

**Cambridge Assessment International Education**  
Cambridge International Advanced Subsidiary and Advanced Level

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9702/22

February/March 2019

**1 hour 15 minutes**

No Additional Materials are required.

## READ THESE INSTRUCTIONS FIRST

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

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

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

This document consists of **15** printed pages and **1** blank page.

**Data**

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

**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	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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

- 1 (a) The ampere, metre and second are SI base units.

State **two** other SI base units.

1. ....

2. ....

[2]

- (b) The average drift speed  $v$  of electrons moving through a metal conductor is given by the equation:

$$v = \frac{\mu F}{e}$$

where  $e$  is the charge on an electron

$F$  is a force acting on the electron

and  $\mu$  is a constant.

Determine the SI base units of  $\mu$ .

SI base units ..... [3]

[Total: 5]

2 (a) Define:

(i) *displacement*

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

(ii) *acceleration*.

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

(b) A man wearing a wingsuit glides through the air with a constant velocity of  $47 \text{ m s}^{-1}$  at an angle of  $24^\circ$  to the horizontal. The path of the man is shown in Fig. 2.1.

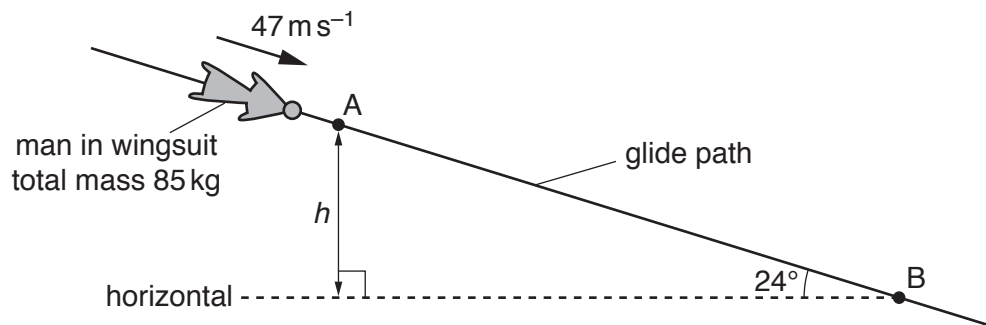


Fig. 2.1 (not to scale)

The total mass of the man and the wingsuit is  $85 \text{ kg}$ . The man takes a time of  $2.8$  minutes to glide from point A to point B.

(i) With reference to the motion of the man, state and explain whether he is in equilibrium.

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

(ii) Show that the difference in height  $h$  between points A and B is  $3200 \text{ m}$ .

[1]

(iii) For the movement of the man from A to B, determine:

1. the decrease in gravitational potential energy

decrease in gravitational potential energy = ..... J [2]

2. the magnitude of the force on the man due to air resistance.

force = ..... N [2]

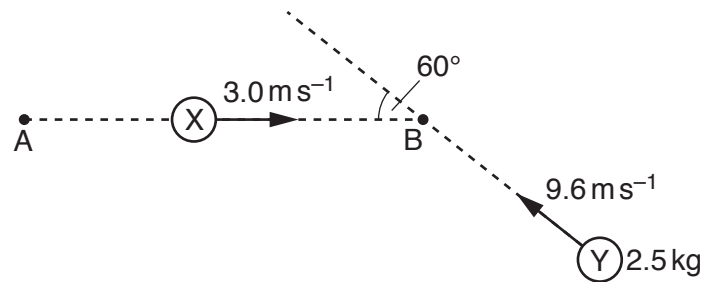
(iv) The pressure of the still air at A is 63 kPa and at B is 92 kPa. Assume the density of the air is constant between A and B.

Determine the density of the air between A and B.

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

[Total: 11]

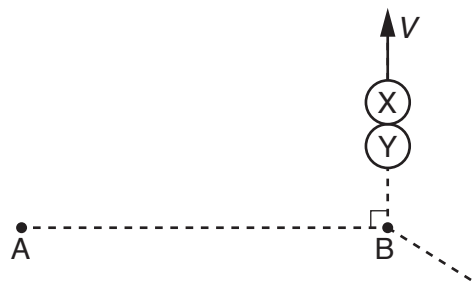
- 3 Two balls, X and Y, move along a horizontal frictionless surface, as illustrated in Fig. 3.1.



**Fig. 3.1** (not to scale)

Ball X has an initial velocity of  $3.0 \text{ m s}^{-1}$  in a direction along line AB. Ball Y has a mass of  $2.5 \text{ kg}$  and an initial velocity of  $9.6 \text{ m s}^{-1}$  in a direction at an angle of  $60^\circ$  to line AB.

The two balls collide at point B. The balls stick together and then travel along the horizontal surface in a direction at right-angles to the line AB, as shown in Fig. 3.2.



**Fig. 3.2**

- (a) By considering the components of momentum in the direction from A to B, show that ball X has a mass of  $4.0 \text{ kg}$ .

[2]



- (b) Calculate the common speed  $V$  of the two balls after the collision.

$$V = \dots\dots\dots \text{ms}^{-1} \text{ [2]}$$

- (c) Determine the difference between the initial kinetic energy of ball X and the initial kinetic energy of ball Y.

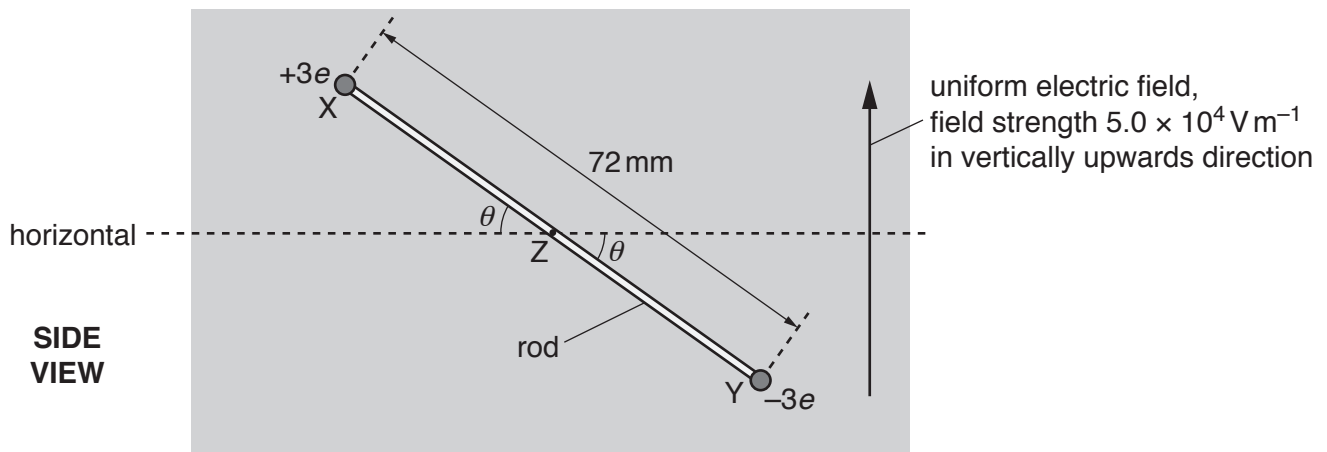
$$\text{difference in kinetic energy} = \dots\dots\dots \text{J [2]}$$

[Total: 6]

- 4 (a) Define *electric field strength*.

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

- (b) Two very small metal spheres X and Y are connected by an insulating rod of length 72 mm. A side view of this arrangement is shown in Fig. 4.1.



**Fig. 4.1** (not to scale)

Sphere X has a charge of  $+3e$  and sphere Y has a charge of  $-3e$ , where  $e$  is the elementary charge. The rod is held at its mid point Z at an angle  $\theta$  to the horizontal. The rod and spheres have negligible mass and are in a uniform electric field. The electric field strength is  $5.0 \times 10^4 \text{ V m}^{-1}$ . The direction of this field is vertically upwards.

- (i) The electric field is produced by applying a potential difference of 4.0 kV between two charged parallel metal plates.

1. Calculate the separation between the plates.

separation = ..... m [2]

2. Describe the arrangement of the two plates. Include in your answer a statement of the sign of the charge on each plate. You may draw on Fig. 4.1.

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

- (ii) Determine the magnitude and direction of the force on sphere Y.

magnitude = ..... N  
direction ..... [2]

- (iii) The electric forces acting on the two spheres form a couple. This couple acts on the rod with a torque of  $6.2 \times 10^{-16} \text{ Nm}$ .

Calculate the angle  $\theta$  of the rod to the horizontal.

$\theta = \dots\dots\dots^\circ$  [2]

[Total: 9]

5 (a) By reference to two waves, state:

(i) the principle of superposition

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

(ii) what is meant by *coherence*.

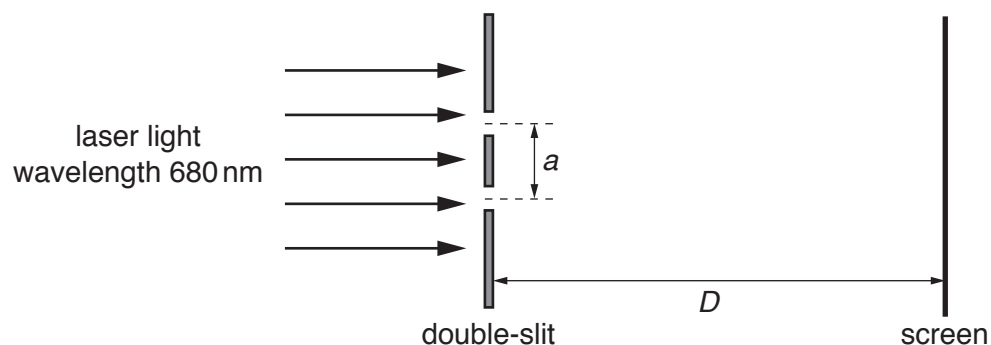
.....  
.....[1]

(b) Two coherent waves P and Q meet at a point in phase and superpose. Wave P has an amplitude of 1.5 cm and intensity  $I$ . The resultant intensity at the point where the waves meet is  $3I$ .

Calculate the amplitude of wave Q.

amplitude = ..... cm [2]

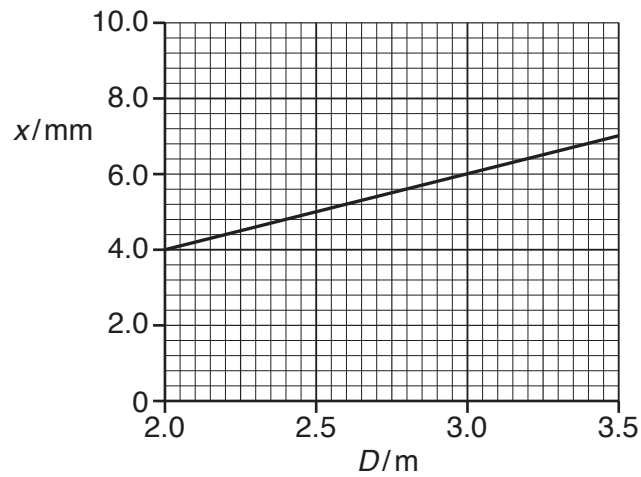
(c) The apparatus shown in Fig. 5.1 is used to produce an interference pattern on a screen.



**Fig. 5.1** (not to scale)

Light of wavelength 680 nm is incident on a double-slit. The slit separation is  $a$ . The separation between adjacent fringes is  $x$ . Fringes are viewed on a screen at distance  $D$  from the double-slit.

Distance  $D$  is varied from 2.0m to 3.5m. The variation with  $D$  of  $x$  is shown in Fig. 5.2.



**Fig. 5.2**

- (i) Use Fig. 5.2 to determine the slit separation  $a$ .

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

- (ii) The laser is now replaced by another laser that emits light of a shorter wavelength.

On Fig. 5.2, sketch a possible line to show the variation with  $D$  of  $x$  for the fringes that are now produced. [2]

[Total: 10]

- 6 (a) Using energy transformations, describe the *electromotive force (e.m.f.)* of a battery and the *potential difference (p.d.)* across a resistor.

e.m.f.: .....

.....

p.d.: .....

.....[2]

- (b) A battery of e.m.f. 6.0V and negligible internal resistance is connected to a network of resistors and a voltmeter, as shown in Fig. 6.1.

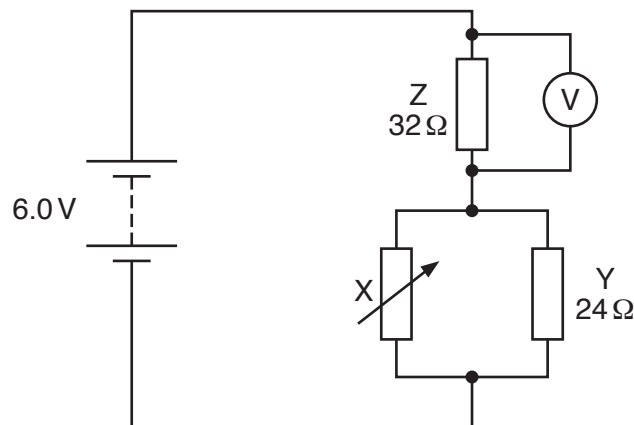


Fig. 6.1

Resistor Y has a resistance of  $24\ \Omega$  and resistor Z has a resistance of  $32\ \Omega$ .

- (i) The resistance  $R_x$  of the variable resistor X is adjusted until the voltmeter reads 4.8 V.

Calculate:

1. the current in resistor Z

current = ..... A [1]

2. the total power provided by the battery

power = ..... W [2]

3. the number of conduction electrons that move through the battery in a time interval of 25 s

number = ..... [2]

4. the total resistance of X and Y connected in parallel

total resistance = .....  $\Omega$  [2]

5. the resistance  $R_X$ .

$R_X$  = .....  $\Omega$  [2]

- (ii) The resistance  $R_X$  is now decreased.

State and explain the change, if any, to the reading on the voltmeter.

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

[Total: 13]

7 (a) The names of four particles are listed below.

alpha      beta-plus      neutron      proton

State the name(s) of the particle(s) in this list that:

(i) are not fundamental

.....[1]

(ii) do not experience an electric force when situated in an electric field

.....[1]

(iii) has the largest ratio of charge to mass.

.....[1]

(b) A hadron has a charge of  $+e$  where  $e$  is the elementary charge. The hadron is composed of only two quarks. One of these quarks is an antidown ( $\bar{d}$ ) quark. By considering charge, state and explain the name (flavour) of the other quark.

.....

.....[3]

[Total: 6]

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