

## Candidate 2 evidence

### SECTION 2 — 110 marks

Attempt ALL questions

1. During a school funfair, a student throws a wet sponge at a teacher. The sponge is thrown with an initial velocity of  $7.4 \text{ m s}^{-1}$  at an angle of  $30^\circ$  to the horizontal.

The sponge leaves the student's hand at a height of  $1.5 \text{ m}$  above the ground.



The sponge hits the teacher.

The effects of air resistance can be ignored.

- (a) (i) Calculate:

- (A) the horizontal component of the initial velocity of the sponge; 1

Space for working and answer

horizontal component

$$= 7.4 \cos 30 = 7.4 \cos 30$$

$$= 6.498.. = 6.498..$$

$$= 6.5 \text{ m s}^{-1} = 6.4 \text{ m s}^{-1}$$

- (B) the vertical component of the initial velocity of the sponge. 1

Space for working and answer

$$\text{vertical component} = 7.4 \sin 30$$

$$= 3.7 \text{ m s}^{-1}$$

## 1. (a) (continued)

- (ii) Calculate the time taken for the sponge to reach its maximum height. 3

Space for working and answer

$$\begin{aligned}
 u &= 3.7 \text{ ms}^{-1} & v &= u + at \\
 v &= 0 \text{ ms}^{-1} & \frac{v-u}{a} &= t \\
 a &= -9.8 \text{ ms}^{-2} & \frac{0-3.7}{-9.8} &= 0.3775\dots \\
 \text{S.A.L.} & & & \\
 t &= ? & & = 0.38 \text{ seconds.}
 \end{aligned}$$

- (iii) The sponge takes a further 0.45 s to travel from its maximum height until it hits the teacher. 4

Determine the height  $h$  above the ground at which the sponge hits the teacher.

Space for working and answer

$$\begin{aligned}
 \text{Total time} &= 0.38 + 0.45 = 0.83 \text{ s} \\
 u &= 0 & v &= u + at \\
 S &= ? & S &= ut + \frac{1}{2}at^2 \\
 a &= -9.8 & S &= (0 \times 0.83) + (-9.8 \times 0.83^2 \times 0.5) \\
 t &= 0.83 & S &= -3.37561 \\
 & & S &= -3.4 \text{ m} - (-1.5) \\
 & & &= -1.87561 \\
 & & &= -1.9 \text{ m} \\
 h &= 1.9 \text{ m}
 \end{aligned}$$

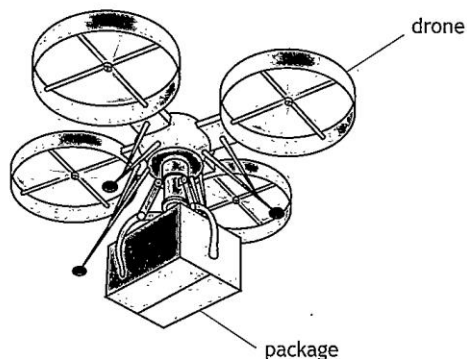
- (b) The student throwing the sponge makes the following statement.

"If the sponge is thrown with a higher speed at the same angle from the same height then it would take a shorter time to hit the teacher in the same place."

Explain why the student's statement is incorrect. 2

it would take a longer time because a higher speed would give a larger vertical component and this would mean that a higher vertical displacement would be reached.

2. An internet shopping company is planning to use drones to deliver packages.



- (a) During a test the drone is hovering at a constant height above the ground.  
The mass of the drone is 5.50 kg.  
The mass of the package is 1.25 kg.

- (i) Determine the upward force produced by the drone.

3

Space for working and answer

$$\begin{aligned}
 & \uparrow \\
 & \square \\
 & \downarrow \\
 & W = mg \\
 & = (5.5 + 1.25) \times 9.8 \\
 & = 66.15 \text{ N} \\
 & = 66.2 \text{ N}
 \end{aligned}$$

As the drone is hovering at a constant height, the upward and downward forces must be equal as there are no unbalanced forces so the upward force must also be 66.2 N.

## 2. (a) (continued)

(ii) The package is now lowered using a motor and a cable.

A battery supplies 12V across the motor. The resistance of the motor is  $9.6\Omega$ .

Calculate the power dissipated by the motor.

3

Space for working and answer

$$P = \frac{V^2}{R} = \frac{12^2}{9.6} = 15W$$

(iii) While the package is being lowered the cable breaks.

The upward force produced by the drone remains constant.

Describe the vertical motion of the drone immediately after the cable breaks:

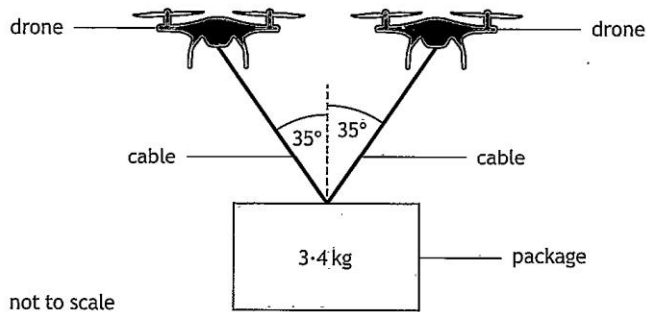
2

Justify your answer.

The drone would accelerate upwards because there will now be an unbalanced force as the upward force is greater than the downward force. An unbalanced force results in an acceleration.

2. (continued)

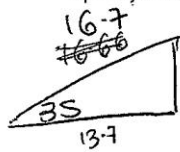
(b) To carry a package with a greater mass two drones are used as shown.



The drones are hovering at a constant height above the ground.  
 The mass of the package suspended from the two drones is 3.4 kg.  
 Determine the tension in each cable.

4

Space for working and answer

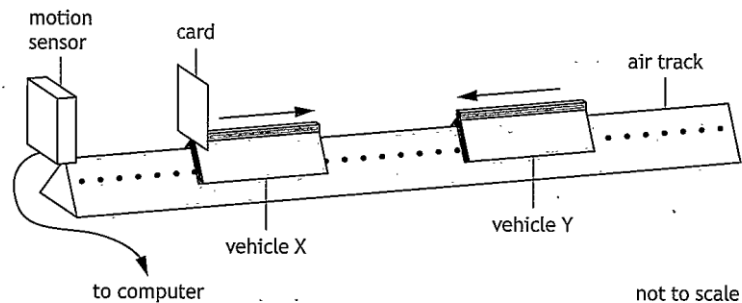


$w = mg$   
 $= 3.4 \times 9.8 = 33.320 \div 2$   
 $= 16.660 \text{ N}$   
 ~~$= 33.32 \text{ N} = 2 = 16.66 \text{ N} = 16.7 \text{ N}$~~   
 ~~$16.7 \text{ N down}$~~   
 ~~$16.7 \text{ N up}$~~   
 ~~$16.66 \text{ N down} = 16.66 \text{ N up}$~~   
 horizontal component =  $16.7 \cos 35 = 13.679$   
 ~~$= 13.7 \text{ N}$~~   
 $= 13.7 \text{ kN}$

~~$3.4 \times 10^3$~~

Net  $F = ma$  (Net)  
 $F = 3.4 \times 10^3 \times a$

3. A student sets up an experiment to investigate a collision between two vehicles on a frictionless air track.

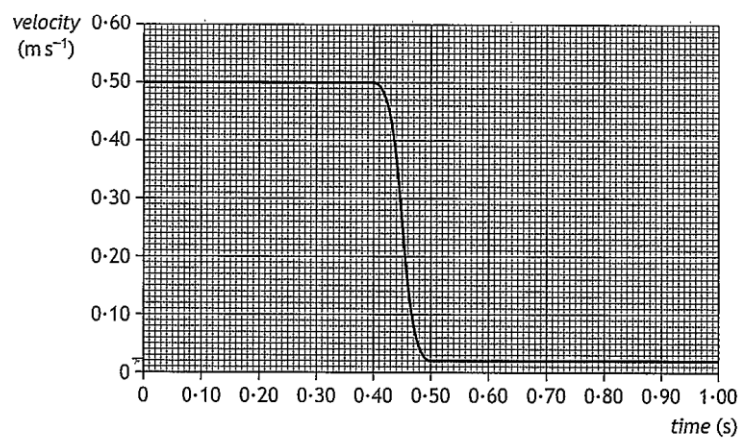


Vehicle X of mass  $0.75 \text{ kg}$  is travelling to the right along the track.

Vehicle Y of mass  $0.50 \text{ kg}$  is travelling to the left along the track with a speed of  $0.30 \text{ m s}^{-1}$ .

The vehicles collide and move off separately.

A computer displays a graph showing the velocity of vehicle X from just before the collision to just after the collision.



## 3. (continued)

- (a) Show that the velocity of vehicle Y after the collision is
- $0.42 \text{ m s}^{-1}$
- . 2

Space for working and answer

$$\begin{aligned} \text{total momentum before collision} &= \text{total momentum after collision} \\ mu_1 + mu_2 &= mv_1 + mv_2 \\ (0.75 \times 0.5) + (0.5 \times -0.3) &= (0.75 \times 0.02) + (0.5 \times x) \\ \cancel{0.375} - 0.15 &= 0.015 + 0.5x \\ \quad \quad \quad 0.21 &= 0.5x \\ \quad \quad \quad x &= \underline{0.42 \text{ m s}^{-1}} \\ &\text{as required.} \end{aligned}$$

- (b) Determine the impulse on vehicle Y during the collision. 3

Space for working and answer

Impulse = change in momentum

$$\begin{aligned} p &= m(v - u) \\ p &= 0.5(0.42 - 0.3) \\ &= 0.06 \text{ kg m s}^{-1} \end{aligned}$$

## 3. (continued)

- (c) Explain how the student would determine whether the collision was elastic or inelastic. 2

First calculate the kinetic energy ~~before~~ of both ~~vehicles~~ <sup>vehicles</sup> before the collision and add them together.

Then calculate the kinetic energy of both ~~vehicles~~ <sup>vehicles</sup> after the collision and add ~~them~~ them together.

Then do the equation:

total kinetic energy before - total kinetic energy after.

If kinetic energy has been conserved and ~~there~~ there is no difference then it is an elastic collision.

If kinetic energy has been lost and therefore not conserved then it is an inelastic collision.

4. A stunt is being carried out during the making of a film.

A car is to be driven up a ramp on a moving lorry by a stunt driver, who will attempt to land the car safely on the roof of a second moving lorry. The car is to stop on the roof of the second lorry while this lorry is still moving.



Using your knowledge of physics, comment on the challenges involved in carrying out the stunt successfully.

The driver must work out the relative speed of the second lorry compared to the car. To do this they must take the speed of the second lorry minus the speed of the ~~second~~ first lorry minus the speed of the car.

~~The driver must be aware that in his first~~  
The driver must ~~not~~ be going fast enough to reach the second lorry but must be able to brake in time to stop on top of the second lorry. His acceleration will be  $9.8 \text{ ms}^{-2}$  and his final velocity must be 0.

The driver must consider the weight of his ~~car~~ car as if it is too heavy then he may not be able to reach a sufficient height in order to cross the gap. Weight can be calculated using  $w = mg$  where  $m$  is mass and  $g$  is  $9.8$ .

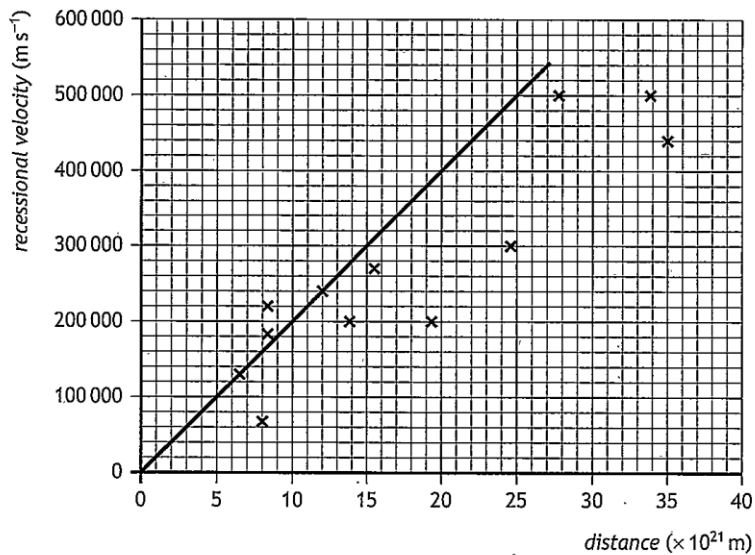
There must be an unbalanced force in the forwards direction to allow the driver to accelerate so his engine force must be bigger than ~~the~~ the frictional force. To consider what the frictional force might be the driver could check the weather as wind will increase air resistance. As the driver goes faster, friction increases. A wet surface will ~~reduce~~ increase the time it takes for the car to stop.

5. Hubble's Law states that the universe is expanding. The expanding universe is one piece of evidence that supports the Big Bang theory.

(a) State one other piece of evidence that supports the Big Bang theory. 1

~~As the Big Bang theory suggests, everything came from a singularity, redshift of stars and far away galaxies show that the further away these things are, the faster they are moving away.~~  
 The abundance of hydrogen and helium currently in the atmosphere is very close to that estimated to be in the atmosphere of the big bang.

(b) A student plots some of the original data from the 1929 paper by Edwin Hubble and adds the line shown in order to determine a value for the Hubble constant  $H_0$ .



The student calculates the gradient of their line and obtains a value for the Hubble constant of  $2.0 \times 10^{-17} \text{ s}^{-1}$ .

The age of the universe can be calculated using the relationship

$$\text{age of universe} = \frac{1}{H_0}$$

## 5. (b) (continued)

- (i) Calculate the age of the universe, in years, obtained when using the student's value for the Hubble constant. 2

Space for working and answer

$$\begin{aligned} \text{age of universe} &= \frac{1}{H_0} = \frac{1}{2.2 \times 10^{-17}} \\ &= 5 \times 10^{16} \text{ years} \end{aligned}$$

- (ii) The current estimate for the age of the universe is  $13.8 \times 10^9$  years.

- (A) State why the value obtained in (b)(i) is different from the current estimate for the age of the universe. 1

scientific advancements have given scientists better ways of determining the age.

- (B) Suggest a change that the student could make to their graph to obtain a value closer to the current estimate for the age of the universe. 1

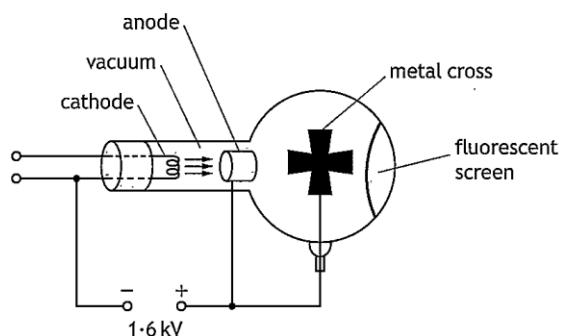
plot more points ~~in a~~ for diff for all values to get a better best fit line  
plot a better best fit line with equal points on either side to get a more valid answer.

- (c) It has been discovered that the rate of expansion of the universe is increasing.

State what physicists think is responsible for this increase. 1

dark energy

6. An experiment is set up to demonstrate a simple particle accelerator.



- (a) Electrons are accelerated from rest between the cathode and the anode by a potential difference of 1.6 kV.

- (i) Show that the work done in accelerating an electron from rest is  $2.6 \times 10^{-16}$  J. 2

Space for working and answer

$$\begin{aligned}
 eW &= QV \\
 &= 1.6 \times 10^{-19} \times 1.6 \times 10^3 \\
 &= 2.56 \times 10^{-16} \\
 &= 2.6 \times 10^{-16} \text{ J} \\
 &\text{as required.}
 \end{aligned}$$

- (ii) Calculate the speed of the electron as it reaches the anode. 3

Space for working and answer

$$\begin{aligned}
 QV &= \frac{1}{2}mv^2 \\
 \frac{2.6 \times 10^{-16}}{0.5 \times 9.11 \times 10^{-31}} &= v^2 \\
 5.7080 \cdot &= v^2 \\
 \sqrt{5.7080 \cdot} &= v \\
 v &= 2.4 \times 10^7 \text{ ms}^{-1}
 \end{aligned}$$

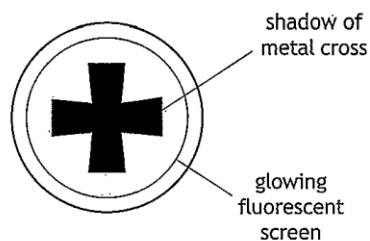
## 6. (continued)

- (b) As the electrons travel through the vacuum towards the fluorescent screen they spread out.

In the path of the electrons there is a metal cross, which is connected to the positive terminal of the supply. The electrons that hit the cross are stopped by the metal.

Electrons that get past the metal cross hit a fluorescent screen at the far side of the tube.

When electrons hit the fluorescent screen, the screen glows.



The potential difference between the anode and the cathode is now increased to 2.2 kV. This changes what is observed on the screen.

Suggest one change that is observed.

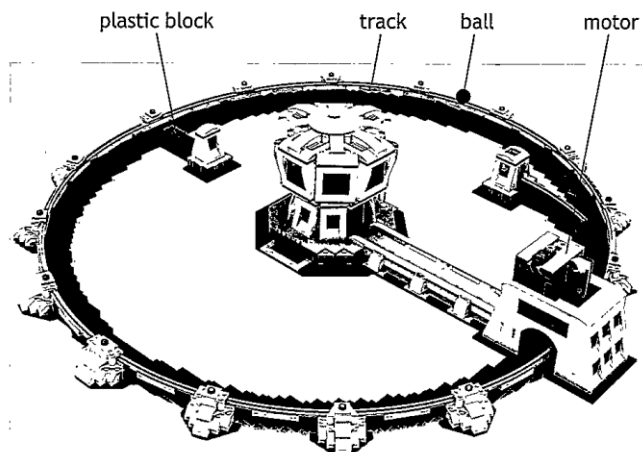
2

You must justify your answer.

As there is a bigger potential difference, electrons will be ~~be~~ attracted more to the cross as it is more positive. As less electrons make it to the glowing fluorescent screen, it will be glowing less

## 6. (continued)

- (c) A student builds a model of a particle accelerator. The model accelerates a small ball on a circular track. A battery-operated motor accelerates the ball each time it passes the motor. To cause a collision a plastic block is pushed onto the track. The ball then hits the block.



Using your knowledge of physics comment on the model compared to a real particle accelerator, such as the large hadron collider at CERN.

3

This is a circular particle accelerator like the ~~cyclo~~ cyclotron, it ~~uses~~ uses an alternating current ~~that~~. The model accelerates about, in the H.C., the particles are accelerated to recession velocities in order to try and recreate the environment of the big bang. Particles are smashed together at high speeds. The ball represents the particles.

The large H.C. will be on a much larger scale and require a lot more energy to accelerate the particles.

6. (c) (continued)

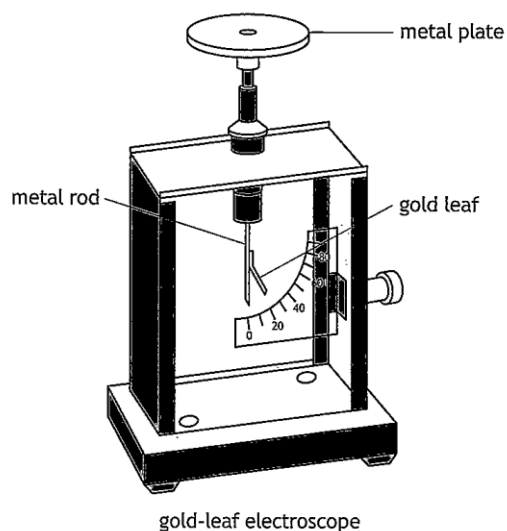
When the particles collide they produce  
more ~~particles~~, smaller particles which  
can in turn be smashed together.

The circular shape allows particles  
to travel faster than in a linear accelerator  
so it is more efficient.

Particles when smashed together will give  
out <sup>more</sup> energy

7. A student uses a gold-leaf electroscope to investigate the photoelectric effect. A deflection of the gold leaf on the electroscope shows that the metal plate is charged.

The student charges the metal plate on the electroscope and the gold leaf is deflected.



- (a) Ultraviolet light is shone onto the negatively charged metal plate. The gold-leaf electroscope does not discharge. This indicates that photoelectrons are not ejected from the surface of the metal.

Suggest one reason why photoelectrons are not ejected from the surface of the metal.

1

they do not have the threshold frequency - which is the minimum frequency a photon must have for photon emission. (to eject the photon from the surface of the metal.)

## 7. (continued)

- (b) The student adjusts the experiment so that the gold-leaf electroscope now discharges when ultraviolet light is shone onto the plate.

The work function for the metal plate is  $6.94 \times 10^{-19}$  J.

- (i) State what is meant by a work function of  $6.94 \times 10^{-19}$  J. 1

$6.94 \times 10^{-19}$  J is the minimum energy that a metal must have for photoemission (to eject a photon from the surface of the metal)

- (ii) The irradiance of the ultraviolet light on the metal plate is reduced by increasing the distance between the gold-leaf electroscope and the ultraviolet light source.

State what effect, if any, this has on the maximum kinetic energy of the photoelectrons ejected from the surface of the metal. 2

Justify your answer.

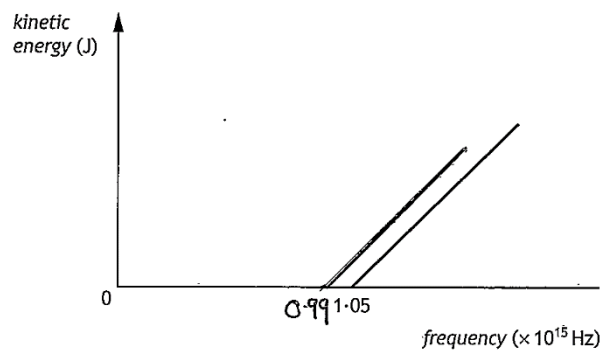
This will have no effect on the maximum kinetic energy as that is only affected by the charge on a photon and the mass of a photon and the velocity which it is going at and these are kept constant

6.9615

7. (continued)

- (c) The graph shows how the kinetic energy of the photoelectrons ejected from the metal plate varies as the frequency of the incident radiation increases.

The threshold frequency for the metal plate is  $1.05 \times 10^{15}$  Hz.



The metal plate is now replaced with a different metal plate made of aluminium.

The aluminium has a threshold frequency of  $0.99 \times 10^{15}$  Hz.

Add a line to the graph to show how the kinetic energy of the photoelectrons ejected from the aluminium plate varies as the frequency of the incident radiation increases.

2

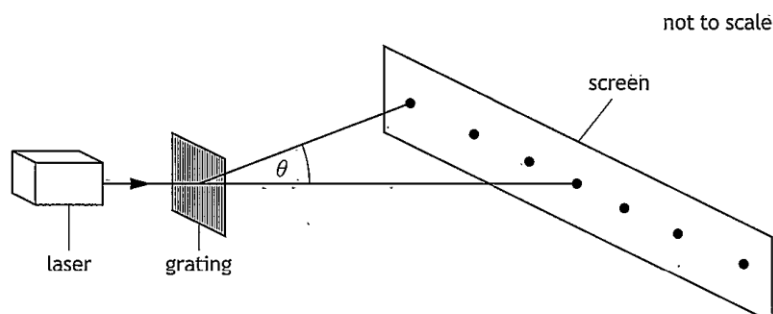
(An additional graph, if required, can be found on page 45.)

- (d) Explain why the photoelectric effect provides evidence for the particle nature of light.

1

it shows that photons can be positive or negative

8. A student investigates interference of light by directing laser light of wavelength 630 nm onto a grating as shown.



- (a) A pattern of bright spots is observed on a screen.

- (i) Explain, in terms of waves, how bright spots are produced on the screen. 1

constructive interference - when a crest meets a crest or a trough meets a trough.

- (ii) The grating has 250 lines per millimetre.

Calculate the angle  $\theta$  between the central maximum and the third order maximum. 3

Space for working and answer

$$m\lambda = d \sin \theta$$

$$\frac{3 \times 630 \times 10^{-9}}{4 \times 10^{-6}} = \sin \theta$$

$$d = \frac{1}{250 \times 1000} = 4 \times 10^{-6} \text{ m}$$

$$\theta = \sin^{-1} (0.4725)$$

$$\theta = 28.196 \dots$$

$$= 28.2^\circ$$

## 8. (a) (continued)

- (iii) The grating is now replaced by one which has 600 lines per millimetre.

State the effect of this change on the pattern observed.

2

Justify your answer.

$$\frac{1}{600 \times 1000} = 1.7 \times 10^{-6}$$

According to  $m\lambda = d \sin \alpha$  rearranged to give  $\sin \alpha = \frac{m\lambda}{d}$ , if  $d$  is decreased,  $\sin \alpha$  will increase and therefore the angle will be bigger and the maxima will be ~~farther~~ further spread ~~out~~ out.

- (iv) The interference pattern is produced by coherent light.

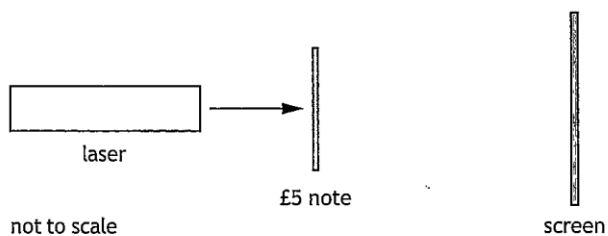
State what is meant by the term *coherent*.

1

It means that the light is of one energy, one frequency and one wavelength.

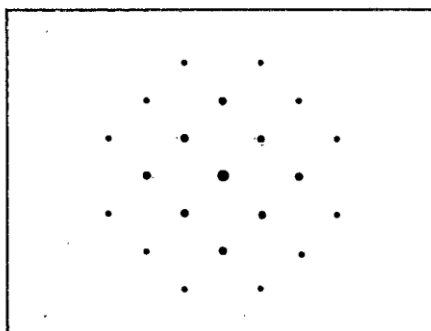
## 8. (continued)

- (b) The student now shines light from the laser onto a £5 note.



When it is shone through the transparent section of the note the student observes a pattern of bright spots on the screen.

The diagram below shows the pattern that the student observes on the screen.

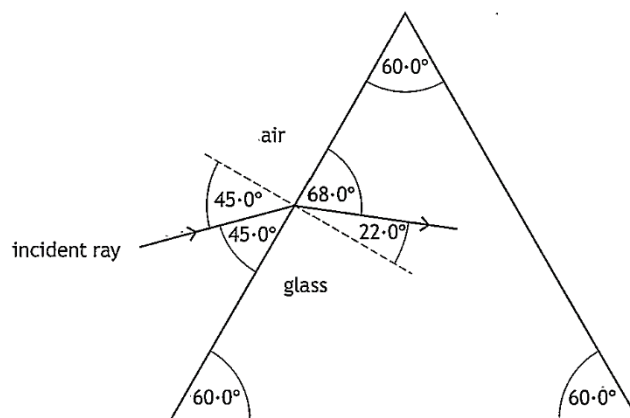


Suggest a reason for the difference in the pattern produced using the £5 note and the pattern produced using the grating.

1

the grating diffracts light but the  
 £5 just lets certain light through.  
~~when you shine more light  
 when the grating diffracts light~~

9. A ray of monochromatic light is incident on a glass prism as shown.



- (a) Show that the refractive index of the glass for this ray of light is 1.89. 2

Space for working and answer

$$n = \frac{\sin i}{\sin r} = \frac{\sin 45}{\sin 22} = 1.8875 \dots = 1.89 \text{ as required.}$$

- (b) (i) State what is meant by the term *critical angle*. 1

The critical angle is the angle at which the refracted ray angle will be 90°.

The critical angle is the angle of incidence which ~~the~~ causes the refracted angle to equal 90°.

## 9. (b) (continued)

(ii) Calculate the critical angle for this light in the prism.

3

*Space for working and answer*

$$\sin \theta_c = \frac{1}{n}$$

$$\sin \theta_c = \frac{1}{1.89}$$

$$\sin \theta_c = 0.529 \dots$$

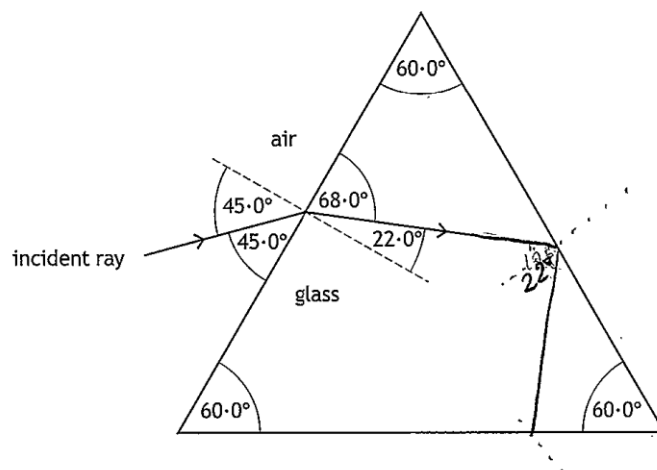
$$\theta_c = \sin^{-1}(0.529 \dots)$$

$$\theta_c = 31.944 \dots = 31.9^\circ$$

(iii) Complete the diagram below to show the path of the ray as it passes through the prism and emerges into the air.

Mark on the diagram the values of all relevant angles.

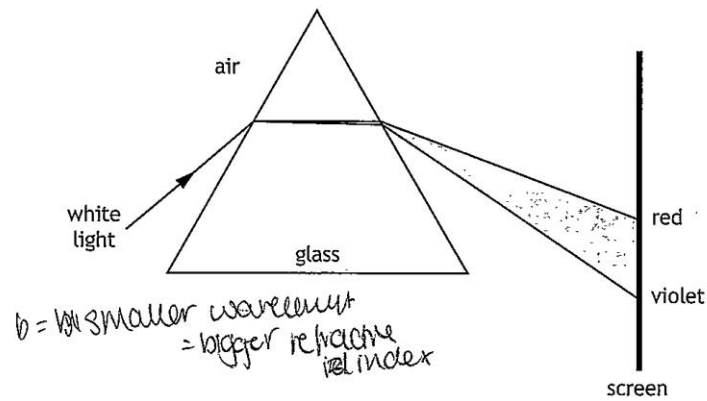
4



(An additional diagram, if required, can be found on page 45.)

## 9. (continued)

- (c) A ray of white light is shone through the prism and a spectrum is observed as shown.



The prism is now replaced with another prism made from a different type of glass with a lower refractive index.

Describe one difference in the spectrum produced by this prism compared to the spectrum produced by the first prism. 1

*a lower refractive index means that the colours will be refracted by a smaller amount so red and violet will be closer to each other.*

10. In a laboratory experiment, light from a hydrogen discharge lamp is used to produce a line emission spectrum. The line spectrum for hydrogen has four lines in the visible region as shown.



- (a) The production of the line spectrum can be explained using the Bohr model of the atom.

State two features of the Bohr model of the atom.

2

- ~~The ground state is~~  
if an electron is in the ground state then it has the lowest energy
- when electrons receive sufficient energy they can be promoted to higher energy levels and when they fall back down, they emit a photon of light
  - An electron is in the ground state when it has the lowest energy

10. (continued)

(b) Some of the energy levels of the hydrogen atom are shown.

$$E_4 \text{ ————— } -0.871 \times 10^{-19} \text{ J}$$

$$E_3 \text{ ————— } -1.36 \times 10^{-19} \text{ J}$$

$$E_2 \text{ ————— } -2.42 \times 10^{-19} \text{ J}$$

$$E_1 \text{ ————— } -5.45 \times 10^{-19} \text{ J}$$

$$E_0 \text{ ————— } -21.8 \times 10^{-19} \text{ J}$$

One of the spectral lines is due to electron transitions from  $E_3$  to  $E_1$ .

Determine the frequency of the photon emitted when an electron makes this transition.

3

Space for working and answer

$$E_3 \rightarrow E_1 = -1.36 \times 10^{-19} - (-5.45 \times 10^{-19})$$

$$= 4.09 \times 10^{-19} \text{ J}$$

change in energy

$$e = hf$$

$$f = \frac{e}{h} = \frac{4.09 \times 10^{-19}}{6.63 \times 10^{-34}}$$

$$= 6.1689 \dots \times 10^{14}$$

$$= \underline{6.2 \times 10^{14} \text{ Hz}}$$

## 10. (continued)

- (c) In the laboratory, a line in the hydrogen spectrum is observed at a wavelength of 656 nm.

When the spectrum of light from a distant galaxy is viewed, this hydrogen line is now observed at a wavelength of 661 nm.

Determine the recessional velocity of the distant galaxy.

5

Space for working and answer

$$z = \frac{\lambda_o - \lambda_r}{\lambda_r}$$

$$z = \frac{661 - 656}{656}$$

~~$$z = 7.622 \times 10^{-3}$$~~

$$z = 7.622 \times 10^{-3}$$

$$z = \frac{v}{c}$$

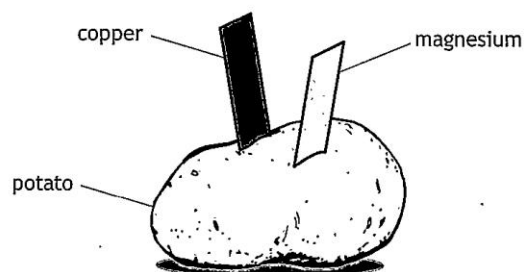
$$v = zc$$

$$= 7.622 \times 10^{-3} \times 3 \times 10^8$$

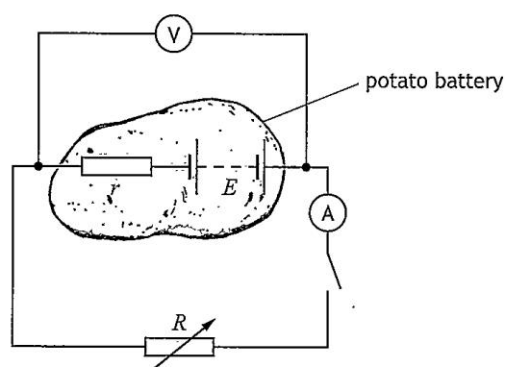
$$= 2286585.366$$

$$= 2.3 \times 10^6 \text{ ms}^{-1}$$

11. A student constructs a battery using a potato, a strip of copper and a strip of magnesium.



The student then sets up the following circuit with the potato battery connected to a variable resistor  $R$ , in order that the electromotive force (e.m.f.) and internal resistance of the battery may be determined.



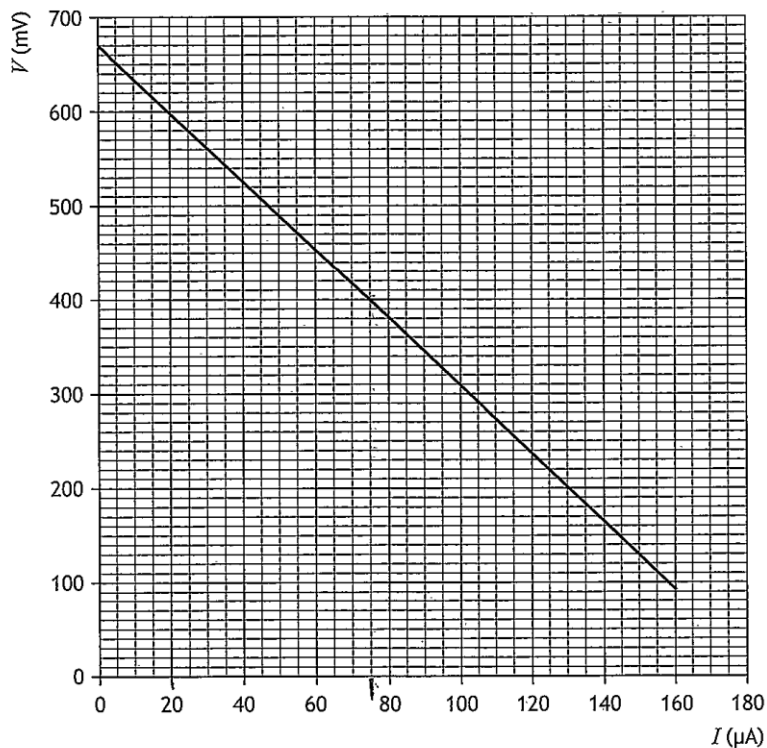
- (a) State what is meant by the term *electromotive force (e.m.f.)*.

1

The maximum amount of energy available to be supplied to each coulomb of charge that passes the source.

11. (continued)

(b) The student uses readings of current  $I$  and terminal potential difference  $V$  from this circuit to produce the graph shown.



Determine the internal resistance of the potato battery.

Space for working and answer

$$-r = \frac{y_2 - y_1}{x_2 - x_1}$$

$$-r = \frac{600 \times 10^{-3} - 400 \times 10^{-3}}{20 \times 10^{-6} - 70.6 \times 10^{-6}}$$

$$-r = -3952.569..$$

$$r = 3952.6 \Omega$$

Handwritten calculations and notes:

- $20 \times (20 \times 10^{-6}, 600 \times 10^{-3})$  with  $y_2$  and  $x_2$  labels
- $(70.6 \times 10^{-6}, 400 \times 10^{-3})$  with  $x_1$  and  $y_1$  labels
- A triangle diagram with vertices at  $(20, 600)$ ,  $(70.6, 400)$ , and  $(20, 400)$ . The vertical side is labeled  $200$ , the horizontal side is labeled  $50.6$ , and the hypotenuse is labeled  $350$ .

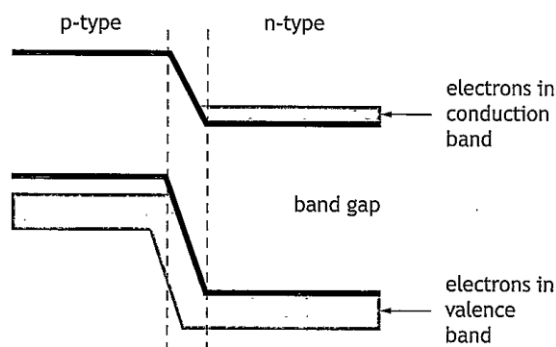
## 11. (continued)

- (c) The student connects a red LED and a blue LED, in turn, to the battery.

The LEDs are forward biased when connected.

The student observes that the battery will operate the red LED but not the blue LED.

The diagram represents the band structure of the blue LED.



LEDs emit light when electrons fall from the conduction band into the valence band of the p-type semiconductor.

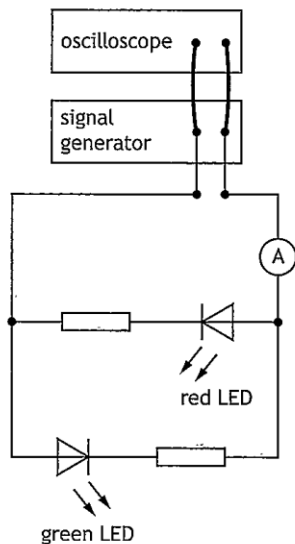
Explain, using band theory, why the blue LED will not operate with this battery.

blue led has a smaller wavelength and hence a higher energy / frequency. When electrons receive sufficient energy they are promoted from the valence band to the conduction band. When they fall back down, ~~they~~ the electrons meet holes at the pn junction and emit a photon. However, the ~~used~~ electrons are not provided with enough energy to ~~emit blue photons~~ be promoted and emit ~~blue~~ blue photons.

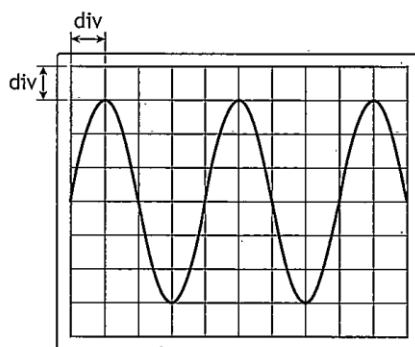
1

12. A student carries out a series of experiments to investigate alternating current.

(a) A signal generator is connected to an oscilloscope and a circuit as shown.



The output of the signal generator is displayed on the oscilloscope.



The Y-gain setting on the oscilloscope is  $1.0\text{ V/div}$ .

The timebase setting on the oscilloscope is  $0.5\text{ s/div}$ .

## 12. (a) (continued)

- (i) Determine the peak voltage of the output of the signal generator. 1  
Space for working and answer

$$PV = 3.21 \\ = 3V$$

- (ii) Determine the frequency of the output of the signal generator. 3  
Space for working and answer

$$f = \frac{1}{\text{period}}$$

$$f = \frac{1}{0.5 \times 4} = 0.5 \text{ Hz}$$

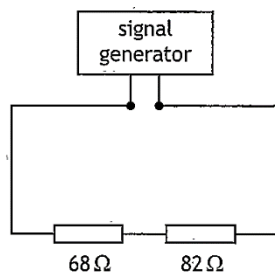
- (iii) The student observes that the red LED is only lit when the ammeter gives a positive reading and the green LED is only lit when the ammeter gives a negative reading.

Explain these observations.

When the ammeter is positive ~~it is~~ ~~so~~ current is flowing in one direction towards red. When it is positive it is flowing in the other direction to green. LEDs are forward biased so will only work in ~~at~~ one ~~direction~~ direction of current.

12. (continued)

- (b) The signal generator is now connected in a circuit as shown.  
The settings on the signal generator are unchanged.  
The signal generator has negligible internal resistance.



Determine the r.m.s. voltage across the 82 Ω resistor.

5

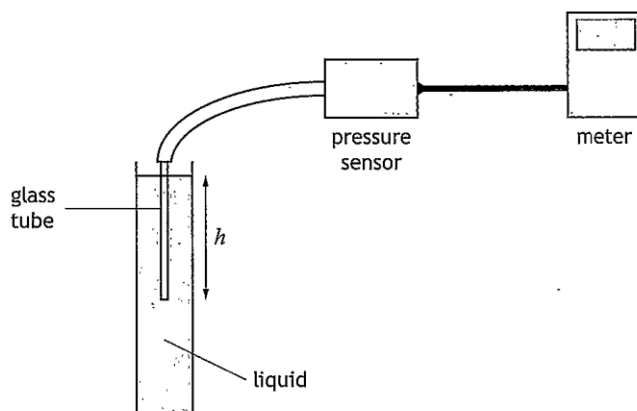
Space for working and answer

$$\frac{3}{(68+82)} \times 82 = 1.04V$$

$$P = \text{RMS}^2$$

$$\text{RMS} = \frac{1.04}{\sqrt{2}} = 1.1596 \dots = 1.2V$$

13. A student sets up an experiment to investigate the pressure due to a liquid as shown.



The pressure due to a liquid is given by the relationship

$$p = \rho gh$$

where  $p$  is the pressure due to the liquid in pascals (Pa),

$g$  is the gravitational field strength in  $\text{N kg}^{-1}$ ,

$\rho$  is the density of the liquid in  $\text{kg m}^{-3}$ ,

and  $h$  is the depth in the liquid in m.

- (a) The student initially carries out the investigation using water.

The density of water is  $1.00 \times 10^3 \text{ kg m}^{-3}$ .

Calculate the pressure due to the water at a depth of 0.35 m.

2

Space for working and answer

$$\begin{aligned}
 p &= \rho gh \\
 &= 1000 \times 9.8 \times 0.35 \\
 &= 3430 \text{ Pa}
 \end{aligned}$$

## 13. (continued)

- (b) The student repeats the experiment with a different liquid.

The pressure meter is set to zero before the glass tube is lowered into the liquid.

The student takes measurements of the pressure at various depths below the surface of the liquid.

The student records the following information.

Depth, $h$ (m)	Pressure, $p$ (kPa)
0.10	1.2
0.20	2.5
0.30	3.6
0.40	4.9
0.50	6.2

- (i) Using the square-ruled paper on page 43, draw a graph of
- $p$
- against
- $h$
- .
- 3

(Additional graph paper, if required, can be found on page 44.)

- (ii) Calculate the gradient of your graph.
- 2

Space for working and answer (0.2, 2.4) (0.33, 4.1)

$$\frac{y_2 - y_1}{x_2 - x_1} = \frac{4 - 2.4}{0.33 - 0.2} = 12.307\dots = 12.3$$

- (iii) Determine the density of this liquid.
- 2

Space for working and answer

$$p = \frac{\rho gh}{\rho} = 9.8 \times \dots$$

$$p = \frac{\rho gh}{\rho} = 9.8 \times 12.3$$

$$= 120.54$$

$$= 120.5 \text{ kgm}^{-3}$$

