



CANDIDATE
NAME

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9702/21

May/June 2022

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.

Data

acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

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- 1 (a) Define velocity.

.....
 [1]

- (b) A rock of mass 7.5 kg is projected vertically upwards from the surface of a planet. The rock leaves the surface of the planet with a speed of 4.0 ms^{-1} at time $t = 0$. The variation with time t of the velocity v of the rock is shown in Fig. 1.1.

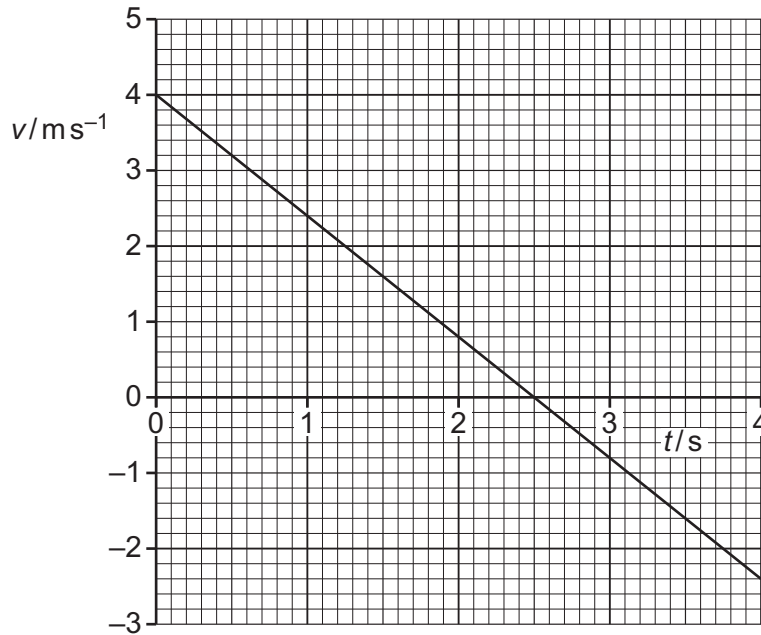


Fig. 1.1

Assume that the planet does not have an atmosphere and that the viscous force acting on the rock is always zero.

- (i) Determine the height of the rock above the surface of the planet at time $t = 4.0 \text{ s}$.

height = ... m [3]

- (ii) Determine the change in the momentum of the rock from time $t = 0$ to time $t = 4.0$ s.

change in momentum = ... N s [2]

- (iii) Determine the weight W of the rock on this planet.

$W =$ N [2]

- (c) In practice, the planet in (b) does have an atmosphere that causes a viscous force to act on the moving rock.

State and explain the variation, if any, in the resultant force acting on the rock as it moves vertically upwards.

.....

 [2]

[Total: 10]

- 2 (a) State what is meant by the centre of gravity of an object.

.....
 [1]

- (b) A non-uniform rod XY is pivoted at point P, as shown in Fig. 2.1.

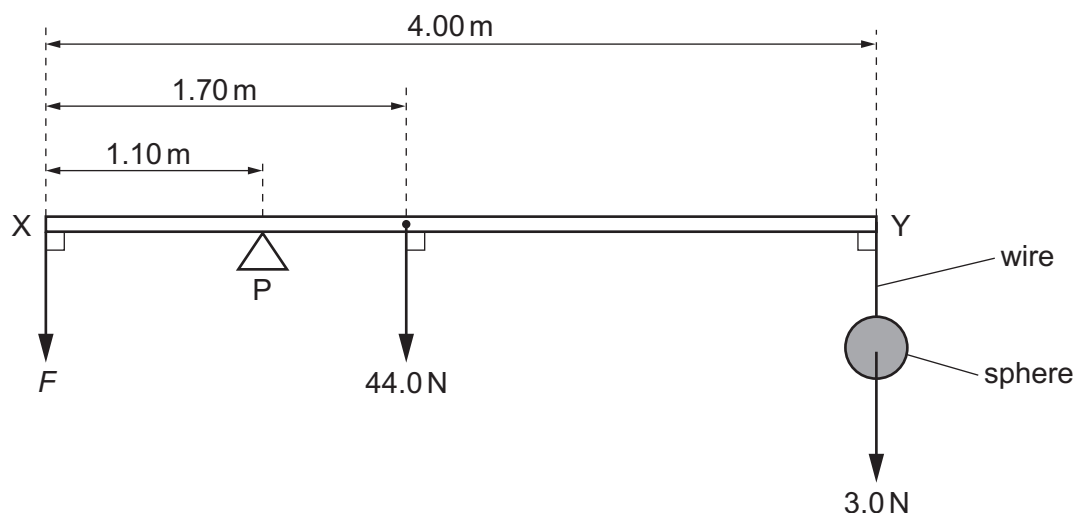


Fig. 2.1 (not to scale)

The rod has length 4.00 m and weight 44.0 N. The centre of gravity of the rod is 1.70 m from end X of the rod. Point P is 1.10 m from end X.

A sphere hangs by a wire from end Y of the rod. The weight of the sphere is 3.0 N. The weight of the wire is negligible.

A force F is applied vertically downwards at end X so that the horizontal rod is in equilibrium.

- (i) By taking moments about P, calculate F .

$F =$ N [3]

- (ii) Calculate the force exerted on the rod by the pivot.

force = ... N [1]

(c) The sphere in (b) is now immersed in a liquid in a container, as shown in Fig. 2.2.



Fig. 2.2

The density of the liquid is 1100 kg m^{-3} . The upthrust acting on the sphere due to the liquid is 2.5 N . The magnitude of F is unchanged so that the horizontal rod is **not** in equilibrium.

(i) Use Archimedes' principle to determine the radius r of the sphere.

$r = \dots\dots\dots\text{ m}$ [3]

(ii) Calculate the magnitude and direction of the resultant moment of the forces on the rod about P.

magnitude of resultant moment = $\dots\dots\dots\text{ Nm}$

direction of resultant moment $\dots\dots\dots$ [2]

[Total: 10]

- 3 (a) (i) Define power.

.....
 [1]

- (ii) A force F takes time t to move an object through a displacement x at constant velocity v in the direction of the force. The work done by the force is W .

Use the definition of power to show that the power P transferred by the force is given by

$$P = Fv.$$

[2]

- (b) A block is pulled up a slope by a wire attached to a motor, as shown in Fig. 3.1.

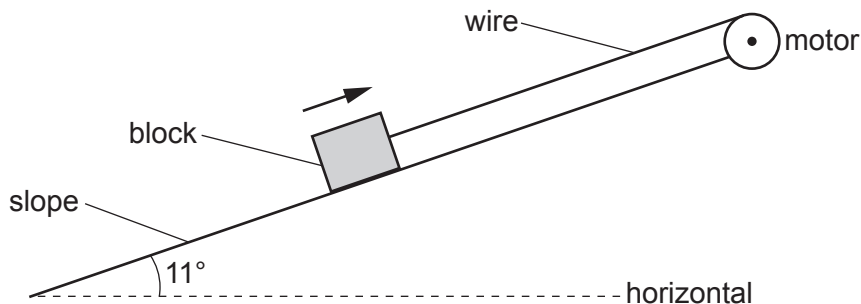


Fig. 3.1 (not to scale)

The useful power output of the motor is 56 W . The block has a weight of 430 N and travels with constant velocity along the slope at an angle of 11° to the horizontal.

Assume that there are no resistive forces opposing the motion of the block.

- (i) Calculate the tension T in the wire.

$T = \dots\dots\dots \text{ N}$ [2]

- (ii) Calculate the speed of the block.

speed = ... ms^{-1} [1]

- (iii) The rate of increase of gravitational potential energy of the block is equal to the useful power output of the motor. One of the reasons for this is that there is no work done against resistive forces.

By considering the motion of the block, state another reason for this.

.....
 [1]

- (iv) The motor has an efficiency of 80%.

Calculate the time taken for an input energy of 1.2 kJ to be supplied to the motor.

time taken = ... s [2]

[Total: 9]

- 4 A spring is suspended from a fixed point at one end and a vertical force is applied to the other end, as shown in Fig. 4.1.

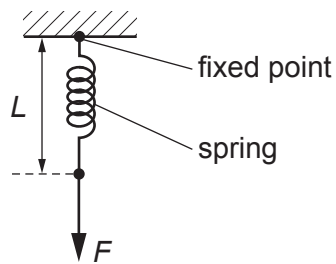


Fig. 4.1

The variation of the applied force F with the length L of the spring is shown in Fig. 4.2.

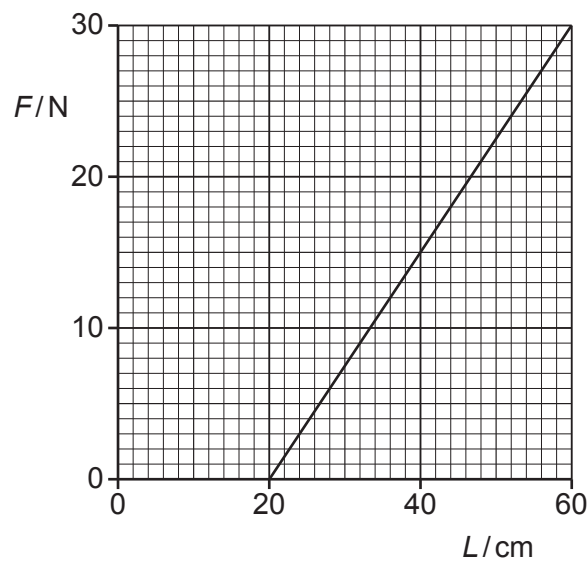


Fig. 4.2

- (a) Determine the spring constant k of the spring.

$k = \dots\dots\dots \text{Nm}^{-1}$ [2]

- (b) Determine the elastic potential energy in the spring when the applied force F is 15 N.

elastic potential energy = ... J [3]

[Total: 5]

- 5 A horizontal string is stretched between two fixed points A and B. A vibrator is used to oscillate the string and produce an observable stationary wave.

At one instant, the moving string is straight, as shown in Fig. 5.1.



Fig. 5.1

The dots in the diagram represent the positions of the nodes on the string. Point P on the string is moving downwards.

The wave on the string has a speed of 35 ms^{-1} and a period of 0.040 s .

- (a) Explain how the stationary wave is formed on the string.

.....

.....

.....

..... [2]

- (b) On Fig. 5.1, sketch a line to show a possible position of the string a quarter of a cycle later than the position shown in the diagram. [1]

- (c) Determine the horizontal distance from A to B.

distance = ... m [3]

- (d) A particle on the string has zero displacement at time $t = 0$. From time $t = 0$ to time $t = 0.060$ s, the particle moves through a total distance of 72 mm.

Calculate the amplitude of oscillation of the particle.

amplitude = ... mm [2]

[Total: 8]

- 6 (a) State Kirchhoff's first law.

.....
 [1]

- (b) A battery is connected to two resistors X and Y, as shown in Fig. 6.1.

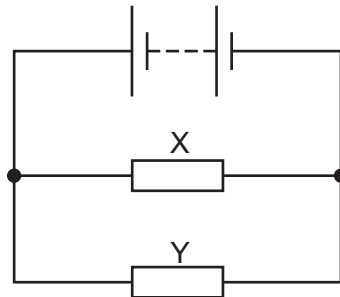


Fig. 6.1

The resistance of resistor X is greater than the resistance of resistor Y.

- (i) State and explain which resistor dissipates more power.

.....

 [3]

- (ii) The two resistors are made of wires that have the same length. Both wires are made from metal of the same resistivity.

State and explain which resistor is made of wire with the larger cross-sectional area.

.....

 [2]

- (c) A battery of electromotive force (e.m.f.) 9.0 V and negligible internal resistance is connected in series with a light-dependent resistor (LDR) and a fixed resistor of resistance $1800\ \Omega$, as shown in Fig. 6.2.

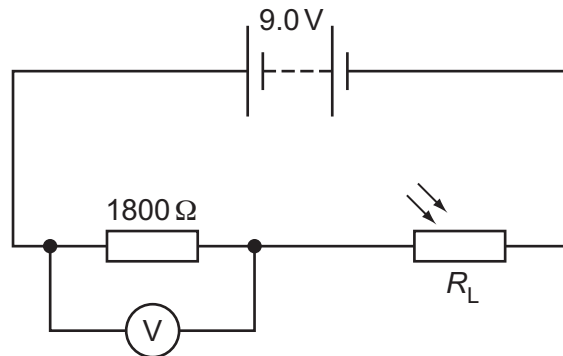


Fig. 6.2

A voltmeter is connected across the fixed resistor. The reading on the voltmeter is 5.4 V.

- (i) Calculate the current in the circuit.

current = ... A [1]

- (ii) Calculate the resistance R_L of the LDR.

R_L = ... Ω [2]

- (iii) The intensity of the light illuminating the LDR increases.

By reference to the current in the circuit, state and explain the change, if any, to the voltmeter reading.

.....

 [2]

[Total: 11]

7 (a) An unstable nucleus ${}^A_Z\text{X}$ decays by emitting a β^- particle.

(i) Determine quantitatively the changes, if any, in A and Z when X decays.

change in A = ...

change in Z = ...

[2]

(ii) In addition to the β^- particle, another lepton is emitted during the decay.

State the name of the other lepton that is emitted.

..... [1]

(b) A particle P is composed of an up quark (u) and a down antiquark ($\bar{d}$).

(i) Calculate the charge q of particle P in terms of e , where e is the elementary charge.

Show your working.

q = ... e [2]

(ii) Particle P belongs to **two** classes (groups) of particles.

State the names of these two classes.

1

2

[2]

[Total: 7]

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- 1 (a) In the following list, underline all units that are SI base units.

ampere degree Celsius kilogram newton [1]

- (b) Fig. 1.1 shows a horizontal beam clamped at one end with a block attached to the other end.

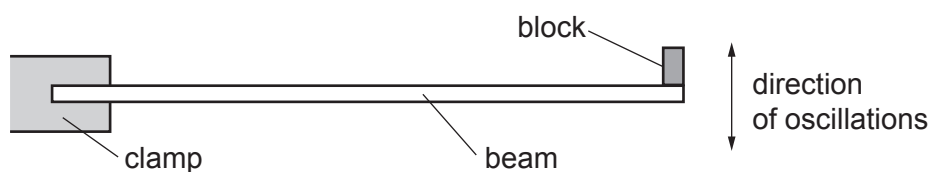


Fig. 1.1

The block is made to oscillate vertically.

The Young modulus E of the material of the beam is given by

$$E = \frac{kM}{T^2}$$

where M is the mass of the block,
 T is the period of the oscillations
 and k is a constant.

A student determines the values and percentage uncertainties of k , M and T .
 Table 1.1 lists the percentage uncertainties.

Table 1.1

quantity	percentage uncertainty
k	$\pm 2.1\%$
M	$\pm 0.6\%$
T	$\pm 1.5\%$

The student uses the values of k , M and T to calculate the value of E as $8.245 \times 10^9 \text{ Pa}$.

- (i) Calculate the percentage uncertainty in the value of E .

percentage uncertainty = ... % [2]

- (ii) Use your answer in (b)(i) to determine the value of E , with its absolute uncertainty, to an appropriate number of significant figures.

$$E = (\text{.....} \pm \text{.....}) \times 10^9 \text{ Pa} \quad [2]$$

[Total: 5]

- 2 A sphere is attached by a metal wire to the horizontal surface at the bottom of a river, as shown in Fig. 2.1.

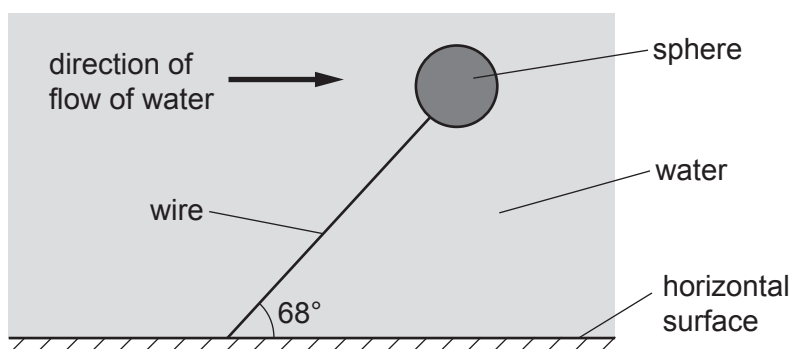


Fig. 2.1 (not to scale)

The sphere is fully submerged and in equilibrium, with the wire at an angle of 68° to the horizontal surface. The weight of the sphere is 32 N. The upthrust acting on the sphere is 280 N. The density of the water is $1.0 \times 10^3 \text{ kg m}^{-3}$.

Assume that the force on the sphere due to the water flow is in a horizontal direction.

- (a) By considering the components of force in the vertical direction, determine the tension in the wire.

tension = ... N [2]

- (b) For the sphere, calculate:

- (i) the volume

volume = ... m^3 [1]

- (ii) the density.

density = ... kg m^{-3} [2]

- (c) The centre of the sphere is initially at a height of 6.2m above the horizontal surface. The speed of the water then increases, causing the sphere to move to a different position. This movement of the sphere causes its gravitational potential energy to decrease by 77 J.

Calculate the final height of the centre of the sphere above the horizontal surface.

height = ... m [3]

- (d) The extension of the wire increases when the sphere changes position as described in (c). The wire obeys Hooke's law.

- (i) State a symbol equation that gives the relationship between the tension T in the wire and its extension x . Identify any other symbol that you use.

.....
 [1]

- (ii) Before the sphere changed position, the initial elastic potential energy of the wire was 0.65 J. The change in position of the sphere causes the extension of the wire to double.

Calculate the final elastic potential energy of the wire after the sphere has changed position.

final elastic potential energy = ... J [2]

[Total: 11]

- 3 A man standing on a wall throws a small ball vertically upwards with a velocity of 5.6 m s^{-1} . The ball leaves his hand when it is at a height of 3.1 m above the ground, as shown in Fig. 3.1.

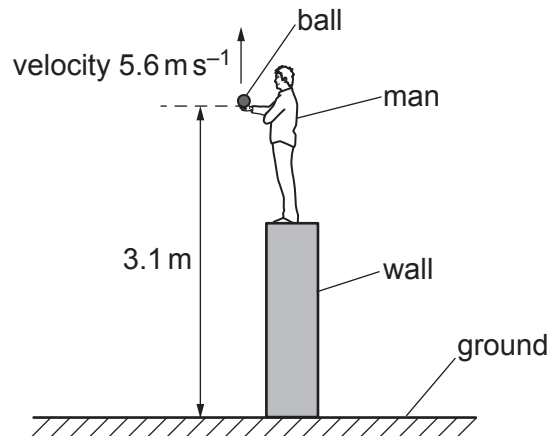


Fig. 3.1 (not to scale)

Assume that air resistance is negligible.

- (a) Show that the ball reaches a maximum height above the ground of 4.7 m .

[2]

- (b) The man does not catch the ball as it falls.

Calculate the time taken for the ball to fall from its maximum height to the ground.

time taken = ... s [2]

- (c) The ball leaves the man's hand at time $t = 0$ and hits the ground at time $t = T$.

On Fig. 3.2, sketch a graph to show the variation of the velocity v of the ball with time t from $t = 0$ to $t = T$. Numerical values of v and t are not required. Assume that v is positive in the upward direction.

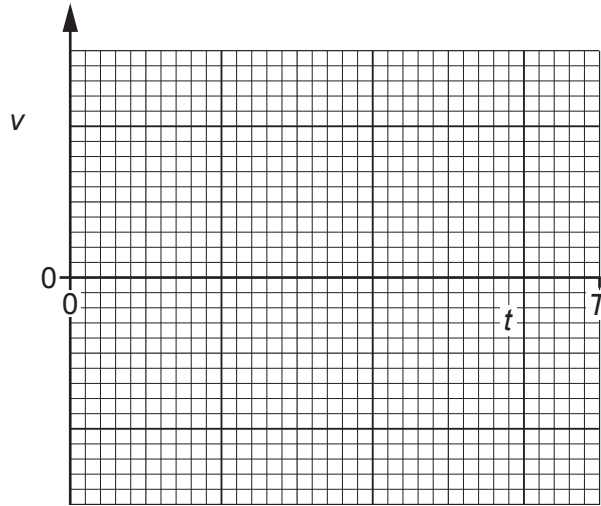


Fig. 3.2

[3]

- (d) State what is represented by the gradient of the graph in (c).

..... [1]

- (e) The man now throws a second ball with the same velocity and from the same height as the first ball. The mass of the second ball is greater than that of the first ball. Assume that air resistance is still negligible.

For the first and second balls, compare:

- (i) the magnitudes of their accelerations

..... [1]

- (ii) the speeds with which they hit the ground.

..... [1]

[Total: 10]

- 4 (a) State the principle of conservation of momentum.

.....

.....

..... [2]

- (b) Two balls, X and Y, move along a horizontal frictionless surface, as shown from above in Fig. 4.1.

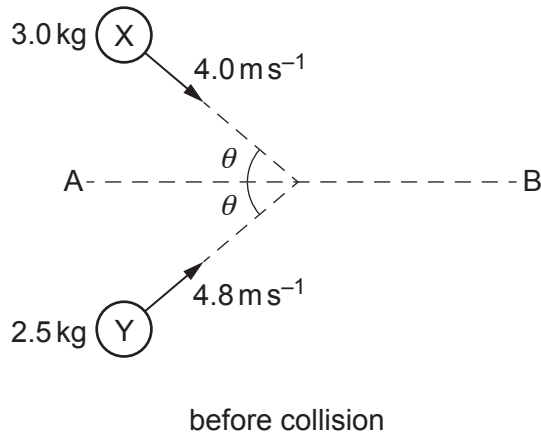


Fig. 4.1 (not to scale)

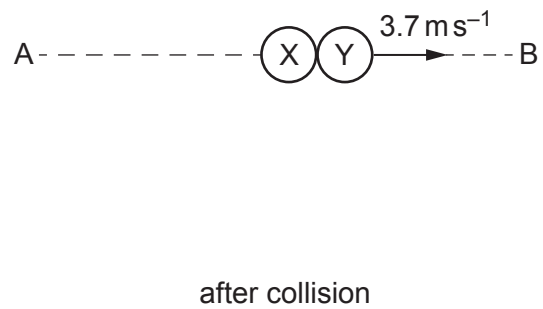


Fig. 4.2 (not to scale)

Ball X has a mass of 3.0 kg and a velocity of 4.0 m s^{-1} in a direction at angle θ to a line AB. Ball Y has a mass of 2.5 kg and a velocity of 4.8 m s^{-1} in a direction at angle θ to the line AB.

The balls collide and stick together. After colliding, the balls have a velocity of 3.7 m s^{-1} along the line AB on the horizontal surface, as shown in Fig. 4.2.

- (i) By considering the components of the momenta along the line AB, calculate θ .

$\theta = \dots\dots\dots^\circ$ [3]

- (ii) By calculation of kinetic energies, state and explain whether the collision of the balls is inelastic or perfectly elastic.

.....

..... [2]

[Total: 7]

- 5 Light from a laser is used to produce an interference pattern on a screen, as shown in Fig. 5.1.

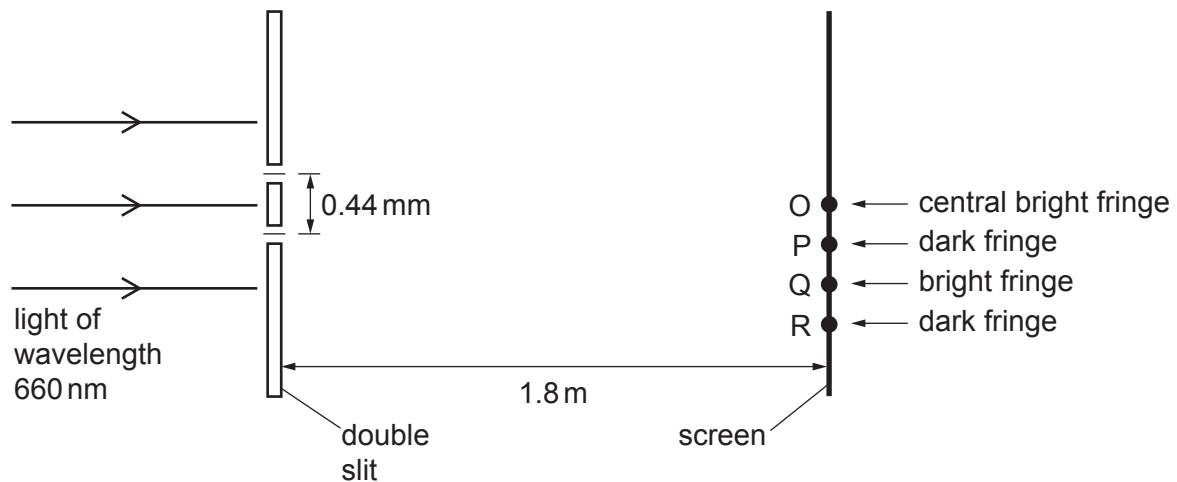


Fig. 5.1 (not to scale)

The light of wavelength 660 nm is incident normally on two slits that have a separation of 0.44 mm. The double slit is parallel to the screen. The perpendicular distance between the double slit and the screen is 1.8 m.

The central bright fringe on the screen is formed at point O. The next dark fringe below point O is formed at point P. The next bright fringe and the next dark fringe below point P are formed at points Q and R respectively.

- (a) The light waves from the two slits are coherent.

State what is meant by coherent.

.....
 [1]

- (b) For the two light waves superposing at R, calculate:

- (i) the difference in their path lengths, in nm, from the slits

path difference = ... nm [1]

- (ii) their phase difference.

phase difference = ... ° [1]

- (c) Calculate the distance OQ.

distance OQ = ... m [3]

- (d) The intensity of the light incident on the double slit is increased without changing the frequency.

Describe how the appearance of the fringes after this change is different from, and similar to, their appearance before the change.

.....

 [3]

- (e) The light of wavelength 660 nm is now replaced by blue light from a laser.

State and explain the change, if any, that must be made to the separation of the two slits so that the fringe separation on the screen is the same as it was for light of wavelength 660 nm.

.....

 [2]

[Total: 11]

- 6 (a) A network of three resistors of resistances R_1 , R_2 and R_3 is shown in Fig. 6.1.

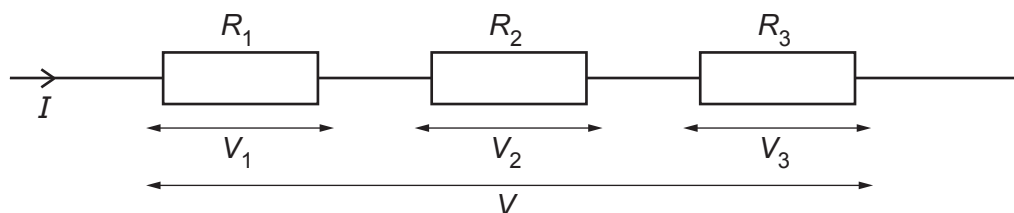


Fig. 6.1

The individual potential differences across the resistors are V_1 , V_2 and V_3 . The current in the combination of resistors is I and the total potential difference across the combination is V .

Show that the combined resistance R of the network is given by

$$R = R_1 + R_2 + R_3.$$

[2]

- (b) A battery of electromotive force (e.m.f.) 8.0V and negligible internal resistance is connected to a thermistor, a switch X and two fixed resistors, as shown in Fig. 6.2.

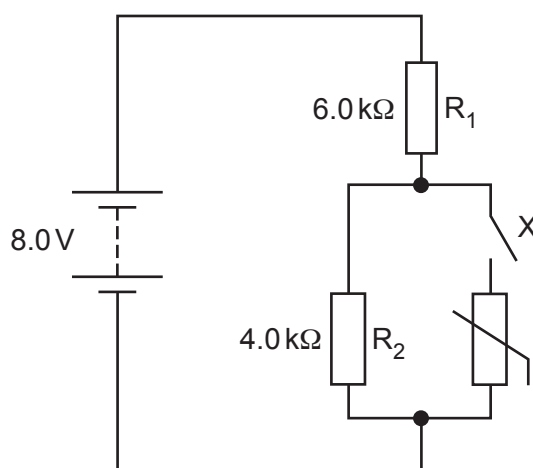


Fig. 6.2

Resistor R_1 has resistance 6.0 kΩ and resistor R_2 has resistance 4.0 kΩ.

- (i) Switch X is open.

Calculate the potential difference across R_1 .

potential difference = ... V [2]

- (ii) Switch X is now closed. The resistance of the thermistor is $12.0\text{ k}\Omega$.

Calculate the current in the battery.

current = ... A [2]

- (c) The switch X in the circuit in (b) remains closed. The temperature of the thermistor decreases.

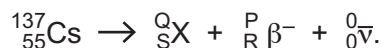
By reference to the current in the battery, state and explain the effect, if any, of the decrease in temperature on the power produced by the battery.

.....

 [3]

[Total: 9]

- 7 (a) A nucleus of caesium-137 ($^{137}_{55}\text{Cs}$) decays by emitting a β^- particle to produce a nucleus of an element X and an antineutrino. The decay is represented by



- (i) State the number represented by each of the following letters.

P

Q

R

S

[2]

- (ii) State the name of the class (group) of particles that includes the β^- particle and the antineutrino.

..... [1]

- (b) A particle Y has a quark composition of ddd where d represents a down quark.

A particle Z has a quark composition of $\bar{u}d$ where $\bar{u}$ represents an up antiquark.

- (i) Show that the charges of particles Y and Z are equal.

[2]

- (ii) State and explain which particle is a meson and which particle is a baryon.

meson:

.....

baryon:

.....

[2]

[Total: 7]

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- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.

Data

acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

- 1 A solid metal sphere has a diameter of $(3.42 \pm 0.02)\text{cm}$ and a mass of $(67 \pm 2)\text{g}$.

(a) Calculate the density, in g cm^{-3} , of the metal.

density = ... g cm^{-3} [3]

(b) Determine the percentage uncertainty in the density.

percentage uncertainty = ...% [2]

[Total: 5]

- 2 An archer releases an arrow towards a target at a velocity of 65.0 m s^{-1} at an angle of 4.30° above the horizontal, as shown in Fig. 2.1.

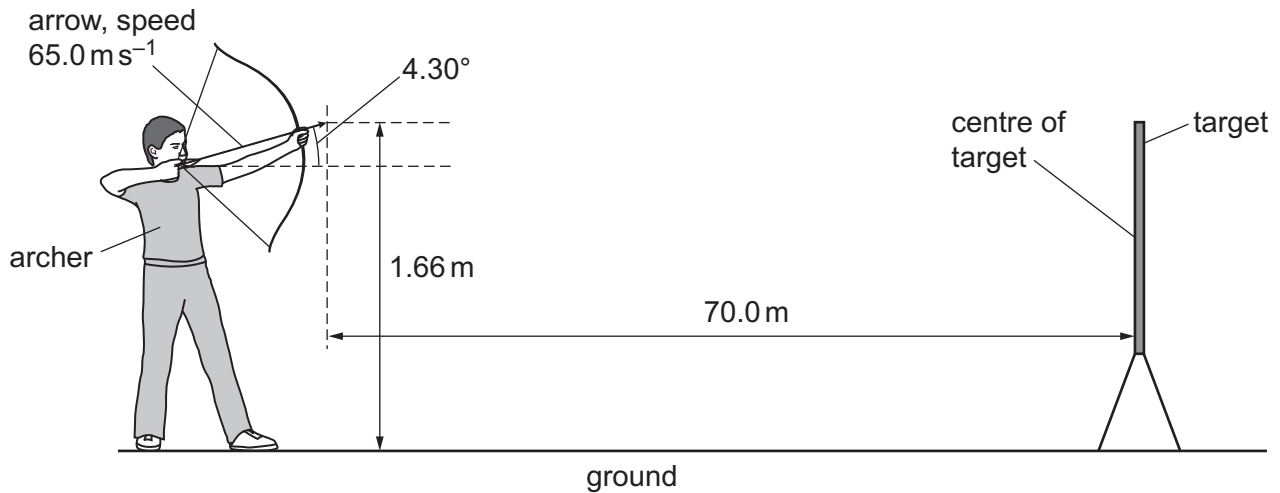


Fig. 2.1 (not to scale)

When released, the tip of the arrow is a horizontal distance of 70.0 m from the target and 1.66 m above the horizontal ground.

The arrow hits the centre of the target.

Assume that air resistance is negligible and that all the mass of the arrow is at its tip.

- (a) Show that the time taken for the arrow to reach the target is 1.08 s.

[2]

- (b) Calculate the height of the centre of the target above the ground.

height above ground = ... m [3]

- (c) By considering energy changes, state and explain how the final kinetic energy of the arrow as it hits the target compares with its initial kinetic energy immediately after release. A numerical calculation is not required.

.....

.....

.....

..... [2]

[Total: 7]

- 3 (a) Define velocity.

.....
 [1]

- (b) A constant driving force of 2400 N acts on a car of mass 1200 kg. The car accelerates from rest in a straight line along a horizontal road.

Assume that the resistive forces acting on the car are negligible.

- (i) Calculate the acceleration of the car.

acceleration = ... ms^{-2} [1]

- (ii) On Fig. 3.1, sketch a graph showing the variation with time t of the velocity v of the car for the first 20 seconds of its motion.

Label this line A.

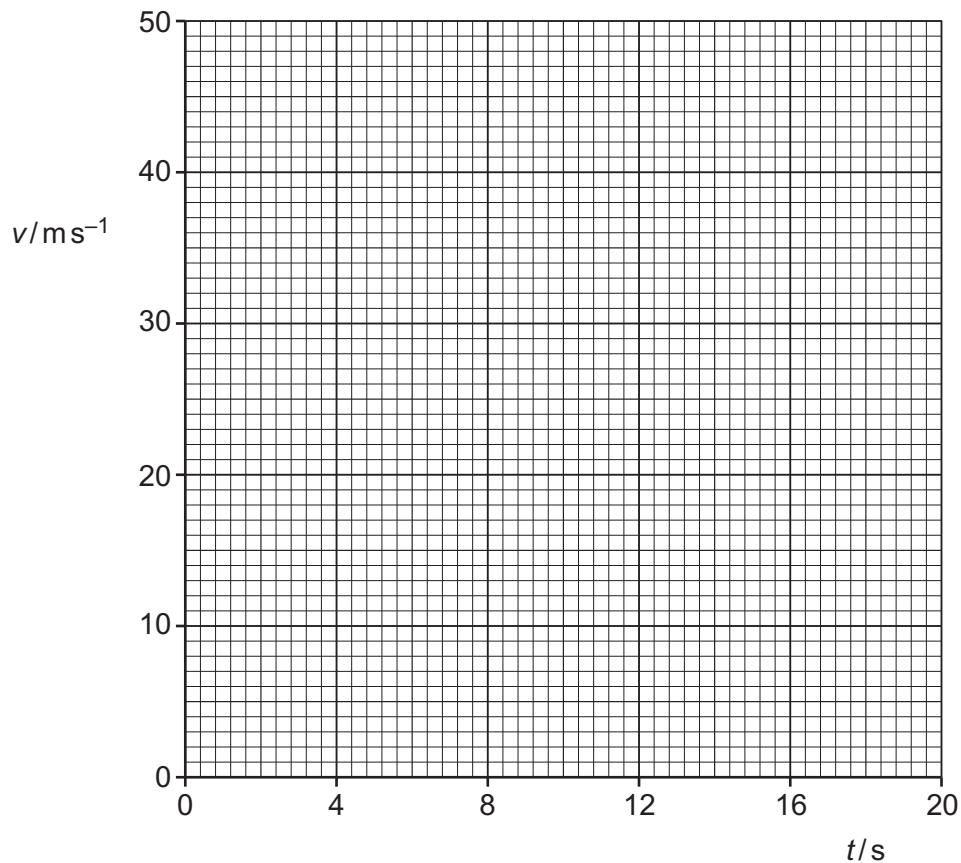


Fig. 3.1

[2]

- (c) In reality, a resistive force due to air resistance acts on the car in (b). This resistive force increases with speed until it becomes equal in magnitude to the driving force at time $t = 12\text{ s}$.
- (i) On Fig. 3.1, sketch a second line to show the variation with time t of the velocity v of the car for the first 20 seconds of its motion. Label this line B. [3]
- (ii) At time $t = 20\text{ s}$, the driving force is increased to 3000 N and remains constant at this value.

Describe how the velocity of the car changes due to this increase in the driving force.

.....

.....

.....

..... [2]

[Total: 9]

- 4 (a) A mass m moves a vertical distance Δh in a uniform gravitational field and gains gravitational potential energy ΔE_p . The acceleration of free fall is g .

Use the concept of work done to show that

$$\Delta E_p = mg\Delta h.$$

[2]

- (b) A 0.60 kg mass is attached to a string which is wrapped around the wheel of a generator, as shown in Fig. 4.1.

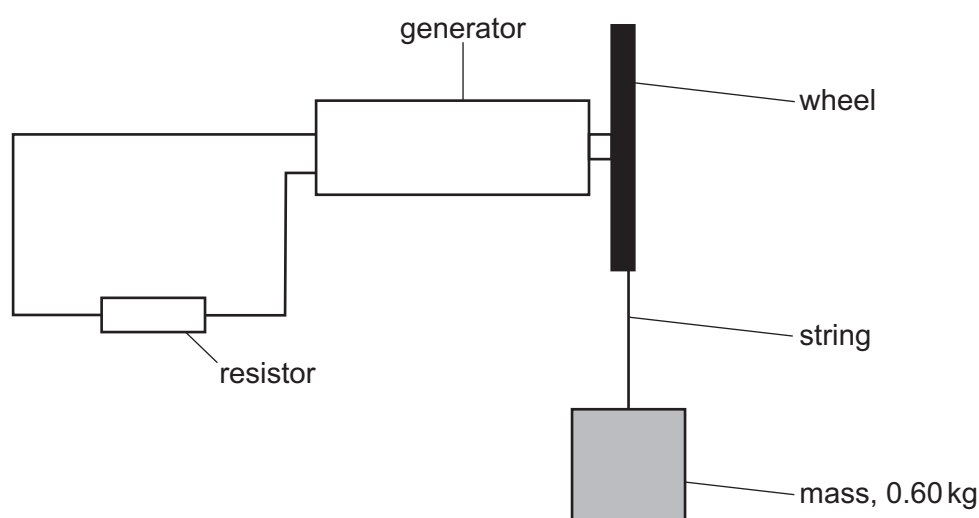


Fig. 4.1

The mass is held stationary above the floor. When released, the mass initially accelerates and then falls at a steady speed and spins the wheel. The generator causes a current in a resistor. Air resistance is negligible.

State the main energy change when the mass is falling at a steady speed.

..... energy to energy.

[1]

- (c) When falling at a steady speed, the mass in (b) falls through a vertical distance of 1.4 m in a time of 4.0 s. This causes a current of 90 mA in the resistor. The resistance of the resistor is $47\ \Omega$.

Calculate:

- (i) the rate of work done by the falling mass

rate of work done = ... W [2]

- (ii) the power dissipated in the resistor

power = ... W [2]

- (iii) the efficiency of the generator.

efficiency = ... [2]

[Total: 9]

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- 5 (a) Parallel light rays from the Sun are incident normally on a magnifying glass. The magnifying glass directs the light to an area A of radius r , as shown in Fig. 5.1.

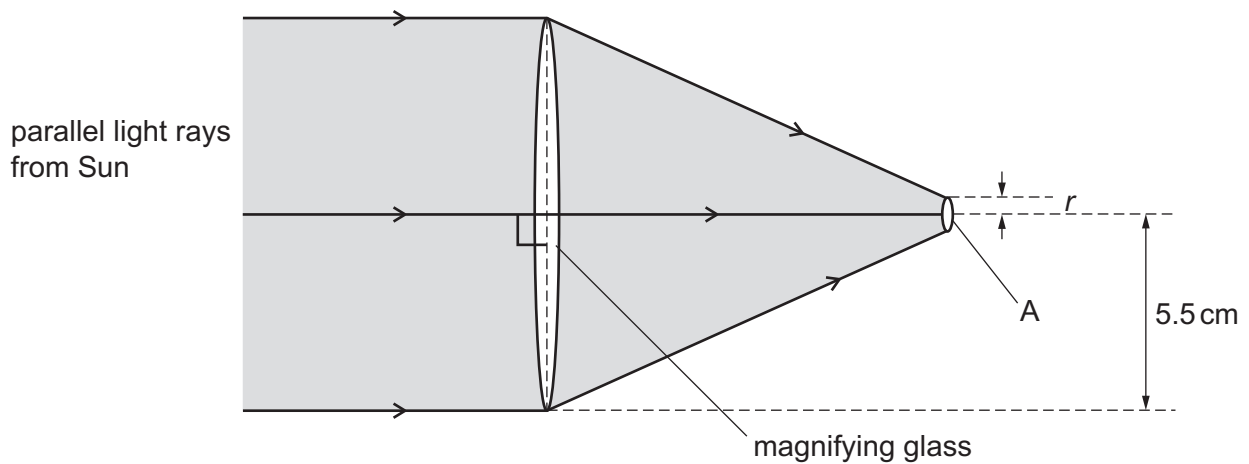


Fig. 5.1 (not to scale)

The magnifying glass is circular in cross-section with a radius of 5.5 cm. The intensity of the light from the Sun incident on the magnifying glass is 1.3 kW m^{-2} .

Assume that all of the light incident on the magnifying glass is transmitted through it.

- (i) Calculate the power of the light from the Sun incident on the magnifying glass.

power = ... W [2]

- (ii) The value of r is 1.5 mm.

Calculate the intensity of the light on area A.

intensity = ... W m^{-2} [1]

(b) A laser emits a beam of electromagnetic waves of frequency $3.7 \times 10^{15} \text{ Hz}$ in a vacuum.

(i) Show that the wavelength of the waves is $8.1 \times 10^{-8} \text{ m}$.

[2]

(ii) State the region of the electromagnetic spectrum to which these waves belong.

..... [1]

(iii) The beam from the laser now passes through a diffraction grating with 2400 lines per millimetre. A detector sensitive to the waves emitted by the laser is moved through an arc of 180° in order to detect the maxima produced by the waves passing through the grating, as shown in Fig. 5.2.

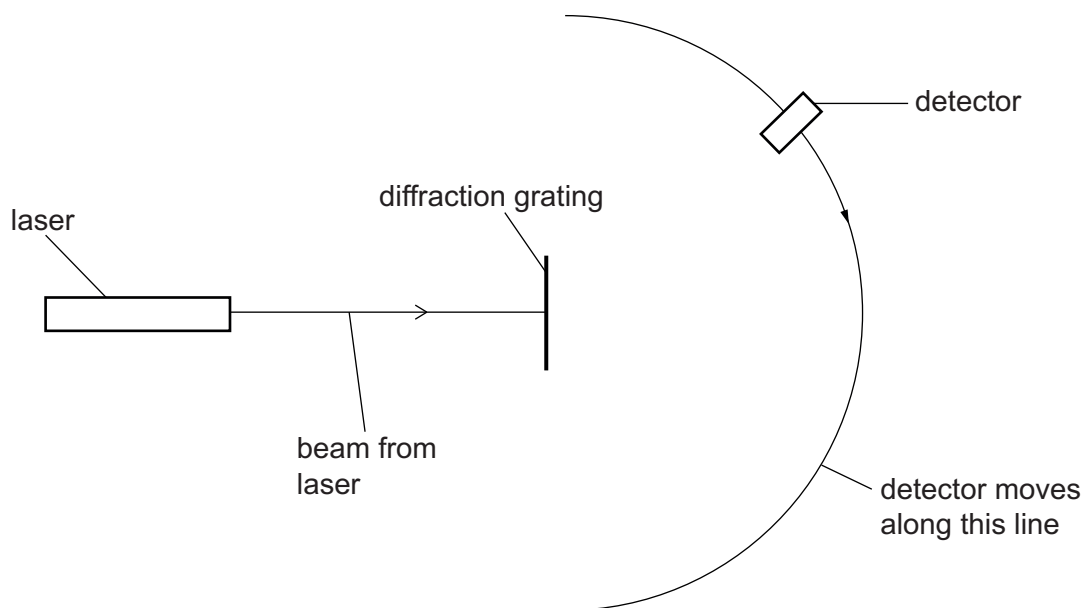


Fig. 5.2

Calculate the number of maxima detected as the detector moves through 180° along the line shown in Fig. 5.2. Show your working.

number of maxima detected = ... [4]

- (iv) The laser is now replaced with one that emits electromagnetic waves with a wavelength of 300 nm.

Explain, without calculation, what happens to the number of maxima now detected. Assume that the detector is also sensitive to this wavelength of electromagnetic waves.

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

[Total: 12]

- 6 (a) (i) On Fig. 6.1, sketch the I – V characteristic of a filament lamp.

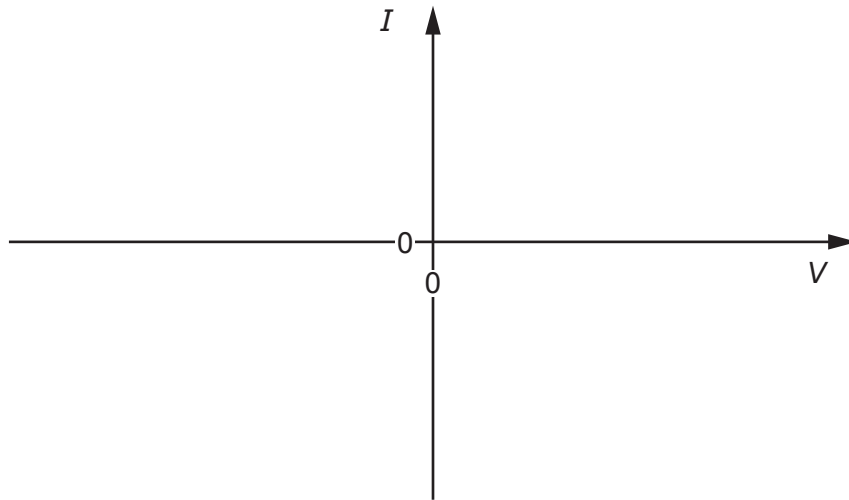


Fig. 6.1

[2]

- (ii) Explain the shape of the line in (a)(i).

.....

.....

.....

..... [3]

- (b) A conducting wire has length 5.8 m and cross-sectional area $3.4 \times 10^{-8} \text{ m}^2$. The resistivity of the metal of the wire is $5.6 \times 10^{-8} \Omega \text{ m}$.

Calculate the resistance of the wire.

resistance = ... Ω [2]

- (c) A resistor of resistance R is placed in a circuit with a cell of negligible internal resistance, two switches S_1 and S_2 , a second resistor of resistance $2R$ and three ammeters X, Y and Z. The circuit is shown in Fig. 6.2.

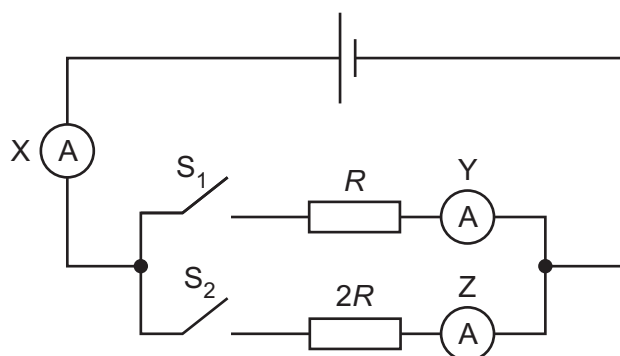


Fig. 6.2

The reading on X is 1.0 A when S_1 is open and S_2 is closed.

Complete Table 6.1.

Table 6.1

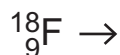
position of switches		ammeter readings		
S_1	S_2	reading on X/A	reading on Y/A	reading on Z/A
open	open	0	0	0
open	closed	1.0		
closed	open			
closed	closed			

[4]

[Total: 11]

- 7 (a) Fluorine-18 ($^{18}_9\text{F}$) is an isotope that decays to an isotope of oxygen (O) by the emission of a β^+ particle.

- (i) Complete the nuclear equation for the decay, including all the particles involved.



[3]

- (ii) A quark in the fluorine-18 nucleus changes flavour during the decay. State this change of flavour.

..... quark to quark.

[1]

- (b) A hadron has a charge of $-2e$, where e is the elementary charge.

- (i) State and explain whether the hadron is a meson or a baryon.

.....

 [2]

- (ii) State a possible quark composition for the hadron.

.....
 [1]

[Total: 7]

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