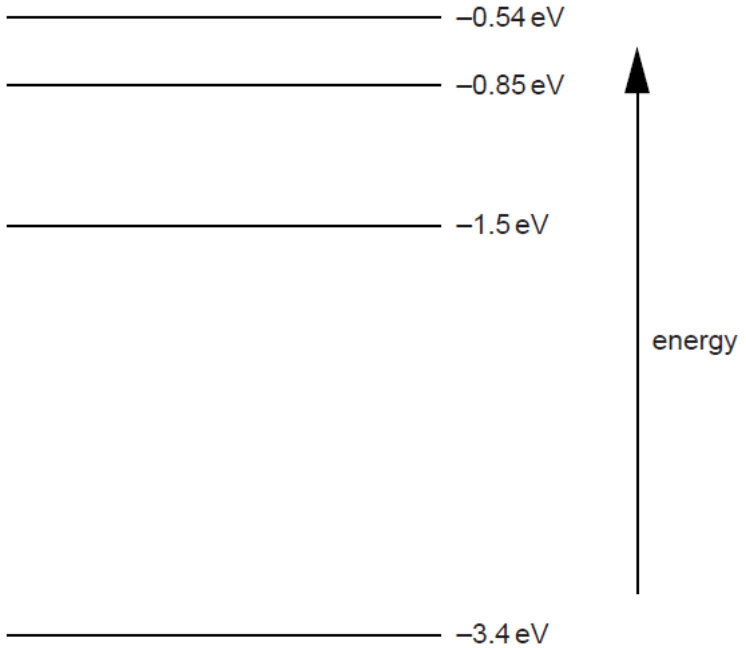


Fig. 8.2

The longest wavelength produced as a result of electron transitions between two of the energy levels shown in Fig. 8.2 is 4.0×10^{-6} m.

(i) On Fig. 8.2,

1. draw, and mark with the letter L, the transition giving rise to the wavelength of 4.0×10^{-6} m, [1]

2. draw, and mark with the letter S, the transition giving rise to the shortest wavelength. [1]

(ii) Calculate the wavelength for the transition you have shown in **(i) part 2**.

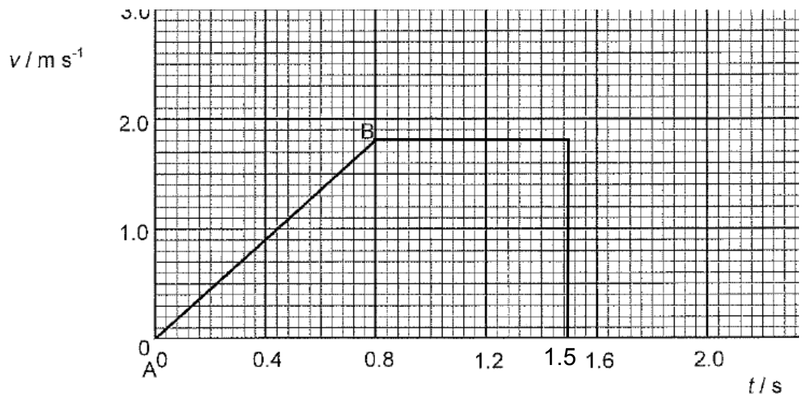
wavelength = …………………………….m [2]

(iii) Photon energies in the visible spectrum vary between approximately 3.66 eV and 1.83 eV.

Determine the energies, in eV, of photons in the visible spectrum that are produced by transitions between the energy levels shown in Fig. 8.2.

photon energies = …………………………….eV [2]

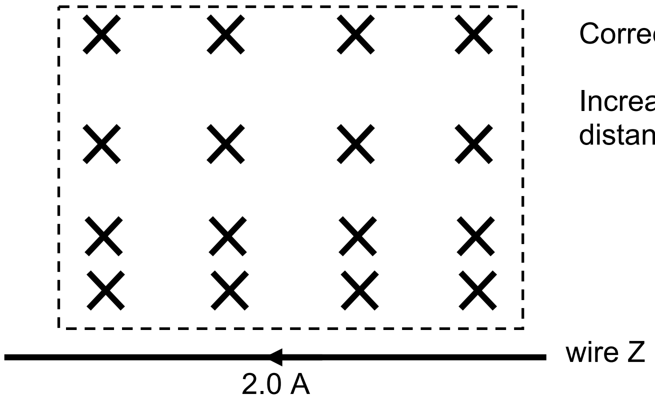
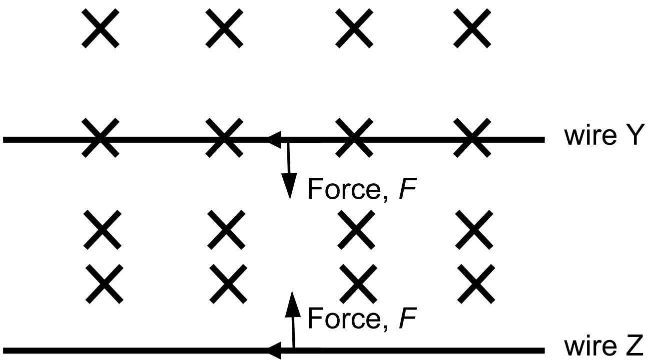
2017 AJC Prelim Physics H1P2 Solutions
Paper 2 (80 marks)

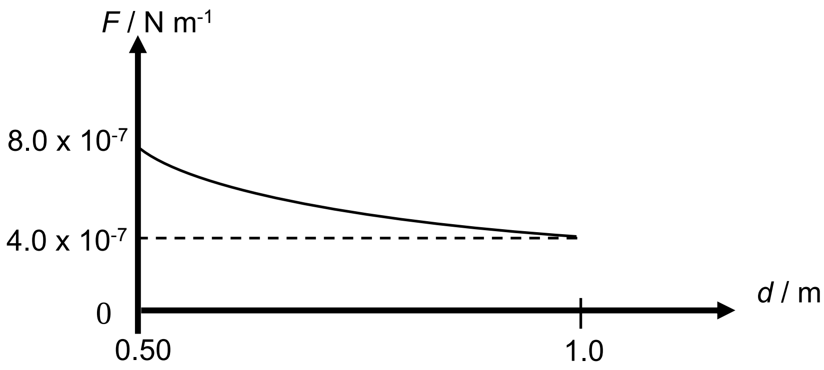
1a	Acceleration = gradient of graph = 1.80 / 0.80 = 2.25 ≈ 2.3 m s^{-2}
1b	Distance = area under the graph = (1.80 x 0.80) / 2 = 0.72 m
1ci	Time = distance BC / speed = (2.0 – 0.72) / 1.8 = 0.71 s
1cii	Straight horizontal line until 1.5 s Steep line to zero speed (ignore gradient) 
1ciii	KE gain by trolley and M = GPE loss by M ½ x (0.80 + M) x 1.8^2 = M x 9.81 x 0.72 M = 0.24 kg

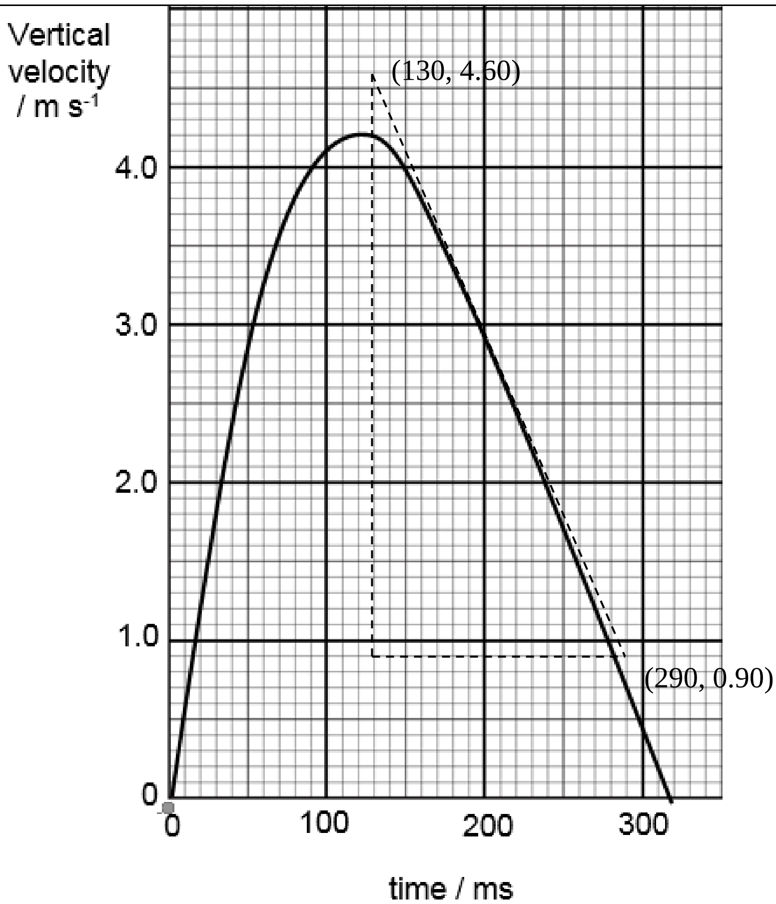
2ai	adjust distance of string from vibrator to pulley adjust frequency of generator
2aii	points on string have amplitudes varying from maximum to zero/minimum
2bi	$\frac{0.10}{0.60} x 2\pi$ = 60° or π/3 rad *or 1.05 rad*
2bii	ratio = $[3.4/ 2.2]^2$ = 2.39 = 2.4

3a	**Diffraction** is the <u>spreading</u> of waves when they <u>pass through an opening or round an obstacle</u>. (Diffraction effects are the greatest when the width of the opening is comparable with the wavelength of the waves.)

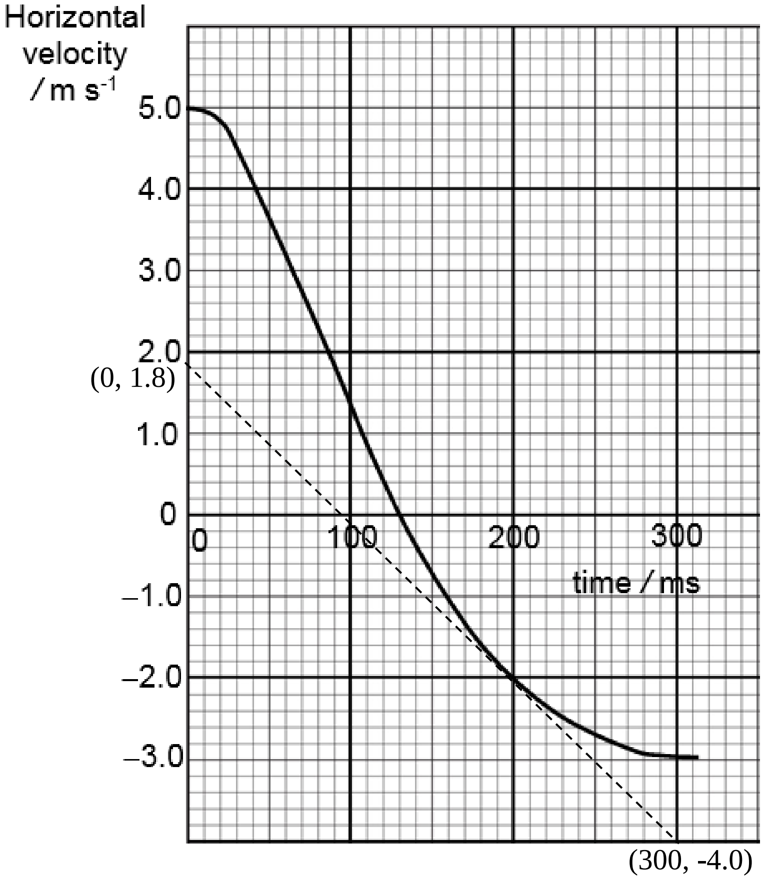
3bi	waves (from slits) overlap (at point X) path difference (from slits to X) is zero or phase difference (between the two waves) is zero so constructive interference gives bright fringe
3bii	$\lambda = ax / D$ $D = [0.41 \times 10^{-3} \times (\mathbf{2 \times 2.0 \times 10^{-3}})] / 580 \times 10^{-9}$ = 2.8 m
3biii	same separation/fringe width/number of fringes bright fringe(s)/central bright fringe/(fringe at) X less bright dark fringe(s)/(fringe at) Y/(fringe at) Z brighter contrast between fringes decreases *Any two of the above four points, 1 mark each, max 2 marks*

4a	 Correct direction of B Increasing spacing with increasing distance from wire Z
4bi	$B = B_Z - B_Y$ $= \dfrac{\mu_0 I_Z}{2\pi r} - \dfrac{\mu_0 I_Y}{2\pi r}$ $= \dfrac{(4\pi \times 10^{-7})}{2\pi(0.5)}(2.0 - 1.0)$ $= 4.0 \times 10^{-7}$ T
4bii	 By right hand grip rule, <u>the magnetic field</u> produced by the current <u>in wire Z acts perpendicular to wire Y</u>. <u>By FLHR</u>, the direction of the magnetic force on wire Y is <u>towards wire Z</u>. By N3L, the direction of the force on wire Z is <u>opposite to that on wire Y / towards wire Y</u>.

4biii	 Correct trend as $F \propto \dfrac{1}{d}$ F at 0.50 m is twice the amount at 1.0 m. (values not required)

5a	height of circle = vertical displacement travelled by mass from A to C = area under the graph = $32 \times (0.5 \times 50 \times 10^{-3})$ = 0.80 m height of circle = diameter of circle $\therefore\ r = \dfrac{0.80}{2}$ = 0.40 Accept $0.38 \leq r \leq 0.42$ m
5bi	

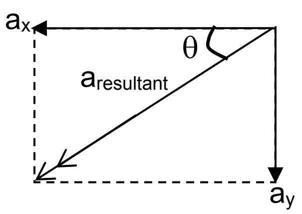
$a_y = \dfrac{4.60-0.90}{(130-290)\times10^{-3}} = \dfrac{3.70}{-0.160} - 23.1\,\text{ms}^{-2}$



$a_x = \dfrac{1.8-(-4.0)}{(0-300)\times10^{-3}} = \dfrac{5.8}{-0.300}$

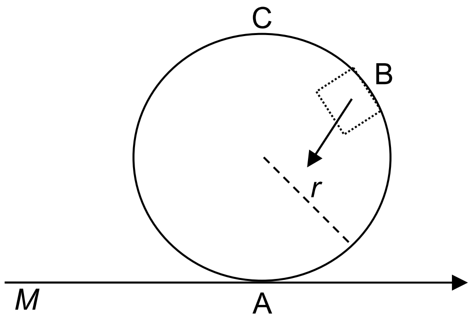
$= -19\,\text{m s}^{-2}$

5bii



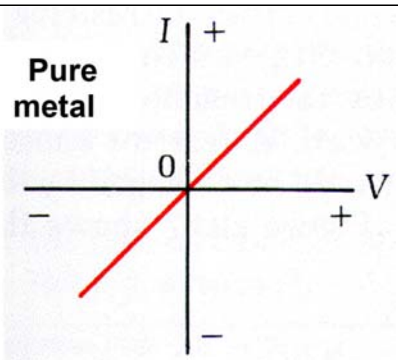
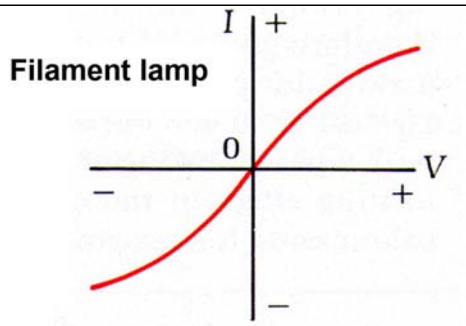
Resultant acceleration = $\sqrt{(23.1)^2+(19)^2}$ = 29.9 m s^{-2}

$\theta = \tan^{-1}(\dfrac{23.1}{19}) = 50.6°$

5biii	 Note: arrow not passing through centre of circle (directed below centre) because angle from horizontal is more than 45°.
5c	The net horizontal displacement travelled by the mass *M* from A to C is zero. Thus, area under the graph is zero.

6ai	By Newton's 2nd Law, rotating blades pushes air and causes it to undergo a rate of change in momentum downwards giving rise to a downward force. From Newton's 3rd Law, the air exerts and equal and opposite force on the blades/helicopter. When this <u>upward force equals the weight</u> of the helicopter, <u>resultant force is zero</u>
6aii	Area = $\pi r^2 = \pi(0.70)^2$ $= 1.5\ \text{m}^2$
6aiii1	Volume of air per second = 1.5 x 4.0 Mass per second = volume per second x density = 1.2 x 1.5 x 4.0 = 7.2 kg s^{-1}
6aiii2	Rate of change of momentum = dm/dt x velocity = 7.2 x 4.0 = 28.8 ≈ 29 N
6aiv	Mg = force on blade = 28.8 N M = 28.8 / 9.81 = 2.9 kg
6bi	Total momentum of the system before collision is in the direction of the long truck By the conservation of momentum, (the total momentum after collision must be the same), the vehicles will move in the same direction as the long truck.
6bii	Total momentum before = total momentum after m x 60 – 2m x 60 = (m + 2m) V V = - 20 km h^{-1} (or 20 km h^{-1} to the left)
6biii	During collision, force on car and truck is the same but car has smaller mass Hence, acceleration of car is greater
6biv	Acceleration of car driver is greater than of truck driver. (For the same mass), force by seatbelt on driver is greater for greater acceleration The car driver will experience a greater restrain.

6bv	Some energy of the system is used to do work to deform the vehicles and lost as heat and sound The principle of conservation of energy is not violated

7ai	The **resistance** of a conductor is the ratio of the potential difference across it to the current flowing through it.
7aii	The **ohm** is the resistance of a conductor in which the current is 1 ampere when a potential difference of 1 volt is applied across it.
7b	 
7ci1	Use $R = \dfrac{\rho l}{A}$ $= \dfrac{(5.5 \times 10^{-8})(2.0)}{\left(\dfrac{\pi(0.020 \times 10^{-3})^2}{4}\right)}$ $= 350\ \Omega$
7ci2	power dissipated = $I^2R = (0.42)^2(350) = 62$ W
7ciii	Any two – high resistivity, high melting point, should not oxidise at high temperature (to ensure long life), non-corrosive
7di1	When $R_3 = 0$, circuit would be reduced to only R_3 connected to the e.m.f. Hence, current in battery $= \dfrac{14}{6.0}$ $= 2.3$ A
7di2	When $R_3 = 24\ \Omega$, effective resistance of R_2 and R_3 in parallel = $\dfrac{12 \times 24}{12 + 24} = 8.0\ \Omega$ total resistance in circuit = 6.0 + 8.0 = 14.0 Ω Hence, current in battery $= \dfrac{14}{14.0}$ $= 1.0$ A
7dii	When $R_3 = 0$, power produced by battery = 14 x 2.3 = 32.2 W When $R_3 = 24\ \Omega$, power produced by battery = 14 x 1.0 = 14 W Change in power produced by battery = 14 – 32.2 = –18 W (accept 18 W)

7ei	Mthd 1 resistance of thermistor at 0 °C = 3900 Ω using potential divider principle, $\left(\frac{R}{R+3900}\right)x1.50 = 1.00$ R = 7800 Ω Mthd 2 p.d. across thermistor = 1.50 – 1.00 = 0.50 V resistance of thermistor at 0 °C = 3900 Ω common current in circuit = $\frac{1.00}{R} = \frac{0.50}{3900}$ R = 7800 Ω
7eii	Mthd 1 resistance of thermistor at 30 °C = 1250 Ω using potential divider principle, $\text{voltmeter reading} = \left(\frac{7800}{7800+1250}\right)x1.50$ $= 1.29\text{ V}$ Mthd 2 resistance of thermistor at 30 °C = 1250 Ω common current, I in circuit = $\frac{1.50}{R+1250} = \frac{1.50}{7800+1250} = \frac{1.50}{9050}$ voltmeter reading = IR = 1.29 V
7eiii	resistance of thermistor at 0 °C = 3900 Ω effective resistance of R and voltmeter = 7800/2 = 3900 Ω (same as thermistor's) voltmeter reading = p.d. across X = 1.50/2 = 0.750 V

8 a 1.	photon is a packet/quantum of energy of electromagnetic radiation (photon) energy = h × frequency
2.	every particle has an (associated) wavelength wavelength = h / p , where p is the momentum (of the particle)
8bi	for a wave, electron can 'collect' energy continuously for a wave, electron will always be emitted / electron will be emitted at all frequencies after a sufficiently long delay
8bii 1.	either wavelength is longer than threshold wavelength or frequency is below the threshold frequency or photon energy is less than work function
8bii 2.	$hc / \lambda = \phi + E_k$ $(6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (240 \times 10^{-9}) = \phi + 4.44 \times 10^{-19}$ $\phi = 3.8 \times 10^{-19}$ J (allow 3.9×10^{-19} J)

8biii1.	photon energy larger so (maximum) kinetic energy is larger
8biii2.	fewer photons (per unit time) so (maximum) current is smaller
8ci1. **2.**	arrow from –0.54 eV to –0.85 eV, labelled L arrow from –0.54 eV to –3.4 eV , labelled S (two correct arrows, but only one label – allow 2 marks) (two correct arrows, but no labels – allow 1 mark)
8cii	$E = hc / \lambda$ $(3.4 - 0.54) \times 1.6 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / \lambda$ $\lambda = 4.35 \times 10^{-7}$ m
8ciii	$-1.50 \rightarrow -3.4 = 1.9$ eV $-0.85 \rightarrow -3.4 = 2.55$ eV (allow 2.6 eV) $-0.54 \rightarrow -3.4 = 2.86$ eV (allow 2.9 eV)