MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
Higher 1

H1 Physics 8866/1

Paper 1 Multiple Choice **21 September 2017**

1 hour

	Class	Reg Number
Candidate Name ______________________________		

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

There are **thirty** questions in this section. 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 Optical Mark Sheet (OMS).

Read very carefully the instructions on the OMS.

Write your name and class in the spaces provided on the OMS.

Shade your Index Number column using the following format:

1) first 2 digits is your index number in class
(e.g. 5th student is shaded as “05”);

2) ignore the last row of alphabets.

DATA AND FORMULAE

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	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$

Answer all 30 questions in this paper and shade your answers on the answer sheet provided.

1 Which estimate is realistic?

A The kinetic energy of a bus traveling on an expressway is 30 000 J.

B The power of a domestic light is 300 W.

C The temperature of a hot oven is 300 K.

D The volume of air in a car tyre is 0.03 m^3.

2 The equation relating current I through a semiconductor diode to the applied potential difference V at temperature T is

$$I = I_o \exp\left(-\frac{qV}{kT}\right)$$

where q is the electron charge, and k is a constant.

If I_o is a characteristic constant of the diode with the same units as current I, what is the unit of k?

A kg m^2 s^{-2} K^{-1} A^{-1} **B** kg m s^{-2} K^{-1} A^{-1} **C** kg m^2 s^{-2} K^{-1} **D** kg m s^{-2} K^{-1}

3 The relation between the velocity v of waves in the sea with its wavelength λ, the surface tension γ and density ρ of sea water is given by :

$$v = k\sqrt{\frac{\gamma}{\lambda\rho}}$$

where k = constant of proportionality.

If γ = (4.30 ± 0.05) N m^{-1}, ρ = (1450 ± 20) kg m^{-3} and the uncertainty in λ is 5 %, what is the percentage uncertainty in the velocity of the waves?

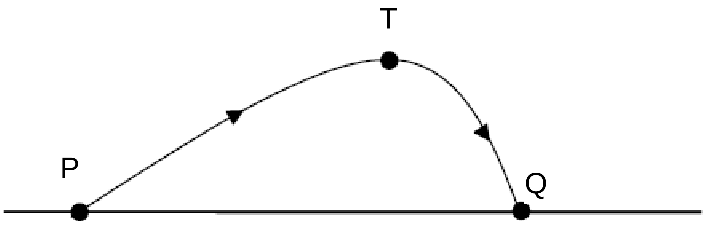
A 2 % **B** 3 % **C** 4 % **D** 8 %

4 A ball is dropped from a window located at the tenth storey of a building. 1 second after it is released, the ball is observed to have fallen by exactly 2 storeys.

At which storey will the ball be at 2 seconds after it is released?

A 2 **B** 4 **C** 6 **D** 8

5 In the presence of air resistance, a stone is thrown from P and follows a path in which the highest point reached is T as shown in the diagram below.



Given that the drag force acting on the stone is directly proportional to the magnitude of its instantaneous velocity, the vertical component of the acceleration of the stone is

A highest at point P.

B highest at point T.

C highest at point Q.

D constant through the travelled path.

6 A car at rest at a traffic junction starts to accelerate at 2.0 m s^{-2} when the traffic light turns green. At this moment, a truck travelling at a constant velocity of 14 m s^{-1} passes the car.

If the car is accelerating uniformly, how long will it take for the car to just overtake the truck?

A 7.0 s **B** 14 s **C** 28 s **D** 56 s

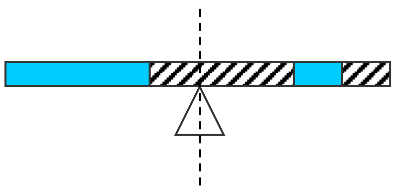
7 Four different composite rods of uniform thickness are to be balanced horizontally on a knife-edge. Each rod is made up of 50% material A and 50% material B, where B is denser than A. The mid-point of each composite rod is indicated by a dotted vertical line.

Legend:

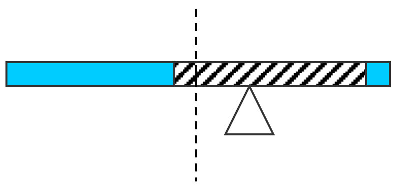
Material A Material B

Which scenario is unlikely to occur?

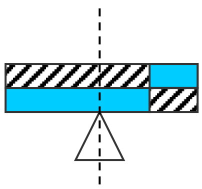
A



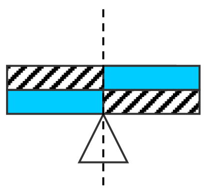
B



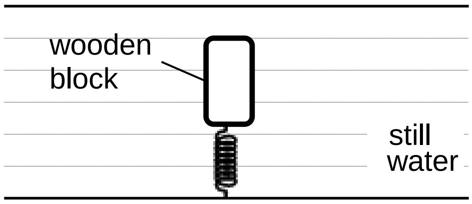
C



D



8 A large wooden block of density 800 kg m^{-3} and volume 1.0 m^3 is fastened to the bottom of a freshwater pond via a spring of force constant 65 kN m^{-1}. The wooden block experiences gravitational force, force from spring and an upward buoyant force. The upward buoyant force is 9810 N.



What is the compression or extension of the spring when the wooden block remains in equilibrium?

A 3.1 cm compression of spring.

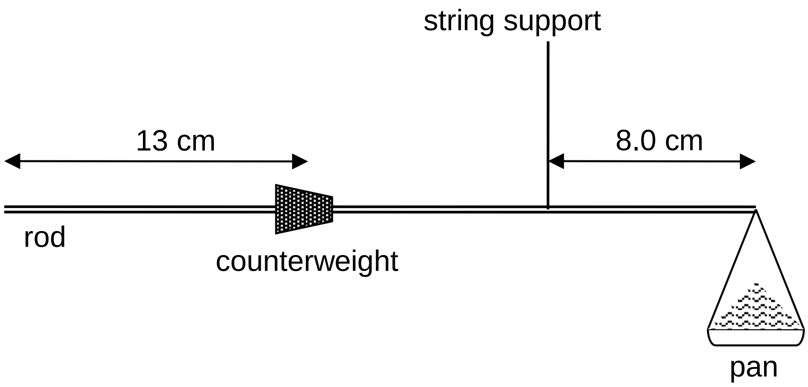
B 3.1 cm extension of spring.

C 3.0 cm compression of spring.

D 3.0 cm extension of spring.

9 A traditional Chinese physician is measuring the mass of herbs with his weighing scale. The scale consists of a uniform 40 g rod, a 100 g counterweight and an 80 g pan.

The rod is 30 cm long, the pan is placed at one end of the rod and the whole system is supported by a string 8.0 cm away from the pan as shown below.

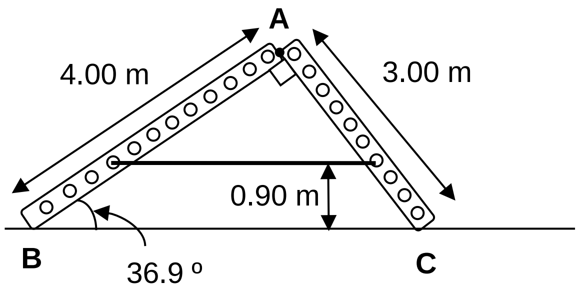


The counterweight is located at 13 cm from the other end of the rod when the system is in equilibrium. What is the mass of the herbs resting on the pan?

A 68 g **B** 108 g **C** 319 g **D** 662 g

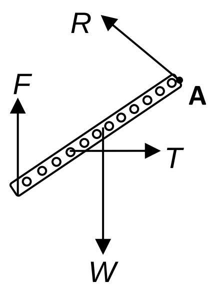
10 Two uniform ladders, 4.00 m and 3.00 m long, weighing 390 N and 290 N respectively are hinged at point **A** (90º apart) and tied together by a horizontal rope 0.90 m above the floor, as shown below. Assume the floor is freshly waxed and frictionless.

The contact force *F* at point **B** is 317 N.

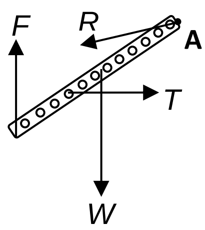


Which of the following diagram shows the correct forces *F*, weight *W* and tension of rope *T* and reaction force *R* acting at point **A** of the 4.00 m ladder?

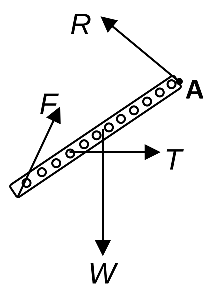
A



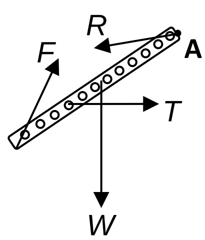
B



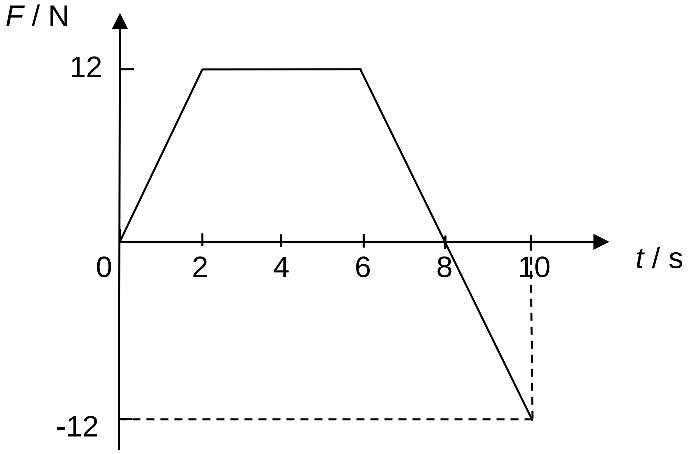
C



D



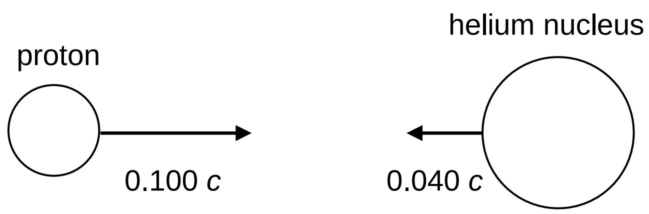
11 A body of mass 300 g initially at rest is acted on by a force F which varies with time t as shown in the diagram below.



What is the speed of the body at the 10th second?

A 200 m s^{-1} **B** 240 m s^{-1} **C** 260 m s^{-1} **D** 280 m s^{-1}

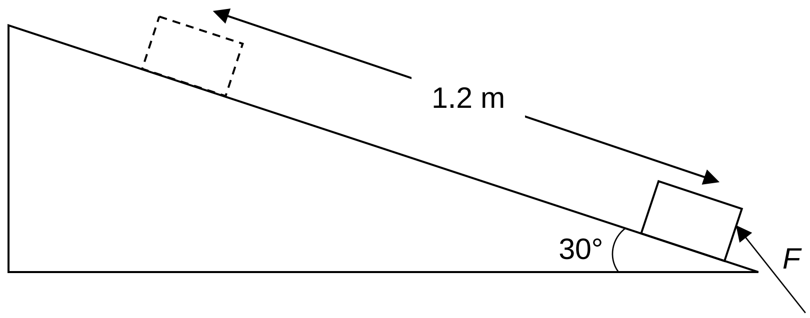
12 A proton (mass 1 u) travelling with velocity +0.100 c collides elastically head-on with a helium nucleus (mass 4 u) travelling with velocity −0.040 c.



What are the velocities of each particle after the collision?

	proton	helium nucleus
A	+0.124 c	+0.016 c
B	-0.124 c	+0.016 c
C	+0.004 c	+0.064 c
D	-0.004 c	+0.064 c

13 A force *F* is applied on a box of weight 200 N to push it up a rough ramp at constant speed through a distance of 1.2 m. The ramp makes an angle of 30° with the horizontal, as shown in the diagram below. The frictional force between the box and the ramp is 80 N.

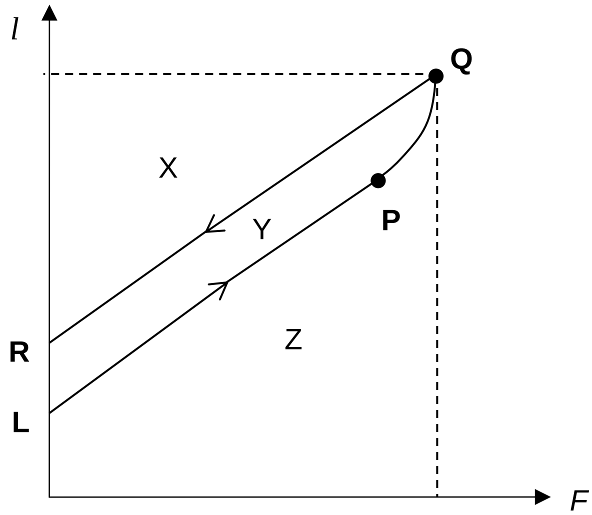


What is the work done by force *F*?

A 300 J **B** 220 J **C** 120 J **D** 24 J

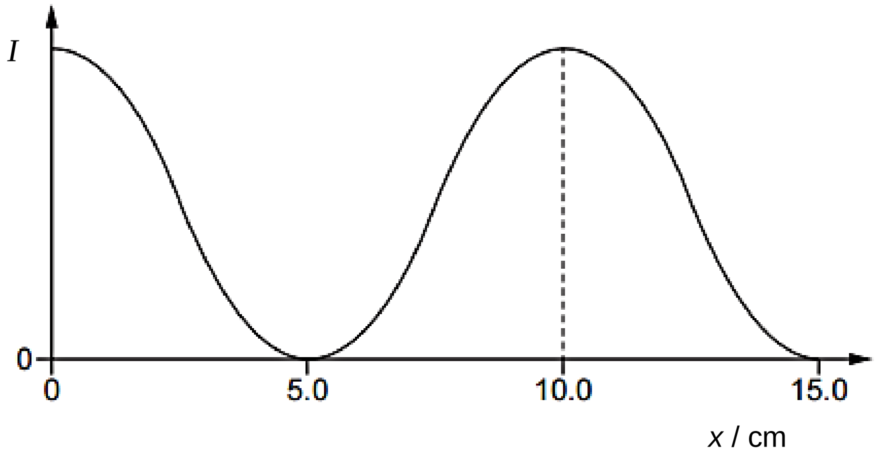
14 A spring is stretched by a varying force *F*, causing its length *l* to increase as shown by the line **LPQ** on the graph. The force is then gradually reduced to zero and the relationship between force and length is indicated by the line **QR**.

Which area represents the elastic potential energy stored in the spring at **Q**?



A X **B** X + Y **C** Y + Z **D** Z

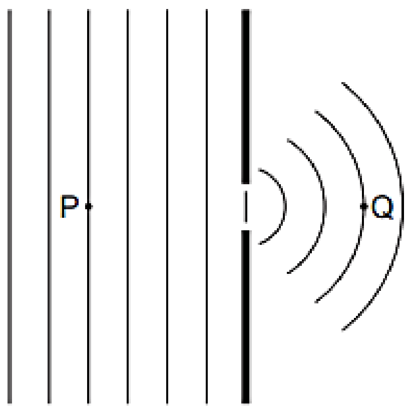
15 The variation with the distance *x* of intensity I along a stationary sound wave in the air is shown by the following graph.



The speed of sound in air is 320 m s^{-1}. What is the frequency of the sound wave?

A 1600 Hz **B** 2130 Hz **C** 3200 Hz **D** 6400 Hz

16 Plane wavefronts in a ripple tank pass through a gap as shown.



What property of the wave will be different at **Q** compared with **P**?

A velocity

B frequency

C amplitude

D wavelength

17 A musical organ produces notes by blowing air into a set of pipes that are open at one end and closed at the other.

What is the lowest frequency of sound produced by a pipe of length 2 m?
(The speed of sound in the pipe is 320 m s^{-1}.)

A 20 Hz **B** 40 Hz **C** 80 Hz **D** 160 Hz

18 Diffraction can be observed when a wave passes an obstruction. The diffraction effect is greatest when the wavelength and the obstruction are similar in size.

For waves travelling through air, what is the combination of wave and obstruction that could best demonstrate diffraction?

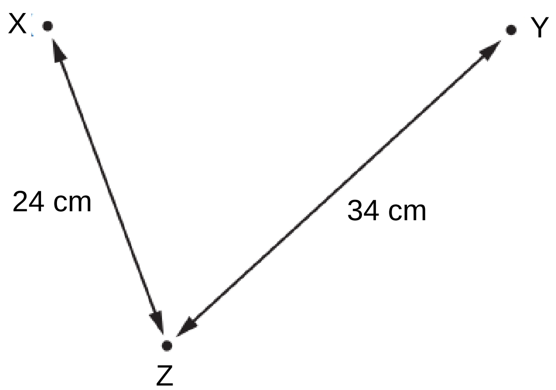
A visible light waves passing through an entrance of a classroom door

B sound waves passing a human hair

C radio waves passing a copper wire

D microwaves passing a steel post

19 Wave generators at points X and Y produce waves of the same wavelength. At point Z, the waves from X have the same amplitude as the waves from Y. Distances XZ and YZ are as shown.

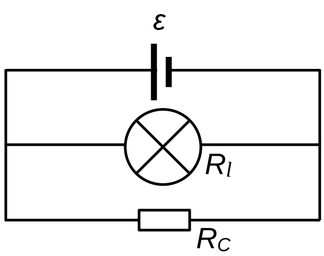


When the wave generators operate in phase, the amplitude of oscillation at Z is zero.

What could be the wavelength of the waves?

A 2 cm **B** 3 cm **C** 4 cm **D** 6 cm

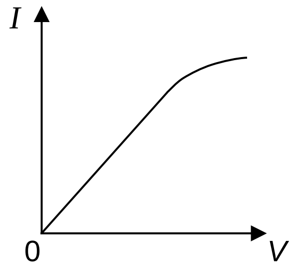
20 The figure below shows a lamp of resistance R_l and a device of resistance R_C being powered by an electrical source, ε.



Which expression gives the fraction of the total power delivered to the lamp?

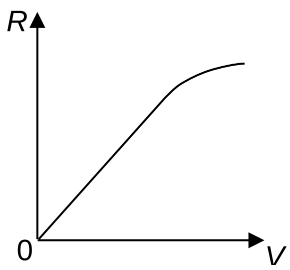
A $\frac{R_C}{R_l}$ **B** $\frac{R_l}{R_C}$ **C** $\frac{R_l}{R_l + R_C}$ **D** $\frac{R_C}{R_l + R_C}$

21 The current I flowing through a component varies with the potential difference V across it as shown.

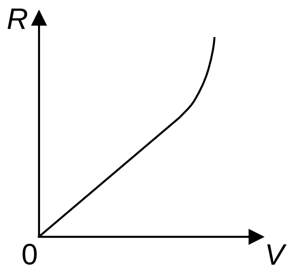


Which graph best represents how the resistance R varies with V?

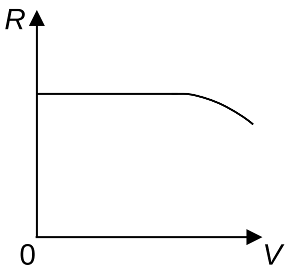
A



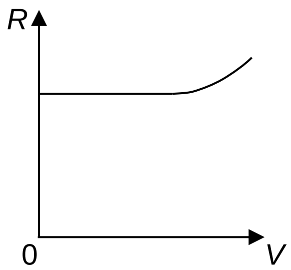
B



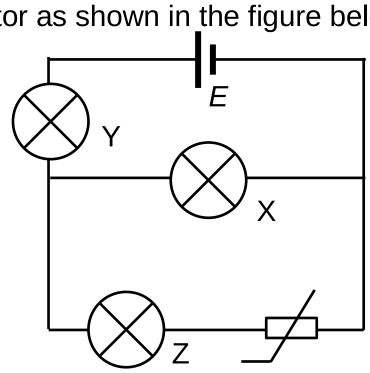
C



D



22 A cell of e.m.f. E is connected to three identical lamps X, Y, and Z, and a negative temperature coefficient thermistor as shown in the figure below.



If the thermistor is heated up, which statement about the change in brightness of bulbs X and Y is true?

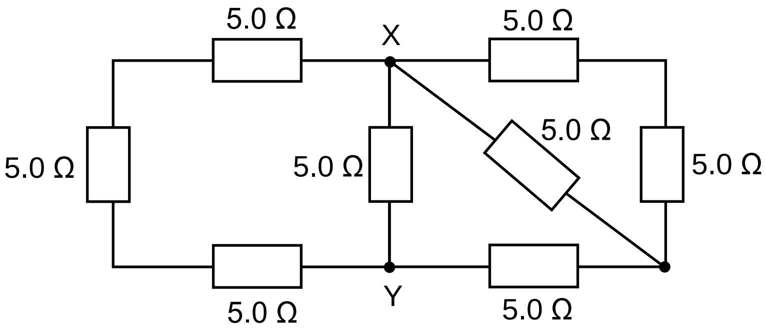
A Both X and Y become brighter.

B Both X and Y become dimmer.

C Y becomes brighter, but X dims.

D X becomes brighter, but Y dims.

23 Eight resistors are connected as shown in the figure below.



What is the equivalent resistance between X and Y?

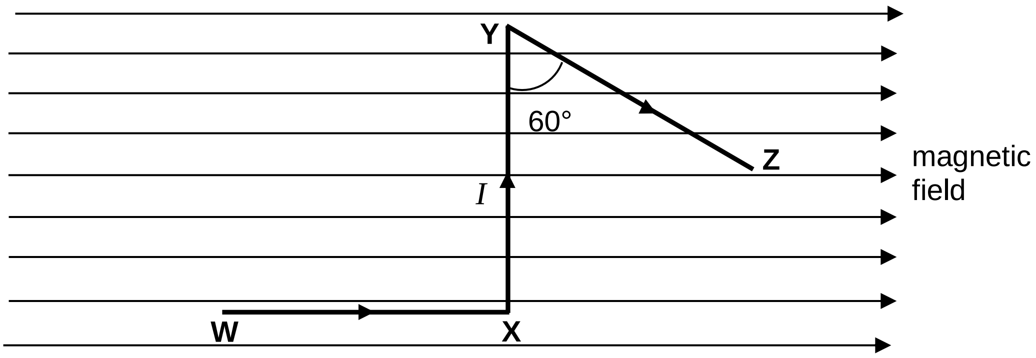
A 2.3 Ω **B** 2.6 Ω **C** 2.9 Ω **D** 3.2 Ω

24 A cell has an internal resistance *r*. A variable resistor is connected across its terminals. When the resistance of the variable resistor is 3.6 Ω, the potential difference across it is 7.2 V. When the resistance of the variable resistor is 7.2 Ω the current through it is 1.1 A.

What is the value of *r* ?

A 0.61 Ω **B** 0.80 Ω **C** 3.5 Ω **D** 4.3 Ω

25 The figure below shows a wire **WXYZ** placed in a uniform magnetic field of flux density 0.40 T. The current, I, flowing through the wire is 5.0 A. The length of **WX**, **XY** and **YZ** are 10 cm each.



What is the net force on the wire **WXYZ**?

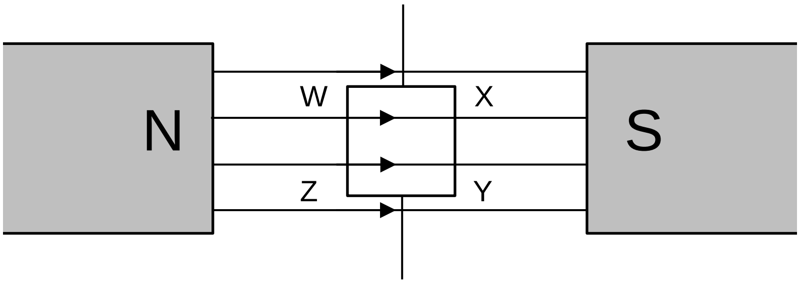
A 0.10 N out of the plane of the paper

B 0.10 N into the plane of the paper

C 0.20 N out of the plane of the paper

D 0.20 N into the plane of the paper

26 In an electric motor, a rectangular coil WXYZ carrying current, I, has 20 turns and is in a uniform magnetic field of flux density 0.80 T.

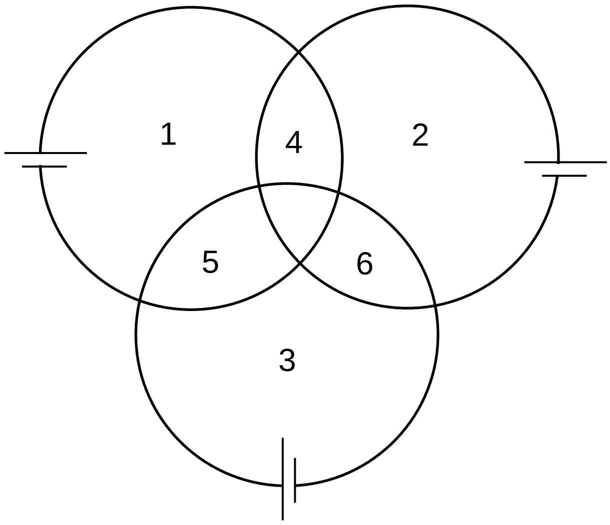


The lengths of sides XY and ZW are 0.17 m and of sides WX and YZ are 0.11 m. The maximum torque provided by the motor is 1.35 N m.

What is the current, I, in the rectangular coil?

A 4.5 A **B** 9.0 A **C** 45 A **D** 90 A

27 Three separate coils of insulated wire are connected to cells as shown. They are placed on a table on top of each other partially overlapping.



Six of the seven areas formed within the coils are numbered.

In which areas do the magnetic fields of all the coils reinforce each other?

A 1 and 6 **B** 2 and 5 **C** 3 and 4 **D** 4 and 6

28 A metal surface in an evacuated tube is illuminated with monochromatic light causing the emission of photoelectrons which are collected at an adjacent electrode.

If the experiment is repeated with light of half the intensity but the same wavelength, how will the photocurrent I and stopping potential V be affected?

A I unchanged, V unchanged

B I unchanged, V halved

C I halved, V unchanged

D I halved, V halved

29 Which type of electromagnetic radiation is emitted when an electron in an atom makes a transition from an energy level at −1.5 eV to an energy level at −3.5 eV?

A microwaves

B infra-red

C orange light

D violet light

30 An electron and a proton have the same de-Broglie wavelength.

Which of the following statements is correct?

A The momentum of the proton is greater than that of the electron.

B The momentum of the proton is smaller than that of the electron.

C The kinetic energy of the proton is greater than that of the electron.

D The kinetic energy of the proton is smaller than that of the electron.

End of Paper

2017 JC2 Preliminary Examination
H1 Physics Paper 1 Suggested Solutions:

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

MCQ 1: D

A: Typical bus mass = 3000 kg, speed = 60 km/h ≈ 17 m s^{-1}, so KE ≈ 400 000 J
B: Typical power of domestic light = 10 to 90 W
C: 300 K is 27 °C, too low for hot oven
D: Typical tyre is 60 cm radius, 20 cm width, 4 cm breadth ⇒ volume ≈ 0.03 m^3

MCQ 2: C

Since $\frac{qV}{kT}$ is a power, it is dimensionless.

Units of k $= \frac{\text{units of energy}}{\text{units of temp}} = \frac{kgm^2s^{-2}}{K} = kgm^2s^{-2}K^{-1}$

MCQ 3: C

Percentage uncertainty in *v* = $\frac{1}{2}\left[5+\left(\frac{0.05}{4.3}\times100\right)+\left(\frac{20}{1450}\times100\right)\right]\approx 4\%$

MCQ 4: A

Use $s = ut + 0.5at^2$

$2 = 0 + 0.5a(1)^2$

$a = 4$ storeys s^{-2}

$s = 0 + (0.5)(4)(2)^2$

$= 8$ storeys

$10 - 8 = 2^{nd}$ storey

MCQ 5: A

At point P, it experiences weight and drag force in the same direction
At point T, it experiences weight only as it is stationary, hence no drag force
At point Q, it experiences weight and drag force but in opposite direction

MCQ 6: B

$s_{car} = 0 + 0.5(2)t^2$
$s_{truck} = (14)t$
$s_{car} = s_{truck}$
$t = 14$ s

MCQ 7: A

To create rotational equilibrium, the sum of moments exerted by the weight of each material about the knife-edge must be equal. Another way is to use visual inspection to estimate the location of the centre of gravity (CG) for the composite rod. The knife-edge must be below the CG for rotational equilibrium.

For C and D, the CG lies in the middle of the rod so knife-edge is placed correctly below the CG.

For B, the CG is off-centre to the right as material B is concentrated to the right. The knife-edge is also positioned more to the right (from centre) There is a chance that rotational equilibrium can be established.

For A, the CG is also off-centre to the right since material B is concentrated to the right, but the knife-edge is at the centre. Hence, rotational equilibrium cannot be established.

MCQ 8: D
Given, upward buoyant force = 9810 N
Weight of block = $\rho_{block} V_{block} g$ = 800 x 1.0 x 9.81 = 7848 N

Therefore force acting on block by spring = 9810 – 7848 = 1962 N (pointing downwards)

Hence force acting on spring by block = 1962 N (pointing upwards)--- leading to an extension of spring.

F = ke
1962 = 65 x 10^3 e
e = 3.0 cm

MCQ 9: A
Let mass of herbs be m
Taking moments about the string support
Clockwise moments = anticlockwise moments
mg (8.0) + 80g (8.0) = 100g (30-8-13) + 40g (15-8)
m = 68 g

MCQ 10: A

Since the floor is frictionless, contact force at point B is only the normal contact force.

At equilibrium,

At point A, there is an upward vertical force (magnitude of 390-317=73 N) to ensure net vertical forces is zero.

At point A, there is a leftward force to counter the rightward tension force.

Hence, reaction force at A is pointing as shown in diagram A.

MCQ 11: A
Change in momentum = area under F-t graph

Area under F-t graph from 0 to 10 seconds = 0.5 x (8+4) x 12 + [(-0.5) x (2) x (12)] = 60 N s

Change in momentum = final momentum – initial momentum
60 = mv – 0
v = 200 m s^{-1}

MCQ 12: B

Using relative speed of approach = relative speed of separation

$$u_1 - u_2 = v_2 - v_1$$
$$0.100c - (-0.040c) = v_2 - v_1$$
$$v_2 = 0.140c + v_1 \quad \text{---------(1)}$$

Using conservation of momentum

$$1u \times 0.100c - 4u \times 0.040c = 1u \times v_1 + 4u \times v_2$$
$$0.100c - 0.160c = v_1 + 4v_2 \quad \text{---------- (2)}$$

Substitute eqn (1) into (2)

$$-0.060c = v_1 + 4 \times (0.140c + v_1)$$
$$v_1 = -0.124c$$
$$v_2 = +0.016c$$

MCQ 13: B
Work done by *F* = gain in GPE + work done against friction
= 200 (1.2 sin 30°) + 80 x 1.2 = 220 J

MCQ 14: A
EPE is equal to the area under the force-extension graph. In this case, a stretched length vs force graph is plotted, hence we consider the area that **Q** makes with the vertical axis.

Note that at point Q, the spring has undergone plastic deformation, hence some energy has been released as heat (represented by area Y)

MCQ 15: A
Graph given is intensity of a stationary wave. Hence peak to peak distance indicates distance between 2 antinodes which is half a wavelength

f = speed / wavelength = 320 / 0.20 = 1600 Hz

MCQ 16: C
Only amplitude changes as distance from source increases. The other factors are affected only if the source changes.

MCQ 17: B
For a closed pipe, the fundamental frequency occurs at 0.25λ
Length of pipe = 2 m = 0.25 λ,
Hence,
$f = v/\lambda$ = 320 / 8 = 40 Hz

MCQ 18: D

Wave	Approx Size	Obstacle	Obstacle Size	Conclusion
visible light wave	400-700nm	Opening of classroom	2 m	
sound waves	1.7 cm – 17 m	Human hair	10^{-5} m	
radiowaves	1 m – 10 m	Copper wire	10^{-3} m	
microwaves	0.1 cm – 10 cm	Steel post	10^{-1} m	Most similar in order of magnitude

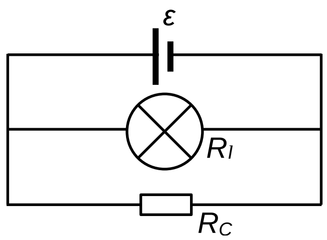
MCQ 19: C

Path difference is 10 cm
For point Z to be at destructive interference, it needs to be in multiples of (n+1/2) λ

Trial and error for all 4 options

If λ = 2cm, PD = 5 λ (CI)
If λ = 3cm, PD = 3.33 λ (no complete cancellation)
If λ = 4cm, PD = 2.5 λ (DI)
If λ = 6cm, PD = 1.67 λ (no complete cancellation)

MCQ 20: D



The potential difference across both the lamp and the resistor is the same

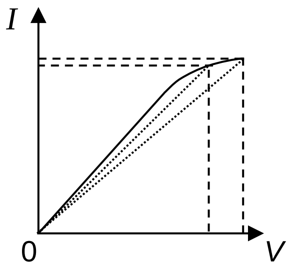
$P_{lamp} = \frac{\varepsilon^2}{R_l}$ $\qquad$ $P_{resistor} = \frac{\varepsilon^2}{R_C}$

Fraction of power delivered to lamp

$$= \frac{P_{out}}{P_{in}} = \frac{\frac{\varepsilon^2}{R_l}}{\frac{\varepsilon^2}{R_l} + \frac{\varepsilon^2}{R_C}} = \frac{R_C}{R_l + R_C}$$

MCQ 21: D

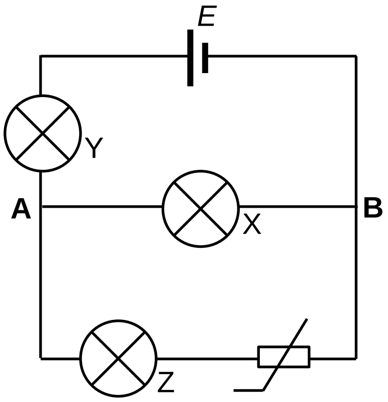
Initially the V to I ratio is constant, hence the resistance is constant.



At large voltage, the V to I ratio increases. Hence the resistance increases.

MCQ 22: C

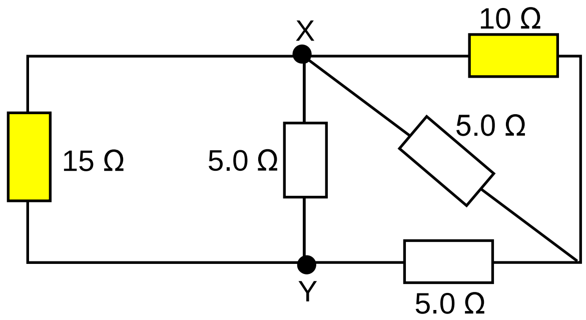
When heated up, resistance of an NTC thermistor decreases.



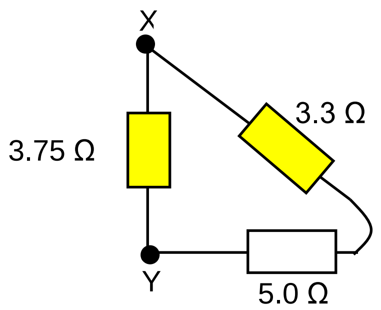
Effective resistance across points **AB** decreases. Hence V_{AB} decreases and p.d. across Y increases. Y will become brighter and X dims.

MCQ 23: B

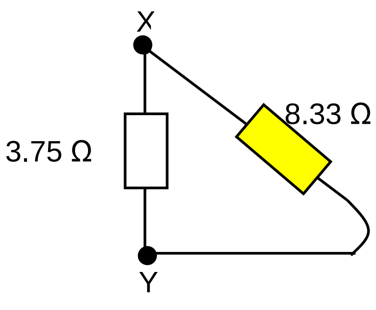
1. Combine those in series



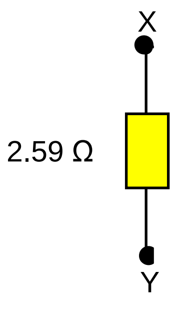
2. Combine those in parallel



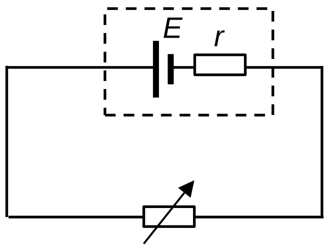
3. Combine those in series



4. Combine those in parallel



MCQ 24: B



$V_T = E - Ir$

$7.2 = E - \frac{7.2}{3.6} r$ $E = 7.2 + 2.0r$ -------(1)

$7.2(1.1) = E - 1.1r$ $E = 7.92 + 1.1r$ -------(2)

Eqn (1)=(2)

$7.2 + 2.0r = 7.92 + 1.1r$

$r = 0.80\ \Omega$

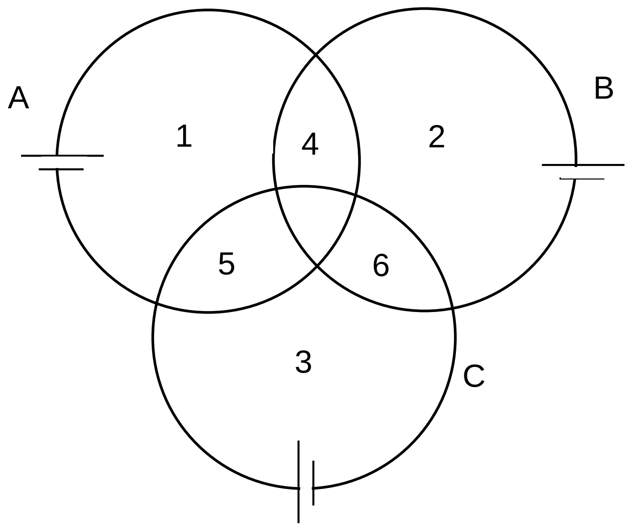
MCQ 25: B

Resultant force on wire = $BIL - BIL \sin 30^0 = 0.10$N
By Fleming's LHR, the resultant force is into the page of the paper.

MCQ 26: A

The forces acting on XY and ZW have the same magnitude in opposite directions.
These two forces form a couple with a torque as follow:
$\tau = NBIL \times d = (20)(0.80)(I)(0.17) \times (0.11) = 1.35$
I = 4.5 A

MCQ 27: B



By applying right hand grip rule,
Coil A produces magnetic field into the paper within the coil and magnetic field out of the paper at region outside of coil
Coil B produces magnetic field out of the paper within the coil and magnetic field into the paper at region outside of coil
Coil C produces magnetic field into the paper within the coil and magnetic field out of the paper at region outside of coil
Hence, in areas 2 and 5, the magnetic fields of all the coils reinforce one another.

MCQ 28: C

Half the intensity, i.e. rate of arrival of photon on surface is halved. Hence current I is halved.

Same wavelength means energy of the photon is the same, hence no change in V for the same surface.

MCQ 29: C

E = (-1.5 – (-3.5)) x 1.6 x 10^{-19} = 3.2 x 10^{-19}

$E = hf = hc / \lambda$ ➔ $\lambda = hc / E$ = 6.63 x 10^{-34} x 3 x 10^{8} / 3.2 x 10^{-19} = 6 x 10^{-7} m ➔ orange light

MCQ 30: D

de-Broglie wavelength $\lambda = h/p$
Same $\lambda \Rightarrow$ same p
$p = m v$
KE = ½ $m v^2$ = ½ p^2/m
$m_p >> m_e \Rightarrow KE_p << KE_e$

MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
Higher 1

H1 Physics 8866/2

Paper 2 Structured Questions **18 September 2017**

2 hours

Class	Reg Number

Candidate Name: ______________________________

READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B 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.

The number of marks is given in brackets [ ] at the end of each question or part question.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

Examiner's Use	
Section A	
Q1	**/6**
Q2	**/6**
Q3	**/8**
Q4	**/8**
Q5	**/12**
Section B	
Q6	**/20**
Q7	**/20**
Q8	**/20**
Deductions	
Subtotal for Paper 2	**/80**
Subtotal for Paper 1	**/30**
Grand total	**/110**

DATA AND FORMULAE

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	=	$R_1 + R_2 + \ldots$
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 basketball player taking a free throw. The ball is thrown with an initial velocity of u at an angle of 52.0° to the horizontal. The ball leaves the player's hands at a point which is at a horizontal distance of 4.6 m from the basket and at a height of 1.6 m above the floor. The basket is 3.1 m above the floor.

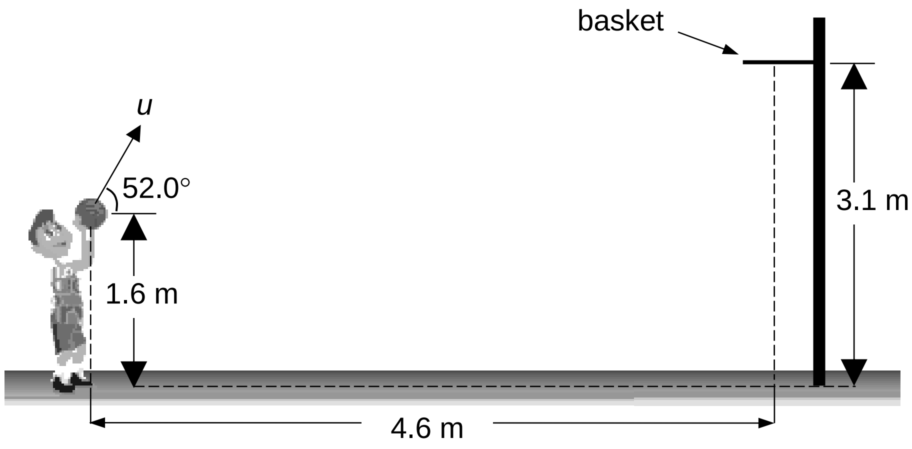


Fig. 1.1

(a) Calculate the initial velocity u of the ball required for it to pass through the basket.

u = ………………….. m s^{-1} [3]

(b) Fig. 1.2 shows the side view of the ball passing through the basket. The ball will be able to pass through the basket if its angle of travel with respect to the horizontal, θ, is larger or equal to 34°.

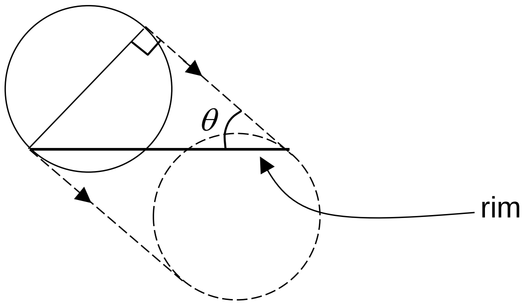


Fig. 1.2 (side view)

By calculating the angle, θ, determine if the ball thrown by the player will pass through the basket.

θ = ………………….. ° [2]

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

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

2 **(a)** Distinguish between transverse waves and longitudinal waves.

………

………

………

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

(b) The variation with distance *x* of the displacement *y* of a transverse wave is shown in Fig. 2.1.

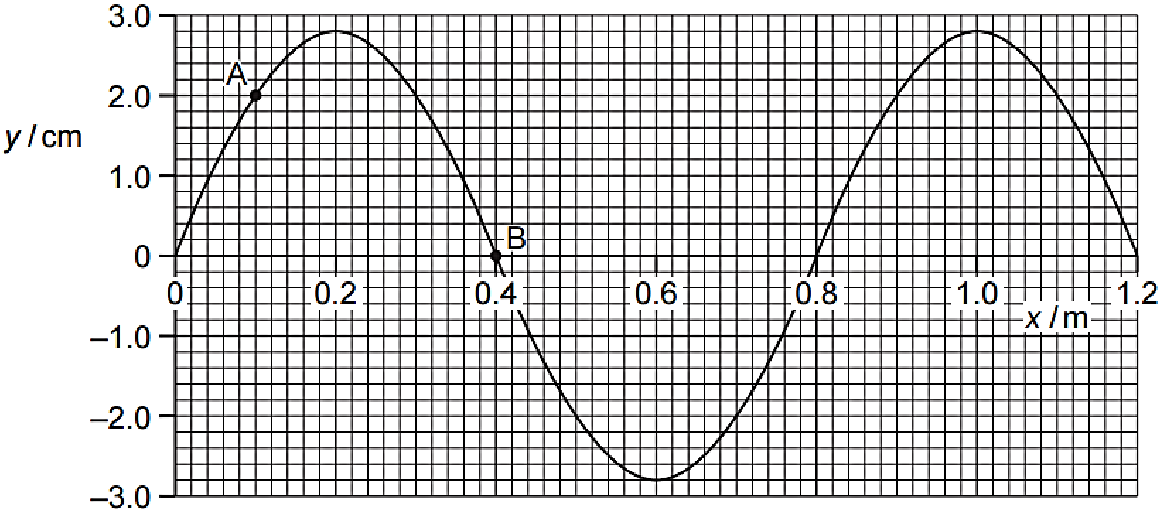


Fig. 2.1

(i) Use Fig. 2.1 to determine the phase difference between the points labelled A and B.

phase difference = ………………….. [2]

(ii) Determine the amplitude of a wave with half the intensity of that shown in Fig. 2.1.

amplitude = ………………….. cm [2]

3 (a) State the Principle of Superposition.

………

………

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

(b) A laser is placed in front of two slits as shown in Fig. 3.1.

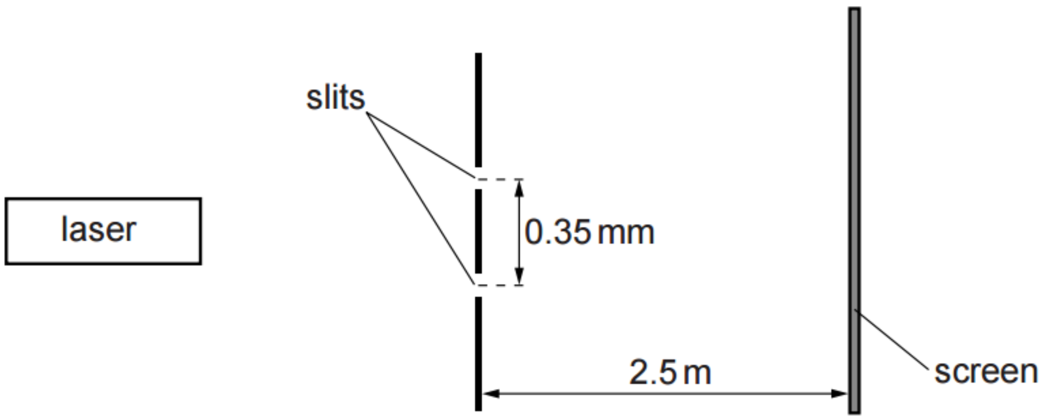


Fig. 3.1 (not to scale)

The laser emits light of wavelength 4.5×10^{-7} m. The distance from the slits to the screen is 2.5 m. The separation of the slits is 0.35 mm. The width of each slit is 2.0×10^{-6} m.

An interference pattern of maxima and minima is observed on the screen.

(i) Explain why an interference pattern is observed on the screen.

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

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

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

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

(ii) Calculate the distance between adjacent maxima.

distance = ………………….. m [2]

(iii) State and explain the effect, if any, on the appearance of the fringes when each of the following changes is made separately.

1. The laser is replaced by another laser emitting red light.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

……………………………………………………………………………………. [1]

2. The screen is rotated slightly so that it is no longer parallel to the plane of the two slits.

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

…………………………………………………………………………………………..

……………………………………………………………………………………. [2]

4 Two conductors, **A** and **B**, each of length 0.20 m and carrying current I of 5.0 A are placed at right angles to the plane of the magnetic field of magnitude 3.2 mT created by a pair of magnets as shown in Fig. 4.1. Conductor **A** carries current out of the plane of the paper while conductor **B** carries current into the plane of the paper.

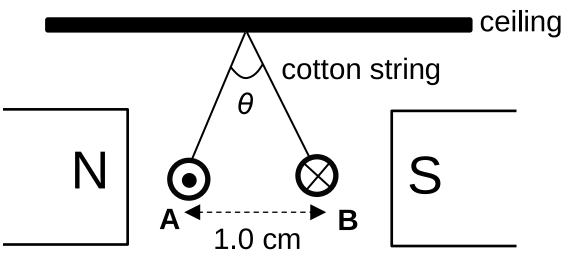


Fig. 4.1

The conductors are hung to the ceiling by cotton strings of equal tensions. At equilibrium, the two conductors make an angle of *θ* with each other and are separated by 1.0 cm.

The magnetic flux density *B* due to a long straight current carrying conductor is given by the expression

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

where *d* is the distance from the conductor. The permeability of free space is μ_0 and it has a value of $4\pi \times 10^{-7}$ H m^{-1}.

You may assume that the entire length of conductors **A** and **B** lie in the magnetic field of the pair of magnets.

(a) Fig 4.2 shows two forces that are acting on conductor **A**. Draw on the same diagram, two other forces that are acting on conductor **A**. Label all forces drawn. [2]

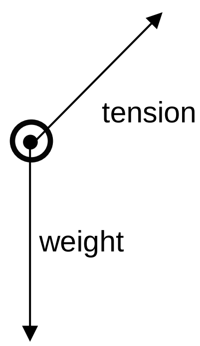


Fig. 4.2

(b) Calculate the magnetic force experienced by conductor **A** due to the pair of magnets.

force = ……………………..N [2]

(c) The mass of conductor **A** is 0.35 g. Determine the tension in the cotton string and the angle, θ.

tension = ……………….. N

θ = ………………… ° [4]

5 (a) Light is incident on a clean metal surface in a vacuum. The maximum kinetic energy KE_{max} of the electrons ejected from the surface is measured for different frequencies *f* of the incident light. The measurements are shown plotted below in Fig. 5.1.

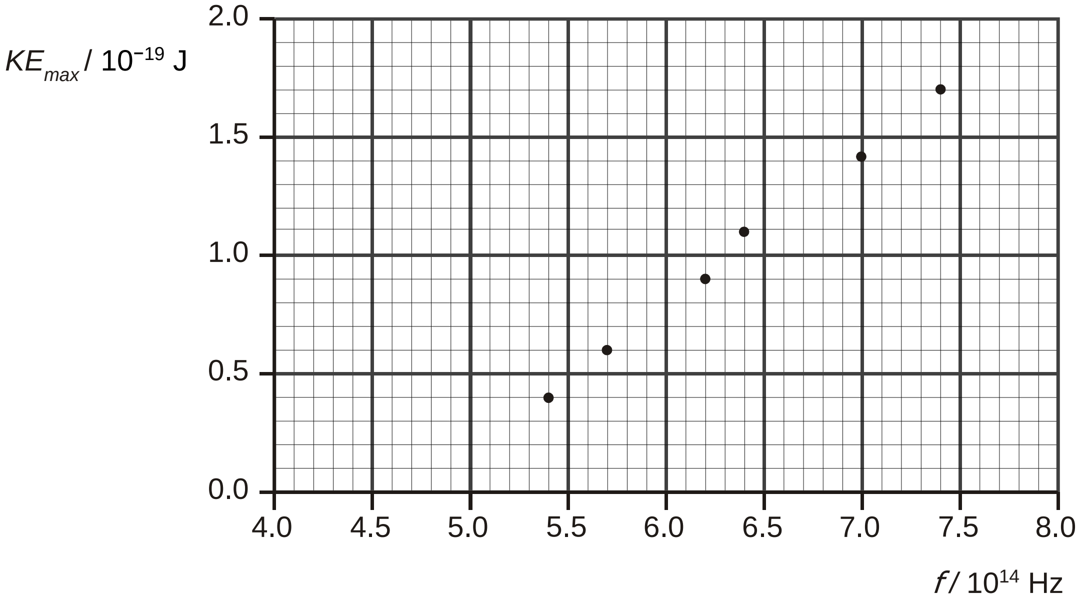


Fig. 5.1

(i) By drawing a suitable straight line on Fig. 5.1, use the graph to determine the Planck constant, *h*.

h = ……………..………….. J s [2]

(ii) Hence, calculate the work function of the metal.

work function = …………….……… J [2]

(b) Explain how a line emission spectrum leads to an understanding of the existence of discrete energy levels in atoms.

………

………

………

………

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

(c) Fig. 5.2 represents some of the allowed electron energy levels within a cool gas atom. The energy for each level is given in the diagram, with level 1 being the lowest energy state.

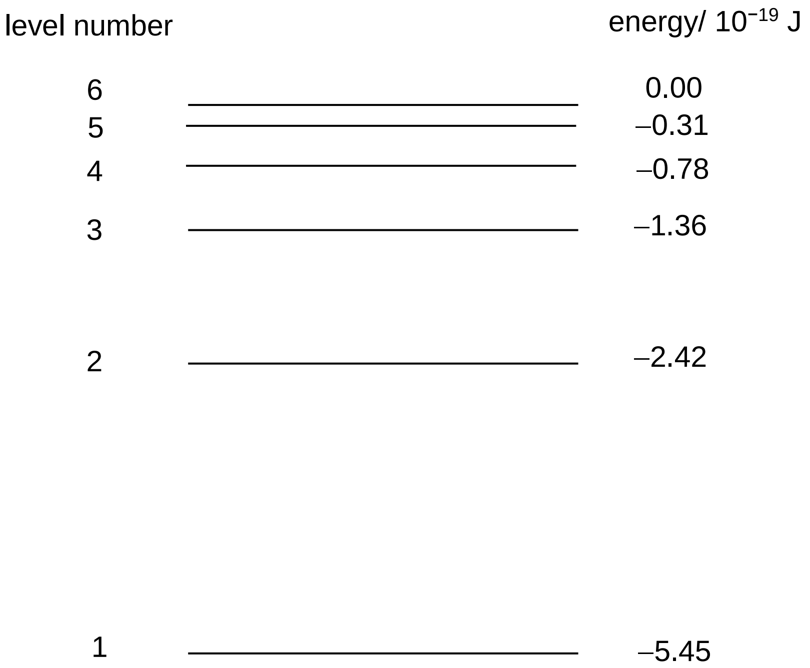


Fig. 5.2

(i) An electron of kinetic energy 5.00×10^{-19} J collides with this atom. Show that the minimum kinetic energy for a scattered electron is 0.33×10^{-19} J. [2]

(ii) Hence determine the the de-Broglie wavelength of the scattered electron.

de-Broglie wavelength = ………………… m [3]

End of Section A

Section B

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

6 **(a)** State the property of a body that resists change in motion.

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

(b) Define *impulse*.

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

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

(c) A soldier, together with his machine gun and bullets, has a combined mass of 90 kg. He stands at rest on a pair of ice skating blades and fires 10 bullets horizontally within 2.0 s in the forward direction. Each bullet has a mass of 10 g and leaves the gun with a speed of 750 m s^{-1}.

Assume there is no friction between the blades and the ground.

(i) Explain the motion of the man after firing by using Newton's laws.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) Calculate the soldier's speed just after he fired the 10^{th} bullet.

speed = ………………… m s^{-1} [3]

(iii) Calculate the average force exerted on the soldier and his machine gun.

average force = ………………… N [2]

(iv) One of the bullet hits a block of uniform mass 500 g which is resting on a horizontal platform. The impact causes the block to slide along the platform. The bullet remains embedded in the block after impact and the block experiences a constant frictional force of 30 N throughout its motion.

1. State the type of collision between the bullet and the block.

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

2. Calculate the distance the block travels before it comes to a complete stop.

distance = ………………… m [4]

3. State and explain how the distance in **(c)(iv)2** changes if the platform is inclined upwards.

………………………………………………………………………………………...

………………………………………………………………………………………...

………………………………………………………………………………………...

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

(d) The solider in **(c)** glided towards the edge of a downward slope of 30° to the horizontal. Just as he slides down the frictionless slope, he fired another 10 bullets along the direction of slope in 1.0 s as shown in Fig. 6.1.

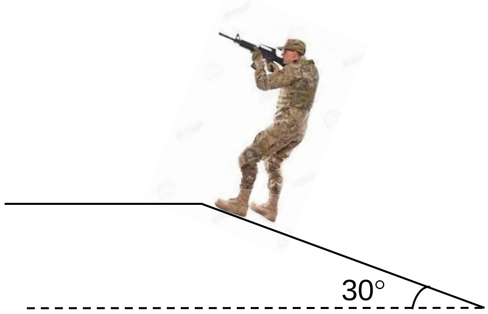


Fig. 6.1

Calculate the average acceleration of the man while firing.

average acceleration = ………………… m s^{-2} [4]

7 **(a)** Explain what is meant by the potential energy of a body.

………

………

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

(b) From the defining equation of work, show that the change in gravitational potential energy of a mass *m,* near the Earth's surface, when moved a distance *h* upwards is given by the equation

$$E_P = mgh,$$

where *g* is the acceleration due to gravity. [2]

(c) A car of mass 820 kg is travelling on a flat road at **P**. It then travels down a slope to **Q**, descending 5.0 m, as shown in Fig. 7.1

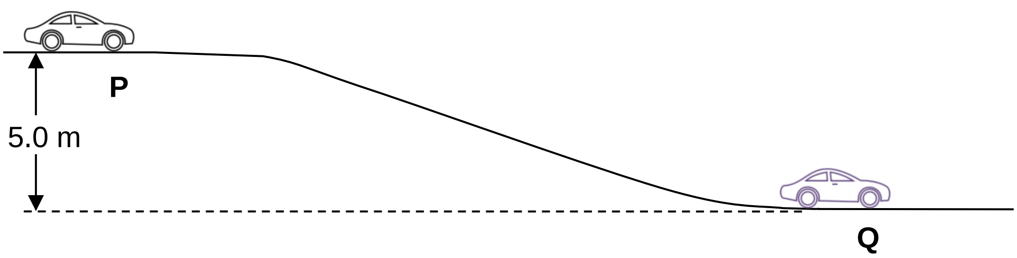


Fig. 7.1

(i) Calculate loss in gravitational potential energy of the car.

loss in gravitational potential energy = ………………… J [2]

(ii) The car is moving at a speed of (10 ± 1) m s^{-1} at point **P** and at (25 ± 3) m s^{-1} at point **Q**.

Determine the gain in kinetic energy of the car with its associated uncertainty.

gain in kinetic energy = ……………±………… J [4]

(iii) The fuel used during the journey has an energy rating of 42 MJ per kilogram. The mass of the fuel used was 35 g.

Calculate the efficiency in converting the stored energy in the fuel to the energy possessed by the car at its final speed at the bottom of the slope.

efficiency = ………………… % [3]

(iv) From point **Q,** the car then travels horizontally off the top of a cliff and enters the sea, as illustrated in Fig. 7.2.

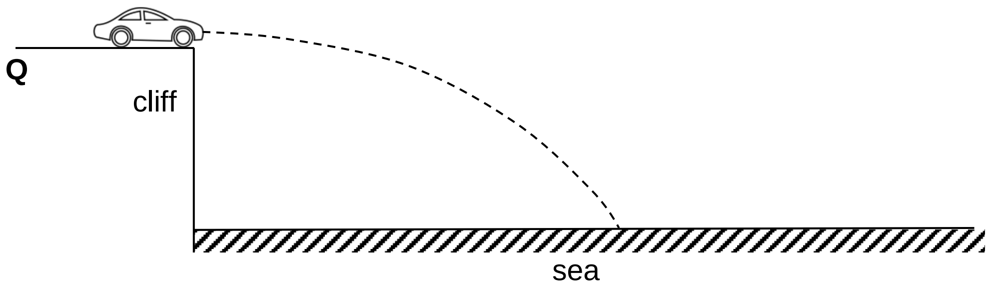


Fig. 7.2

Use energy considerations to suggest why, if the car causes a large splash on hitting the sea, it will be slowed down in a shorter distance than when no splash is produced.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(d) The variation with speed v of the total resistive force F_R acting on a car at speed v to oppose its motion is shown in Fig. 7.3.

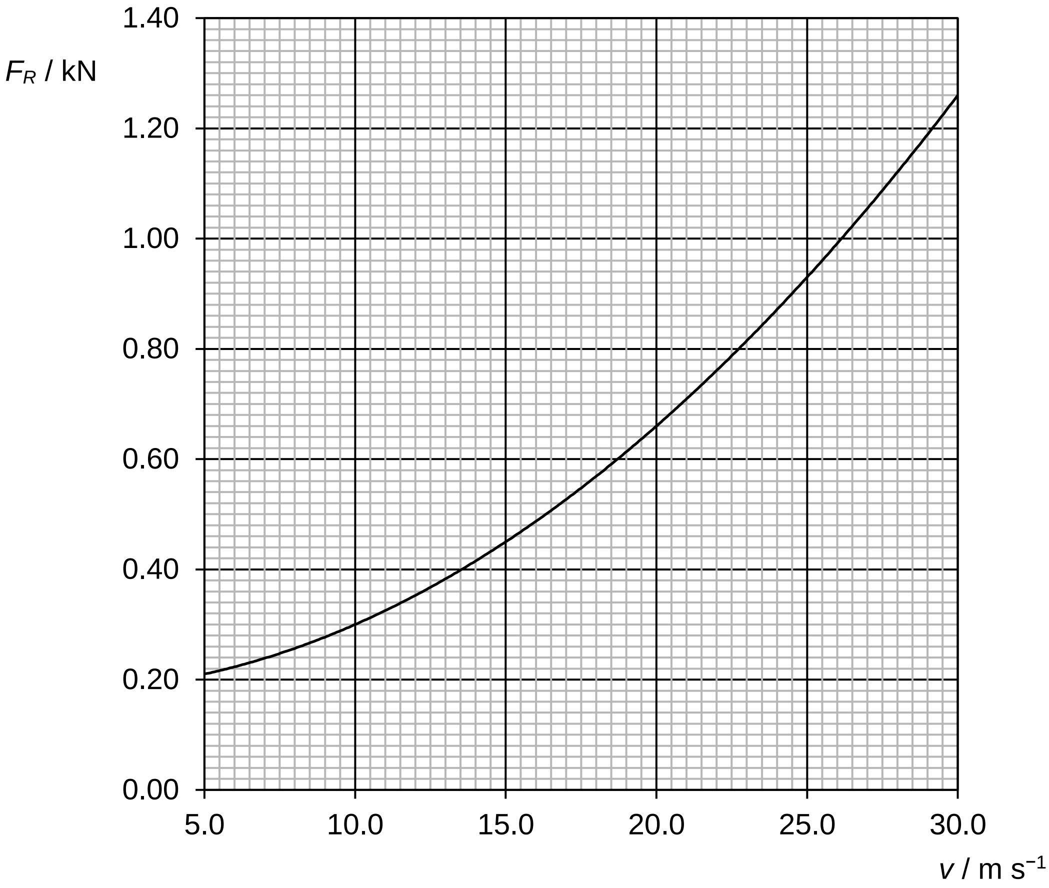


Fig. 7.3

Using the graph, show that the engine of the car needs to provide a greater power when the car is travelling at a constant speed of 30 m s^{-1} on a level road as compared to when it is travelling at a constant speed of 10 m s^{-1} on the same road.

Explain your workings. [4]

8 **(a)** Fig. 8.1 shows a set up for the electrolysis of sodium chloride solution using a 12 V cell. When dissolved in water, each sodium chloride yields a pair of oppositely charged ions; a positively charged sodium ion (Na^+) and a negatively charged chloride ion (Cl^-), both with a charge of *e*.

Fig. 8.2 shows the portion of the electrodes immersed in the solution. The electrodes are 7.5 cm apart and the immersed area parallel to each other is 23 cm^2. The resistivity of the given sodium chloride solution is 9.0 Ω cm.

You can assume that Na^+ and Cl^- are the only charge carriers.

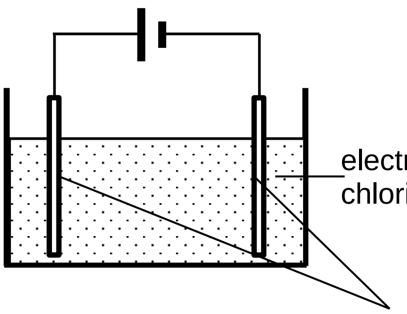


Fig. 8.1

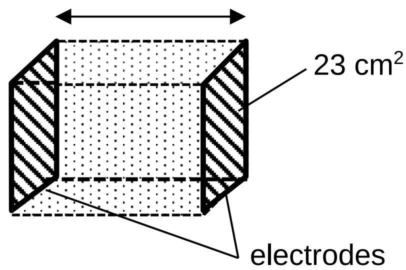


Fig. 8.2

(i) State what is meant by *resistance of a conductor*.

....

.... [1]

(ii) Calculate the resistance *R* of the sodium chloride solution.

R = ………………… Ω [2]

(iii) Hence calculate the current *I* passing through the sodium chloride solution.

I = ………………… A [2]

(iv) With reference to Fig. 8.1, state the direction of the net motion of sodium and chloride ions.

sodium ion = …………………

chloride ion = ………………… [1]

(v) Calculate the number of chloride ions that reaches the electrode in 2.0 s.

number of chloride ions = ………………… [3]

(vi) Calculate the energy supplied by the cell in 2.0 s.

energy supplied = …………………J [1]

(vii) Chloride ions forms chlorine gas as the electrolysis process progresses.

State and explain how the current would change.

....

....

.... [2]

(b) Fig. 8.3 shows a light-dependent resistor (LDR), a resistor R, and a relay in a circuit. The resistance of the LDR varies with the ambient light. In a bright environment, the LDR has a low resistance; as the environment darkens, its resistance increases.

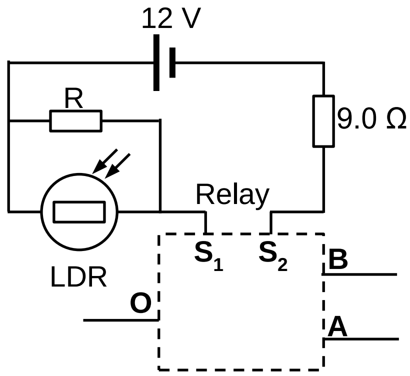


Fig. 8.3

Fig. 8.4 shows an electromagnetic switch setup within the relay. When the potential difference (p.d.) across S_1S_2 is below 5.0 V, the metal lever, held in position by a spring, forms a conducting path between **O** and **A** (as shown).

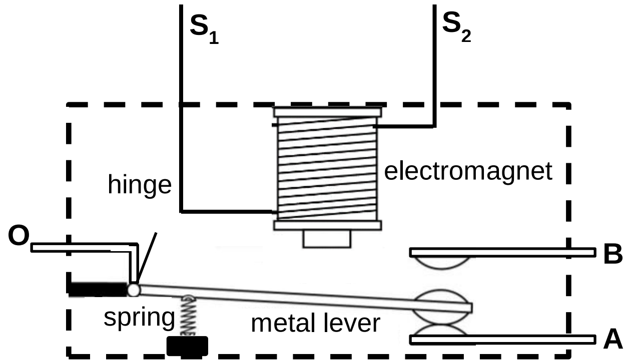


Fig. 8.4

When p.d. across S_1S_2 is at the rated voltage of 5.0 V, 80 mA of current flows through the electromagnet. The electromagnet produces a sufficiently strong magnetic field to attract the metal lever, forming a conducting path between **O** and **B**. The relay is said to be triggered.

(i) A simple lighting circuit, using a battery and a lamp, can be connected to the relay in Fig. 8.3 such that the lamp lights up when the ambient light is below a certain threshold brightness.

On Fig. 8.3 sketch a possible circuit using appropriate circuit symbols. [2]

(ii) At the threshold brightness, the resistance of the LDR is 3.5 kΩ. Calculate a suitable resistance for the resistor R.

resistance = ………………… Ω [3]

(iii) An electrician found that when she replaces the 12 V cell in Fig. 8.3 with another cell of the same e.m.f., the threshold brightness that triggers the relay changes. Suggest a reason to why this happens.

....

....

.... [2]

(iv) The electrician wants to maintain the same threshold brightness without having to replace any component every time she changes the 12 V cell. Suggest how she can modify the circuit in Fig. 8.3.

....

.... [1]

End of Section B

H1 P2 solutions

1(a)

$u(\cos 52)t = 4.6 ------1$

$u(\sin 52)t + 0.5(-9.81)t^2 = 1.5 ------- 2$

Solve,

$t = 0.946$ s

$u = 7.90$ m s^{-1}

(b)

$v_x = 7.8998 \cos 52 = 4.8636$

$v_y = 7.8998 \sin 52 + (-9.81)(0.9458) = -3.0532$

$\theta = \tan^{-1}\left(\frac{3.0532}{4.8636}\right) = 32.1°$

Less than 34°, therefore the ball will not pass through the basket.

2 **(a)** transverse waves have vibrations that are perpendicular / normal to the direction of energy travel [B1]

longitudinal waves have vibrations that are parallel to the direction of energy travel [B1]

(b) **(i)** phase difference
=(0.4-0.1)/0.8 x 2π

Acceptable answers:
135° or 0.75π rad or ¾π rad or 2.36 radians

(three sf) numerical value [M1]
unit [A1]

(ii) Using

$I \propto A^2$

$\frac{I_1}{I_2} = (\frac{A_1}{A_2})^2$

$\frac{I_1}{0.5I_1} = (\frac{2.8}{A_2})^2 \quad [M1]$

$A_2 = 1.98 cm \quad [A1]$

3 **(a)** The Principle of Superposition states that when two or more waves of the same kind overlap, the resultant displacement at any point at any instant is the vector sum of the displacements that the individual waves would have separately produced at that point and at that instant. (from notes) [B1]

(b) **(i)** When coherent waves emerging from slits meet at a point on the screen with a phase/path difference, [B1]

When waves meet in phase with phase difference is n(2π rad)/ path difference is integer ×λ, constructive interference occurs. And at the points where the waves meet exactly out of phase (any equivalent explanation of minima e.g. (n+½)×360°), destructive interference occurs. [B1]

(ii) $x = \frac{\lambda D}{a}$

x = (4.5 × 10^{-7})(2.5)/(0.35 × 10^{-3}) [M1]

= 3.21 x 10^{-3} m [A1]

(iii) 1. Red light has <u>longer wavelength</u>, hence <u>larger separation/distance between maximas [B1]</u>

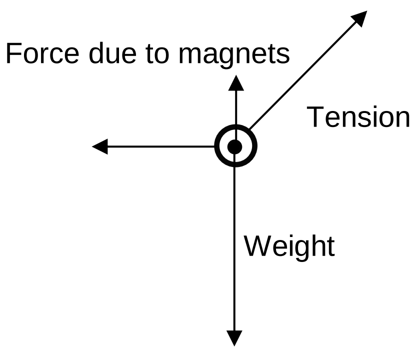
$x = \frac{\lambda D}{a}$

Since D and a remains constant, when wavelength increases, slit separation increases

2. <u>The fringe separation close to the screen will be closer to one another and the fringe separation further from the screen will be further apart</u> as screen separation is directly proportional to screen-to-slit distance. [B1]

<u>The nearer fringes will be brighter and have greater contrast and those futher away will be dimmer and less contrast. [B1]</u>

4 (a) (i)



For each force drawn, it must be labelled and of the correct length [B2]

(ii) $F = BIL = (3.2\times10^{-3})(5.0)(0.20) = 3.2\times10^{-3}$N [B1]

(iii) Magnitude of T_x = Magnitude of force due to conductor B [B1]

$|T_x| = |BIL| = \frac{\mu_o I}{2\pi d}(I)(L) = \frac{4\pi\times10^{-7}}{2\pi(0.010)}(5.0)(5.0)(0.20)$

$= 1.0\times10^{-4}$N

T_y + $F_{magnets}$ = mg

$T_y = mg - F_{magnets} = (\frac{0.35}{1000}\times9.81) - 3.2\times10^{-3}$ [B1]

$= 2.3\times10^{-4}$N

[B1]

Tension = $\sqrt{(1.0\times10^{-4})^2 + (2.3\times10^{-4})^2} = 2.54\times10^{-4}$

$$\tan(\frac{\theta}{2}) = \frac{T_x}{T_y} = \frac{1.0\times10^{-4}}{2.3\times10^{-4}}$$ [B1]

$\theta = 47^0$

5 a (i) Using the points (4.90, 0.10), (7.70. 1.90)

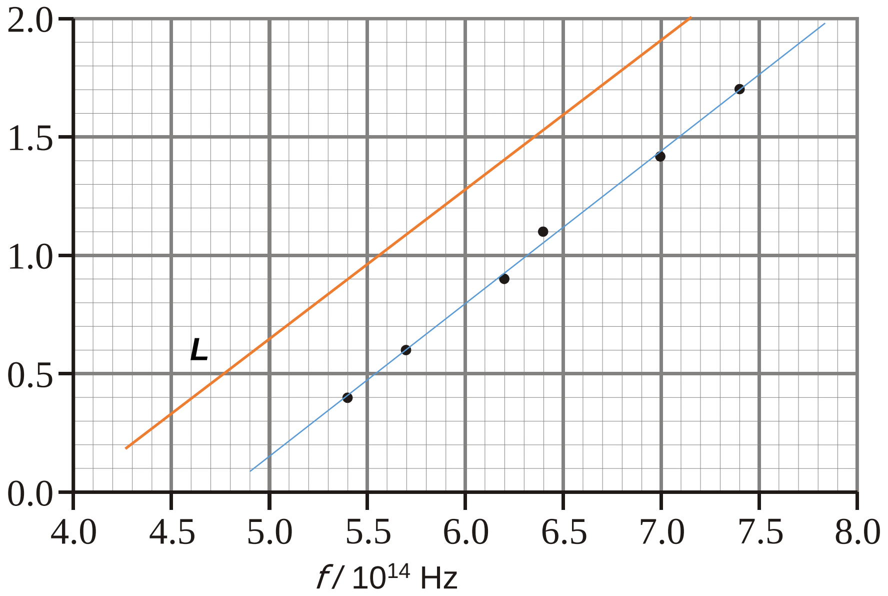


Fig. 5.1

h = slope of the graph = $\frac{(1.90-0.10)\times10^{-19}}{(7.70-4.90)\times10^{14}} = \frac{1.8\times10^{-19}}{2.8\times10^{14}}$

= 6.4×10^{-34} J s

($5.9 \le h/10^{-34}$ Js ≤ 6.8) accepted

[M1] – calculation of gradient using two points on line of best fit (not plotted point)

[A1]- correct calculation of Planck's constant.

(ii) frequency intercept, $f_o = 4.9\times10^{14}$ Hz; [M1]

therefore work function $\phi = hf_o = (4.9\times10^{14})\times(6.9\times10^{-34})$

= 3.4×10^{-19} J [A1]

(Students must use value for h obtained in (b)(i) for full credit, to be consistent with KEmax = hf - ϕ, i.e. if answer had been found instead from the vertical intercept)

Minus 1 only if h = 6.63×10^{-34} Js used)

(b)

The spectral lines are produced when **photons emitted when the electrons in the atoms de-excite from a higher energy level to a lower energy level**. [B1]

The **photon energy/wavelength/frequency depends on the energy difference** between the 2 energy levels. [B1]

Since the energy levels are discrete, **only light of specific wavelengths/frequency** are produced. [B1]

(c) **(i)** Energy absorbed by the ground state electron to transit to higherst possible level 4 = (5.45 – 0.78) $\times 10^{-19}$ = 4.67 $\times 10^{-19}$ J [C1]

Kinetic energy of the scattered electron, K = (5.00 – 4.67) $\times 10^{-19}$ [M1]
= 0.33 $\times 10^{-19}$ J [A0]

(ii)

Momentum of the scattered electron, p = $\sqrt{2mK}$

$= \sqrt{2 \times 9.11 \times 10^{-31} \times 0.33 \times 10^{-19}}$ [C1]

= 2.45 $\times 10^{-25}$ kg m s^{-1}

de-Broglie wavelength = h/p = [M1]

$= \frac{6.63 \times 10^{-34}}{2.45 \times 10^{-25}} = 2.70 \times 10^{-9}$ m [A1]

6 **(a)** Mass [B1]

(b) Impulse of a force is defined as the product of force and time of impact, and is equal to the change in momentum. [B1]

(c) **(i)** By Newton's 3rd law, when the machine gun exerts a force on the bullet, the bullet exerts an equal force but opposite direction on the gun and soldier. [B1]

This force causes the soldier and the machine gun to experience a change in momentum according to Newton's 2nd law that propelled the man backwards. [B1]

(ii) By conservation of momentum,
total momentum just before firing = total momentum just after firing

0 = momentum of bullets + momentum of man
[C1- for stating zero initial momentum]

$0 = 10 \times 1.0 \times 10^{-2} \times 750 - [90 - (10 \times 1.0 \times 10^{-2})]\, v$ [M1]

$v = 0.83426 \text{ m s}^{-1}$
$= 0.834 \text{ m s}^{-1}$ [A1]

[Note: deduct one mark for ii, iii, iv if students did not consider reduction in mass due to bullets being shot out]

(iii) Let average force exerted on man be F
$F\Delta t = \Delta p$

$F\Delta t$ = mass of man (final velocity of man – initial velocity of man)

$F(2.0) = [90 - (10 \times 1.0 \times 10^{-2})]\,(0.83426 - 0)$ [M1]

$F = 37.5 \text{ N}$ [A1]
.

(iv) **1.** Perfectly inelastic collision [B1]

2. By conservation of momentum,
initial momentum = final momentum

$0.010 \times 750 = (0.010 + 0.500)v$ [M1]

$v = 14.706 \text{ m s}^{-1}$

Acceleration of block and bullet,
$F_{net} = ma$
$30 = 0.510a$
$a = 58.82 \text{ m s}^{-2}$ [M1]

By kinematics
$v^2 = u^2 + 2as$
$0 = 14.706^2 + 2(-58.82)s$ [M1]
$s = 1.84 \text{ m}$ [A1]

OR:
By conservation of momentum,
initial momentum = final momentum

$0.010 \times 750 = (0.010 + 0.500)v$ [M1]

$v = 14.706$ m s^{-1}

By conservation of energy,
Loss in KE = Work done by frictional force

½ mv^2 = F s [C1- if using conservation of energy correctly]

½ x 0.510 x 14.706^2 = 30 s [M1]

s = 1.84 m [A1]

3. Part of the loss in KE needs to account for the increase in gravitational potential energy of the block-bullet system besides the work done by frictional force. [M1]

Hence, the distance would be shorter. [A1]

(d) Since the man fired another 10 bullets in 1.0s, the average force acting on the man by the bullets is now doubled; i.e. F = 75 N (along the slope). [M1]

The man also experiences a downward force along the slope due to the component of gravitational force along the slope.
F_{down} = mg sin30° = (90- (20x0.01)) x 9.81 x sin 30 = 440.5 N. [M1]

Therefore, Fnet = ma
440.5 +75 = [90- (20x0.01)] a [M1]
a = 5.74 m s^{-2} [A1]

7 **(a)** Potential energy of a body is its ability to do work [B1] as a result of the position / shape, etc of an object [B1]

(b) The mass is raised to a <u>vertical height</u> h_f above the ground at a *constant velocity (i.e. there is* ***no change in kinetic energy****)* by an <u>**external force *F*.**</u>

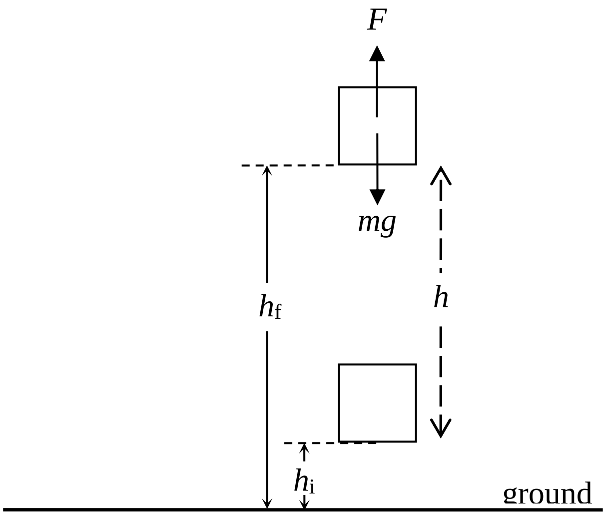


Figure: An object of mass *m* raised vertically by $h = h_f - h_i$.

Since <u>velocity is constant</u>, *Net force = 0*
[M1 given for describing constant velocity/ evidence of understanding that acceleration = 0]

$$F - mg = 0 \rightarrow F = mg$$

Hence,

Work done by external force *F* moving mass m through height
$= mg\,(h_f - h_i)$ = Change in Gravitational Potential energy [M1]
h_i must be shown

Since $h = h_f - h_i$,
Change in gravitational potential energy = *mgh* [A0]

(c) **(i)** Loss in GPE = initial GPE – final GPE
= (820)(9.81)(5.0) [M1]
= 4.0 x 10^4 J [A1]

(ii) Gain in KE $= \frac{1}{2}\, m(v_f^2 - v_i^2)$ [C1]
$= \frac{1}{2}\,(820)(25^2 - 10^2)$ [M1]
= 215 250 J

Max-Best method
Max change in KE = ½ (820)(28^2 – 9^2) = 288 230 J
Absolute uncertainty = (288 230 – 215 250) [M1]
= 72 980 J
= 70 000 J (1 s.f.)

Change in KE = (220 000 ± 70 000) J [A1]

(iii) Change in energy = change in GPE + change in KE
= -40 200 + 215 250 [M1]
= 1.751×10^5 J

Energy supplied by fuel = (35/1000) (42×10^6) = 1.47×10^6 J [M1]

Efficiency = $\frac{1.751\times10^5}{1.470\times10^6}\times100\%$ = 12 % [A1]

(iv) When the car enters the water, its kinetic energy is converted into sound energy, thermal energy due to work done again resistive forces and kinetic energy of the water splash. [B1]

When there is a large splash, a larger part of the car's initial kinetic energy is converted to KE of the water. Hence a smaller part of the car's initial kinetic energy can be converted to work done against resistive forces in the sea. [B1]

Since work done against resistive force = resistive force x displacement against the force, the car will slow down in a shorter distance if there is a large splash. [B1]

(d) To travel at constant speed, the driving force provided by the car engine must be equal in magnitude to the resistive force such that there is no net force on the car. [B1]

Power provided by the car engine = driving force x velocity of the car, [B1]
(do not accept F_R x v) Unclear workings without explanation gains 2 max 2 marks.

When the car is travelling at 10 m s^{-1}, therefore the driving force = 0.30 kN P = 3.0 kW [B1] [B1]

When the car is travelling at 30 m s^{-1}, therefore the driving force = 1.26 kN. P = 37.8 kW [B1] [B1]

Hence a greater power must be delivered at 30 m s^{-1}.

8 **(a)** **(i)** Resistance of a conductor is the ratio of the potential difference **across** the conductor to the current flowing **through** it. [B1]

(ii)

$$R = \rho \frac{l}{A}$$

$$= (9.0)\left(\frac{7.5}{23}\right)$$ [M1]

$$= 2.9\ \Omega$$ [A1]

(iii)

$$I = \frac{V}{R}$$

$$= \frac{12}{2.9}$$ [M1]

$$= 4.1\text{ A}$$ [A1]

(iv) sodium ion = right; chloride ion = left [B1]

(v)

$$Q = It$$

$$= (4.1)(2.0) = 8.2\text{ C}$$ [M1]

Each sodium chloride will produce two charge carriers, one of which is chloride ion.

No. of chloride ions

$$= \frac{8.2}{2(1.6 \times 10^{-19})}$$ [M1]

$$= 2.6 \times 10^{19}$$ [A1]

(vi)

$$W = IVt$$

$$= (4.1)(12)(2.0) = 98.4\text{ J}$$ [B1]

Alt:

$$W = qV$$

$$= (8.2)(12) = 98.4\text{ J}$$ [B1]

(vii) As chloride ions form chlorine gas, the number of charge carriers per unit volume decreases. [M1]

Hence the current decreases. [A1]

(b) **(i)** Note: When it is dark, the LDR will have high resistance. As such a small voltage will fall across the relay, which will not be sufficient to flip the metal lever to **B**. Hence the lighting circuit should be connected to **OA**.

[B1] – connection of a closed circuit (with power source) to **OA**. (award even if circuit if not workable)
[B1] – a workable lighting circuit drawn using appropriate circuit symbols

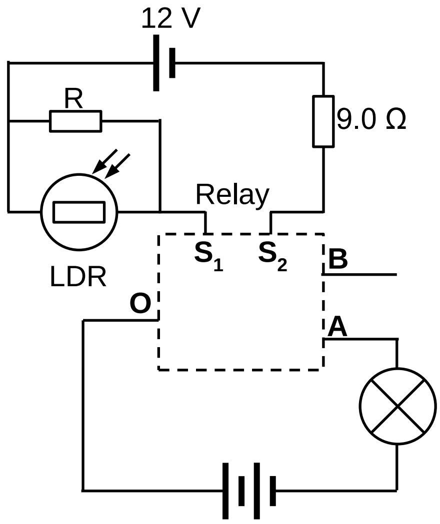


Fig. 8.3

(ii) To activate the relay, I = 80 mA and p.d. across **S_1S_2** is 5.0 V

$$\text{Total resistance of circuit} = \frac{\text{"p.d. across LDR, R and 9.0 }\Omega\text{"}}{\text{current}}$$

$$= \frac{12 - 5.0}{80 \times 10^{-3}}$$

$$= 87.5\ \Omega$$

Resistance of LDR and R $= 87.5 - 9.0$ [M1]

$$= 78.5\ \Omega$$

$$\frac{1}{3500} + \frac{1}{R_R} = \frac{1}{78.5}$$ [M1]

$$R_R = 80\ \Omega$$ [A1]

(iii) The new cell may have a <u>different internal resistance</u>. [M1]
At the original threshold brightness, the <u>potential difference across the relay is lower</u> than 5.0V. [A1]
Hence it is not able to trigger the relay.

(iv) <u>Replace the 9.0 Ω with a variable resistor</u>. [B1]
OR
<u>Replace resistor R with a variable resistor</u>.