

Candidate Name

Candidate Number

Centre Name

Centre Number

Paper 1: Physics

For Examination December 2023

(2 hours)

It is necessary to respond on the answer sheets provided alongside this question paper. Additionally, you must have a soft pencil (preferably of type B or HB), a clean eraser and a dark blue or black pen.

INSTRUCTIONS:

- You must write your name, candidate number, centre name and centre number on the answer sheets in the designated spaces.
- Objective section consists of 40 questions, and it is essential that you attempt all of them.
- Each question has four options labelled A, B, C, and D. Select the option that you think is correct. Mark it on the multiple choice answer sheet using a soft pencil.
- Attempt all the questions from subjective section using a dark blue or black pen.
- It is important to follow the instructions provided on the answer sheets.
- Do not use correction fluid.
- Avoid writing on any bar codes.
- You are allowed to use a calculator if needed.

INFORMATION:

- This paper has a total of 85 marks.
- In objective section there are 25 questions, each carries one mark. There is no negative marking for incorrect responses.
- In subjective section, 30 marks are for extended theory and 15 marks for practical component.
- The number of marks assigned for every question or its parts is indicated within brackets []

Section A: Multiple Choice Questions (40 marks)

1 What is a unit for stress?

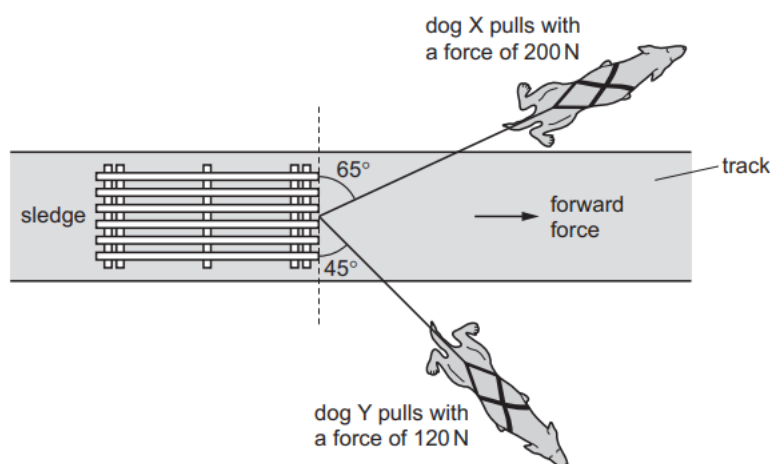
- A** $\text{kg m}^{-1} \text{s}^{-2}$ **B** $\text{kg m}^{-2} \text{s}^{-2}$ **C** N m^{-1} **D** N m

2 Physical quantities can be classed as vectors or as scalars. Which pair of quantities consists of two vectors?

- A** kinetic energy and force
B momentum and time
C velocity and electric field strength
D weight and temperature

3 Two dogs pull a sledge along an icy track, as shown.

Dog X pulls with a force of 200 N at an angle of 65° to the front edge of the sledge. Dog Y pulls with a force of 120 N at an angle of 45° to the front edge of the sledge.



What is the resultant forward force on the sledge exerted by the two dogs?

- A** 80N **B** 170N **C** 270N **D** 320N

4. The sides of a cube are measured with calipers.

The measured length of each side is $(30.0 \pm 0.1) \text{ mm}$.

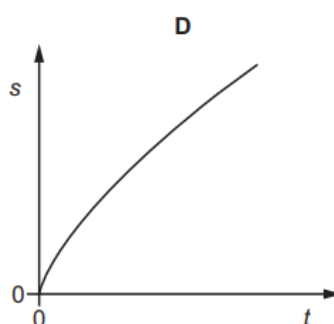
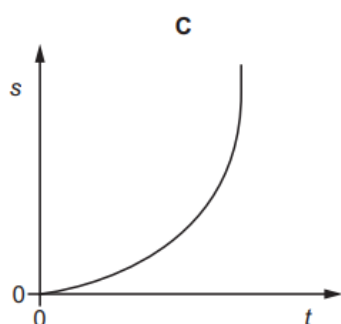
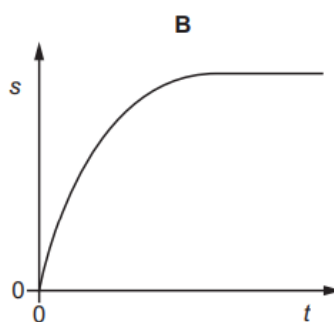
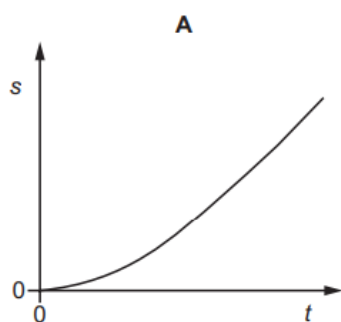
The measurements are used to calculate the volume of the cube.

What is the percentage uncertainty in the calculated value of the volume?

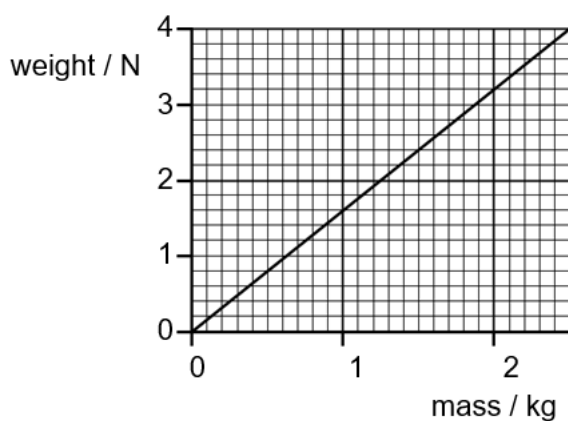
- A** 0.01% **B** 0.3% **C** 1% **D** 3%

5. A tennis ball falls freely, in air, from the top of a tall building.

Which graph best represents the variation with time t of the distance s fallen?



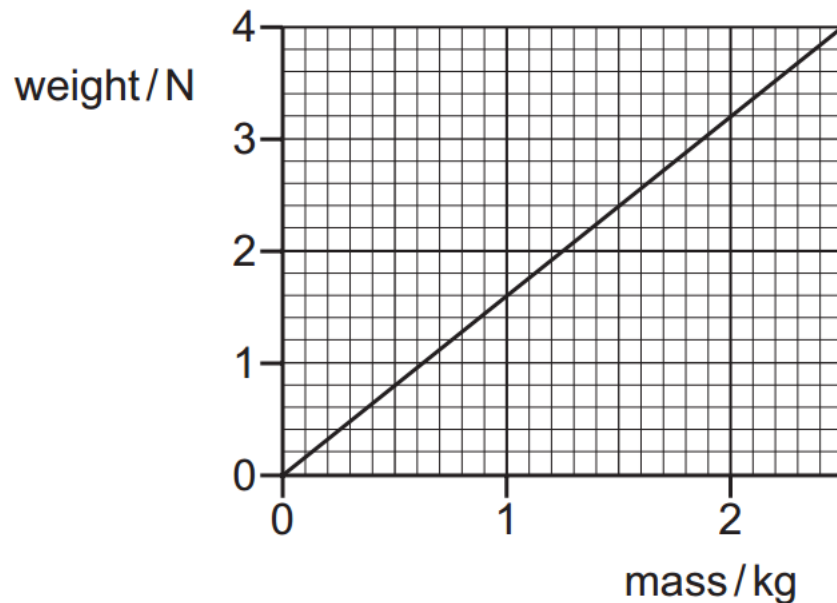
6 The graph shows the variation with mass of the weight of objects on a particular planet.



What is the value of the acceleration of free fall on the planet?

- A** 0.63 m s^{-2} **B** 1.6 m s^{-2} **C** 3.2 m s^{-2} **D** 9.8 m s^{-2}

7 The graph shows the variation with the mass of certain objects on a particular planet.



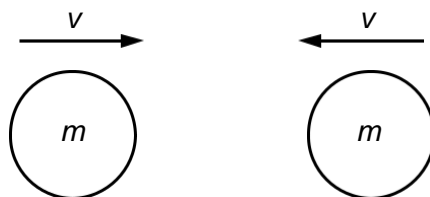
What is the value of the acceleration of free fall on the planet?

- A** 0.63 m s^{-2} **B** 1.6 m s^{-2} **C** 3.2 m s^{-2} **D** 9.8 m s^{-2}

8 The momentum of a car of mass m increases from p_1 to p_2 . What is the increase in the kinetic energy of the car?

- A** $\frac{(p_2^2 - p_1^2)}{2m}$ **B** $\frac{(p_2 - p_1)^2}{2m}$ **C** $\frac{p_2 - p_1}{2m}$ **D** $\frac{p_1 - p_2}{2m}$

9 Two similar spheres, each of mass m and travelling with speed v , are moving towards each other.



The spheres have a head-on elastic collision. Which statement is correct?

- A** The spheres stick together on impact.
B The total kinetic energy after impact is mv^2 .
C The total kinetic energy before impact is zero.
D The total momentum before impact is $2mv$.

- 10** Liquids X and Y are stored in large open tanks. Liquid X has a density of 800 kg m^{-3} and liquid Y has a density of 1200 kg m^{-3} .

At which depths are the pressures equal?

	depth in liquid X / m	depth in liquid Y / m
A	8	20
B	10	15
C	15	10
D	20	8

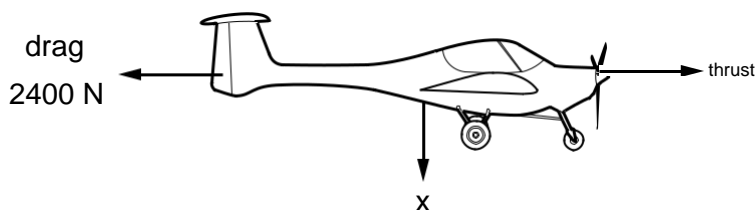
- 11** A cannon-ball of mass 3.50 kg is fired at a speed of 22.0 m s^{-1} from a gun on a ship at a height of 6.00 m above sea level.

The total energy of the cannon-ball is the sum of the gravitational potential energy relative to the surface of the sea and the kinetic energy.

What is the total energy of the cannon-ball as it leaves the gun?

- A** 206J **B** 641J **C** 847J **D** 1050J

- 12** An aircraft travels at a constant velocity of 90 m s^{-1} in horizontal flight. The diagram shows some of the forces acting on the aircraft.



The mass of the aircraft is 2000 kg .

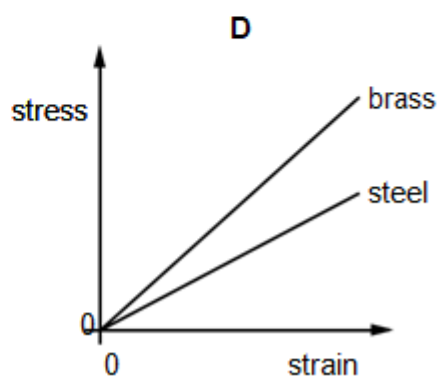
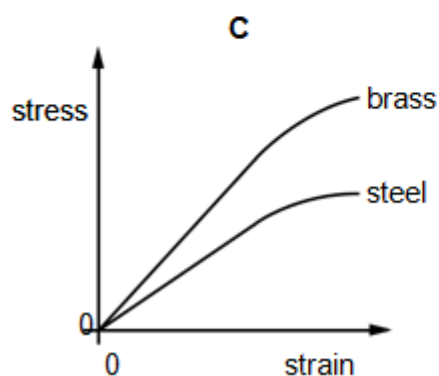
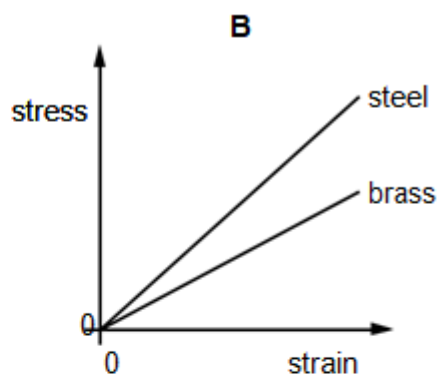
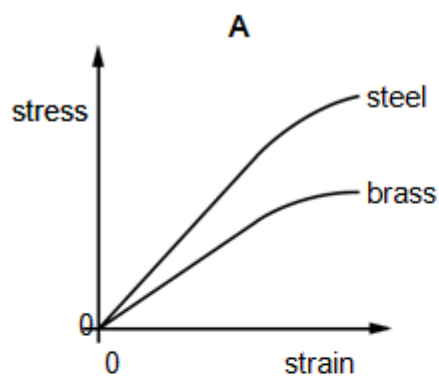
Which of the following would be a suitable label for **x**?

- A** trust **B** drag **C** air resistance **D** weight

13 Two wires, one made of brass and the other of steel, are stretched in an experiment. Both wires obey Hooke's law during this experiment.

The Young modulus for brass is less than the Young modulus for steel.

Which graph shows how the stress varies with strain for both wires in this experiment?



- 14 A student creates a table to show reasonable estimates of some physical quantities. Which row is **not** a reasonable estimate?

	quantity	value
A	current in a fan heater	12 A
B	mass of an adult person	70 kg
C	speed of an Olympic sprint runner	10 m s^{-1}
D	water pressure at the bottom of a garden pond	10^6 Pa

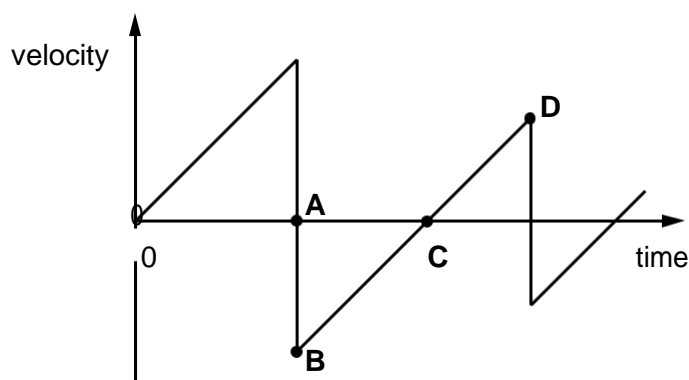
- 15 The values of displacement, velocity and acceleration of a vehicle can be deduced from graphs representing its motion. Often the areas under these graphs, or the gradients of the graphs, are used.

What would **not** give a value for a displacement, a velocity or an acceleration?

- A** area under a velocity-time graph
- B** gradient of a displacement-time graph
- C** gradient of a velocity-time graph
- D** gradient of an acceleration-time graph

- 16 A ball is released from rest above a hard, horizontal surface. The graph shows how the velocity of the bouncing ball varies with time.

At which point on the graph does the ball reach its maximum height after the first bounce?



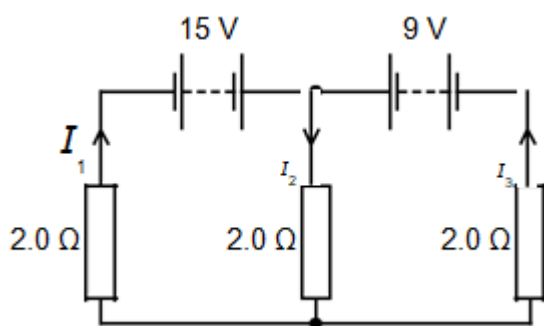
17 A ball is kicked upwards at an angle of 45° to horizontal ground. After a short flight, the ball returns to the ground.

It may be assumed that air resistance is negligible.

What is **never** zero during the flight of the ball?

- A** the horizontal component of the ball's acceleration
- B** the horizontal component of the ball's velocity
- C** the vertical component of the ball's momentum
- D** the vertical component of the ball's velocity

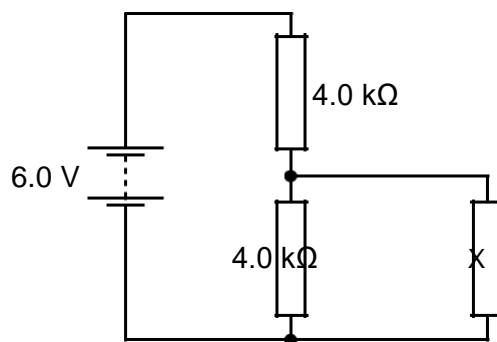
18 In the circuit shown, the batteries have negligible internal resistance.



What are the values of the currents I_1 , I_2 and I_3 ?

	I_1/A	I_2/A	I_3/A
A	-5.5	1.0	6.5
B	0.5	4.0	3.5
C	3.5	4.0	0.5
D	6.5	1.0	-5.5

19 A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to three resistors as shown.



Each resistor has a resistance of 4.0 kΩ.

What is the current in resistor X?

- A** 0.25 mA **B** 0.50 mA **C** 0.75 mA **D** 1.0 mA

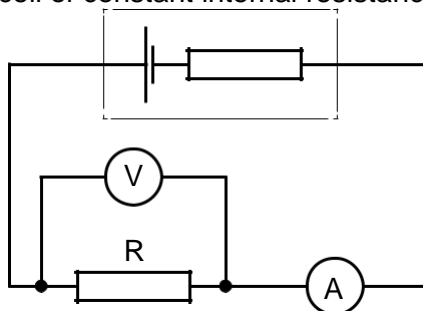
20 Which unit is equivalent to the coulomb?

- A** ampere per second **B** joule per volt **C** watt per ampere
D watt per volt

21 Which row shows a quantity and an **incorrect** unit?

	quantity	unit
A	efficiency	no unit
B	moment of force	N m^{-1}
C	momentum	N s
D	work done	J

- 22 The circuit shown includes a cell of constant internal resistance and an external resistor, R .



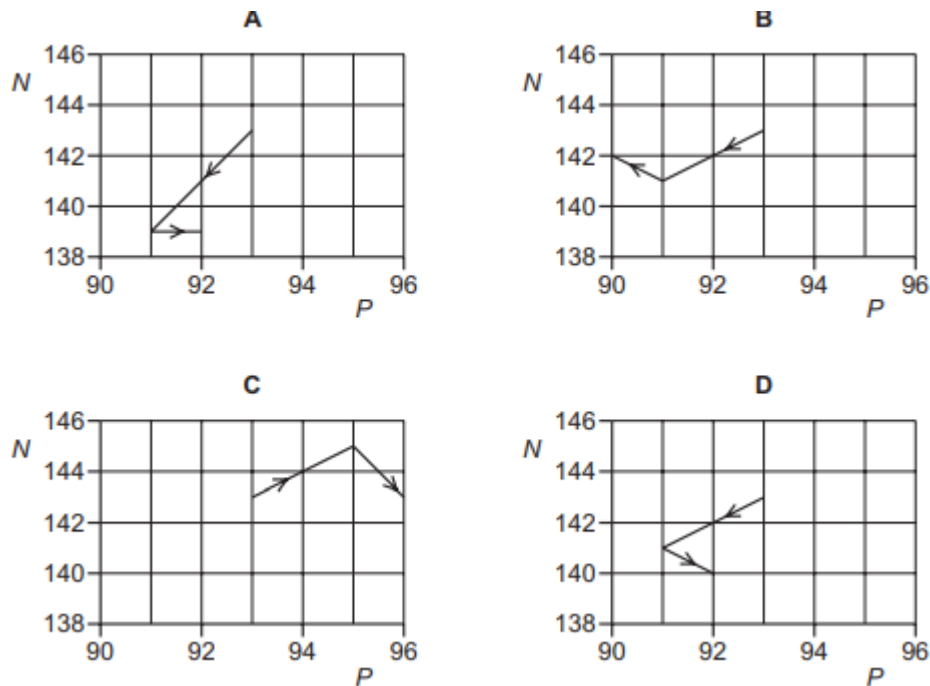
A student records the ammeter and voltmeter readings. She then connects a second identical external resistor in parallel with the first external resistor.

What happens to the ammeter reading and to the voltmeter reading?

	ammeter reading	voltmeter reading
A	decreases	decreases
B	decreases	stays the same
C	increases	decreases
D	increases	stays the same

23 A nucleus of neptunium-236 contains 93 protons and 143 neutrons. This nucleus decays with the emission of an α -particle. The nucleus formed then emits a β^- particle.

Which diagram shows the changes in the number P of protons and the number N of neutrons in these nuclei?

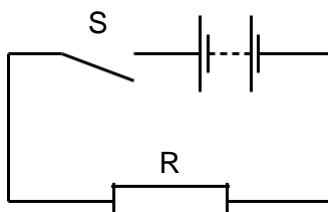


24 An isolated neutron decays to produce a proton, a β^- particle and an antineutrino.

Which row gives the quark composition of the neutron and the proton and the type of force that gives rise to this reaction?

	quark composition		type of force
	neutron	proton	
A	down, down, up	down, up, up	strong interaction
B	down, down, up	down, up, up	weak interaction
C	down, up, up	down, down, up	strong interaction
D	down, up, up	down, down, up	weak interaction

25 The diagram shows a simple circuit.

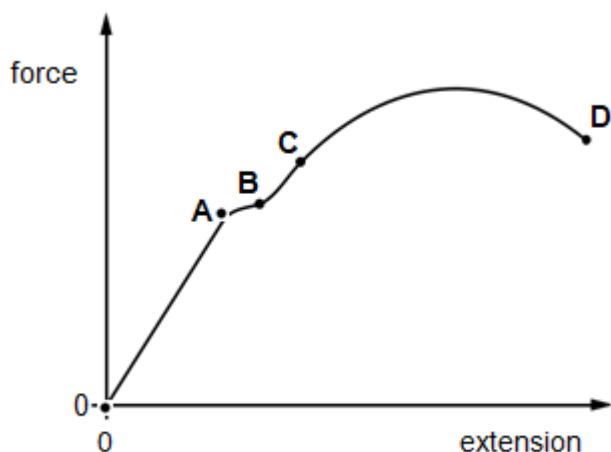


Which statement is correct?

- A** When switch S is closed, the e.m.f. of the battery falls because work is done against the internal resistance of the battery.
- B** When switch S is closed, the e.m.f. of the battery falls because work is done against the resistance of R.
- C** When switch S is closed, the potential difference across the battery falls because work is done against the internal resistance of the battery.
- D** When switch S is closed, the potential difference across the battery falls because work is done against the resistance of R.

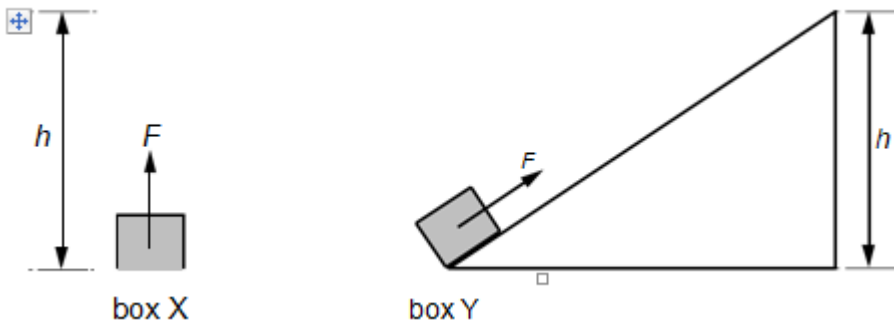
26 The force-extension graph of a metal wire is shown.

At which point on the graph does the metal wire stop obeying Hooke's law?



27 Two boxes X and Y have the same mass. Box X is lifted vertically through a height h by a force of magnitude F .

Box Y is pulled along a slope by a force of the same magnitude to reach the same height, as shown.



Which statement is correct?

- A** Both boxes gain the same amount of gravitational potential energy and the same amount of work is done by the two forces.
- B** Both boxes gain the same amount of gravitational potential energy but more work is done by the force acting on box Y than by the force acting on box X.
- C** Box Y gains less gravitational potential energy than box X because the weight of box Y is less than the weight of box X.
- D** Box Y gains more gravitational potential energy than box X as more work is done by the force acting on box Y than by the force acting on box X.

28 The mass of a rocket-propelled truck is approximately equal to the mass of the fuel in its tank. The fuel is ignited and the truck is propelled along horizontal tracks by a constant force. The effect of air resistance is negligible.

During a test run the fuel is consumed at a constant rate.

Which statement describes the acceleration of the truck during the test run?

- A** The acceleration of the truck decreases as the fuel is consumed.
- B** The acceleration of the truck increases as the fuel is consumed.
- C** The acceleration of the truck remains constant.
- D** The acceleration of the truck is zero and the truck moves at a constant velocity.

29 The density of paper is 800 kg m^{-3} . A typical sheet of paper has a width of 210 mm and a length of 300 mm.

The thickness of a pack of 500 sheets of paper is 50 mm.

What is the mass of a single sheet of paper?

- A** 0.5 g **B** 5 g **C** 50 g **D** 500 g

30. A person calculates the potential difference across a wire by using the measurements shown.

Which measured quantity has the greatest contribution to the percentage uncertainty in the calculated potential difference?

	quantity	value	uncertainty
A	current / A	5.0	± 0.5
B	diameter of wire / mm	0.8	± 0.1
C	length of wire / m	150	± 5
D	resistivity of metal in wire / $\Omega \text{ m}$	1.6×10^{-8}	$\pm 0.2 \times 10^{-8}$

31 A stone of mass m is dropped from a tall building. There is significant air resistance. The acceleration of free fall is g .

When the stone is falling at a constant (terminal) velocity, which information is correct?

	magnitude of the acceleration of the stone	magnitude of the force of gravity on the stone	magnitude of the force of air resistance on the stone
A	g	zero	mg
B	zero	mg	mg
C	zero	zero	mg
D	zero	mg	zero

32 A girl throws a ball vertically upwards. It takes a time of 3.20 s to return to her hand.

Assume air resistance is negligible.

What is the initial speed with which the ball is thrown?

- A** 3.07 m s^{-1} **B** 7.85 m s^{-1} **C** 15.7 m s^{-1} **D** 31.4 m s^{-1}

33 A metal block has a mass of 750 g. 60% of the mass is magnesium and the remainder is copper.

The density of magnesium is 1.7 g cm^{-3} .

The density of copper is 9.0 g cm^{-3} .

What is the density of the block?

- A** 2.5 g cm^{-3} **B** 4.6 g cm^{-3} **C** 5.4 g cm^{-3} **D** 10.7 g cm^{-3}

34 The table lists the nucleon number and the proton number of various nuclei. The nuclei are represented by the letters L to T.

nucleus	nucleon number	proton number
L	227	89
M	226	89
N	225	89
O	227	90
P	226	90
Q	225	90
R	227	91
S	226	91
T	225	91

Which row in the following table correctly shows three nuclei of the same element, and three nuclei that have the same number of neutrons?

	same element	same number of neutrons
A	L M N	R P N
B	M P S	R S T
C	O P Q	M P S
D	R P N	O P Q

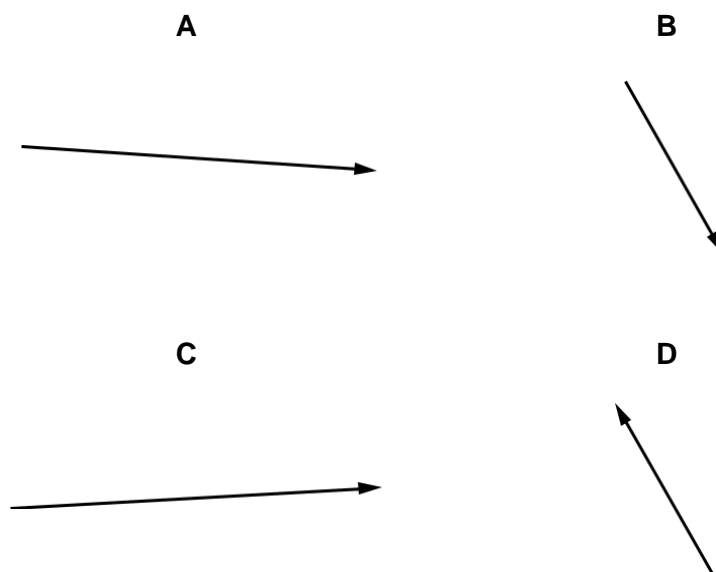
35 What are the structures of the proton and of the neutron in terms of quarks?

	proton		neutron	
	up quark	down quark	up quark	down quark
A	1	1	2	2
B	1	2	2	1
C	2	1	1	2
D	2	2	1	1

36 Vectors P and Q are drawn to scale.



Which diagram represents the vector $(P + Q)$?



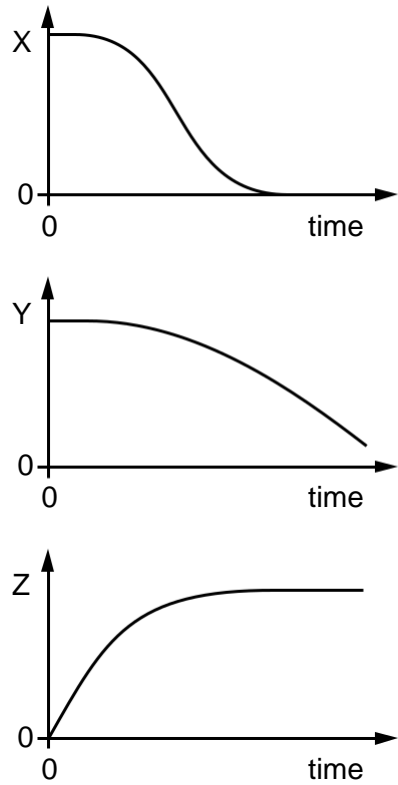
37 An object is dropped at time $t = 0$ from a high building. Air resistance is significant.

Three graphs are plotted against time.

the height of the object above the ground

the speed of the object

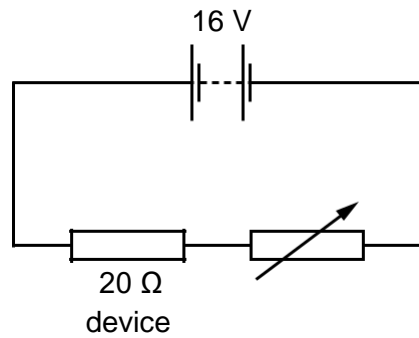
the magnitude of the resultant force on the object



What are the quantities X, Y and Z?

	height of the object above the ground	speed of the object	magnitude of the resultant force on the object
A	X	Y	Z
B	X	Z	Y
C	Y	Z	X
D	Z	Y	X

38 An electrical device of fixed resistance $20\ \Omega$ is connected in series with a variable resistor and a battery of electromotive force (e.m.f.) $16\ \text{V}$ and negligible internal resistance.



What is the resistance of the variable resistor when the power dissipated in the electrical device is $4.0\ \text{W}$?

- A** $16\ \Omega$ **B** $36\ \Omega$ **C** $44\ \Omega$ **D** $60\ \Omega$

39 A certain type of hadron has zero charge. It is composed of a down quark, a strange quark and one other quark.

What could be the other quark?

- A** up **B** down **C** strange **D** anti-strange

40 A proton in a nucleus undergoes β^+ decay. One of the products is a neutron. What are the other products?

- A** an electron and a neutrino
B an electron and an antineutrino
C a positron and a neutrino
D a positron and an antineutrino

Section B (Short- and Extended- Responses)

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

Question 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 μ is a constant.

Determine the SI base units of μ .

SI base units [3]

[Total: 5]

Question 2

(a) Define:

a. *displacement*

.....
[1]

(ii) *acceleration*.

.....
[1]

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

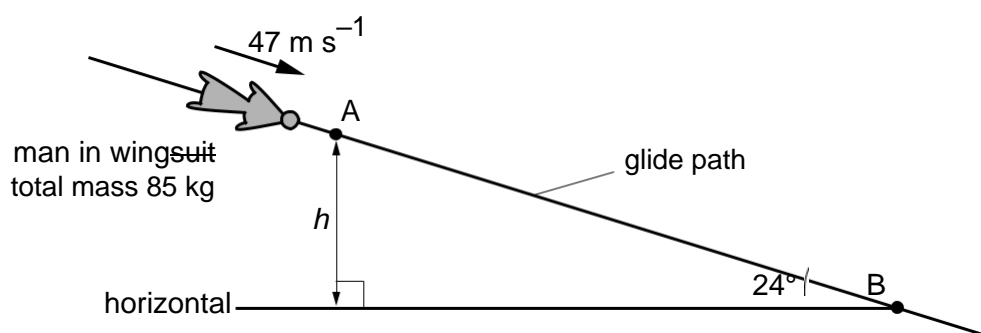


Fig. 2.1 (not to scale)

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

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

.....

[2]

(d) Show that the difference in height h between points A and B is 3200 m.

[1]

(e) 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]

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

[Total: 11]

Question 3

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

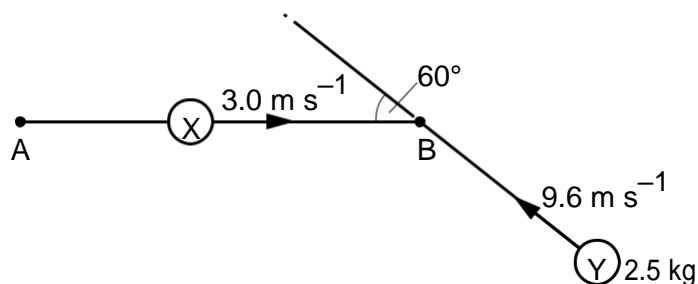


Fig. 3.1 (not to scale)

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

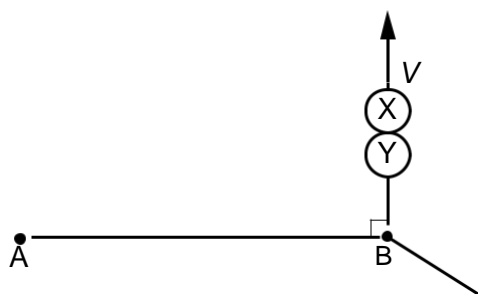


Fig. 3.2

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

[2]

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

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

[Total: 4]

Question 4

(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.:

.....[4]

(b) A battery of e.m.f. 6.0 V and negligible internal resistance is connected to a network of resistors and a voltmeter, as shown in Fig. 4.1.

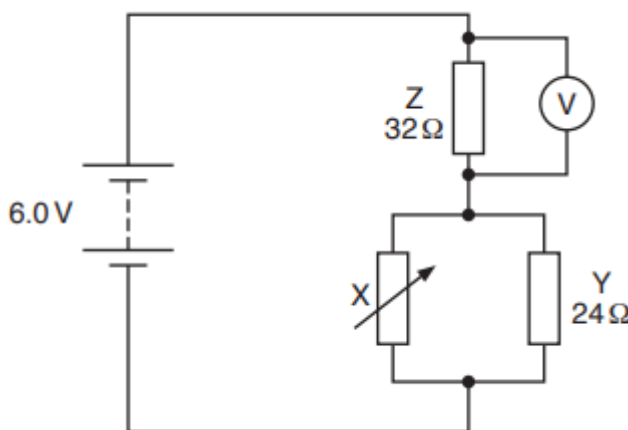


Figure 4.1

Resistor Y has a resistance of 24 Ω and resistor Z has a resistance of 32 Ω .

(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]

[Total: 5]

Question 5

(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.

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

[Total: 5]

Section C (Practical-based questions) – 15 marks

- 1 A hammer is often used to force a nail into wood. The faster the hammer moves, the deeper the nail moves into the wood.

This can be represented in a laboratory by a mass falling vertically onto a nail.

It is suggested that the depth d of the nail in the wood (see Fig. 5.1) is related to the velocity v of the mass at the instant it hits the nail by the equation

$$d = kv^n$$

where k and n are constants.

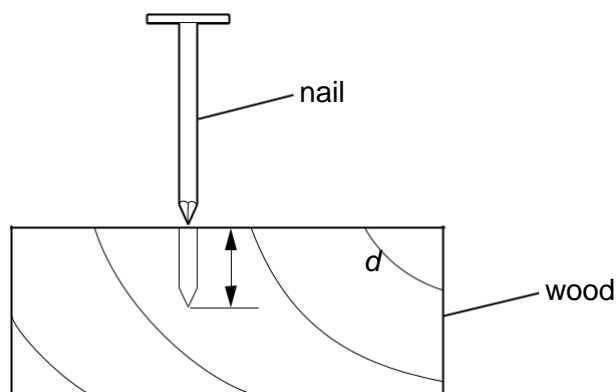


Fig. 5.1

Design a laboratory experiment to investigate the relationship between v and d so as to determine a value for n . You should draw a diagram showing the arrangement of your equipment. In your account you should pay particular attention to

- (a) the procedure to be followed,
- (b) the measurements to be taken,
- (c) the control of variables,
- (d) the analysis of the data,
- (e) the safety precautions to be taken.

Total: 15 marks

Diagram

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, providing a template for handwriting practice or general writing. There are no margins, text, or other markings on the page.

[Total:15]

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Data and Formulae

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	$\lambda = \frac{0.693}{t_{1/2}}$