Cambridge Pre-U

Cambridge Assessment International Education
Cambridge Pre-U Certificate

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

3680797245

PHYSICS (PRINCIPAL) **9792/02**

Paper 2 Written Paper **May/June 2019**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Section 1
Answer **all** questions.
You are advised to spend about 1 hour 30 minutes on this section.

Section 2
Answer the **one** question.
You are advised to spend about 30 minutes on this section.
The question is based on the material in the Insert.

Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Total	

This syllabus is regulated for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **27** printed pages, **1** blank page and **1** Insert.

Cambridge Assessment International Education

[Turn over

Data

gravitational field strength close to Earth's surface	$g = 9.81\,\mathrm{N\,kg^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
speed of light in vacuum	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
electron mass	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
proton mass	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\,\mathrm{W\,m^{-2}\,K^{-4}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
	$s = \left(\frac{u+v}{2}\right)t$
heating	$\Delta E = mc\Delta\theta$
change of state	$\Delta E = mL$
refraction	$n = \frac{\sin\theta_1}{\sin\theta_2}$
	$n = \frac{v_1}{v_2}$

diffraction	
single slit, minima	$n\lambda = b\sin\theta$
grating, maxima	$n\lambda = d\sin\theta$
double slit interference	$\lambda = \frac{ax}{D}$
Rayleigh criterion	$\theta \approx \frac{\lambda}{b}$
photon energy	$E = hf$
de Broglie wavelength	$\lambda = \frac{h}{p}$
simple harmonic motion	$x = A\cos\omega t$
	$v = -A\omega\sin\omega t$
	$a = -A\omega^2\cos\omega t$
	$F = -m\omega^2 x$
	$E = \frac{1}{2}mA^2\omega^2$
energy stored in a capacitor	$W = \frac{1}{2}QV$
capacitor discharge	$Q = Q_0 e^{-\frac{t}{RC}}$
electric force	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
electrostatic potential energy	$W = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r}$
gravitational force	$F = -\frac{Gm_1 m_2}{r^2}$
gravitational potential energy	$E = -\frac{Gm_1 m_2}{r}$
magnetic force	$F = BIl\sin\theta$
	$F = BQv\sin\theta$

electromagnetic induction	$E = -\frac{\mathrm{d}(N\Phi)}{\mathrm{d}t}$
Hall effect	$V = Bvd$
time dilation	$t' = \frac{t}{\sqrt{1-\frac{v^2}{c^2}}}$
length contraction	$l' = l\sqrt{1-\frac{v^2}{c^2}}$
kinetic theory	$\frac{1}{2}m\langle c^2\rangle = \frac{3}{2}kT$
work done on/by a gas	$W = p\Delta V$
radioactive decay	$\frac{\mathrm{d}N}{\mathrm{d}t} = -\lambda N$
	$N = N_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda}$
attenuation losses	$I = I_0 e^{-\mu x}$
mass-energy equivalence	$\Delta E = c^2\Delta m$
hydrogen energy levels	$E_n = \frac{-13.6\,\text{eV}}{n^2}$
Heisenberg uncertainty principle	$\Delta p\Delta x \geqslant \frac{h}{2\pi}$
Wien's displacement law	$\lambda_{max} \propto \frac{1}{T}$
Stefan's law	$L = 4\pi\sigma r^2 T^4$
electromagnetic radiation from a moving source	$\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{v}{c}$

Section 1

You are advised to spend about 1 hour 30 minutes on this section.

1 Fig. 1.1 shows a firefighter standing on an elevated platform directing water upwards and towards a burning building.

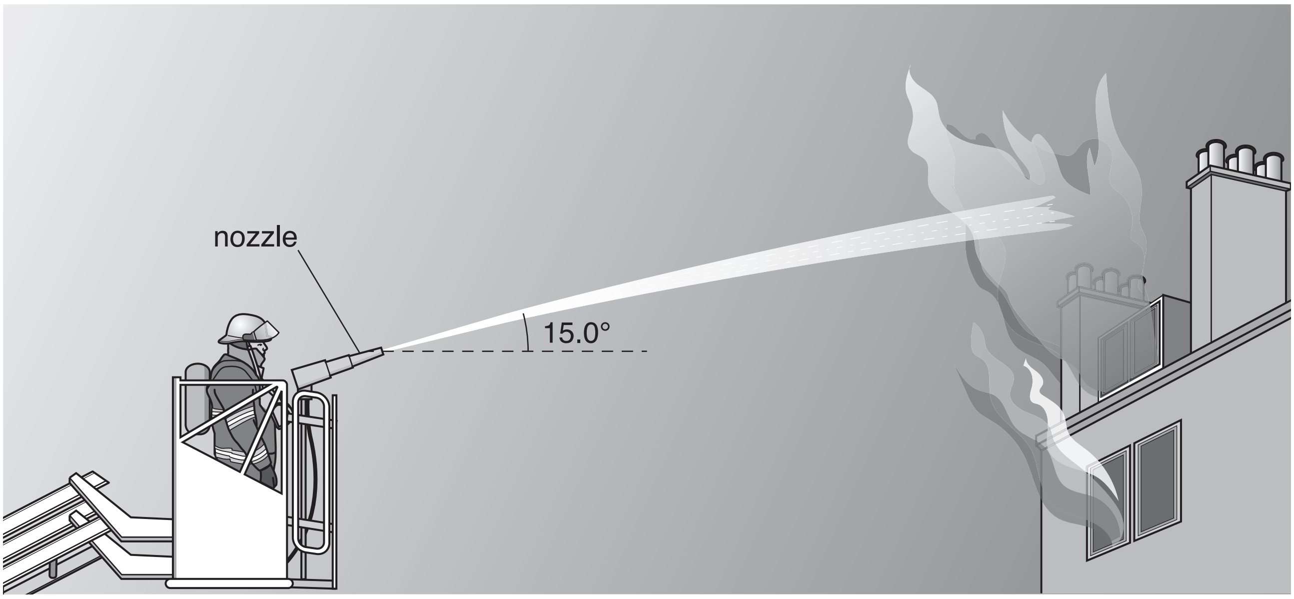


Fig. 1.1 (not to scale)

Water leaves the nozzle with a velocity of $13.1\,m\,s^{-1}$ at 15.0° to the horizontal.

(a) State how *velocity* differs from *speed*.

....

.... [1]

(b) **(i)** Calculate the vertical component of the velocity of the water.

vertical component = ... $m\,s^{-1}$ [2]

(ii) Calculate the vertical distance travelled by the water from when it leaves the nozzle until it reaches its maximum height.

vertical distance travelled = ...m [2]

(c) State, in terms of momentum, Newton's second law of motion.

....

.... [1]

(d) The density of water is 1000 kg m^{-3} and the diameter of the circular hole in the nozzle at the end of the hose is 4.00 cm.

(i) Determine the momentum of the water that emerges from the nozzle in one second.

momentum = ... kg m s^{-1} [2]

(ii) Explain why the value calculated in **(d)(i)** is **not** numerically equal to the force on the nozzle due to the momentum change of the water.

....

....

.... [1]

[Total: 9]

2 A uniform, rectangular canopy (the flat roof above the front door of a house) is 1.30 m wide. It is kept horizontal and in equilibrium by two steel cables. Fig. 2.1 shows the canopy fixed to the wall by a hinge.

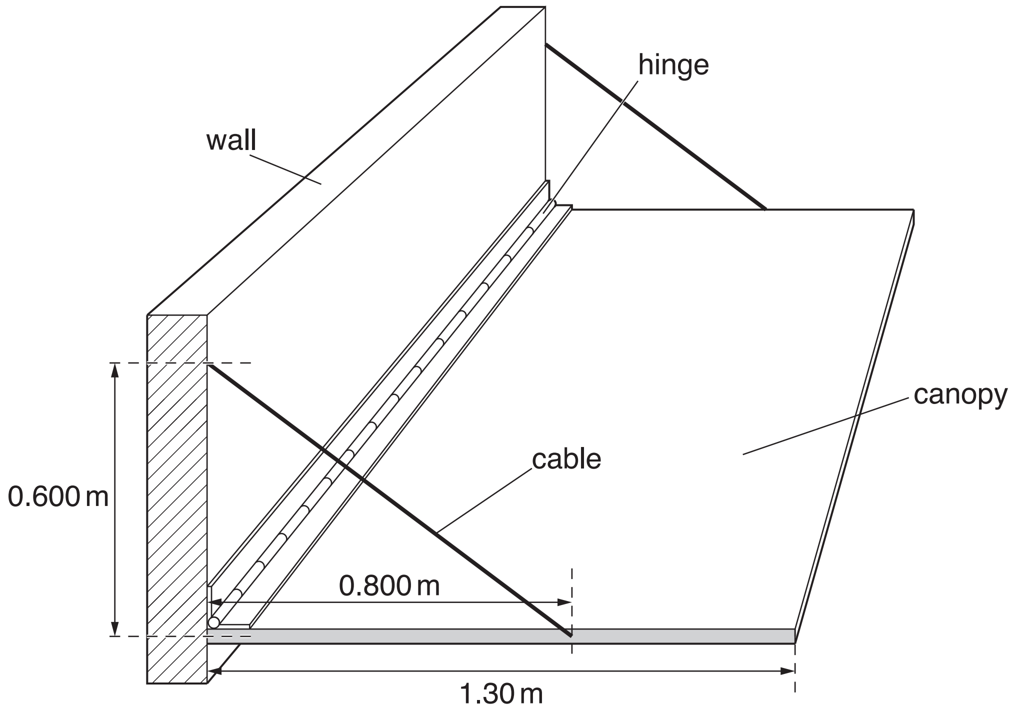


Fig. 2.1 (not to scale)

One end of each cable is attached to the canopy at a distance of 0.800 m from the wall. The other ends are attached to the wall at a distance of 0.600 m above the canopy.

The tension in each cable is 47.2 N.

(a) **(i)** State the **two** conditions for an object to be in equilibrium.

1. ....

....

2. ....

....
[2]

(ii) Determine the mass of the canopy.

mass = ... kg [3]

(b) The Young modulus of the steel from which the cables are made is 1.90×10^{11} Pa and each cable has a cross-sectional area of $7.50 \times 10^{-5}\,m^2$.

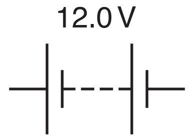
Determine the extension of each cable.

extension = ... m [3]

[Total: 8]

3 A student wishes to plot the V-I characteristic graph of a 12.0 V, 24.0 W tungsten filament lamp. The circuit used must enable the potential difference (p.d.) across the lamp to be varied continuously from 0 to 12.0 V. The power supply used is a 12.0 V battery.

(a) On Fig. 3.1, draw an appropriate circuit that includes the power supply shown.



[2]

Fig. 3.1

(b) Fig. 3.2 is the V-I characteristic graph obtained.

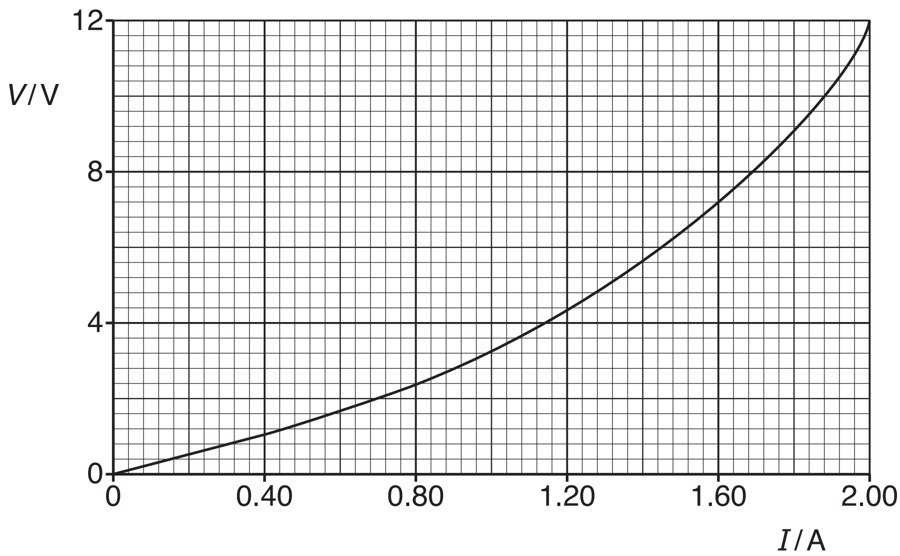


Fig. 3.2

(i) Use Fig. 3.2 to determine the resistance of the lamp when it is operating at 12.0 V.

resistance = ... Ω [1]

(ii) Use Fig. 3.2 to estimate the resistance of the lamp when it is switched off.

resistance = …………………………….. Ω [1]

(iii) The lamp is connected in series with the 12.0 V battery and a switch. The switch is closed and the potential difference across the lamp increases from 0 to 12.0 V almost immediately.

On Fig. 3.3, sketch a graph to suggest how the current in the lamp changes from the moment the lamp is switched on, until the moment the filament reaches its normal operating temperature.

[2]

Fig. 3.3

(c) Fig. 3.4 shows a variable resistor connected in series with a 2.50 Ω fixed resistor and a 12.0 V battery.

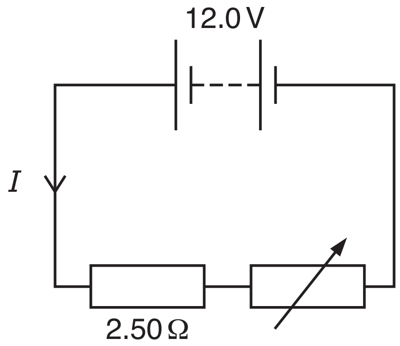


Fig. 3.4

The resistance of the variable resistor is adjusted and the current I in the circuit varies.

Show that the potential difference across the variable resistor is given by:

$$V = 12.0 - 2.50I$$

....

.... [1]

(d) The variable resistor in the circuit in Fig. 3.4 is replaced with the 12.0 V, 24.0 W tungsten filament lamp.

(i) On the *V-I* characteristic graph in Fig. 3.2, draw the line that represents the expression:

$$V = 12.0 - 2.50I$$ [2]

(ii) Use Fig. 3.2 to determine the p.d. across the 2.50 Ω fixed resistor.

p.d. = ... V [1]

[Total: 10]

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4 Fig. 4.1 shows gas trapped by a piston in a cylinder of cross-sectional area $2.00 \times 10^{-3}\,m^2$.

Fig. 4.1

From the position shown in Fig. 4.1, the piston is pushed very quickly into the cylinder. The piston moves a distance *x* to the right.

(a) State why work is done on the gas by the piston.

.... [1]

(b) Fig. 4.2 shows how the force of the piston on the gas changes as the distance *x* changes.

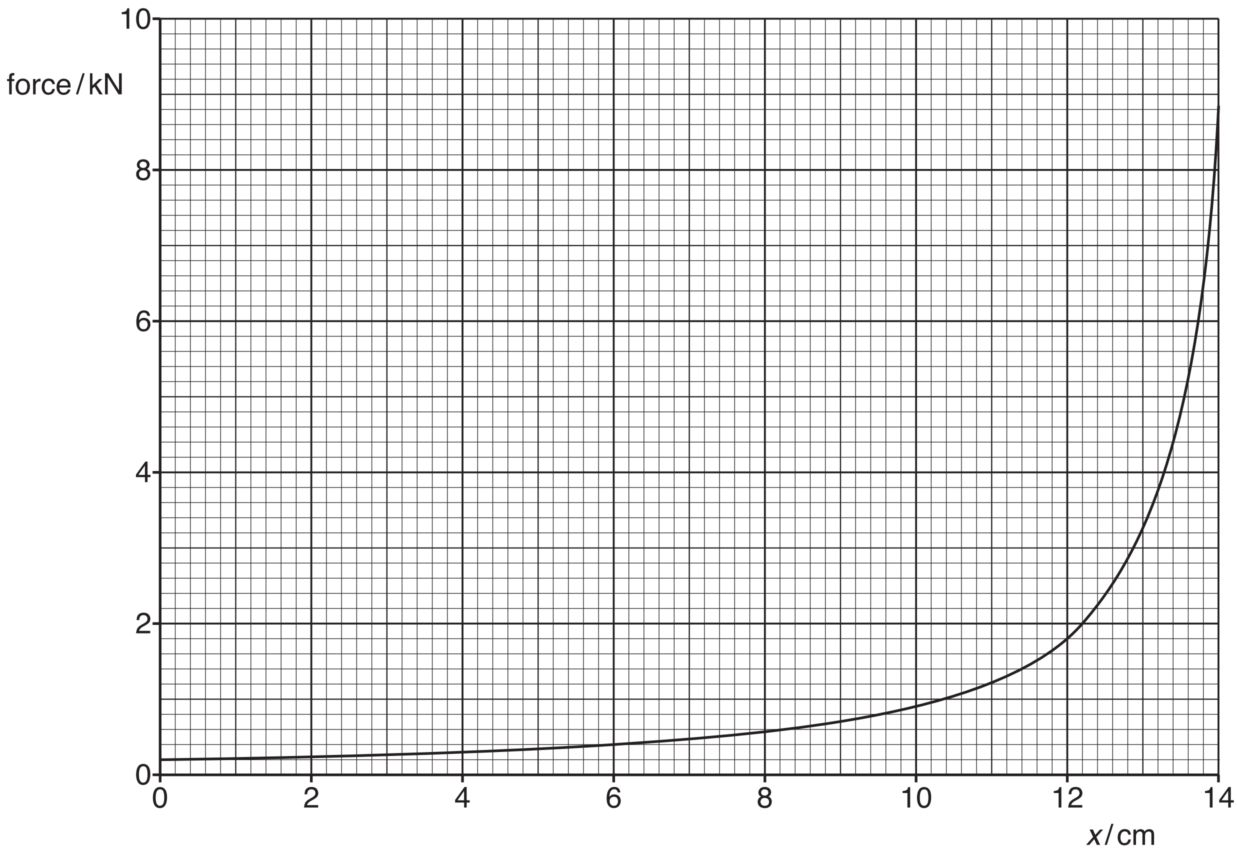


Fig. 4.2

(i) Determine the pressure exerted by the piston on the gas when $x = 0$.

pressure = ...Pa [2]

(ii) Estimate the work done on the gas by the piston as it moves through 14.0 cm.

work done = ... J [3]

(iii) As the gas is compressed its temperature increases.

State and explain how pushing the piston into the cylinder affects the kinetic energy of the gas molecules.

....

....

....

.... [3]

(c) The gas in the cylinder is a mixture of fuel and air. When $x = 14.0$ cm, the gas explodes and the piston is pushed back to its original position where $x = 0$.

(i) Explain how the work done on the piston by the expanding gas compares with the answer to **(b)(ii)**.

....

....

....

.... [3]

(ii) The cylinder is one part of a heat engine.

State what a *heat engine* does.

....

....

.... [1]

[Total: 13]

5 A double slit is placed in front of a light source and the light from the source falls perpendicularly on the slits. This produces a pattern on a wall some distance from the slits.

A light sensor that is connected to a datalogging interface is mounted on a trolley. A distance sensor that determines the distance between the sensor and the near end of the trolley is also connected to the interface.

Fig. 5.1 shows the arrangement.

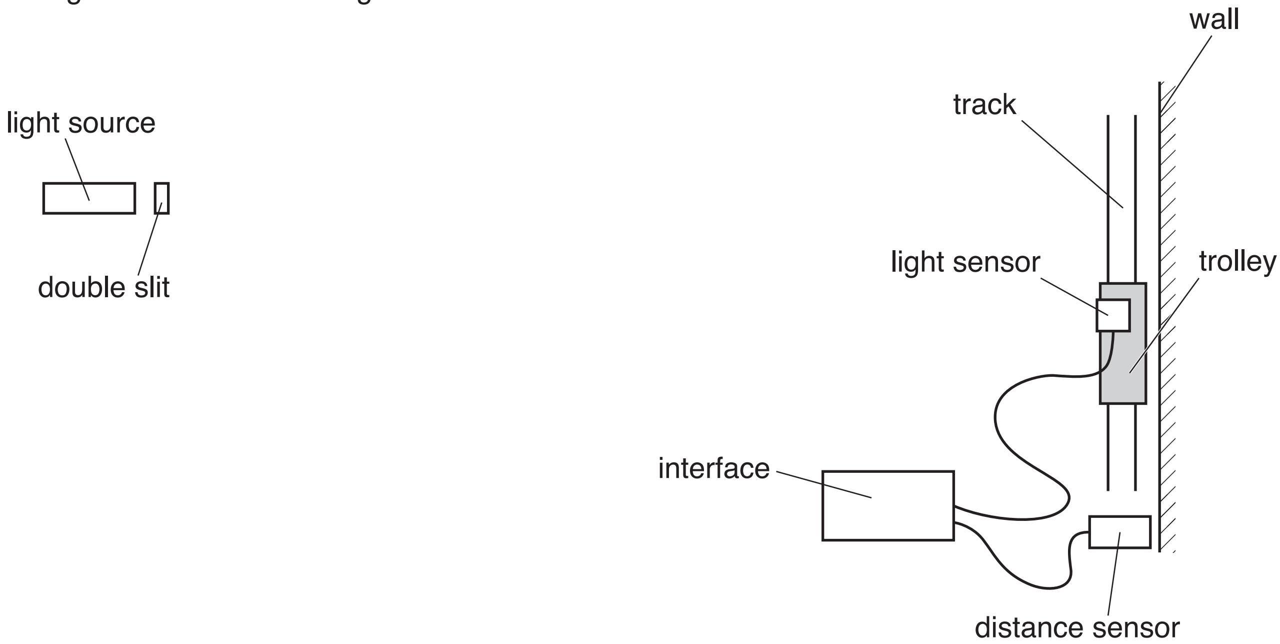


Fig. 5.1 (not to scale)

The interface is linked to a datalogging program that is being operated by a computer.

The trolley is pulled along a track parallel to the double slit and the light sensor detects the light intensity. The computer produces a graph of light intensity against the distance of the trolley from the sensor, as shown in Fig. 5.2.

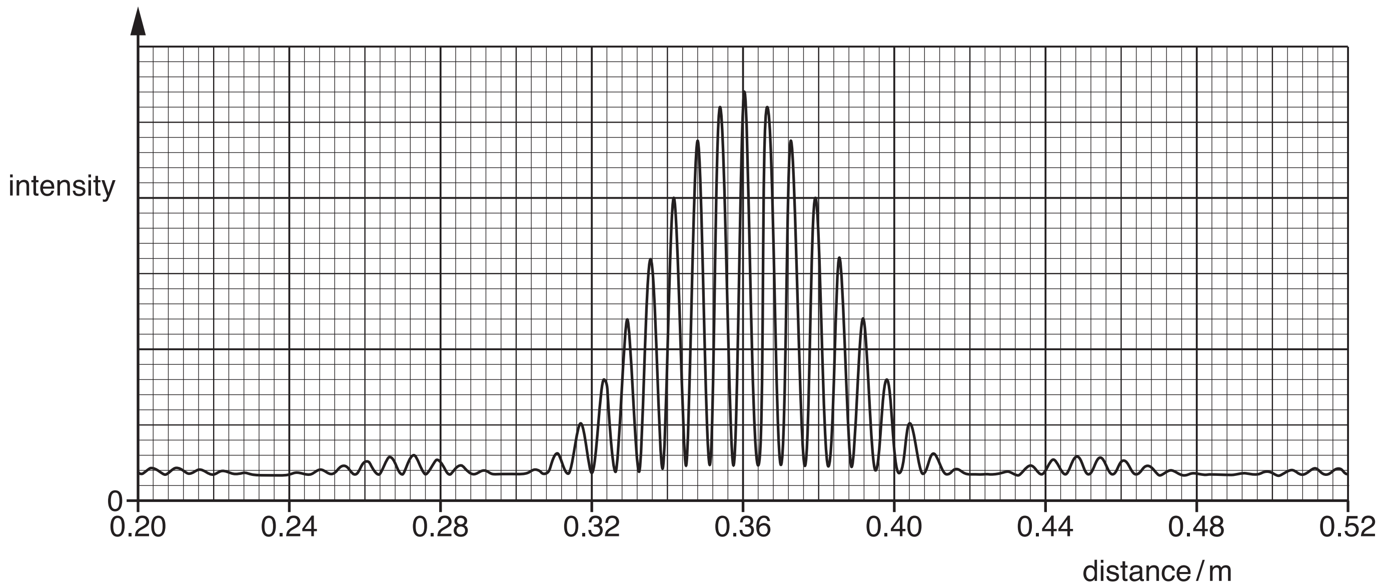


Fig. 5.2

Each of the slits has a width of 5.20×10^{-5} m. The light sensor is a perpendicular distance of 5.00 m from the double slit.

List what can be deduced from the graph. Your answer should, where appropriate, include relevant calculations.

....

....

....

....

....

....

....

....

....

....

....

.... [8]

6 The light from a particular laser is plane-polarised with its plane of polarisation vertical. The intensity of the light produced is I_0.

(a) State how plane-polarised light differs from unpolarised light.

....

....

.... [2]

(b) The light from the laser is incident normally on an ideal polarising filter that is vertical. The intensity of the light that emerges from the filter is equal to I_0.

(i) State what this shows about the polarising direction of the filter.

.... [1]

(ii) Fig. 6.1 shows the polarising filter rotating slowly about a horizontal axis at right angles to its surface.

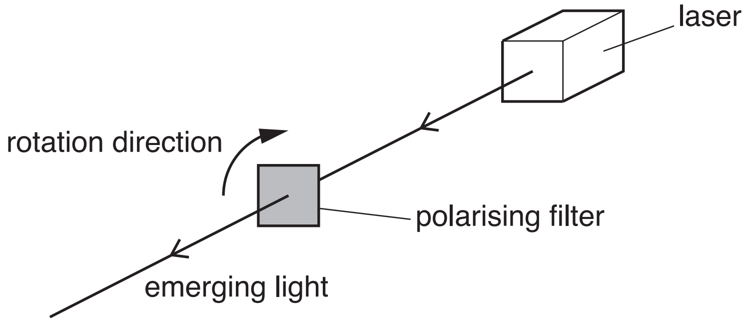
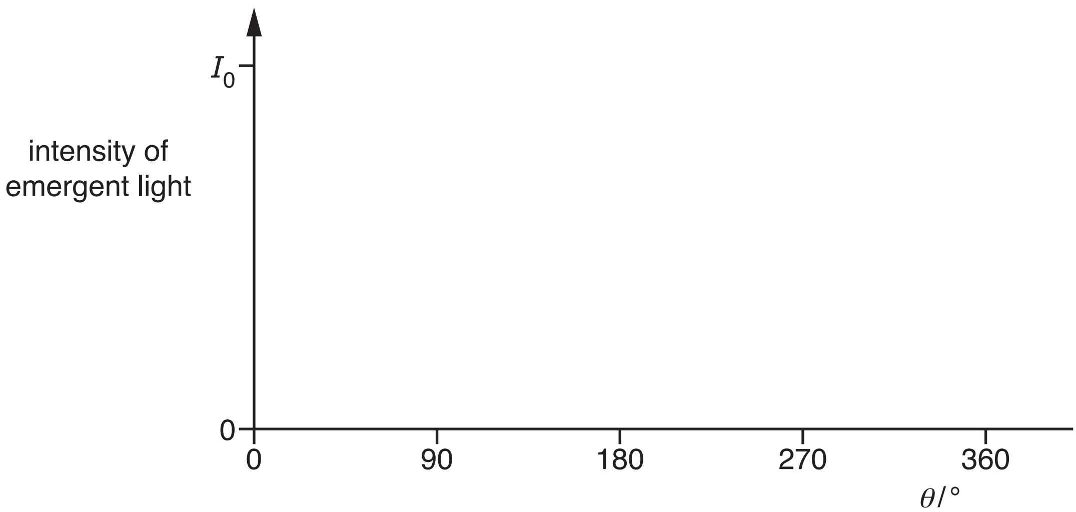


Fig. 6.1

As the angle θ through which the filter rotates increases from 0° to 360°, the intensity of the emerging light varies.

On Fig. 6.2, sketch a graph to show how the intensity of the emergent light varies with angle θ.



[2]

Fig. 6.2

(c) Fig. 6.3 shows light that reflects from a surface and passes through a vertical polarising filter.

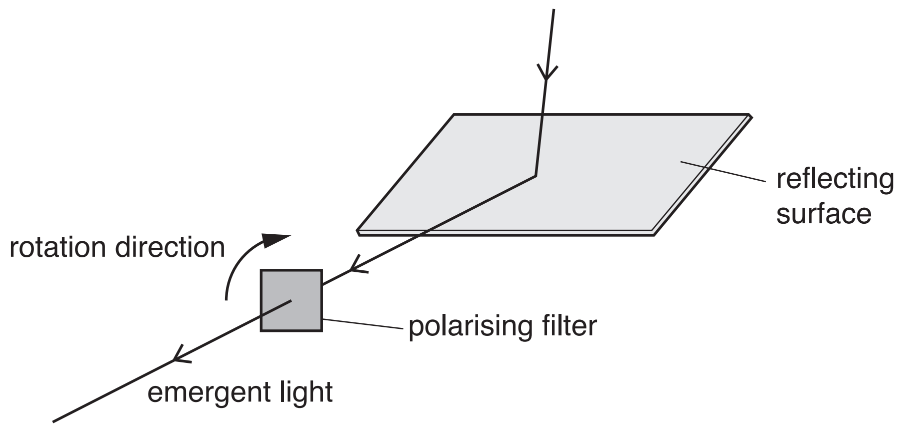


Fig. 6.3

The light that reflects from the surface is an unequal mixture of vertically polarised and horizontally polarised light.

When the polarising direction of the filter is vertical, the intensity of the emergent light is $0.262I_0$. When the polarising direction of the filter is horizontal the intensity is $0.850I_0$.

Determine the intensity of the emergent light when the polarising direction of the filter is 30.0° from the vertical.

intensity = ... I_0 [2]

[Total: 7]

7 **(a)** A nuclear particle X is fired at a nucleus of an isotope of lithium, lithium-6 ($^{6}_{3}Li$).

(i) In the space, draw a labelled diagram that represents the structure and composition of a neutral atom of lithium-6.

[2]

(ii) The nuclear particle X is absorbed by the nucleus of lithium-6 to produce a highly unstable beryllium (Be) nucleus. The nucleus of beryllium then splits into two α-particles.

Complete the equation that represents this reaction.

$$^{.....}_{.....}X + ^{6}_{3}Li \longrightarrow ^{.....}_{.....}Be \longrightarrow 2\,^{.....}_{.....}\alpha$$

[3]

(b) In the α-particle scattering experiment, a straight beam of α-particles is fired at a very thin sheet of gold in a vacuum.

State and explain why:

(i) almost all of the α-particles fired at the gold sheet continue in a straight line through the gold and out the other side

....

....

.... [2]

(ii) some α-particles are deflected through angles greater than 90° when they reach the gold sheet.

....

....

.... [2]

(c) A radioactive source that emits only α-particles is a very minor health risk when it is located outside a human body. If, however, the same source is swallowed the consequences may be very serious.

Explain, in terms of the properties of α-particles, why this is so.

....

....

....

.... [2]

[Total: 11]

8 An electron gun is a device that uses a potential difference (p.d.) V to accelerate free electrons in a vacuum. This produces a beam of electrons. Fig. 8.1 represents an electron gun.

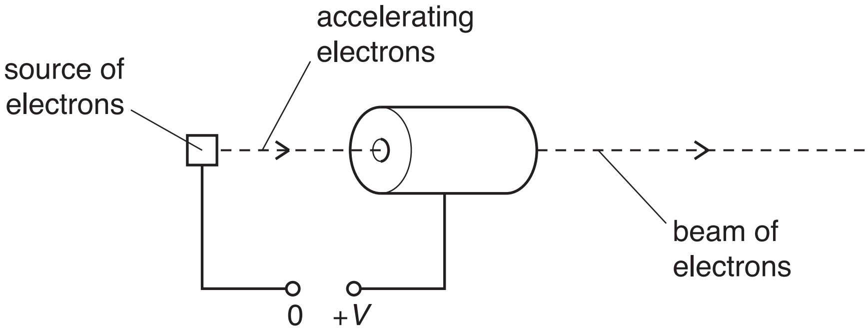


Fig. 8.1

(a) A p.d. of 182 V is used in an electron gun to accelerate electrons from rest.

Calculate the speed at which the electrons emerge from the electron gun.

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

(b) Fig. 8.2 shows apparatus that uses an electron gun to produce a beam of electrons in a vacuum tube.

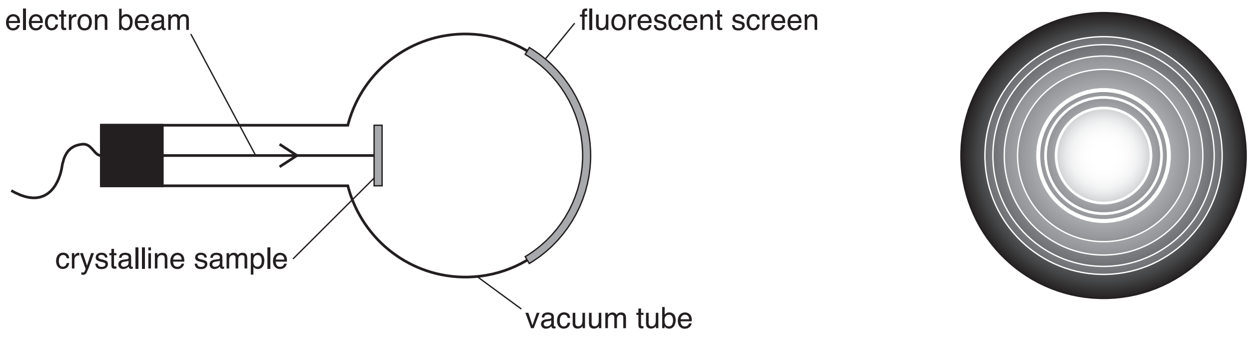


Fig. 8.2

The beam of electrons strikes a thin sample of a crystalline material. The pattern produced on the fluorescent screen at the front of the vacuum tube is also shown in Fig. 8.2.

Explain what the pattern on the screen shows about the electrons.

....

....

....

....

.... [3]

(c) An electron microscope produces an image using electrons instead of electromagnetic waves.

The momentum of each of the electrons is 1.95×10^{-22} kg m s^{-1}. The microscope can only resolve objects that have an angular separation θ greater than 1.25×10^{-7} radians.

Calculate an approximate value for the diameter of the aperture of the microscope.

diameter ≈ .... m [3]

[Total: 9]

Section 2

You are advised to spend about 30 minutes on this section.

The questions in this section refer to the pre-released material provided as an insert to the paper.

Your answers should, where possible, make use of any relevant Physics.

9 **(a)** **(i)** Complete the nuclear equation that represents the beta-plus (β^+) decay of the proton by the weak force.

$$^{\dots\dots}_{\dots\dots}\text{p} \longrightarrow {}^{\dots\dots}_{\dots\dots}\text{n} + {}^{\dots\dots}_{1}\beta + {}^{\dots\dots}_{\dots\dots}\nu$$

[2]

(ii) Place ticks in Table 9.1 to show how the n, β^+ and ν are classified.

Table 9.1

	classification			
particle	hadron	baryon	meson	lepton
n				
β^+				
ν				

[3]

(b) The strong force is a short-range force within the nucleus that binds neighbouring nucleons.

The graph in Fig. 9.1 shows how the strong force between two nucleons varies with their separation.

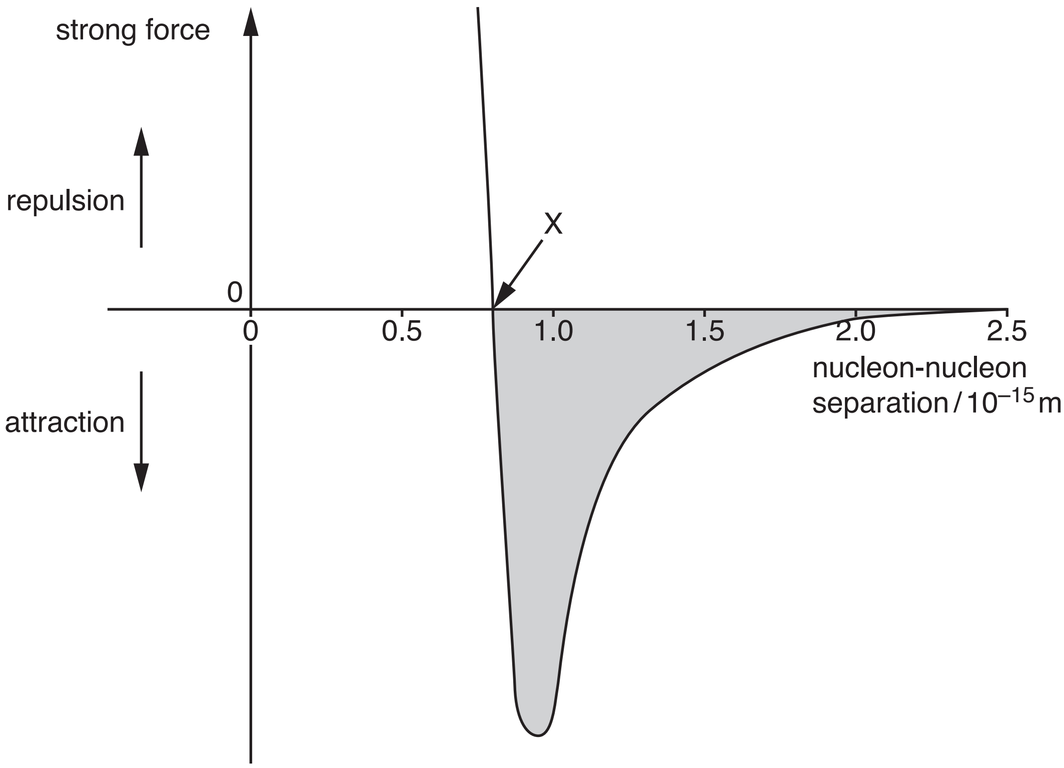


Fig. 9.1

Forces of repulsion are positive and forces of attraction are negative.

(i) State how the strong force prevents nuclei from collapsing.

....

.... [1]

(ii) Explain why the separation at X in Fig. 9.1 is not equal to the average separation of nucleons in the nucleus.

....

....

.... [2]

(iii) State the significance of the shaded area in Fig. 9.1.

....

....

.... [2]

(c) The graph in Fig. 9.2 shows the relationship between the total potential energy of a pair of nucleons and their separation.

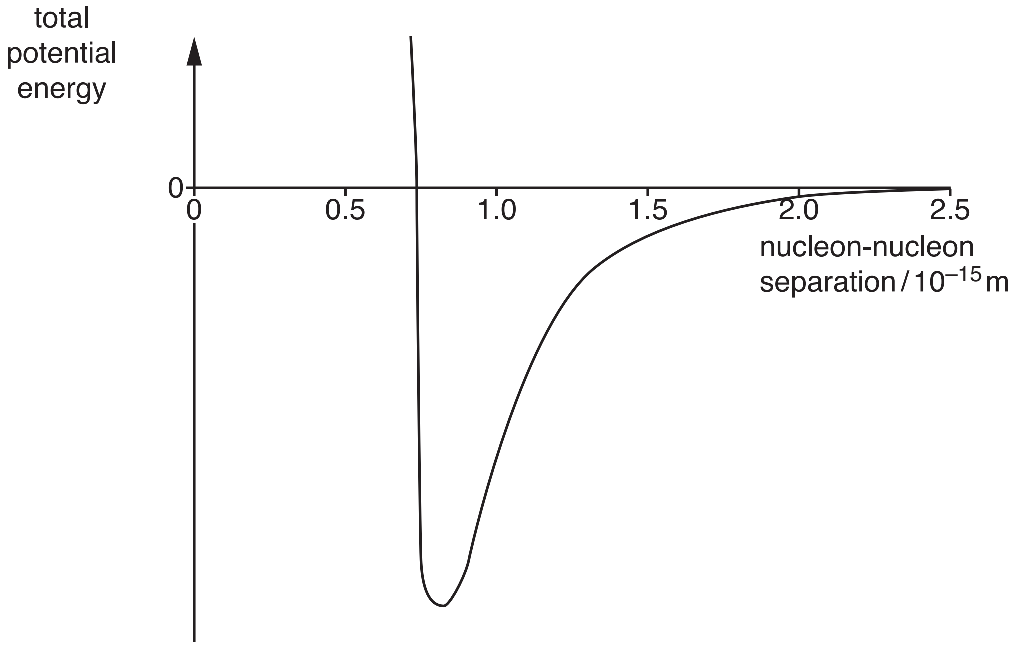


Fig. 9.2

The equilibrium separation is the average separation of two nucleons in a nucleus.

(i) On Fig. 9.2 mark a point on the *x*-axis to indicate the equilibrium separation.

Label this point E. [1]

(ii) Explain why the point you have chosen is the equilibrium separation.

....

.... [1]

(d) A neutral xi-zero particle Ξ^0 can decay to a neutral lambda particle Λ^0 and a neutral pion, π^0. The quark contents of the Ξ^0 and the π^0 are given.

The quark content of the Λ^0 is represented by qqq, where q is the symbol for an unidentified quark, s is the symbol for the strange quark (Extract 3) and ū is the symbol for an anti-up quark.

$$\Xi^0 \longrightarrow \Lambda^0 + \pi^0$$

quark content	uss	qqq	ūu

During this decay a strange quark becomes an up quark by emitting a W^- particle which, in turn, decays to a down quark and an anti-up quark.

$$s \longrightarrow u + W^-$$

$$W^- \longrightarrow d + \bar{u}$$

(i) Fig. 9.3 is a Feynman diagram representing the decay of a xi-zero particle Ξ^0.

Complete the diagram by transferring information given in the above equations into the numbered boxes in the diagram.

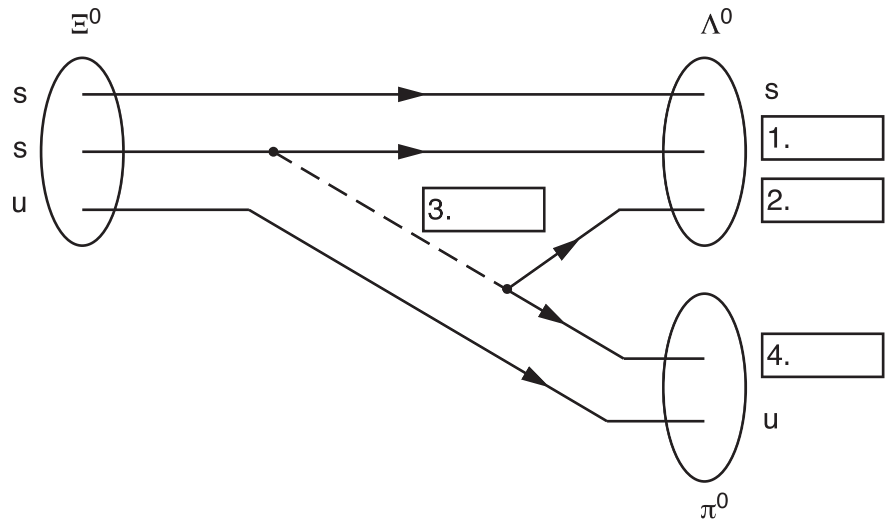


Fig. 9.3

[2]

(ii) State the type of particles to which the W^- belongs.

.... [1]

(e) An omega-minus particle, Ω^-, can decay to a neutral xi-zero particle, Ξ^0, and a pi-minus particle, π^-.

$$\Omega^- \longrightarrow \Xi^0 + \pi^-$$

quark content sss uss $\bar{u}d$

Table 9.2 provides information about the up, down and strange quarks.

Table 9.2

quark	charge	strangeness
u	$+\frac{2}{3}$	0
d	$-\frac{1}{3}$	0
s	$-\frac{1}{3}$	–1

In Extract 3, there are examples showing how the values of strangeness for particles can be used to determine the nature of a decay.

Use the information about quarks in Table 9.2 and the decay equation for the Ω^- to show:

(i) this decay is permissible

[3]

(ii) this is a weak decay.

[2]

(f) A bubble chamber uses a uniform magnetic field to make a moving charged particle follow a curved path.

A particle with charge Q and mass m is travelling at speed v, and at right angles to a magnetic field of constant magnetic flux density B, in a curved path of radius r.

(i) Show that the radius of curvature r of this path is directly proportional to the momentum of the particle.

[1]

(ii) Fig. 9.4 is part of a diagram of the bubble chamber photograph in Extract 5.

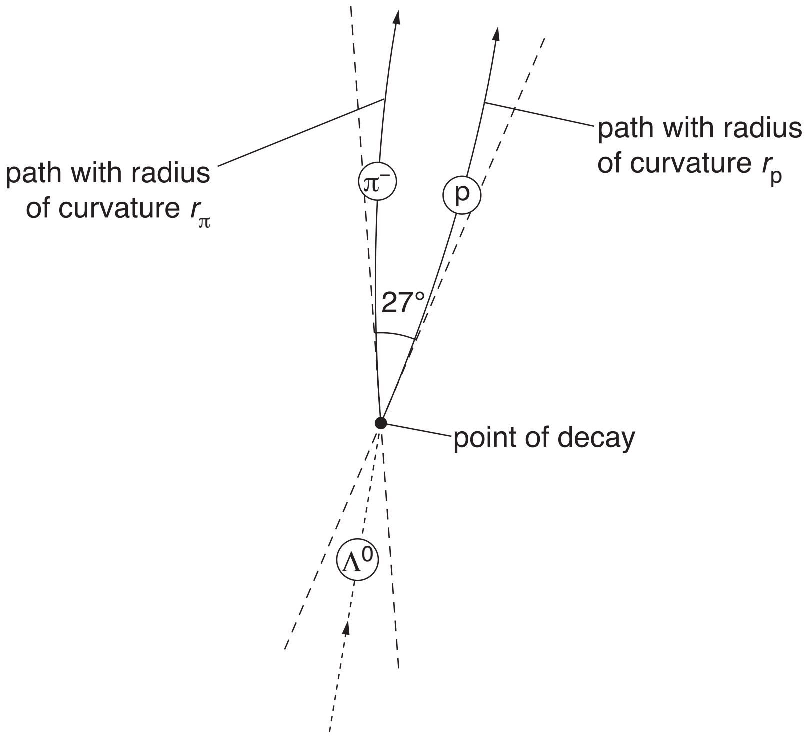


Fig. 9.4 (not to scale)

The lambda particle Λ^0 in Fig. 9.4 decays into a proton and a pi-minus particle and in this decay momentum is conserved.

$$\Lambda^0 \longrightarrow p + \pi^-$$

The angle between the tracks at the point of decay is 27°.

The radius of curvature of the path of the proton is r_p and that of the pi-minus is r_π.

The fraction $\frac{r_p}{r_\pi}$ is equal to 1.1.

Use this information to draw a vector diagram representing conservation of momentum for this decay.

- Label your vectors.
- Mark the angle 27° on your diagram.
- Determine the angle θ between the direction of the path of the Λ^0 and the direction of the path of the π^- at the point of decay.

θ = ...° [4]

[Total: 25]