TEMASEK JUNIOR COLLEGE

2017 Preliminary Examination
Higher 1

PHYSICS

8866/01

Paper 1 Multiple Choice

18 September 2017
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and Civics group on the Answer Sheet in the spaces provided.

There are **thirty** questions in 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.

Read the instructions on the Answer Sheet very carefully.

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

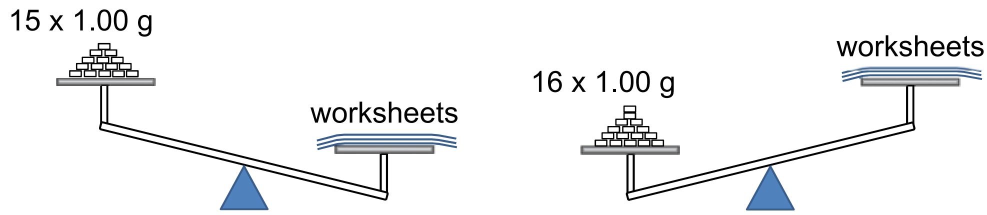
Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-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	=	ρgh
resistors in series	R	=	$R_1 + R_2 + ...$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + ...$

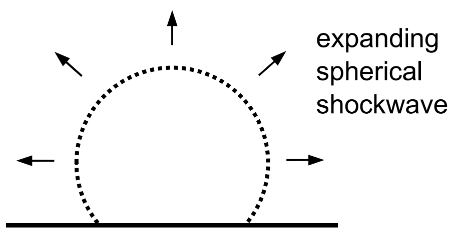
1 A Physics student measures the mass of his Measurement tutorial worksheets using a simple balance and some standard masses, each of 1.00 ± 0.02 g. He finds that 15 masses are not quite enough for balance but 16 masses are just too much.



What is an appropriate value, with its associated uncertainty, for the mass of the worksheets?

A 15.50 ± 0.02 g **B** 15.5 ± 0.3 g **C** 15.5 ± 0.5 g **D** 15.5 ± 0.8 g

2 The detonation of an atomic bomb results in a shockwave that reflects off the ground, propagating outwards as shown.



The radius R of the shockwave at time t after the explosion is related to the energy E that is released and the density ρ of the surrounding medium as follows:

$$R = \left(\frac{Et^2}{\rho}\right)^{\frac{1}{x}}$$

where x is a constant.

What is the value of x?

A $-\frac{1}{5}$ **B** –1 **C** 4 **D** 5

3 A man is running on a horizontal road towards the north at 8 km h^{-1} in the rain. He sees the rain drops falling vertically as he runs. He increases his speed to 16 km h^{-1} and finds that the rain drops now make an angle of 30° with the vertical.

What is the velocity of the rain drops?

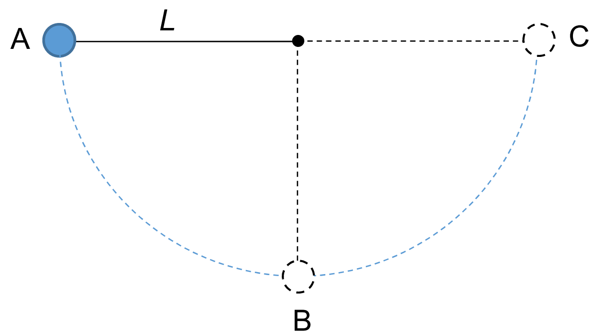
A 16 km h^{-1}, 30° with the vertical, downwards and northwards

B 16 km h^{-1}, 30° with the vertical, downwards and southwards

C 32 km h^{-1}, 30° with the vertical, downwards and northwards

D 32 km h^{-1}, 30° with the vertical, downwards and southwards

4 A pendulum of length L is released from A and swings to C where it comes to rest momentarily as shown. It follows a circular path and has maximum velocity at B.



What is the average velocity of the pendulum bob as it moves from A to C, if the time taken is T?

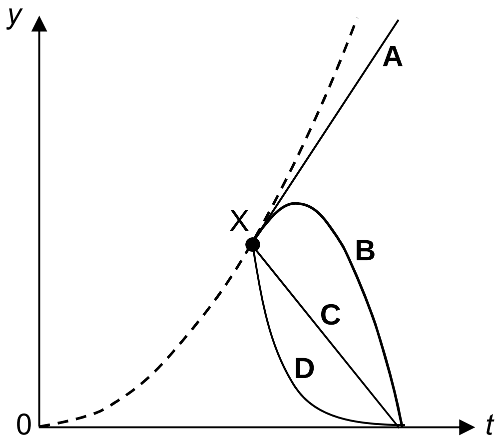
A 0 **B** $\frac{\sqrt{2gL}}{2}$ **C** $\frac{2L}{T}$ **D** $\frac{\pi L}{T}$

5 Water drops fall from rest at regular intervals from a tap which is 5.00 m above the ground. The third drop is leaving the tap at the instant the first drop reaches the ground.

How far above the ground is the second drop at that instant?

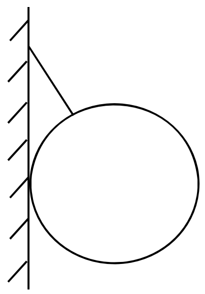
A 1.25 m **B** 2.50 m **C** 2.78 m **D** 3.75 m

6 A toy rocket is moving upward with constant acceleration. The dashed curve in the figure shows the height y of the rocket from the ground with respect to time t. At the instant indicated by the point X, a tail fin of the rocket breaks loose and drops from the rocket.



Ignoring air resistance, which of the curves labelled **A** to **D** best represents the position of the tail fin with respect to t?

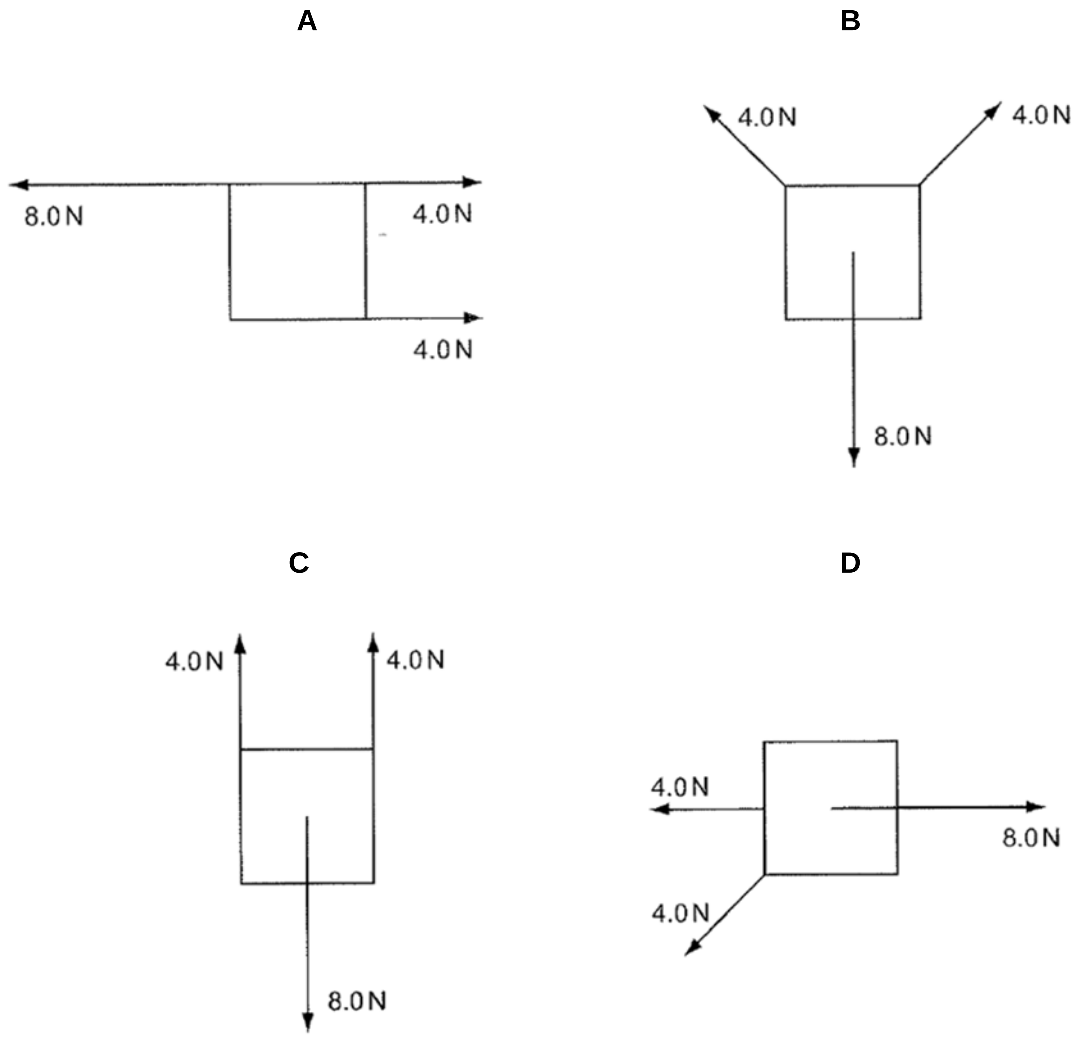
7 The diagram shows a uniform sphere of weight *W* attached to a smooth wall by a string of length equal to its radius.



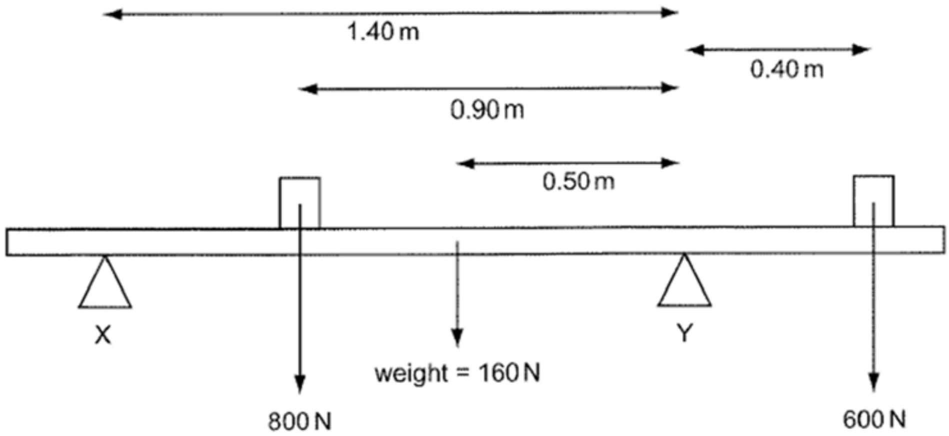
What is the tension in the string?

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

8 Which vector diagram showing three forces acting on a body will produce equilibrium?



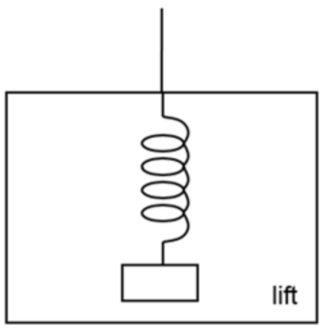
9 A beam of weight 160 N is supported at X and Y. Loadings on the beam and dimensions are shown in the diagram below.



What are the forces exerted by supports X and Y?

	Force due to X	Force due to Y
A	400 N	1960 N
B	400 N	1160 N
C	570 N	9970 N
D	740 N	820 N

10 A light spring of natural length 25.0 cm is suspended from the ceiling of a lift. A mass is hung from the end of the spring, as shown in the figure below.



When the lift is moving downwards at a constant speed, the length of the spring is 50.0 cm. The lift then slows down with a constant acceleration of 2.0 m s^{-2}.

Which of the following is correct? (Take g = 10.0 m s^{-2}.)

A The spring shortens by a length of 5.0 cm.

B The spring lengthens by a length of 5.0 cm.

C The spring shortens by a length of 10.0 cm.

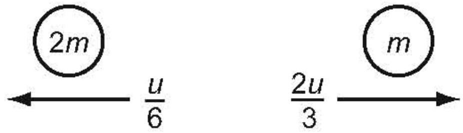
D The spring lengthens by a length of 10.0 cm.

11 The diagram shows two spherical masses approaching each other head-on at an equal speed u. One has mass 2*m* and the other has mass *m*.

Which diagram represents the situation after an elastic collision?

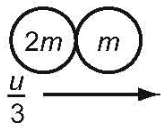
A

B



C

D

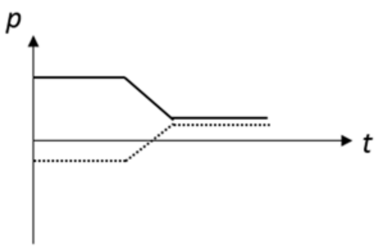


the spheres stick together

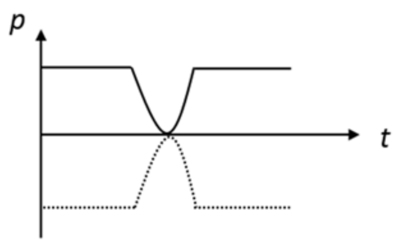
12 Two vehicles, not necessarily of the same mass or momentum, approach one another with constant velocities along a linear air track and make a head-on collision. The graphs below show the momentum of each vehicle against time for the period just before the collision until just after it.

Which of the following graphs is **not** possible?

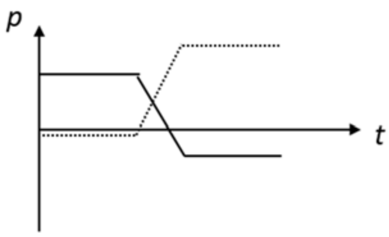
A



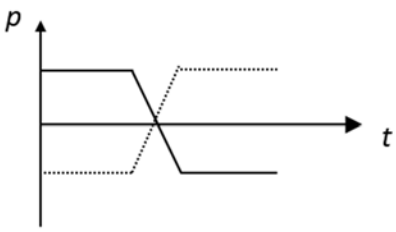
B



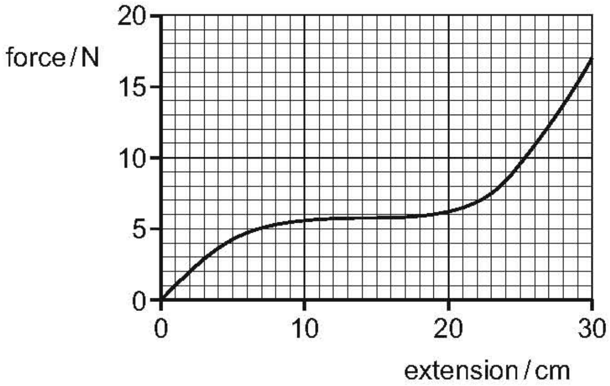
C



D



13 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 strain energy stored in the rubber band when it is extended 30 cm?

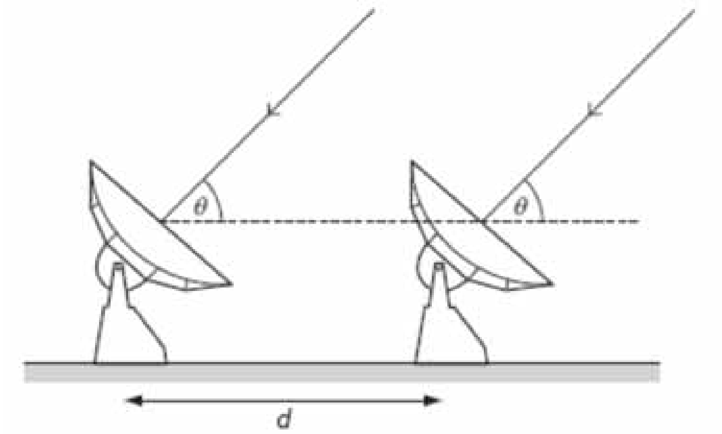
A 2.0 J **B** 2.6 J **C** 5.1 J **D** 200 J

14 A crane lifting a container out of the hold of a ship is working at a rate of 670 kW. The container has a mass of 40 tonnes and is rising with a constant speed of 1.3 m s^{-1}. (1 tonne = 1000 kg)

What is the efficiency of the arrangement?

A 0.078% **B** 7.8% **C** 59% **D** 76%

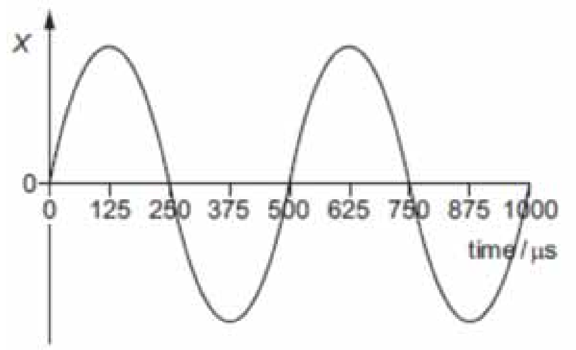
15 Two radio telescopes separated by a distance d detect parallel waves of wavelength λ from the same distant radio source.



What is the correct expression for the path difference between the waves received at the telescopes?

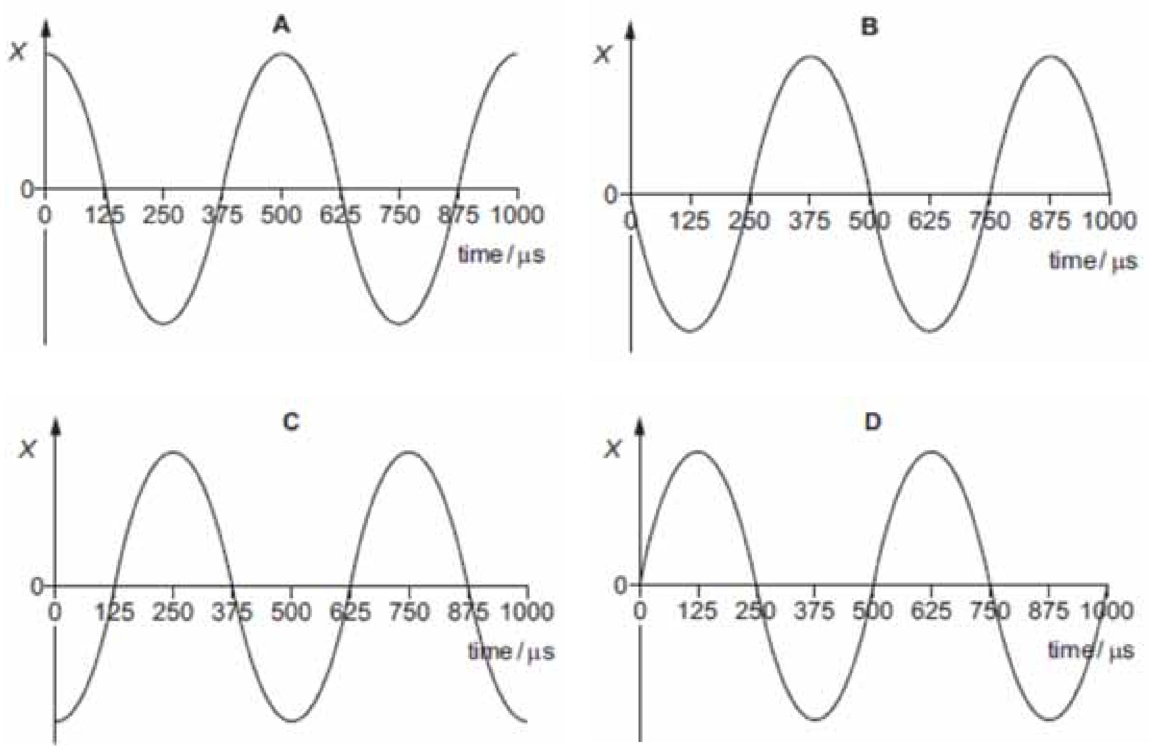
A $d\sin\theta$ **B** $d\cos\theta$ **C** $\frac{d\sin\theta}{\lambda}$ **D** $\frac{d\cos\theta}{\lambda}$

16 The graph shows the variation with time of the displacement X of a gas molecule as a continuous sound wave passes through a gas.



The velocity of sound in the gas is 330 m s^{-1}. All the graphs below have the same zero time as the graph above.

What is the displacement-time graph for a molecule that is a distance of 0.289 m further away from the source of the sound?

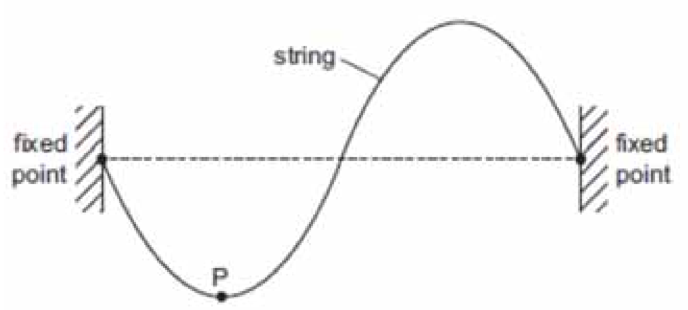


17 A plane wave of amplitude *A* is incident on a surface of area *S* placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time reaching the surface is *E*.
The amplitude of the wave is increased to 2*A* and the area of the surface is reduced to ½*S*.

How much energy per unit time reaches this smaller surface?

A 4*E* **B** 2*E* **C** *E* **D** ½ *E*

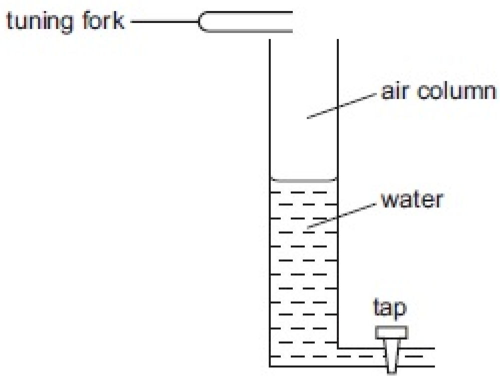
18 A stationary wave is formed on a stretched string. The diagram illustrates the string at an instant of time when the displacement of the string is at its maximum.



The frequency of the wave is 250 Hz. Point P on the string has a vertical displacement of –1.0 mm. What will be the vertical displacement of the point P after a time of 5 ms?

A –0.5 mm **B** zero **C** + 0.5 mm **D** + 1.0 mm

19 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.



The tube is filled and then water is allowed to run out of it. The first two stationary waves occur when the air column lengths are 0.14 m and 0.42 m.

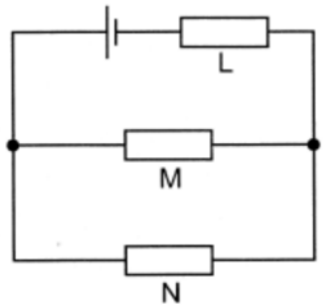
What is the wavelength of the sound wave?

A 0.14 m **B** 0.28 m **C** 0.42 m **D** 0.56 m

20 What is the **definition** of resistance?

A It is the ratio of the voltage to the current.
B It is the gradient of the graph of potential difference against current.
C It is the voltage required for a current of one ampere.
D It is the product of the resistivity of the material and the length of the wire divided by its area of cross-section.

21 In the circuit shown, a battery supplies a current of 0.025 A for 80 s. During this time it produces 18 J of electrical energy while resistor M receives 11 J and resistor N receives 4.0 J.



What is the e.m.f. of the battery and its internal resistance L?

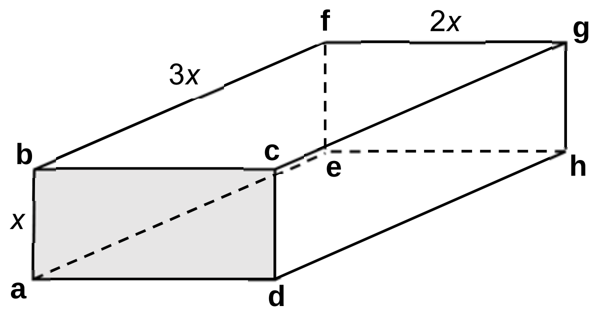
	e.m.f. of battery / V	internal resistance L of battery / Ω
A	1.5	60
B	9.0	60
C	9.0	360
D	16.5	360

22 The filament of a 240 V, 100 W electric lamp heats up from room temperature to its operating temperature. As it heats up, its resistance increases by a factor of 16.

What is the resistance of this lamp at room temperature?

A 36 Ω **B** 580 Ω **C** 1.5 kΩ **D** 9.2 kΩ

23 The diagram shows a rectangular block with dimensions x, $2x$ and $3x$. Electrical contact can be made to the block between opposite pairs of surfaces (for example, between surface **abcd** and surface **efgh**).



Between which two surfaces would the maximum electrical resistance be obtained?

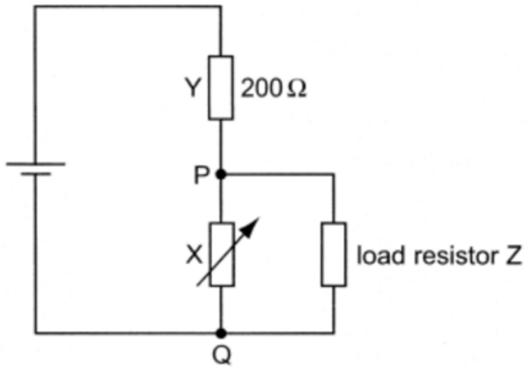
A the surfaces **bcgf** and **adhe**

B the surfaces **abcd** and **efgh**

C the surfaces **abfe** and **dcgh**

D the resistance is the same whichever pair of surfaces is used

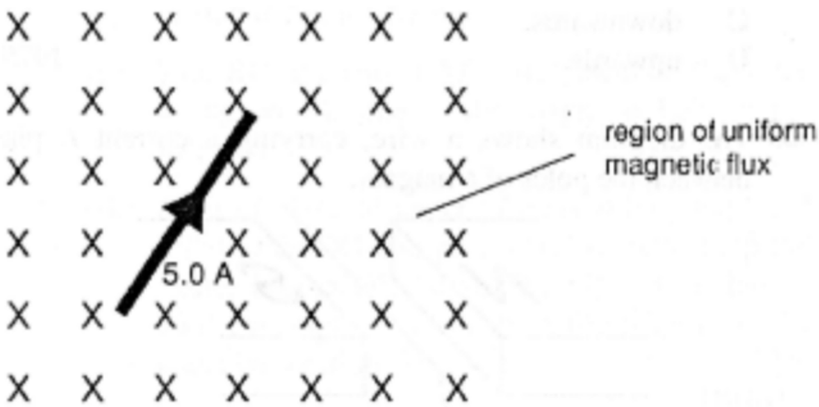
24 The circuit below consists of a 12 V battery of negligible resistance, a fixed resistor Y of resistance 200 Ω and a variable resistor X whose resistance can be changed between 100 Ω and 1200 Ω. The circuit is used to provide a variable voltage across terminals P and Q.



What range of potential differences can be obtained across the load resistor Z when its value is 400 Ω?

	maximum p.d. / V	minimum p.d. / V
A	7.2	3.4
B	10.3	4.0
C	10.7	8.6
D	12.0	8.0

25 A wire of length 3.0 cm is placed in the plane of this page while a uniform magnetic field of flux density 0.040 T acts perpendicularly into this page. The wire carries a current of 5.0 A.



What is the magnitude of the force which the field exerts on the wire?

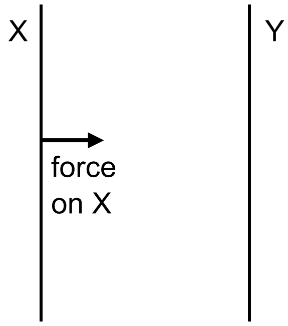
A less than 0.0060 N

B 0.0060 N

C greater than 0.0060 N but less than 0.60 N

D 0.60 N

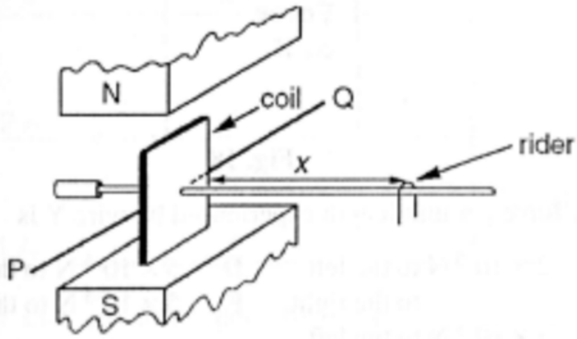
26 Two long parallel vertical wires X and Y carry currents of 3 A and 5 A respectively. The current in wire X flows upward and the force per unit length experienced by wire X is 3×10^{-5} N m^{-1} to the right as shown below.



What is the direction of the current in wire Y and the force per unit length experienced by wire Y?

	direction of current	force per unit length / N m^{-1}
A	upward	3×10^{-5}
B	downward	3×10^{-5}
C	upward	5×10^{-5}
D	downward	5×10^{-5}

27 A small square coil of N turns has sides of length L and is mounted so that it can pivot freely about a horizontal axis PQ, parallel to one pair of sides of the coil, through its centre, as shown below.



The coil is situated between the poles of a magnet which produces a uniform magnetic field of flux density B. The coil is maintained in a vertical plane by moving a rider of weight W along a horizontal beam attached to the coil. When a current I flows through the coil, equilibrium is restored by placing the rider a distance x along the beam from the coil.

Which of the following gives the correct expression for the distance x?

A $\dfrac{W}{BINL^2}$ **B** $\dfrac{W}{BINL}$ **C** $\dfrac{BINL}{W}$ **D** $\dfrac{BINL^2}{W}$

28 Which of the following statements on photoelectric effect is **not** an evidence for particulate nature of light?

A Emission of electrons happens as soon as light shines on metal.

B Increasing intensity of light increases rate at which electrons leave metal.

C Maximum speed of emitted electrons is dependent on the frequency of incident light.

D A minimum threshold frequency of light is needed.

29 The world's first interplanetary solar sail spacecraft, called IKAROS, works on the principle that photons reflected from the sail, of area *A*, undergo a change of momentum and, by Newton's Third Law, exert a forward force on the sail.

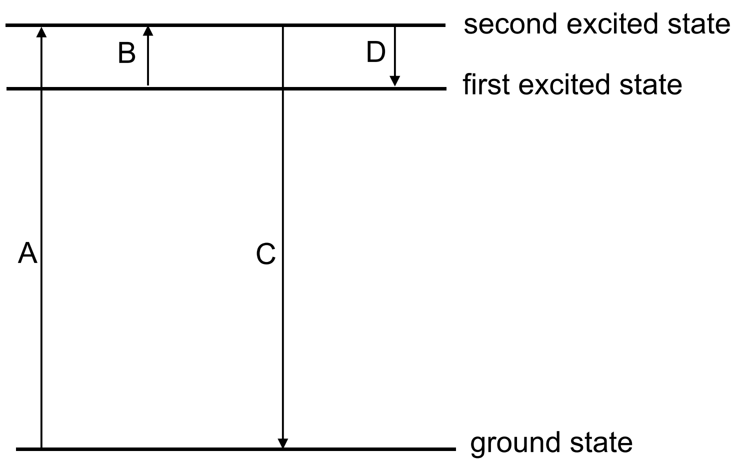
A beam of light of frequency *f* and intensity I, traveling at speed *c*, is reflected at right angles to a solar sail.

What is the force exerted on the sail?

A $\frac{IA}{hf}$ **B** $\frac{2hf}{c}$ **C** $\frac{I}{c}$ **D** $\frac{2IA}{c}$

30 The diagram below shows some possible electron transitions between three principal energy levels in the hydrogen atom.

Which transition is associated with the absorption of a photon of the longest wavelength?



2017 TJC H1 Physics Prelim Paper 1 Solutions

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

1 **D** M_{min} = 15 x (0.98 g) = 14.7 g

M_{max} = 16 x (1.02 g) = 16.3 g

$\langle M \rangle$ = 15.5 g

$\Delta M = (M_{max} - M_{min})/2 = 0.8$ g

Thus $M = 15.5 \pm 0.8$ g

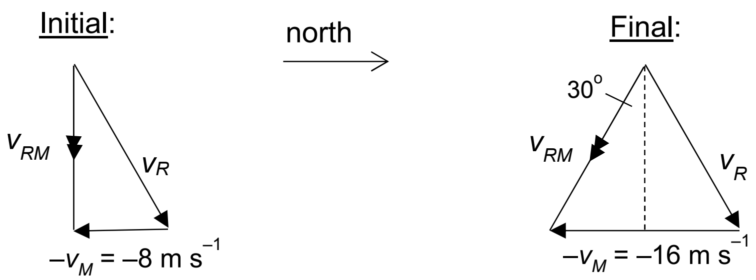
2 **D**

$$[R]^x = \left[\frac{Et^2}{\rho}\right]$$

$$\text{m}^x = \frac{(\text{kg}\,(\text{m}\,\text{s}^{-1})^2)(\text{s}^2)}{(\text{kg}\,\text{m}^{-3})} = \text{m}^5$$

$x = 5$

3 **A** Relative velocity v_{RM} of rain with respect to man is $v_{RM} = v_R - v_M$, a vector subtraction. v_R is the velocity of the rain (which stays the same) and v_M is the velocity of the man.



4 **C** Average velocity = (change in displacement) /(time taken)

= (AC) /(T) = $2L/T$

5 **D** Let T be the time interval between the drops falling from the tap. The first drop takes $2T$ (from $t = 0$ to $t = 2T$) to fall 5.00 m to ground, thus we have:

$$5.00 = \tfrac{1}{2} g(2T)^2$$

The 2nd drop would have fallen in a time of T (from $t = T$ to $t = 2T$) a distance

$$y = \tfrac{1}{2} g(T)^2$$

Solving, y = 1.25 m. Thus distance of 2nd drop from ground = 5.00 – 1.25 = 3.75 m

6 **B** At X when the tail fin breaks off, its initial velocity is the same as the rocket. Thus the gradients of the *s-t* graphs for both the rocket and the tail fin must be the same at X. Thereafter, the motion of the tail fin would be that of a vertical projectile.

7 **C** Angle that the string makes with vertical is 30°.

$$Cos30^o = \frac{W}{T} = \frac{\sqrt{3}}{2} \Rightarrow T = \frac{2W}{\sqrt{3}}$$

8 **C** For equilibrium, net force = 0, net torque about any axis = 0.
Only C satisfy these two conditions.

9 **B** Take moment about the support X,
0.5(800) + 0.9(160) + 1.80(600) = F_Y(1.40) => F_Y = 1160N.
$F_X + F_Y$ = 800 + 160 + 600 = 1560 N. Thus F_X = 400 N

10 **B** Constant velocity downwards gives:
↑+: $T - mg = 0 \Rightarrow ke_o - mg = 0 \Rightarrow ke_o = mg$ …..(1)

Slowing down, velocity downwards ⇒ acceleration points upwards:
↑+: $T_1 - mg = ma \Rightarrow ke_1 - ke_o = ma \Rightarrow k(e_1 - e_o) = ma$ …..(2)

$$(2)/(1) \Rightarrow \frac{(e_1 - e_o)}{e_o} = \frac{a}{g} \Rightarrow (e_1 - e_o) = \frac{e_o a}{g} = \frac{(50.0 - 25.0)(2.0)}{10.0} = 5.0\,\text{cm}$$

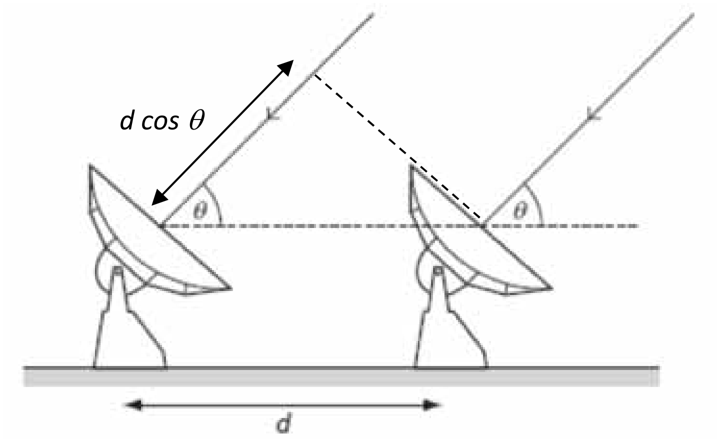
11 **C** *For head on elastic collision, relative speed of approach = relative speed of separation,*
The relative speed of approach = u – (– u) = 2u.
For answer C: relative speed of separation = 5u/3– (– u/3) = 2u.
The other options do not give relative speed of separation of 2 u.

12 **B** Answer B is not possible as the two vehicles that came to a stop at the same time cannot continue their motion again with their individual same initial momentum as that would imply the trucks had passed through each other.

13 **A** EPE = area under the force-extension graph ≈ area of triangle= ½ (0.30)13 = 2.0

14 **D** $$\eta = \frac{P_o}{P_i} = \frac{mgh/t}{P_i} = \frac{mgv}{P_i} = \ldots = 76\%$$

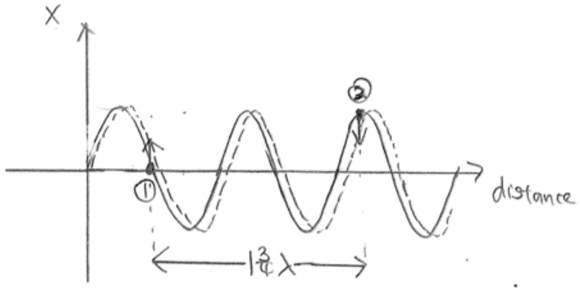
15 **B**



16 **A** $v = f\lambda$

$v = \frac{\lambda}{T} \Rightarrow \lambda = 330(500 \times 10^{-6}) = 0.165 \text{ m}$

A distance of 0.289 m $\Rightarrow$ 0.289/0.165 = 1 ¾ λ further away from source



17 **B** $P = \frac{Energy}{time} = IS \ \alpha \ A^2S$

$\frac{P'}{P} = \left(\frac{A'}{A}\right)^2 \left(\frac{S'}{S}\right)$

$\frac{P'}{E} = \left(\frac{2A}{A}\right)^2 \left(\frac{\frac{1}{2}S}{S}\right)$

$P' = 2E$

18 **B** *T = 1/f = 1/250 = 4 ms*
∴after 5 ms = 1.25 cycles

19 **D** Distance between 2 consecutive resonant positions = $\lambda/2$
$(0.42 – 0.14) = \lambda/2$
$\lambda = 0.56$ m

20 **A**

21 **B** Energy produced by cell = ε I t = *18 J*
ε x 0.025 x 80 =18 $\Rightarrow$ ε = 9.0 V

Energy dissipated in the cell = I^2r t = *18 – 11 – 4 = 3 J*
0.025^2 x r x 80 = 3
r = 60 Ω

22 **A** Let *R* be the resistance of the lamp at room temperature.
$P = V^2 / (16R)$
$100 = 240^2 / (16R) \Rightarrow R = 36\ \Omega$

23 **B** $R = \rho L / A$
For maximum resistance, *L* should be maximum and *A* should be minimum.

24 **A** *When* R_X = *1200 Ω, effective resistance across PQ = 300 Ω.*
p.d. across PQ = 300/500 × 12 = 7.2 V.

When R_X = *100 Ω, effective resistance across PQ = 80 Ω.*
p.d. across PQ = 80/280 × 12 = 3.4 V.

25 **B** F = BIL sin θ
= 0.040 × 5.0 × 3.0 × 10^{-2} sin 90^o = 0.0060 N

26 **A** *Applying Newton's third law, force on Y is towards X. Force per unit length experienced by Y is the same as that experienced by X and current in Y flows in the same direction as that in X.*

27 **D** *Taking moments about axis PQ,*
clockwise moment due to W = *anticlockwise moment due to magnetic force* F *acting on the pair of sides parallel to axis PQ*

$$Wx = FL$$
$$= (BILN)\,L$$
$$x = BINL^2/W$$

28 **B**

29 **D** momentum of photon = $h/\lambda = hf/c$

change in momentum on rebound from sail = 2 *hf/c*

Intensity $I = nhf/A$ where n = number of photons incident per unit time

force = total rate of change of momentum = $n \times 2\,hf/c = IA/hf \times 2\,hf/c = 2\,IA/c$

30 **B** For absorption of a photon to take place, the energy transition is from a lower energy level to a higher energy level. For absorption of a photon with highest wavelength, the difference between the 2 energy levels is the smallest. i.e. $\Delta E = \frac{hc}{\lambda}$

TEMASEK JUNIOR COLLEGE

2017 Preliminary Examination
Higher 1

CANDIDATE NAME			
CIVICS GROUP		INDEX NUMBER	

PHYSICS — 8866/02

Paper 2 Structured Questions

12 September 2017
2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your Civics group, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, 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.

You are advised to spend about one hour on each section.

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	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

This document consists of **21** printed pages.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-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	=	ρgh
resistors in series	R	=	$R_1 + R_2 + ...$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + ...$

Section A

Answer **all** the questions in the spaces provided.

1 To investigate how well a basketball can bounce after hitting a hard surface, a student drops the basketball from a fixed height h_1 and measures the rebound height h_2. The experimental setup is shown in Fig. 1.1.

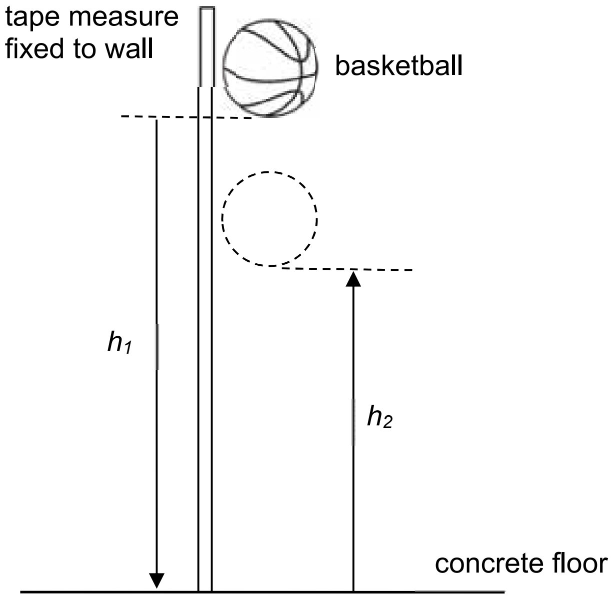


Fig. 1.1

Theory suggests that h_1 and h_2 are related by the expression

$$h_2 = e^2 h_1$$

where e is a constant known as the *coefficient of restitution*.

The following results are obtained by the student:

$h_1 = 200 \pm 1$ cm
$h_2 = 135 \pm 5$ cm

(a) Suggest why the uncertainty for h_2 is larger than that for h_1.

....

....

.... [1]

(b) **(i)** Calculate the value of e.

e = ... [1]

(ii) Calculate the actual uncertainty in e.

actual uncertainty in e = ... [2]

(iii) State the value of e and its actual uncertainty to the appropriate number of significant figures.

e = ... ± .... [1]

(c) The student decides to obtain further sets of readings for different h_1 and h_2. A graph of h_2 against h_1 is plotted, as shown in Fig. 1.2. From the graph, the gradient of the best-fit line is determined and the value of e^2 and hence e is obtained.

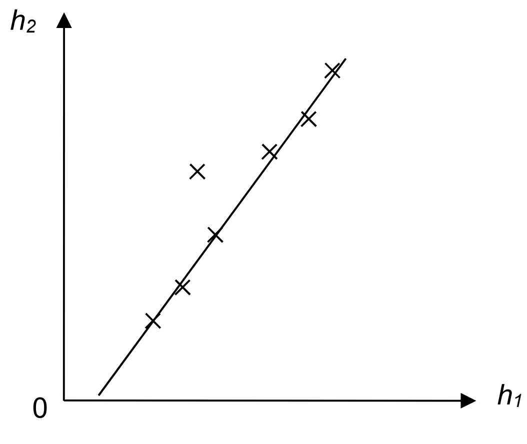


Fig. 1.2

Suggest two advantages that plotting this graph might provide, compared to just using a single set of data for h_1 and h_2 to compute e.

1. ....

....

2. ....

....

[2]

2 A train passenger is running at a maximum velocity of 3.0 m s^{-1} to catch a train. At time t = 0 s, when the passenger is at a distance d from the nearest entrance of the train, the train starts from rest with a constant acceleration of 0.30 m s^{-2} away from the passenger. The passenger just catches the train to jump into the nearest entrance.

(a) Fig. 2.1 shows the variation with time t of the displacement of the nearest entrance of the train.

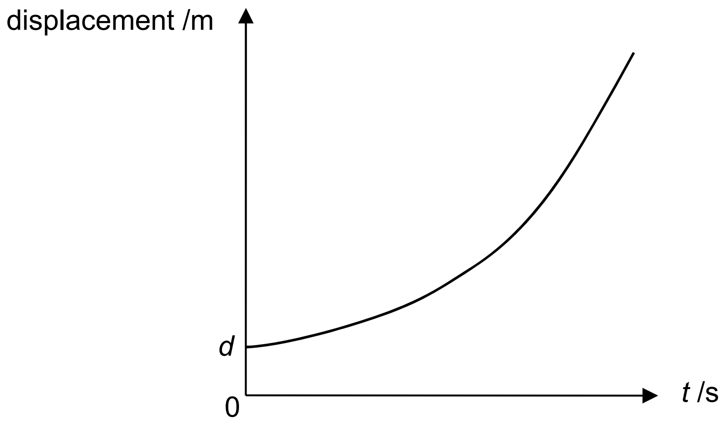


Fig. 2.1

Sketch on Fig. 2.1 a line showing the variation with time t of the displacement of the passenger. Label the line P. [1]

(b) Determine how long it will take the passenger to catch the train.

time = ... s [3]

(c) Hence calculate the distance d.

d = ... m [3]

3 Fig. 3.1 shows an arrangement which can be used to determine the speed of sound in air.

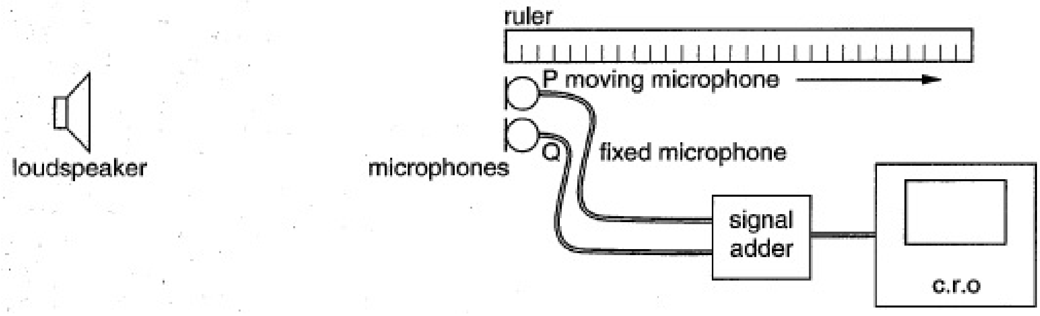


Fig. 3.1

The loudspeaker emits a sinusoidal sound wave. The electrical signals from the two microphones P and Q are added together in the electronic "signal adder" and the resultant signal is displayed on the cathode-ray oscilloscope (c.r.o.) screen. This process may be regarded as equivalent to the superposition of the waves.

Microphone Q is **fixed** and microphone P is **slowly moved** back along the edge of the ruler.

(a) Fig. 3.2 shows the appearance of the trace on the c.r.o. when both microphones are at the left hand end of the ruler, that is, the same distance from the loudspeaker.

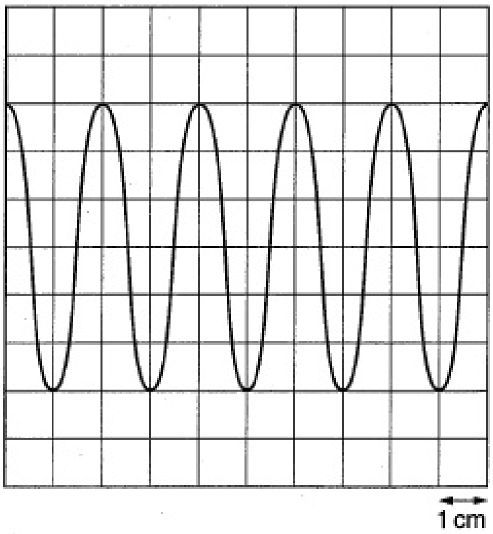


Fig. 3.2

The time-base setting of the c.r.o is 0.2 ms cm^{-1}. Determine the frequency of the sound wave.

frequency = ... Hz [2]

(b) As P is moved slowly along the edge of the ruler, the amplitude of the trace is seen to decrease, then increase, then decrease and so on.
Explain

(i) why the amplitude is a maximum when P and Q are at the left hand of the ruler,

....

....

.... [2]

(ii) why the amplitude of the trace varies.

....

....

.... [2]

(c) The first minimum of the amplitude occurs when P is at a distance of 6.8 cm from the left hand end of the ruler. Determine

(i) the wavelength of the sound.

wavelength = ... m [2]

(ii) the speed of the sound in air.

speed = ... m s^{-1} [1]

4 **(a)** **(i)** A force acts on a long, straight copper wire carrying a current I at an angle θ to a uniform magnetic field of flux density B.
Write down the expression for the force per unit length of the wire in terms of B, I and θ.

force per unit length of wire = ... [1]

(ii) Hence define the *tesla*.

....

....

.... [1]

(b) Fig. 4.1 shows a moving-coil loudspeaker.

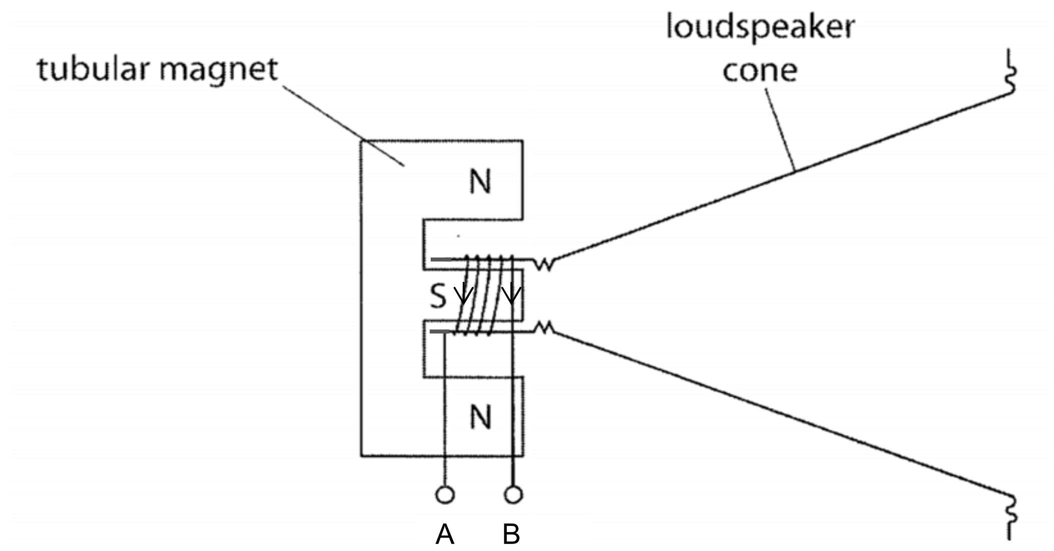


Fig. 4.1

The tubular magnet provides a radial magnetic field between the poles. A coil of copper wire surrounds the south pole of the tubular magnet. A current of 25 mA is passed through the coil from terminal A to terminal B. Each turn of the copper wire experiences a constant magnetic field of flux density 28 mT. The copper coil has a mean diameter of 16.4 mm and 250 turns.

(i) State and explain the direction of the force experienced by the coil of wire.

....

....

....

.... [2]

(ii) Calculate the force experienced by the coil of wire.

force = ... N [3]

5 According to some scientists, battery-powered cars offer many advantages over petrol driven cars. Rechargeable lead batteries are the most common type of batteries used in cars. The data below shows some properties of petrol, of a particular lead-acid battery and of a typical car.

Petrol
density = 700 kg m^{-3}
chemical energy available = 45 MJ kg^{-1}

Typical lead-acid battery
energy available when fully charged = 2.8 MJ
mass = 20 kg
e.m.f. = 12 V

Car
volume of petrol tank = 4.0×10^{-2} m^3
efficiency of transfer of chemical energy of petrol to kinetic energy of car = 25 %
drag force at 30 m s^{-1} = 580 N

(a) Calculate the chemical energy available from a full tank of petrol.

energy = ... MJ [2]

(b) A fully-charged car battery delivers a constant current of 8.0 A. Calculate the time in hours before the battery needs to be charged again.

time = ... h [2]

(c) **(i)** Calculate the total mass of lead-acid batteries needed to provide the same energy as a full tank of petrol.

mass = ... kg [1]

(ii) Suggest how your answer to **(i)** may affect the performance of a battery-powered car.

....

.... [1]

(d) Calculate the total distance in km travelled by the car on a full tank of petrol when traveling at a constant speed of 30 m s^{-1} on a level road.

distance = ... km [2]

(e) The drag force on the car is directly proportional to the square of its speed. Show that a reduction of speed by 20% can lead to a power saving of almost 50%.

Section B

Answer **two** questions from this section.

6 A group of students built a catapult to test its capability as a launcher. In one of their test launches, a ball was successfully projected over a 5.0 m wall. The ball was released 1.0 m above the ground with an initial velocity u at an angle θ to the horizontal. At the highest part of the trajectory, the ball managed to just go over the wall with a horizontal speed of 10 m s^{-1}. Assume that air resistance is negligible.

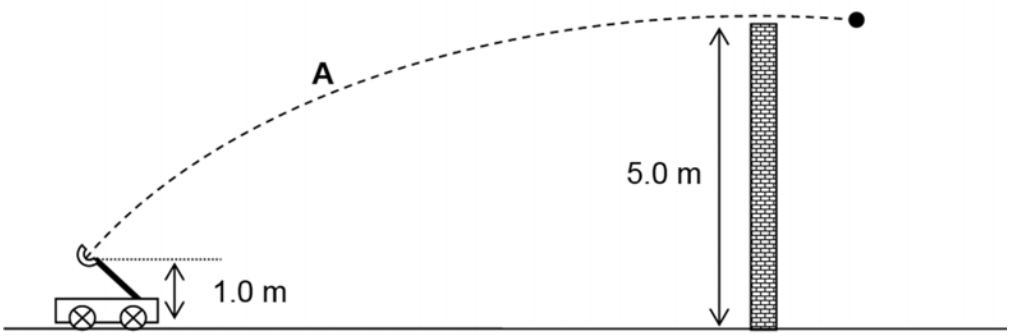


Fig. 6.1

(a) Describe the shape of the trajectory (labelled A) of the ball.

....

.... [1]

(b) Calculate

(i) the vertical component of the initial velocity u,

vertical component of u = ... m s^{-1} [2]

(ii) the angle θ of projection,

θ = ... ° [2]

(iii) the time taken for the ball to reach top of the wall, and

time taken = ... s [2]

(iv) the horizontal distance between the wall and the point of projection.

horizontal distance = ... m [2]

(c) If air resistance was significant, sketch the path of the trajectory on Fig. 6.1 and label it B. State two differences between trajectories A and B.

....

....

.... [3]

(d) The estimated normal contact force acting on the ball upon hitting the floor is shown in Fig. 6.2. Assume that the floor is frictionless.

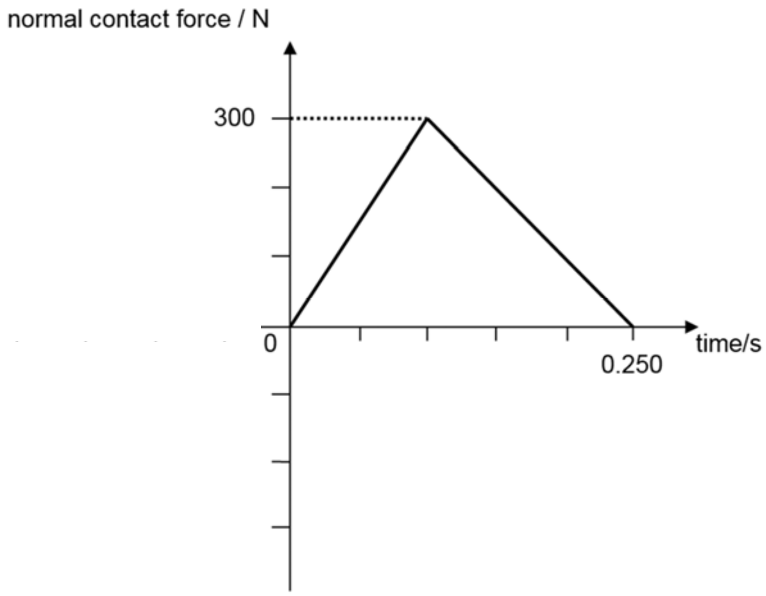


Fig. 6.2

(i) Sketch on Fig.6.2 the normal contact force exerted by the ball on the floor. [1]

(ii) Define *impulse*.

....

.... [1]

(iii) Determine the impulse delivered to the ball in the vertical direction.

vertical component of impulse = ... N s [2]

(iv) Hence find the average normal contact force acting on the ball.

average normal contact force = ... N [2]

(v) Describe the energy changes during the collision of the ball with the floor.

....

....

....

....

.... [2]

7 **(a)** **(i)** Explain why some solids are electrical conductors while some are insulators.

....

.... [1]

(ii) Describe how electrical conduction occurs in a metal.

....

....

.... [2]

(b) A certain electric hotplate, designed to operate on a 250 V supply, has two coils of nichrome wire of resistivity 9.8×10^{-7} Ω m. Each coil consists of 16 m of wire of cross-sectional area 0.20 mm^2.

For one of the coils, calculate

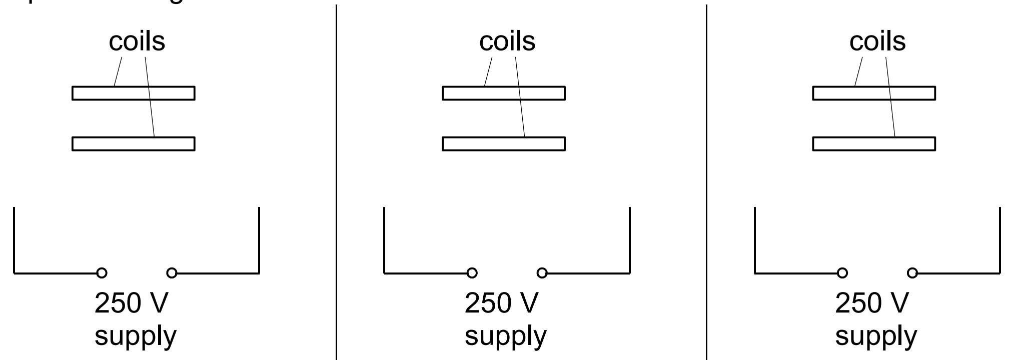
(i) its resistance,

resistance = ... Ω [2]

(ii) the power dissipated when a 250 V supply is connected across the coil, assuming its resistance does not change with temperature.

power dissipated = ... W [2]

(c) Complete the circuits in Fig. 7.1 to show how the coils in **(b)** may be arranged so that the hotplate may be made to operate at three different powers. In each case calculate the power rating.



power rating = ________ W | power rating = ________ W | power rating = ________ W

Fig. 7.1 [5]

(d) The hotplate in **(b)** is connected to the 250 V supply by means of cable of resistance 3.0 Ω.

(i) Calculate the power loss in the connecting cable when the hotplate is being used on its **middle power rating** in **(c)**.

power loss = ... W [3]

(ii) Comment qualitatively on any change in power loss in the cable when the hotplate is operating at each of its other power ratings in **(c)**.

....

....

....

....

.... [3]

(e) Different connecting cables are available for use with the hotplate in **(b)**. The maximum safe current which can be used in any one of the cables is 1 A or 3 A or 6 A or 12 A. State which is the most appropriate cable to use and briefly explain one possible danger of using cable with a lower maximum safe current.

....

....

....

.... [2]

8 **(a)** By reference to the photoelectric effect, explain

(i) what is meant by *work function energy*,

....

....

.... [2]

(ii) why, even when the incident light is monochromatic, the emitted electrons have a range of kinetic energy up to a maximum value.

....

....

.... [2]

(b) Electromagnetic radiation of frequency *f* is incident on a metal surface. The variation with frequency *f* of the maximum kinetic energy E_{MAX} of electrons emitted from the surface is shown in Fig. 8.1.

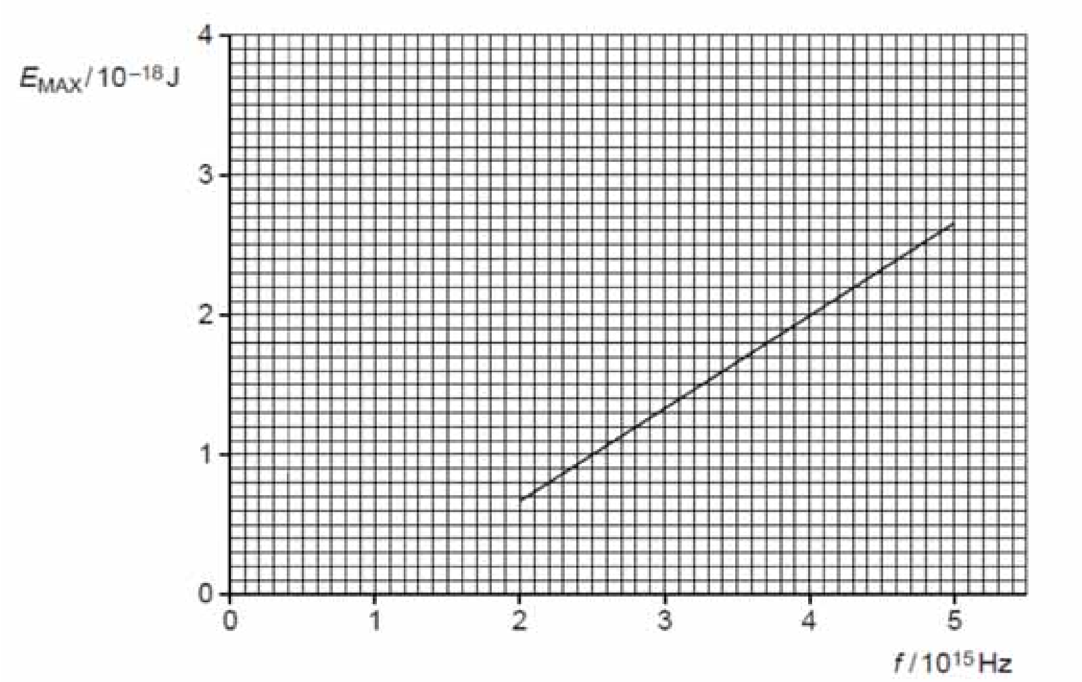


Fig. 8.1

(i) Use Fig. 8.1 to determine the work function energy of the metal surface.

work function energy = ... J [3]

(ii) A second metal has a greater work function energy than that in **(i)**.
On Fig. 8.1, draw a line to show the variation with *f* of E_{MAX} for this metal. [2]

(iii) Explain why the graphs in **(i)** and **(ii)** do not depend on the intensity of the incident radiation.

....

....

.... [2]

(c) **(i)** State what is meant by the *de Broglie wavelength*.

....

.... [1]

(ii) An electron is accelerated in a vacuum from rest through a potential difference of 850 V. Calculate the de Broglie wavelength of this electron.

wavelength = ... m [4]

(iii) Describe an experiment to demonstrate the wave nature of electrons.
You may draw a diagram if you wish.

....

....

....

....

....

....

.... [4]

Solutions to TJC 2017 H1 Physics Prelim Paper 2

1 **(a)** The basketball started at rest at the height of h_1, thus the uncertainty for its position when measuring h_1 is small. B1

It is however <u>difficult to determine when the ball has come to rest</u> on its rebound, thus <u>the final position of the ball</u> and hence the height h_2 has a larger uncertainty.

-*Other possible suggestion: <u>ball might not bounce perpendicularly to floor</u>, thus the <u>measured rebound height might not be accurate, and has a larger uncertainty</u>.*

-note that the measurement of h_2 involves the determination of <u>2 position readings, that at the start and also the maximum height position</u>. h_2 is also required to be <u>perpendicular to the ground</u>. Thus any factor that affects the reading of the 2 positions, or affects the perpendicular bounce of the ball would add to the uncertainty.

(b) **(i)**

$$e = \sqrt{\frac{h_2}{h_1}} = \sqrt{\frac{135}{200}} = 0.822$$ A1

(ii)

$$\frac{\Delta e}{e} = \frac{1}{2}\left(\frac{\Delta h_2}{h_2} + \frac{\Delta h_1}{h_1}\right)$$ C1

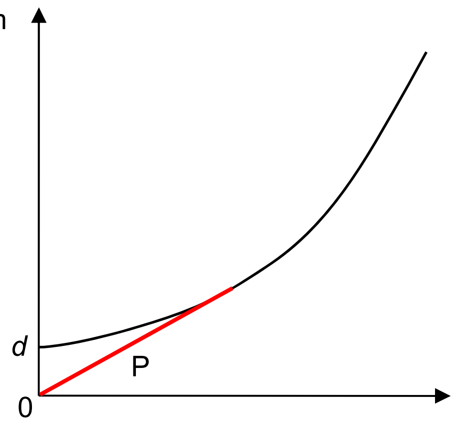
$$\Delta e = \frac{1}{2}\left(\frac{5}{135} + \frac{1}{200}\right)(0.822) = 0.02$$ A1

(iii) $e = 0.82 \pm 0.02$ A1

(c) Any 2 of the following points: B2

- The graph provides a confirmation of the linear relationship between h_1 and h_2.
- The best-fit line reduces the effects of random errors in the reading of each data point.
- The graph uncovers outlying data points, which could then be further investigated.
- The graph did not pass through the origin, as predicted by the given equation. This could indicate the presence of systematic error in the experiment.

2 **(a)**



B1

P is a straight line just touching the bottom of the displacement-time graph of the train. The straight line should not extend beyond the point of contact as the passenger would have boarded the train.

(b) When the passenger 'just' catches the train, $v_P = v_T$ C1
3.0 = (0) + (0.30)t C1
t = 10 s A1

(c) $s_P = d + s_T$ C1
(3.0)(10) = d + [(0)(10) + ½ (0.30)(10)^2] C1
d = 15 m A1

3 **(a)** One cycle is represented by 2 cm.
Thus period = 2 x 0.2 x 10^{-3} = 4.0 x 10^{-4} s C1
f = 1/T = 1/4.0 x 10^{-4} = 2500 Hz A1

(b)(i) P and Q are the same distance from speaker, thus the sound waves arrive in phase/zero path difference. B1
Constructive interference occurs. B1

(b)(ii) As P is moved, the path difference changes. B1
Minima when P moves odd number of ½ λs, and maxima if P moves whole number of λs. B1
OR Phase difference of waves arriving at P and Q changes; minima when waves meet out of phase & maxima when waves meet in phase)

(c)(i) First minimum corresponds to ½ λ path difference. C1
Wavelength = 2 x 6.8 = 13.6 cm = 0.136 m A1

(c)(ii) v = fλ = 2500 (0.136) = 340 ms^{-1} A1

4 **(a)** **(i)** force per unit length of wire = $B I \sin\theta$ A1

(ii) The tesla is the uniform magnetic flux density which, acting normally to a long straight wire carrying a current of 1 A, causes a force per unit length of 1 N m^{-1} to act on the wire. B1

(b) **(i)** consider top part of coil: I in wire flows out of page and B points down.
<u>or</u> consider bottom part of coil: I in wire flows into page and B points up. M1
(From Fleming's left-hand rule) force on coil points to the right. A1

(ii) $F = B I L (\sin\theta) \times N$
$= 28 \times 10^{-3} \times 25 \times 10^{-3} \times (\pi \times 16.4 \times 10^{-3}) \times 250$ C2
$= 9.0 \times 10^{-3}$ N (2 or 3 s.f.) A1

5 **(a)** Chemical energy = density x volume x 45 MJ kg^{-1} C1
= 700 (4.0 x 10^{-2}) (45) = 1260 MJ A1

(b) $E = Pt$ C1

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

$$= \frac{2.8 \times 10^6}{(8.0)(12)} \text{ s}$$

$$= \frac{2.8 \times 10^6}{(8.0)(12)(60 \times 60)}$$

$= 8.1$ hours A1

(c)(i) $mass = \frac{1260}{2.8} \times 20 = 9000$ kg A1

(ii) The total mass of the car becomes very large. Thus the acceleration of the car will be small and it will take a longer time for it to attain its required speed. B1

(d) To travel at constant speed of 30 m s^{-1} $\Rightarrow F_{drive} = f_{drag} = 580$ N C1
Kinetic energy of the car is used to do work against drag forces.
$\therefore$ KE = $f \times d$
$0.25(1260 \times 10^6) = 580 \times d$
$d = 5.43 \times 10^5$ m = 543 km A1

(e) $f_{drag} = kv^2$
$P = F_{drive} \times v = f_{drag} \times v = (kv^2)v = kv^3$ C1

$$\frac{P'}{P} = \left(\frac{v'}{v}\right)^3 = \left(\frac{0.80v}{v}\right)^3 = 0.512$$ M1

$\therefore$ power savings = (1- 0.512) P = 0.488 P or 48.8 % A0

6 **(a)** *Shape of the trajectory is parabolic* B1

(b) **(i)** $\uparrow +\ \ v_Y{}^2 = u_Y{}^2 + 2gS$ C1

$\Rightarrow 0 = u_Y{}^2 + 2(-9.81)(5.0 - 1.0)$ A1

$\Rightarrow u_Y = 8.86\ \text{m s}^{-1}$

(ii) $\tan\theta = \dfrac{u_Y}{u_X} = \dfrac{8.86}{10}$ C1 A1

$\Rightarrow \theta = 41.5^o$

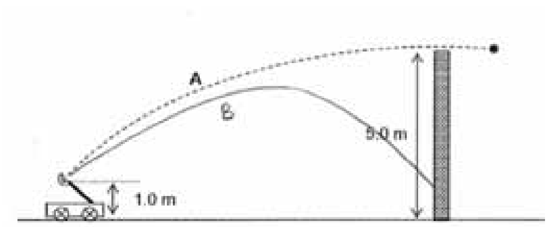
(iii) $\uparrow +\ \ 0 = u_Y + gt = 8.86 + (-9.81)t$ C1

$\Rightarrow t = 0.903\ \text{s}$ A1

(iv) $->+\ \ s_X = u_X t$ C1

$= 10(0.903) = 9.03\ \text{m}$ A1

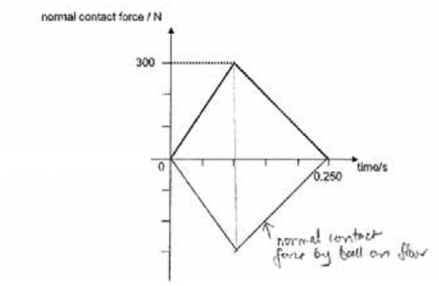
(c) B1 B1 B1



*Compared to **A, B** has shorter range.*

*Peak for **B** occurs earlier and is of lower height*

(d) **(i)** B1



(ii) Impulse is the product of the force acting on a body and the time interval during which the force is exerted. (It is given by the area under the force–time graph.) A1

(iii) Impulse = area under *F* - *t* graph C1

$= \frac{1}{2}(0.250)300 = 37.5\ \text{N s}$ A1

(iv) *<F>t = impulse* C1

<F>0.250 = 37.5 => <F> = 150 N A1

(v) During collision, KE of the ball is converted into sound energy, thermal energy and elastic PE as the ball deforms. A2

Part of the elastic PE is returned to the ball as KE on rebound.

7 **(a)** **(i)** Electrical conductors contain abundant charge carriers (eg. free electrons in a metal) whereas insulators have no charge carriers. B1

(ii) Electrical conduction in a metal arises due to the flow of free electrons through a lattice of fixed positive ions. M1 A1

(b) **(i)**

$$R = \frac{\rho L}{A} = \frac{9.8 \times 10^{-7} \times 16}{0.20 \times 10^{-6}}$$ C1

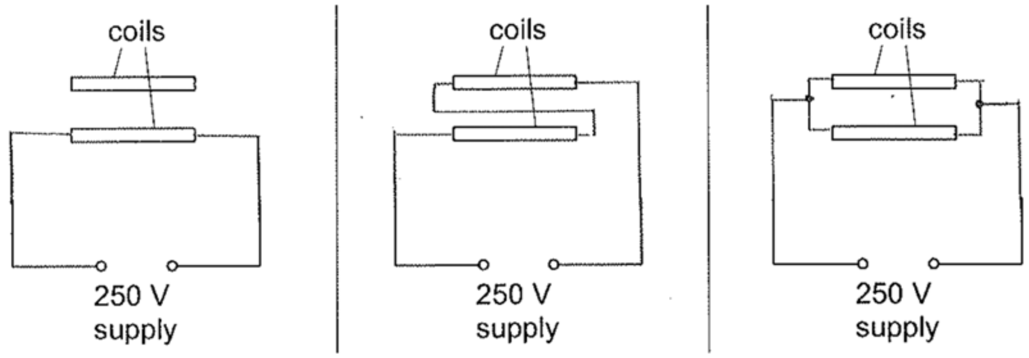
$= 78.4\ \Omega$ A1

(ii)

$$P = \frac{V^2}{R} = \frac{250^2}{78.4}$$ C1

$= 797$ W A1

(c)



power rating = 797 W	power rating = 399 W	power rating = 1590 W

B1 - each correct circuit diagram
A1 - correct power rating for series
A1 - correct power rating for parallel arrangement
-1 mark if power rating for one coil is not given

(d) **(i)**

$$P_{loss} = I^2 r = \left(\frac{250}{78.4 + 3.0}\right)^2 \text{ X } 3.0$$ C2

$= 28.3$ W A1

(ii) When the coils are in series, the total resistance of both coils doubles and so the current from the supply decreases. M1
When the coils are in parallel, the total resistance of both coils halves and so the current from the supply increases. M1
Hence the power loss decreases in the series arrangement but increases in the parallel arrangement. A1

	(e)		Most appropriate cable – 6 A	B1
			If a cable with a lower maximum safe current is used, then for two of the arrangements of the coils, the current in the circuit would exceed this value. The cable will overheat and might cause a fire.	B1
8	**(a)**	**(i)**	minimum photon energy	B1
			to remove an electron from the metal surface	B1
		(ii)	Either maximum kinetic energy = photon energy – work function energy Or electron has maximum kinetic energy when ejected from surface	B1
			Electrons within metal require energy to bring them to surface and so have lower energies than maximum KE.	B1
	(b)	**(i)**	threshold frequency = 1.00×10^{15} Hz (allow $\pm 0.05 \times 10^{15}$ Hz)	C1
			work function energy = hf_0 $= 6.63 \times 10^{-34} \times 1.00 \times 10^{15}$	C1
			$= 6.63 \times 10^{-19}$ J	A1
			(allow alternative approaches based on use of coordinates of points on the line)	
		(ii)	straight line with same gradient	M1
			displaced to right	A1
		(iii)	For the same incident frequency, intensity determines number of photons arriving per unit time and	B1
			therefore it affects number of electrons emitted per unit time (not maximum kinetic energy of electrons).	B1
	(c)	**(i)**	Either wavelength (of a wave) associated with a particle that is moving Or wavelength (of a wave) associated with a particle having momentum *p* given by $\lambda = h/p$ where *h* is the Planck's constant.	B1
		(ii)	energy of electron = $850 \times 1.60 \times 10^{-19}$ $= 1.36 \times 10^{-16}$ J	M1
			energy = $p^2 / 2m$ or $p = mv$ and $KE = \frac{1}{2} mv^2$ momentum = $\sqrt{(1.36 \times 10^{-16} \times 2 \times 9.11 \times 10^{-31})}$ $= 1.57 \times 10^{-23}$ N s	M1
			$\lambda = h / p$ wavelength = $(6.63 \times 10^{-34}) / (1.57 \times 10^{-23})$	C1
			$= 4.2 \times 10^{-11}$ m	A1
		(iii)	description (and diagram) showing: electron beam in a vacuum incident on thin metal target / carbon film	B1
			fluorescent screen	B1
			pattern of concentric rings observed	M1

pattern similar to diffraction pattern observed with visible light. A1