Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

4150141635

PHYSICS **9702/23**

Paper 2 AS Level Structured Questions **May/June 2016**

1 hour 15 minutes

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.

Answer **all** questions.

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.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega\sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 **(a)** A list of quantities that are either scalars or vectors is shown in Fig. 1.1.

quantity	scalar	vector
distance	✓	
energy		
momentum		
power		
time		
weight		

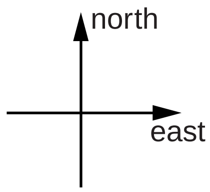
Fig. 1.1

Complete Fig. 1.1 to indicate whether each quantity is a scalar or a vector.

One line has been completed as an example. [2]

(b) A girl runs 120 m due north in 15 s. She then runs 80 m due east in 12 s.

(i) Sketch a vector diagram to show the path taken by the girl. Draw and label her resultant displacement R.



[1]

(ii) Calculate, for the girl,

1. the average speed,

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

2. the magnitude of the average velocity v and its angle with respect to the direction of the initial path.

magnitude of v = ... $m s^{-1}$

angle = ... °

[3]

[Total: 7]

2 **(a)** Describe the effects, one in each case, of systematic errors and random errors when using a micrometer screw gauge to take readings for the diameter of a wire.

systematic errors: ....

....

random errors: ....

....

[2]

(b) Distinguish between precision and accuracy when measuring the diameter of a wire.

precision: ....

....

accuracy: ....

....

[2]

[Total: 4]

3 **(a)** Explain what is meant by *gravitational potential energy* and by *kinetic energy*.

gravitational potential energy: ....

....

kinetic energy: ....

.... [2]

(b) A motion sensor is used to measure the velocity of a ball falling vertically towards the ground, as illustrated in Fig. 3.1.

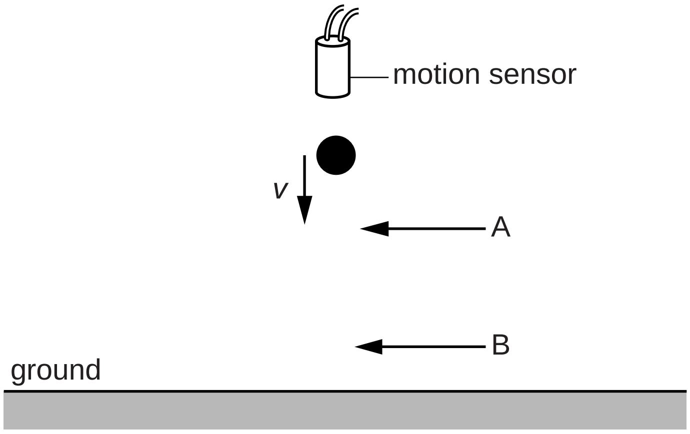


Fig. 3.1

The ball passes through points A and B as it falls. The ball has a mass of 1.5 kg.

The variation with time t of the velocity v of the ball as it falls from A to B is shown in Fig. 3.2.

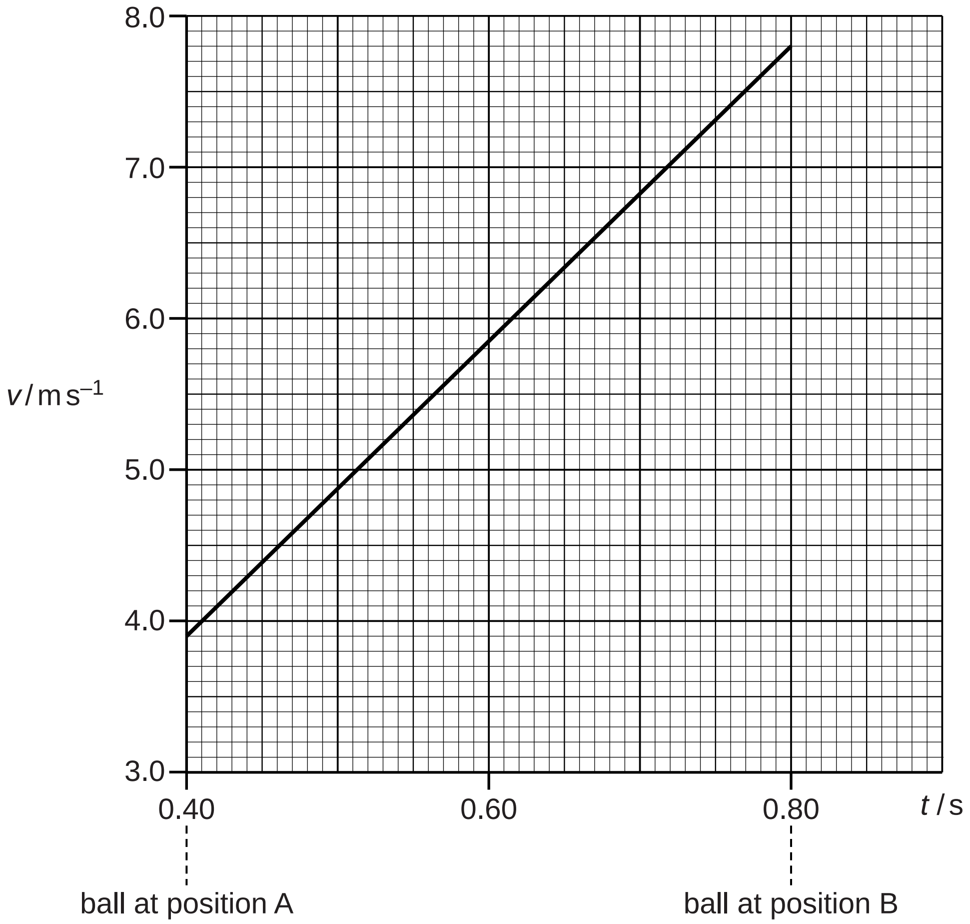


Fig. 3.2

Use Fig. 3.2 to calculate, for the ball falling from A to B,

(i) the displacement,

displacement = ... m [3]

(ii) the acceleration,

acceleration = ... $m\,s^{-2}$ [2]

(iii) the change in kinetic energy.

change in kinetic energy = ... J [3]

(c) Show that the work done by the gravitational field on the ball in **(b)** as it moves from A to B is equal to the change in kinetic energy.

[2]

[Total: 12]

4 A spring balance is used to weigh a cylinder that is immersed in oil, as shown in Fig. 4.1.

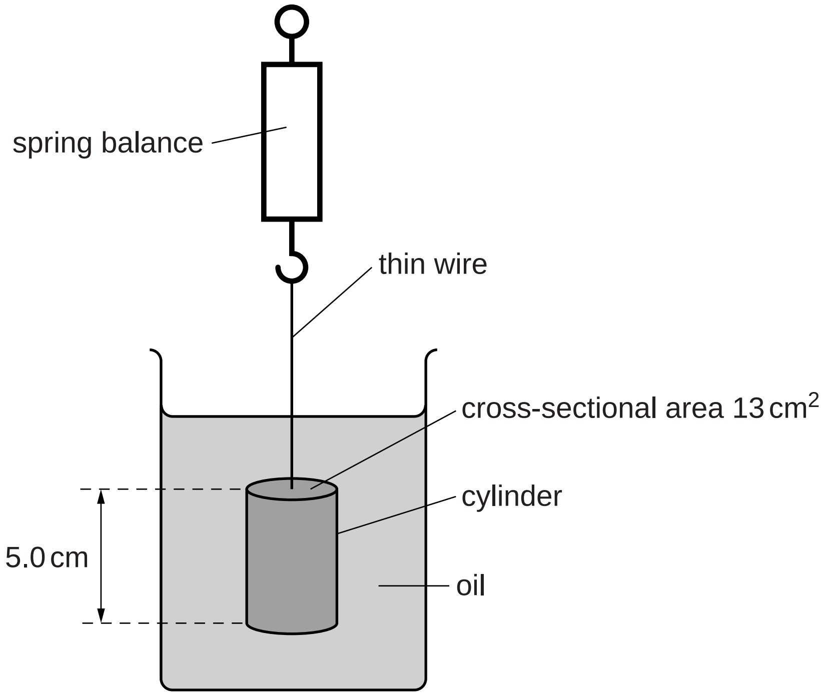


Fig. 4.1

The reading on the spring balance is 4.8 N. The length of the cylinder is 5.0 cm and the cross-sectional area of the cylinder is 13 cm^2. The weight of the cylinder is 5.3 N.

(a) The cylinder is in equilibrium when it is immersed in the oil. Explain this in terms of the forces acting on the cylinder.

....

.... [1]

(b) Calculate the density of the oil.

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

[Total: 4]

5 **(a)** State the law of conservation of momentum.

....

....

.... [2]

(b) Two particles A and B collide elastically, as illustrated in Fig. 5.1.

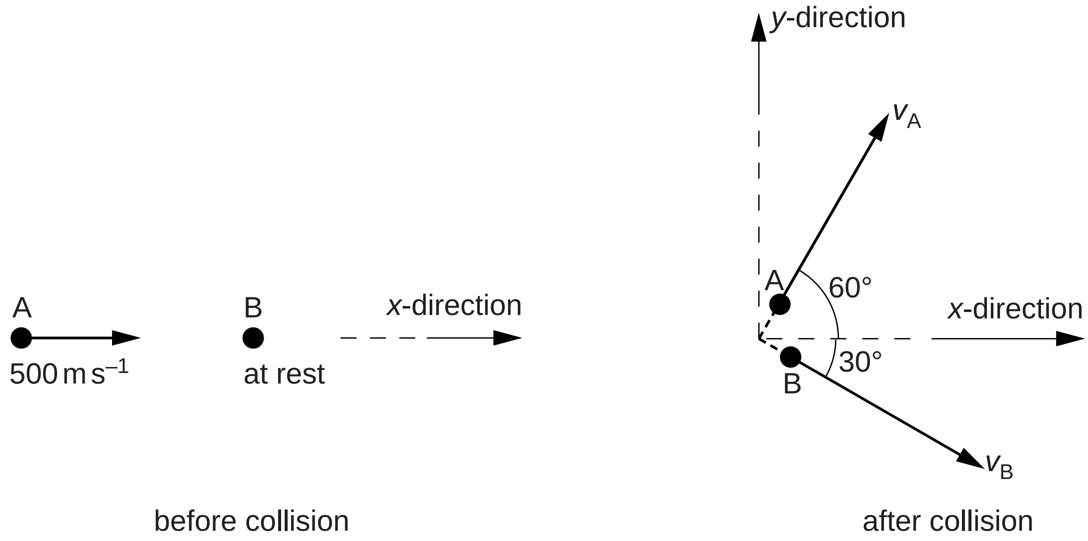


Fig. 5.1

The initial velocity of A is 500 m s^{-1} in the x-direction and B is at rest.

The velocity of A after the collision is v_A at 60° to the x-direction. The velocity of B after the collision is v_B at 30° to the x-direction.

The mass m of each particle is 1.67×10^{-27} kg.

(i) Explain what is meant by the particles colliding *elastically*.

.... [1]

(ii) Calculate the total initial momentum of A and B.

momentum = ...N s [1]

(iii) State an expression in terms of m, v_A and v_B for the total momentum of A and B after the collision

1. in the x-direction,

....

2. in the y-direction.

....
[2]

(iv) Calculate the magnitudes of the velocities v_A and v_B after the collision.

v_A = ... $m\,s^{-1}$

v_B = ... $m\,s^{-1}$
[3]

[Total: 9]

6 **(a)** Define the *ohm*.

.... [1]

(b) A 15V battery with negligible internal resistance is connected to two resistors P and Q, as shown in Fig. 6.1.

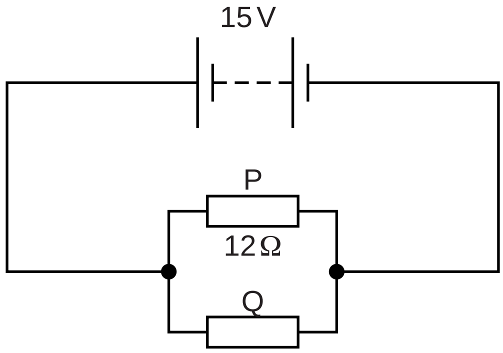


Fig. 6.1

The resistors are made of wires of the same material. The wire of P has diameter *d* and length 2*l*. The wire of Q has diameter 2*d* and length *l*.

The resistance of P is 12Ω.

(i) Show that the resistance of Q is 1.5Ω.

[3]

(ii) Calculate the total power dissipated in the resistors P and Q.

power = ... W [3]

(iii) Determine the ratio

$$\frac{\text{average drift speed of the charge carriers in P}}{\text{average drift speed of the charge carriers in Q}}.$$

ratio = ... [3]

[Total: 10]

7 **(a)** Apparatus used to produce stationary waves on a stretched string is shown in Fig. 7.1.

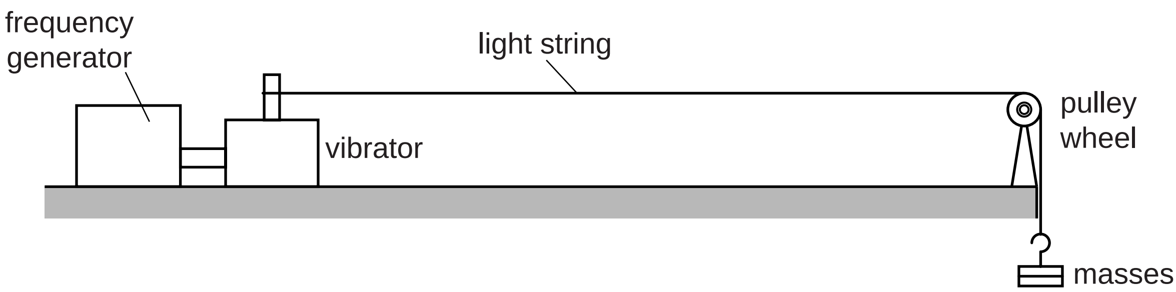


Fig. 7.1

The frequency generator is switched on.

(i) Describe two adjustments that can be made to the apparatus to produce stationary waves on the string.

1. ....

....

2. ....

....
[2]

(ii) Describe the features that are seen on the stretched string that indicate stationary waves have been produced.

.... [1]

(b) The variation with time *t* of the displacement *x* of a particle caused by a progressive wave R is shown in Fig. 7.2. For the same particle, the variation with time *t* of the displacement *x* caused by a second wave S is also shown in Fig. 7.2.

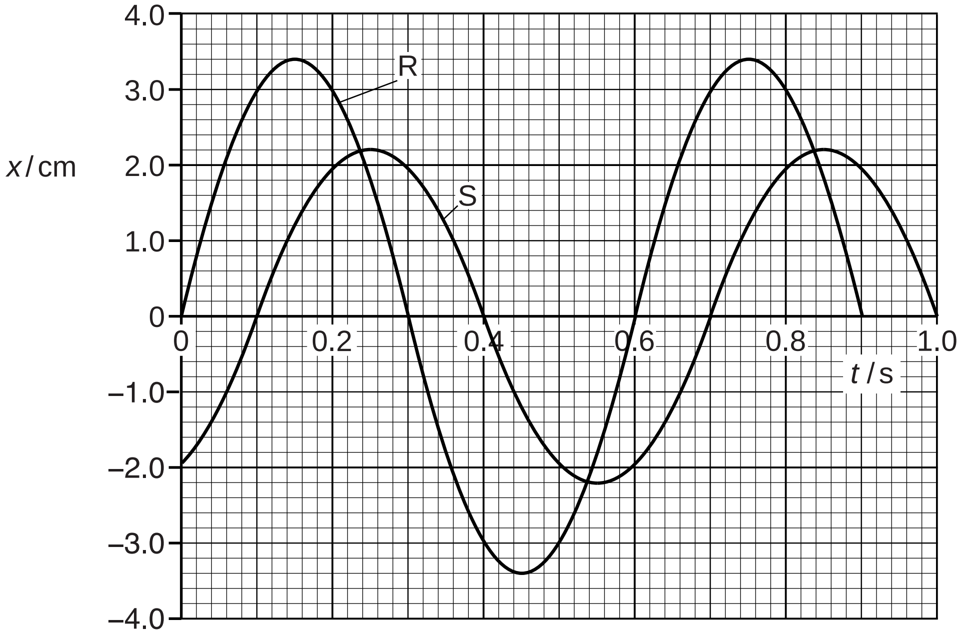


Fig. 7.2

(i) Determine the phase difference between wave R and wave S. Include an appropriate unit.

phase difference = ... [1]

(ii) Calculate the ratio

$$\frac{\text{intensity of wave R}}{\text{intensity of wave S}}.$$

ratio = ... [2]

[Total: 6]

8 **(a)** Distinguish between an α-particle and a β^+-particle.

....

....

....

....

....[3]

(b) State the equation that shows the decay of a particle in a nucleus that results in β^+ emission. All particles in the equation should be shown in the notation that is usually used for the representation of nuclides.

[2]

(c) **(i)** State the quark composition of

1. a proton,

....

2. a neutron.

....

[2]

(ii) Use the quark model to explain the charge on a proton.

....

....

....[1]

[Total: 8]