Parent's Signature …………………..

Candidate's Name ………………………………………… CTG …………..…

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2016

PHYSICS **8866/2**
HIGHER 1 **19 August 2016**
Paper 2 **Friday**
Structured Questions **2 hours**

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

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.
Write your name and CTG 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 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.

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.

Paper 2	
Section A	
Q1	**/5**
Q2	**/11**
Q3	**/6**
Q4	**/6**
Q5	**/6**
Q6	**/6**
Section B	
Q7	**/20**
Q8	**/20**
Q9	**/20**
Penalty	
Total	
	/80
	%

This question paper 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	=	$\rho g h$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
Resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$

Section A

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

1 A student times the fall of a small metal ball. Data for the time t taken for the ball to fall through a vertical distance h from rest are given below.

h = (348 ± 1) cm
t = (0.842 ± 0.001) s

Use these data to determine

(a) the acceleration of free fall, g to five significant figures.

$$h = \frac{1}{2} g t^2$$

$$g = \frac{2h}{t^2} = \frac{2 \times 3.48 \times 10^{-2}}{0.842^2} \quad [1]$$

$$= 9.8171 \text{ m s}^{-2} \quad [1]$$

g = ……………………………….. m s^{-2} [2]

(b) the value of g and its uncertainty, to an appropriate number of significant figures.

$$\frac{\Delta g}{g} = \frac{\Delta h}{h} + 2\frac{\Delta t}{t}$$

$$\frac{\Delta g}{9.8171} = \frac{1}{348} + 2 \times \frac{0.001}{0.842} \quad [1]$$

Δg = 0.0052489 = 0.006 s (round up to 1 S.F) [1]

g = 9.817 ± 0.006 s (round off to same d.p as error) [1]

g = ……………………………… ± ……………………….. m s^{-2} [3]

2 The graph of Fig 2.1 shows the variation with time t of the velocity v of a ball from the moment it is thrown with velocity v of 26 m s^{-1} vertically upwards.

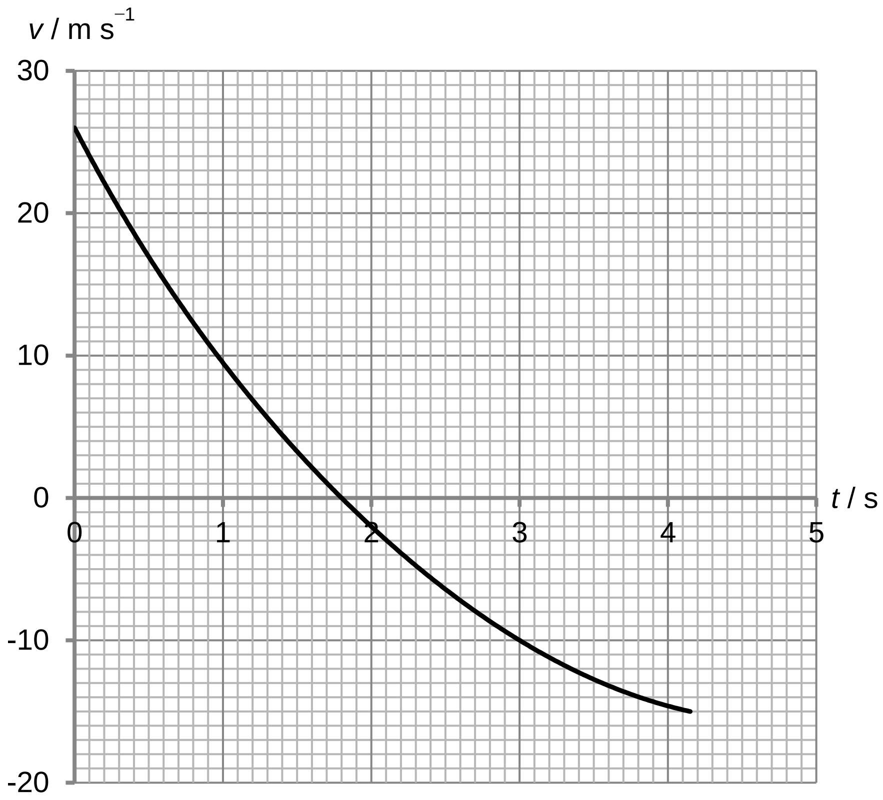


Fig. 2.1

(a) State the time at which the ball reaches its maximum height.

At max height, v = 0
From the graph, ***t* = 1.8 s** when v = 0.

time = …………………… s [1]

(b) Just after the ball leaves the thrower's hand, it has a downward acceleration of approximately 20 m s^{-2} which is much larger than g. Explain how this is possible.

<u>Downward drag force</u> due to air resistance is acting on it. [1]

The <u>resultant force</u> which equals to the sum of the weight and the drag force is

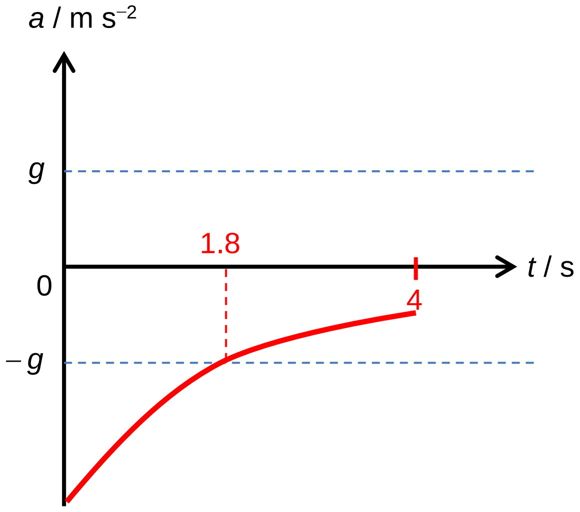
larger than the weight. [1] Hence the acceleration is larger than g. [2]

(c) It is found that the acceleration at t = 1.8 s is g. Explain how this is possible.

The velocity of object is zero, hence no drag force is acting on it. [1]

The resultant force acting on the object equals to the weight [1] Hence the acceleration equals to g. [2]

(d) Sketch the acceleration-time graph and displacement-time graph in Fig. 2.2 for the motion from t = 0 to t = 4 s, following the sign convention taken for the velocity-time graph in Fig. 2.1. The value of g is marked out in the acceleration-time graph. Label other critical values. [6]



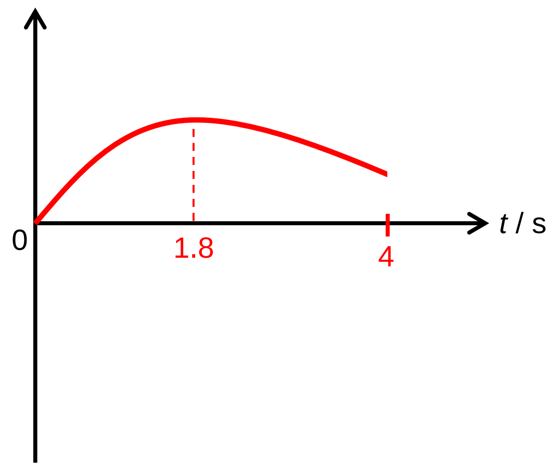
Max 3 marks

Curve with decreasing gradient – 1M

Shown cutting value of g at t = 1.8 s + labelling of 1.8 s & 4 s – 1M

Understanding the sign convention – 1M

If drawn cutting the time-axis at any point including t = 4s will have 1M deducted.



Max 3 marks

Asymmetrical curve skewed towards left – 1M

Shown max height at t = 1.8 s + labelling of 1.8 s & 4 s – 1M

If graph cuts time-axis at t = 4s will have 1M deducted.

Fig. 2.2

3 A light helical spring is suspended vertically from a fixed point, as shown in Fig. 3.1.

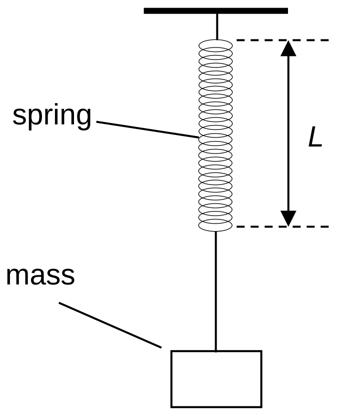


Fig. 3.1

Different masses are suspended from the spring. The weight *W* of the mass and the length *L* of the spring are noted.

The variation with the weight *W* of the length *L* is shown in Fig. 3.2

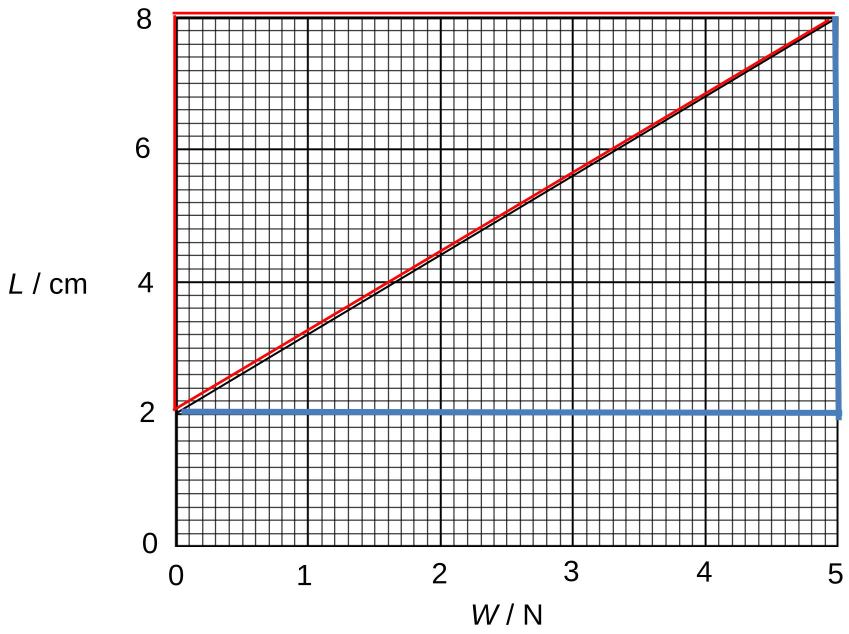


Fig. 3.2

(a) On Fig. 3.2, shade the area in the graph that represents the energy stored in the spring when the weight on the spring is increased from zero to 5.0 N. [1]

The area bounded by the red lines

(b) A mass of weight 4.0 N is suspended from the spring.

When the mass is stationary, a force is then applied to pull the mass downwards through a distance of 1.0 cm and held stationary.

At this position,

(i) Determine the total length of the spring.

When 4.0 N is suspended, the length of the spring = 6.8 cm
Hence total length = 6.8 + 1.0 = 7.8 cm

length = ……………………………. cm [1]

.

(ii) Determine the total elastic potential energy of the spring.

$$\text{spring constant} = \frac{\text{force}}{\text{extension}}$$

$$= \frac{5}{(0.08 - 0.02)} = 83.333 \text{ N m}^{-1} \qquad [1]$$

$$\text{elastic potential energy} = \frac{1}{2} k x^2$$

$$= \frac{1}{2} (83.333)(0.078 - 0.02)^2 \qquad [1]$$

$$= 0.14 \text{ J}$$

elastic potential energy = ………………………………… J [2]

(iii) Determine the force required to hold the mass stationary.

$$T = k x$$
$$= (83.333)(0.078 - 0.02) \qquad [1]$$
$$= 4.8333 \text{ N}$$

$$T = W + F_{applied}$$
$$4.8333 = 4.0 + F_{applied} \qquad [1]$$
$$F_{applied} = 0.833 \text{ N}$$

Force = ……………………………….. N [2]

4 A common game in carnivals is the "high striker" whereby a player uses a hammer to hit a target pad at one end of a lever in order to launch a puck at the other end. The player wins if the puck hits the bell at the top of a tower. This is illustrated in Fig. 4.1.

In one such carnival, the hammer and puck weigh 9.00 kg and 0.40 kg respectively. The bell is located 5.00 m above the puck.

A student plays the game and just manages to ring the bell.

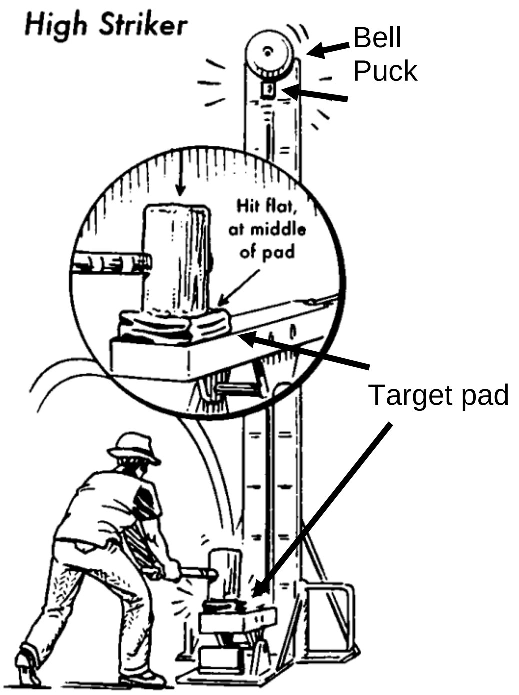


Fig. 4.1

(a) Determine the gain in gravitational potential energy of the puck.

Gain in g.p.e.= $m\,g\,h$
$= 0.4 \times 9.81 \times 5.00$ [1]
$= 19.6$ J

gain in gravitational potential energy = ………… J [1]

(b) Suppose that 75% of the final kinetic energy of the hammer is transformed into thermal and sound energy, calculate the speed of impact of the student's hammer with the lever.

$0.25 \times$ Loss in k.e. $= 19.6$ [1]
$\Rightarrow 0.5\,m\,v^2 = 78.4$ [1]
$\Rightarrow v = 4.2$ m/s [1]

speed of impact = ……………. m s^{-1} [3]

(c) Suggest and explain one modification in which the game can be made more difficult to win.

Any reasonable answer.
The mass of the puck could be increased. [1]
More energy is required to launch the puck to the top of the tower. [1] [2]

5 (a) When a circuit is connected using an e.m.f. cell with an internal resistor, the following equation is used:

$$V = E - Ir$$

. whereby E is the e.m.f., r the internal resistance and I the mains current. State what V represents.

The potential difference (p.d.) across the cell's terminals or p.d. across the resistor ....[1]

(b) A voltmeter connected across the terminals of a cell reads 1.61 V. The reading drops to 1.34 V when a 3.0 Ω resistor is connected in parallel with the voltmeter as shown in Fig. 5.1.

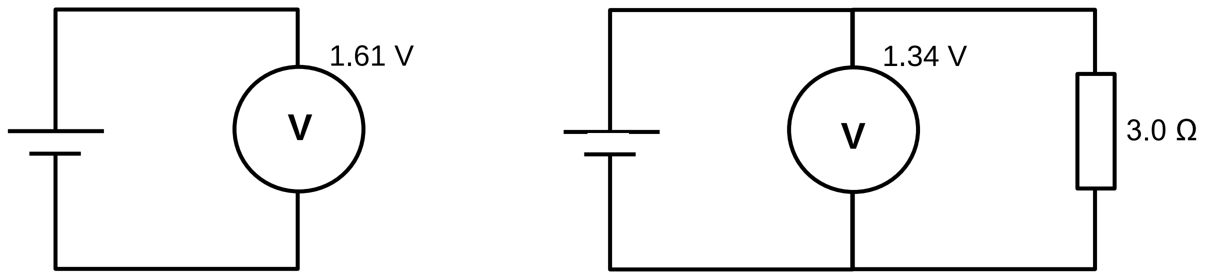


Fig. 5.1

(i) Calculate the internal resistance of the cell.

Since E = 1.61 V and V = 1.34 V, we have $I r$ = 0.27 V [1]

Given that $V = I$ (3) = 1.34 V, we have I = 0.4467 A [1]

Thus, (0.4467) r = 0.27 ⇒ r = 0.60 Ω [1]

internal resistance = ... Ω [3]

(ii) A second resistor is connected in parallel with the 3.0 Ω resistor. Without doing any calculations, state and explain how V changes.

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

Effective external resistance decreases [1]

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

⇒ Draws more current from cell

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

⇒ "P.d. across r" increases, thus V decreases [1]

6 Einstein's photoelectric equation appears in several forms, one of which is shown below

$$E_{k\ max} = h f - \phi$$

Monochromatic light of frequency 7.40×10^{14} Hz is irradiated onto a caesium surface, and $E_{k\ max}$ is measured. The procedure is repeated for three other frequencies, enabling four points to be plotted on the graph grid of Fig. 6.1 below.

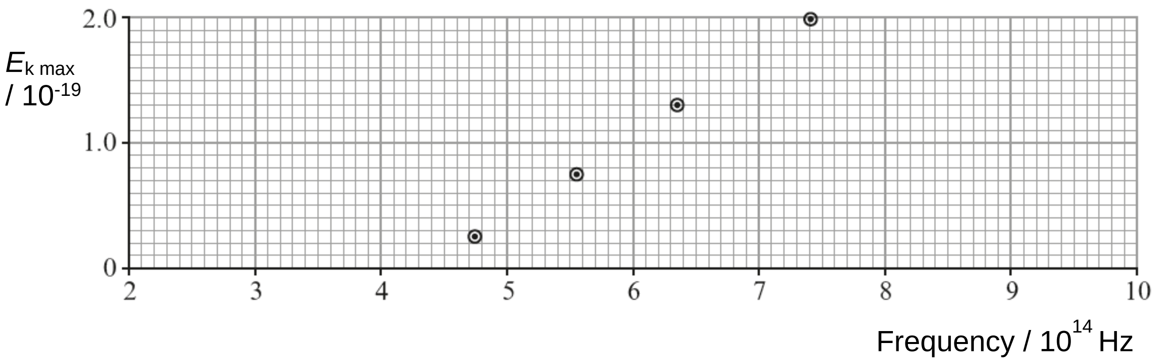


Fig. 6.1

(a) By showing your working, determine from Fig. 6.1

(i) a value for the Planck constant,

Gradient of graph gives Planck constant, h [C1]

Value = 6.6 [± 0.3] × 10^{-34} J s [A1]

Planck constant = ……………….. J s [2]

(ii) the threshold frequency of caesium.

Read off x-intercept = 4.4 [± 0.1] × 10^{14} Hz [1]

threshold frequency = ……………… Hz [1]

(b) When a lithium surface is used instead of a caesium surface, $E_{k\ \max}$ is found to be 0.40 × 10^{-19} J for light of frequency 7.40 × 10^{14} Hz.

(i) Draw the expected line of $E_{k\ \max}$ against frequency on the same grid in Fig. 6.1. [1]

(ii) This line cannot be checked satisfactorily by experiment if visible light is used. Name the region of the electromagnetic spectrum which is required.

Ultraviolet region [1]
…………………………………………………………………………………[1]

(iii) State what is different about lithium, as compared to caesium, which makes it necessary to use the region stated in (b)(ii).

The workfunction [threshold frequency] of lithium is larger. [1]
…………………………………………………………………………………[1]

Section B

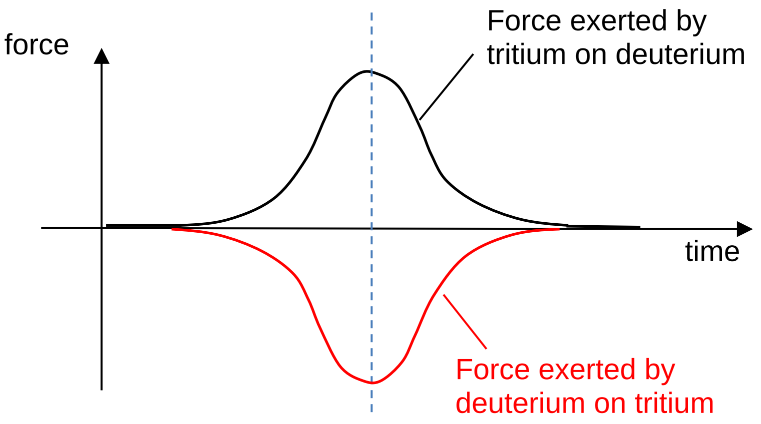
Answer **two** questions in this section.

7 (a) A tritium nucleus moves towards a deuterium nucleus at a large distance from deuterium nucleus as illustrated in Fig. 7.1.

Fig. 7.1

The nuclei initially have the same speed *v*. The tritium nucleus consists of two nucleons and a proton. The deuterium nucleus consists of a neutron and a proton. The proton and neutron have the same mass *m*.

(i) Fig. 7.2 shows the electric force exerted by tritium nucleus on deuterium nucleus. Draw the electric force exerted by deuterium nucleus on tritium nucleus in Fig. 7.2.



[1]

Fig. 7.2

(ii) Explain your answer to **(i)**.

According to Newton's third law, when tritium nucleus exerts a force on deuterium nucleus, deuterium nucleus will also exert a force of an equal magnitude but in opposite direction on tritium nucleus. [1]

…………………………………………………………………………………

………………………………………………………………………………… [1]

(iii) Explain how your answer to **(i)** is consistent with the principle of conservation of momentum.

Principle of conservation of momentum states that the total momentum of a system will be constant if the total net external force acting on the system is zero. [1]
Area under force –time graph gives the change in momentum. [1]
Since the areas under force –time graph for tritium and deuterium nuclei have the same magnitude but are of opposite sign. [1]
the sum of the change in momentum of tritium and deuterium nuclei is equal to zero.
Hence the total momentum of tritium and deuterium nuclei remains constant.

…………………………………………………………………………………

………………………………………………………………………………… [3]

(iv) Determine the final speed of tritium nucleus in terms of *v*.

Applying Conservation of momentum:

Total momentum before = Total momentum after

$(3m)v + (2m)(-v) = (3m)v_T + (2m)v_D$

$v = 3v_T + 2v_D$ …………………(1) [1]

Relative speed of approach = Relative speed of separation

$v - (-v) = v_D - v_T$ [1]

$v_D = v_T + 2v$ ……………….. (2)

Substitute (2) into (1) to solve for v_T:

$v = 3v_T + 2(v_T + 2v)$

$v_T = -0.6v$ [1]

final speed = …………………………… [3]

(b) State Newton's second law of motion.

The rate of change of momentum is directly proportional to the net external force and takes place in the same direction as the net external force.

………………………………………………………………………………… [1]

(c) A car of mass 750 kg is travelling at 30 m s^{-1} along a horizontal road. The brakes are applied and the car is brought to rest by an average resistive force *F*. The average deceleration of the car is 5.0 m s^{-2}.

(i) Show that the resistive force, *F* is 3750 N.

$F_{net} = m\,a = 750 \times 5.0 = 3750$ N

[1]

(ii) Calculate the change in momentum of the car.

change in momentum = $m\,v_f - m\,v_i = 0 - (750)(30) = 22500$ N s

change in momentum = ... N s [1]

(iii) Hence, using the answer in **(i)** and **(ii)**, calculate the time taken for the car to be brought to rest after the brake is applied.

Impulse = change in momentum

$F_{net}\,t = \Delta$ p

3750 t = 22500

t = 6.0 s

time = ... s [1]

Describe, in terms of Newton's third law, the horizontal forces acting on the tyres and on the road with relation to the motion of the car.

The ground will exert frictional force which is <u>opposite to the motion of car</u> on the car' tyre. [1]

By Newton's third law, the car's tyre will exert frictional force which is <u>equal in magnitude</u> but <u>opposite in direction</u> on the ground. [1]

Hence, the direction of frictional force from the car' tyre on the ground is in the same direction as the car motion.

.... [2]

(d) The car in **(c)** now travels at 30 m s^{-1} down a slope where the angle to the horizontal is 10°. The car is brought to rest by applying the brakes. The same resistive force, *F* of 3750 N acts on the car.

(i) In Fig. 7.3, draw all the forces acting on the car as it is decelerating. Label the forces clearly. [1]

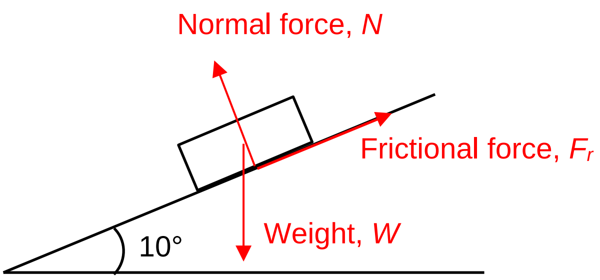


Fig. 7.3

(ii) Explain why the distance that the car travels before coming to rest is greater than that in **(c)**.

The component of weight which is parallel to the slope is downslope in direction. Hence the net force in upslope direction is reduced and the deceleration is reduced. [1] .... [1]

(iii) Calculate the deceleration of the car.

$F_{net} = m\,a$

3750 – (750) (9.81) (sin10°) = (750) (a) [1]

a = 3.30 m s^{-2} (marks not awarded for –ve sign)

deceleration = ... m s^{-2} [2]

(iv) The mass of the car is increased from 750 kg to 1000 kg. State and explain what would happen to the deceleration of the car.

The component of weight which is parallel to the slope in downslope direction increases. Hence the net force in upslope direction is reduced [1]. As the mass is increased, the deceleration will be reduced since $F_{net} = m\,a$ [1]

.... [2]

8(a) Explain what is meant by the following terms in italics.

(i) *coherent* sources

....

....[1]

(ii) *phase difference*

....

....[1]

(iii) *diffraction*

....

....[1]

(b) **(i)** State the conditions for a well-defined stationary wave to be formed using two separate sound sources.

....

....

....[2]

(ii) Compare the amplitude, phase and frequency of wave motion between a stationary and progressive wave.

....

....

....

....

....

....

....

....

....

....

....

....

....[5]

(c) In Fig. 8.1, a straight road runs parallel to the line joining two radio transmitting aerials A and B which are 600 m apart. Both aerials radiate signals at a frequency of 50 MHz. The road is 4.8 km from the aerials at its nearest point X.

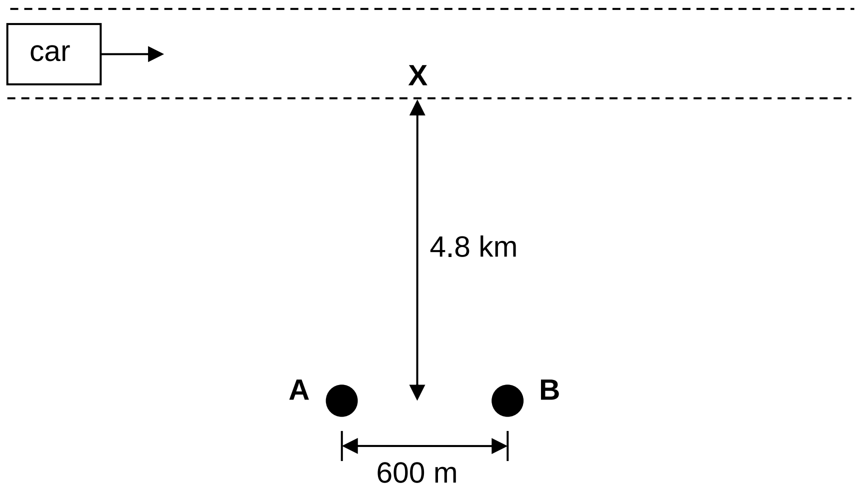


Fig. 8.1

A car travels at a steady speed along the road. As it passes along the road, it receives a radio signal that varies periodically.

(i) Explain why the radio signal varies as described.

....

....

....

....

....[3]

(ii) If the maximum intensity of the radio signal received varies at a frequency of 0.50 Hz, calculate the speed of the car.

speed of car = ……….......... m s^{-1} [3]

(d) In Fig. 8.2, S_1 and S_2 are two coherent point sources placed a distance *d* apart.

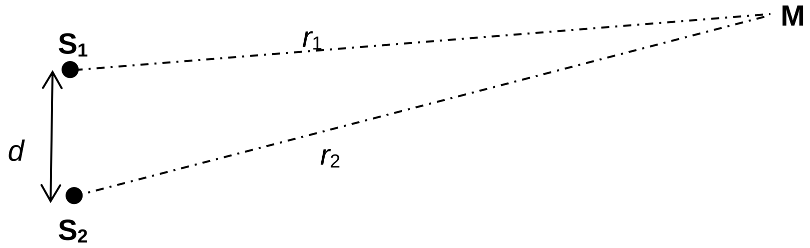


Fig. 8.2

The sources emit waves that are in phase. Each wave has an amplitude *A* and wavelength λ. The distances of M from S_1 and S_2 are r_1 and r_2 respectively.

(i) Deduce the ratios of the intensities and the amplitudes, in terms of r_1 and r_2, of the waves from S_1 and S_2 when they arrive at M. [3]

ratio of intensities = ……………………………..

ratio of amplitudes = ……………………………..

(ii) Hence or otherwise, explain why there is no complete cancellation of the two waves at M although the waves arrive at M in anti-phase to each other.

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

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

9 **(a)** **(i)** Define magnetic flux density.

……………………………………………………………………………………………..

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

…………………………………………………………………………………… [2]

(ii) Using the definition of magnetic flux density in **(a)(i)**, express the unit of magnetic flux density in terms of SI base units.

SI base units of magnetic flux density = ………………………… [2]

(b) A square coil ABCD with length 20.0 cm and 100 turns is placed in a region of uniform magnetic field of 0.15 T as seen in Fig. 9.1.

The current in the coil is 5.0 A.

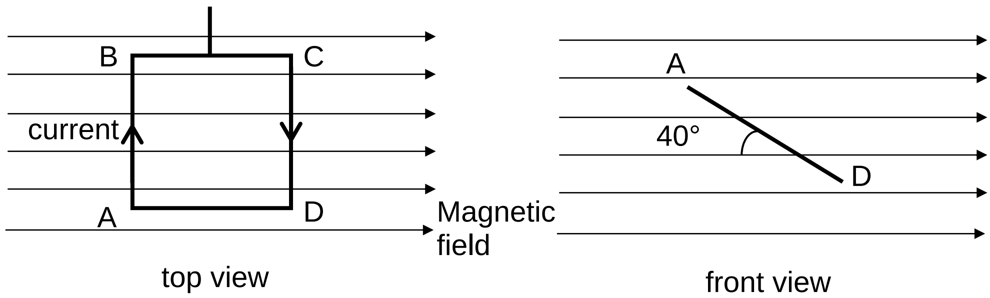


Fig. 9.1

(i) Draw two arrows on the *front* view of Fig. 9.1 to indicate the direction of the magnetic forces acting on wires AB and CD due to the field. [1]

(ii) Calculate the magnetic force acting on side AB of the square coil.

magnetic force = ………………………… N [2]

(iii) Hence determine the torque of the couple acting on the coil at that instant due to the magnetic forces.

torque = …………………………. N m [2]

(c) (i) A simplified *front* view of Fig. 9.1 is shown below in Fig. 9.2.

On Fig. 9.2, sketch the magnetic field lines around the wires AB and CD due to the current flowing in the coil. [2]

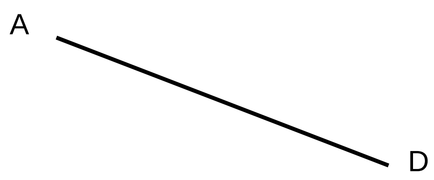


Fig. 9.2

(ii) On Fig. 9.2, draw two arrows to indicate direction of two *other* magnetic forces acting on wires AB and CD due to each other. [1]

(iii) Explain the origin and direction of these two magnetic forces.

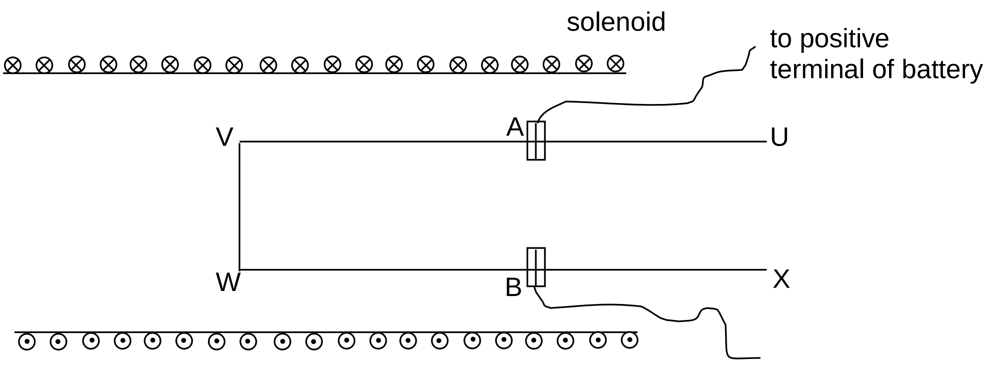
……………………………………………………………………………………………...

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

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

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

(d) A light wire frame UVWX is supported on two knife edges A and B so that the section AVWB of the frame lies within a solenoid, as shown in Fig 9.4.



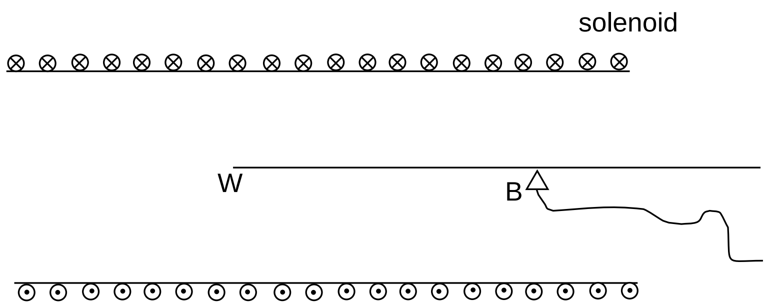


Fig 9.4

Electrical connections are made to the frame through the knife-edges so that AVWB of the frame and solenoid can be connected in series with a battery. When there is no current in the circuit, the frame is horizontal.

(i) The solenoid has 500 turns per metre and carries a current of 3.5 A. Given that the magnetic flux density B inside a long solenoid is $B = \mu_0 nI$ **,** where $\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}, n is the number of turns per metre and I is the current, calculate the magnetic flux density experienced by side VW of the frame.

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

(ii) Side VW has length 4.0 cm. Calculate the force acting on VW due to the magnetic field in the solenoid.

force on VW = ………………….. N [2]

(iii) A small object of mass 0.10 g is placed on the side BX and positioned so as to keep the frame horizontal. The length of BW is 15.0 cm. Determine the distance from the knife-edge where the object must be positioned.

distance from knife-edge = ………………….. cm [2]

End of Paper

<table>
<tr><td>8(a)</td><td>(i)</td><td>coherent refers to sources that produce waves of constant phase difference. [1]</td></tr>
<tr><td></td><td>(ii)</td><td>Phase difference refers to the difference in the stages of oscillation for one cycle. [1]</td></tr>
<tr><td></td><td>(iii)</td><td>diffraction refers to the phenomenon of bending or spreading of waves when they pass an obstacle or through an aperture. [1]</td></tr>
<tr><td>(b)</td><td>(i)

(ii)</td><td>The waves from the two separate sound sources must have equal amplitude and frequency [1] and travel with the same speed in opposite direction [1]

<table>
<tr><th></th><th>Stationary Wave</th><th>Progressive Wave</th></tr>
<tr><td>amplitude</td><td>varies from zero at the nodes to maximum at the antinodes. [1]</td><td>same for all particles. [1]</td></tr>
<tr><td>phase</td><td>all particles between 2 adjacent nodes are in phase. Particles between adjacent pairs of nodes are in anti-phase. [1]</td><td>all particles within one wavelength have different phases. [1]</td></tr>
<tr><td>frequency</td><td>all particles vibrate with same frequency as the wave (except those at the nodes).</td><td>all particles vibrate with same frequency as the wave. [1]</td></tr>
</table></td></tr>
<tr><td>(c)</td><td>(i)</td><td>Signals emitted from A and B undergo interference at different points along the road. [1]
When the phase difference is such that they in phase, constructive interference takes place and the intensity is a maximum. [1]
When the phase difference is such that they are anti-phase, destructive interference takes place and the intensity is a minimum.
Since the maxima and minima are equally spaced the signal intensity varies periodically along the road. [1]

(maximum of 2 marks to be given if the answer is in terms of path difference = nλ for constructive interference or $(n+\frac{1}{2})\lambda$ for destructive interference)</td></tr>
<tr><td></td><td>(ii)</td><td>wavelength of signal, $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{50 \times 10^6} = 6\ m$ [1]
Using $\lambda = \frac{ax}{D}$: $6 = \frac{600x}{4800} \Rightarrow x = 48\ m$ [1]
$v = f\lambda$ = 0.5 x 48 = 24 m s^{-1} [1]</td></tr>
<tr><td>(d)</td><td>(i)</td><td>since $I \propto A^2$ and $I \propto \frac{1}{r^2}$, then $A \propto \frac{1}{r}$ [1]
ratio of intensities $\frac{I_1}{I_2} = \left(\frac{r_2}{r_1}\right)^2$ [1]
ratio of amplitudes $\frac{A_1}{A_2} = \left(\frac{r_2}{r_1}\right)$ [1]</td></tr>
<tr><td></td><td>(ii)</td><td>Since the amplitudes of the two waves arriving at P are not equal, the resultant amplitude at destructive interference is not zero. [1]</td></tr>
</table>

9 **(a) (i)** Magnetic flux density is the **force per unit length per unit current** acting on an **infinitely long current carrying conductor placed perpendicularly** to the magnetic field. [1]

(ii) $T = \dfrac{N}{Am}$ [1]

$T = \dfrac{kgms^{-2}}{Am} = kgA^{-1}s^{-2}$ [1]

(b) (i) [1]

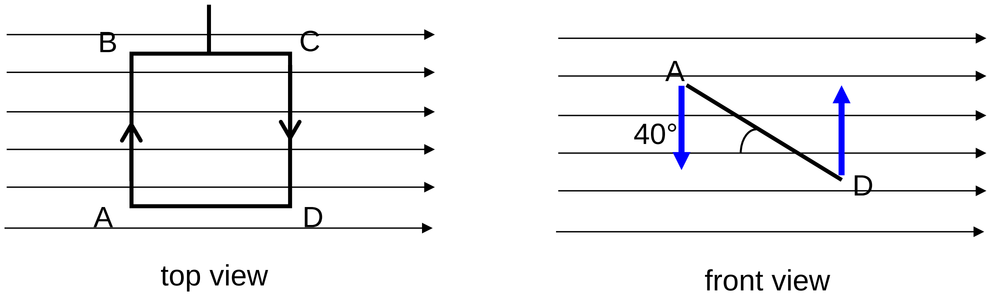


Fig. 9.1

(ii) $F_B = (100)(0.15)(0.2)(5.0)$

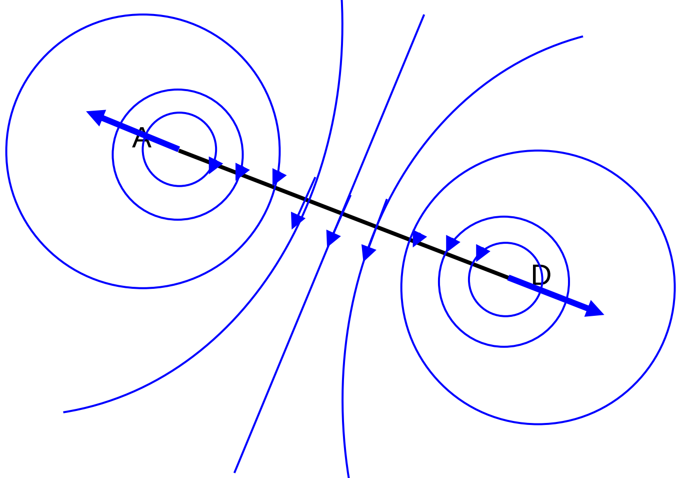
$F_B = 15$ N

(iii) $\tau = 15 \times 0.2\ \cos 40°$ [1]

$\tau = 2.30$ Nm [1]

(c) (i) correct directions (clockwise for A, anticlockwise for D) [1]

(ii) [1]



closer field lines in the middle, field lines farther apart on the outside [1]

(iii) The current in AB sets up a magnetic field that interacts with the current in CD giving rise to the force acting on CD and vice versa. [1]

The directions of the forces can be found using Fleming's Left Hand Rule. [1]

(d) (i) B = μ_0 nI = (4π x 10^{-7})(500)(3.5) [1]

= 2.20 x 10^{-3} T or Wb m^{-2} [1]

(ii) F = BIl sin θ = (2.2 x 10^{-3})(3.5)(4 x 10^{-2}) [1]

= 3.08 x 10^{-4} N [1]

(iii) Taking pivot about the knife-edge,

Using the principle of moments,

Sum on CW moments = Sum of ACW moments

(0.10 x 10^{-3})g(x) = (3.08 x 10^{-4})(0.15) [1]

$$x = \frac{\left(3.08 \text{ x } 10^{-4}\right)\left(0.15\right)}{\left(0.10\text{x}10^{-3}\right)\left(9.81\right)}$$ [1]

x = 0.0471 m

= 4.71 cm