



Cambridge International AS & A Level

PHYSICS

9702/11

Paper 1 Multiple Choice

October/November 2022

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.



Data

acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

1 What is needed to accurately represent all physical quantities?

- A a base unit and a number
- B a unit and a number expressed in standard form (scientific notation)
- C a unit and a numerical magnitude
- D an SI unit and a numerical magnitude

2 A voltmeter connected across a resistor in a circuit reads 3.6 V.

What could be the current in the resistor and the resistance of the resistor?

	current	resistance
A	150 mA	0.24 k Ω
B	15 mA	2.4 k Ω
C	1.5 mA	0.24 M Ω
D	15 μ A	240 k Ω

3 In an experiment to determine the acceleration of free fall g , the time t taken for a ball to fall through distance s is measured. The percentage uncertainty in the measurement of s is 2%. The percentage uncertainty in the measurement of t is 3%.

The value of g is determined using the equation shown.

$$g = \frac{2s}{t^2}$$

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

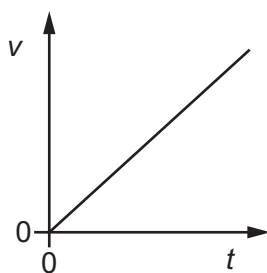
- A 1% B 5% C 8% D 11%

4 Which quantity is a vector?

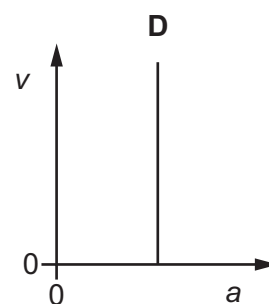
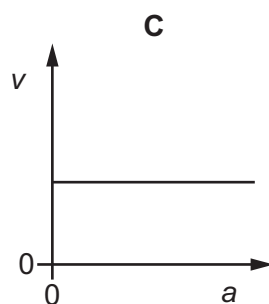
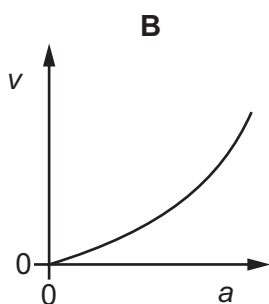
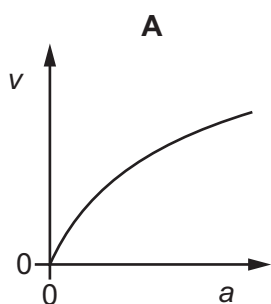
- A momentum
- B speed
- C temperature
- D Young modulus

- 5 A particle accelerates from rest.

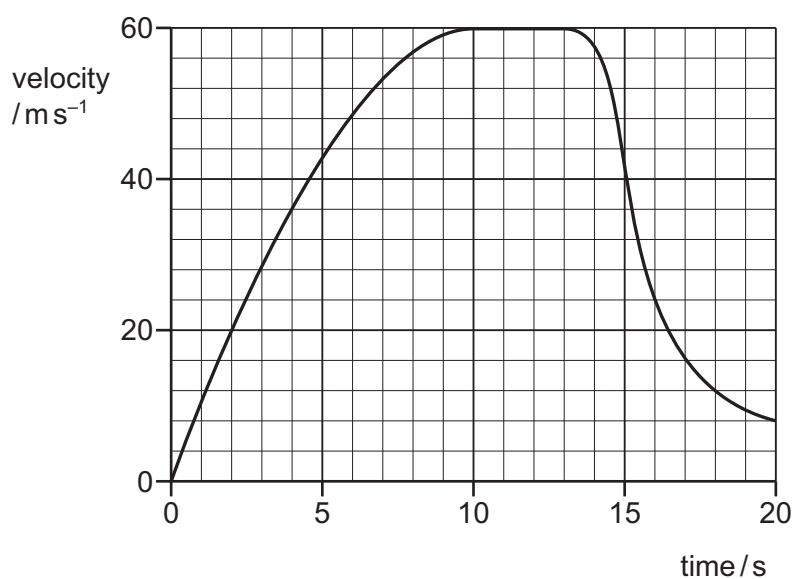
The graph shows the variation of the velocity v of the particle with time t .



Which graph shows the variation of the velocity v with the acceleration a of the particle?



- 6 The graph shows the vertical velocity of a parachutist during the first 20 s of her jump.



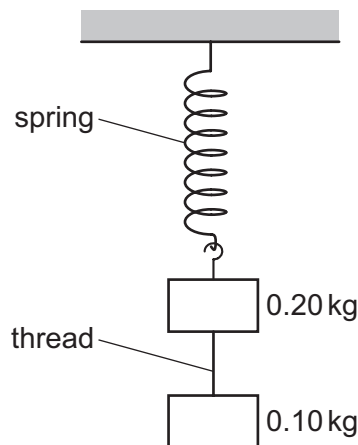
Approximately how far does she fall **before** opening the parachute?

- A** 390 m **B** 570 m **C** 710 m **D** 770 m

7 What is the definition of linear momentum?

- A force per unit time
- B product of force and time
- C product of velocity and mass
- D velocity per unit mass

8 A mass of 0.20 kg is suspended from the lower end of a light spring. A second mass of 0.10 kg is suspended from the first mass by a thread. The arrangement is allowed to come into static equilibrium and then the thread is cut.



Immediately after the thread is cut, what is the upward acceleration of the 0.20 kg mass?

- A 4.9 ms^{-2} B 6.5 ms^{-2} C 9.8 ms^{-2} D 15 ms^{-2}

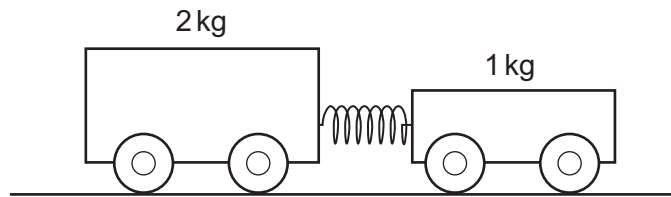
9 A snowflake and a raindrop are in still air. They both fall from rest at the same time and from the same height, far above the ground.

The snowflake and raindrop contain the same mass of water. Assume that there is no evaporation or melting. Also assume that, for a given speed, the drag force acting on the snowflake is greater than the drag force acting on the raindrop.

Which statement about the snowflake and raindrop is correct?

- A The raindrop takes more time than the snowflake to reach terminal velocity.
- B The raindrop takes more time than the snowflake to reach the ground.
- C They reach the same terminal velocity.
- D They take the same amount of time to reach the ground.

- 10 Two trolleys are held together on a horizontal surface with a compressed spring between them.

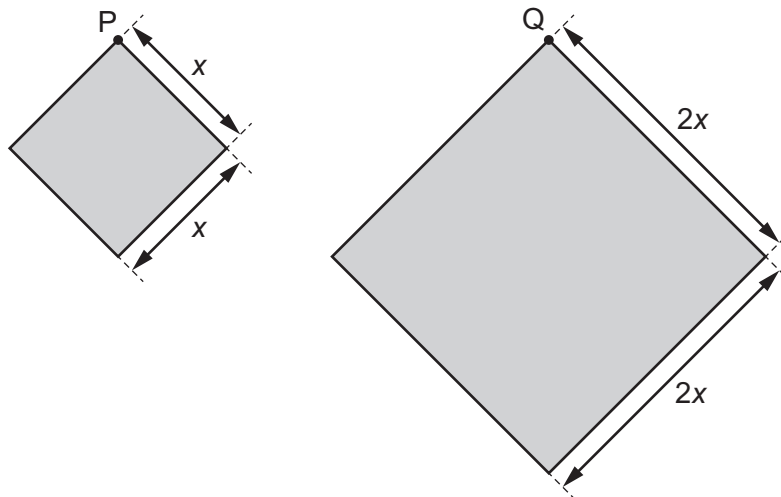


When they are released, the trolleys lose contact with the spring. The trolley of mass 2 kg moves to the left at a final speed of 2 m s^{-1} .

How much elastic potential energy was stored in the spring?

- A 4 J B 6 J C 8 J D 12 J
- 11 A square board, of side length x , hangs freely from a nail P, as shown.

The board has uniform thickness and is made from material of uniform density.



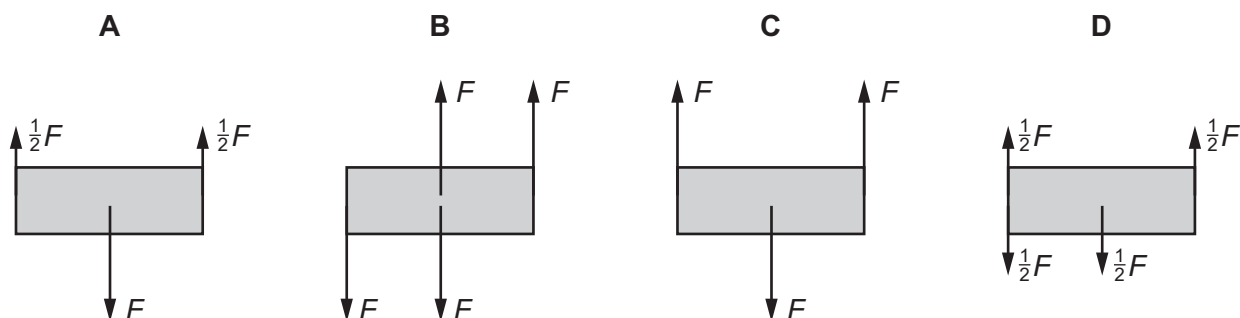
A second square board, of side length $2x$, is made of the same material and has the same thickness as the original board. This second board is then hung from a nail Q. Nails P and Q are at the same height.

What is the vertical distance between the positions of the centres of gravity of the two boards?

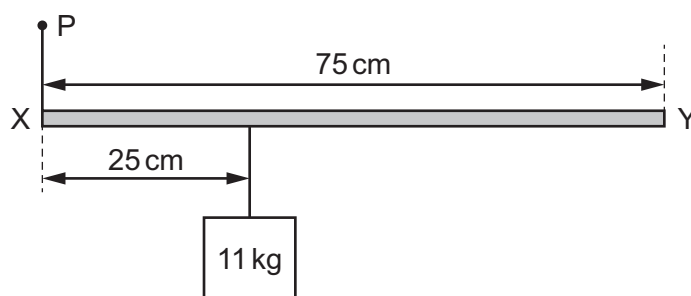
- A 0 B $\frac{x}{\sqrt{2}}$ C x D $x\sqrt{2}$

- 12 Forces are applied to a rigid object. The forces all act in the same plane.

In which diagram is the object in equilibrium?



- 13 A rigid rod XY has negligible mass and length 75 cm. The rod is suspended from a fixed point P by a string attached to end X. An object of mass 11 kg is suspended by a string that is attached to the rod at a distance of 25 cm from end X, as shown.



Which vertically upward force acting on end Y of the rod would hold the rod horizontally in equilibrium?

- A 3.7 N B 33 N C 36 N D 320 N

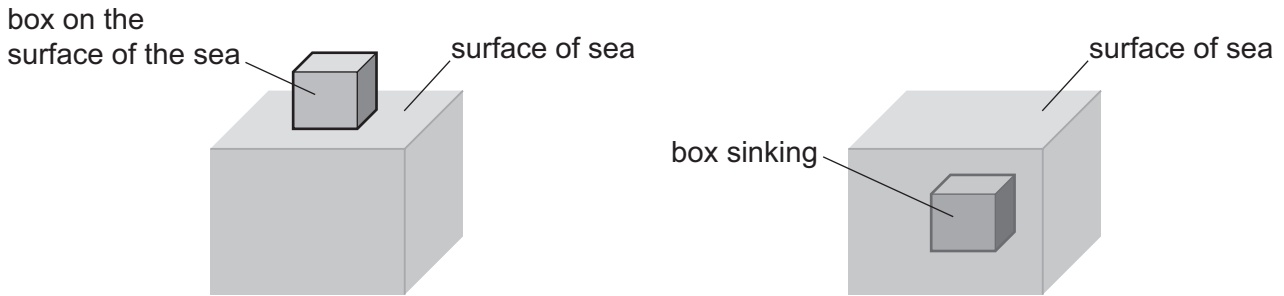
- 14 The density of water is 1.0 g cm^{-3} and the density of glycerine is 1.3 g cm^{-3} .

Water is added to a measuring cylinder containing 40 cm^3 of glycerine so that the density of the mixture is 1.1 g cm^{-3} . Assume that the mixing process does not change the total volume of the liquid.

What is the volume of water added?

- A 40 cm^3 B 44 cm^3 C 52 cm^3 D 80 cm^3

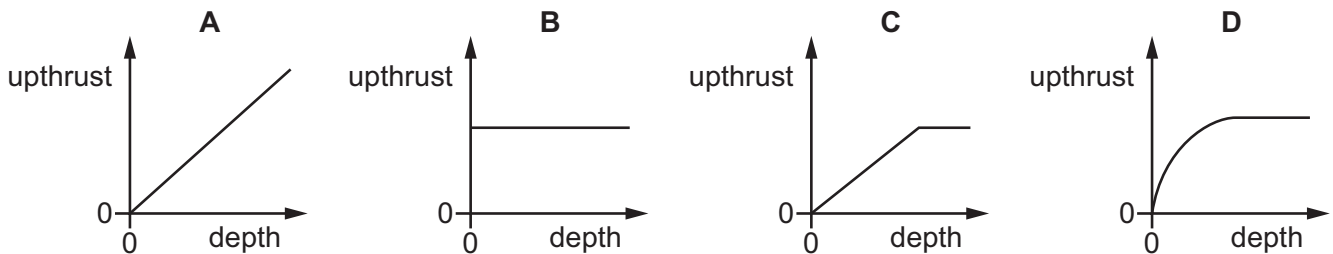
- 15** A box, in the shape of a cube, falls from a ship into the sea. The box lands with its lower face level with the surface of the sea.



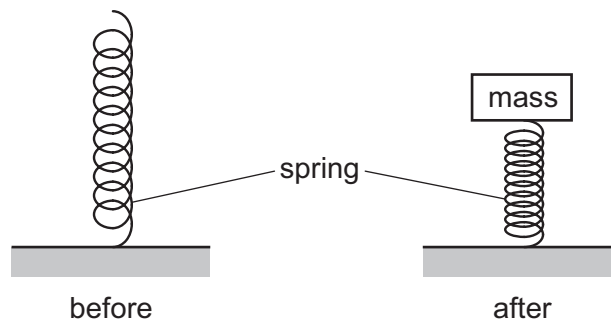
The box begins to sink, becomes totally submerged and then sinks deeper into the sea.

As the box sinks, its lower face is always parallel to the surface of the sea.

Which graph best represents the variation of the upthrust acting on the box with the depth of its lower face below the surface of the sea?



- 16** A spring is compressed by a mass, as shown.



Which statement describes the changes to the energy of the spring when it is compressed by the mass?

- A** The spring gains both gravitational potential energy and elastic potential energy.
- B** The spring gains gravitational potential energy and loses elastic potential energy.
- C** The spring loses both gravitational potential energy and elastic potential energy.
- D** The spring loses gravitational potential energy and gains elastic potential energy.

- 17** A man of mass 75 kg runs up a staircase consisting of 30 steps. Each step is 20 cm high.

The man takes a time of 7.0 s to run from the bottom of the staircase to the top.

What is the average rate of increase of gravitational potential energy of the man?

- A** 64 W **B** 450 W **C** 630 W **D** 4400 W

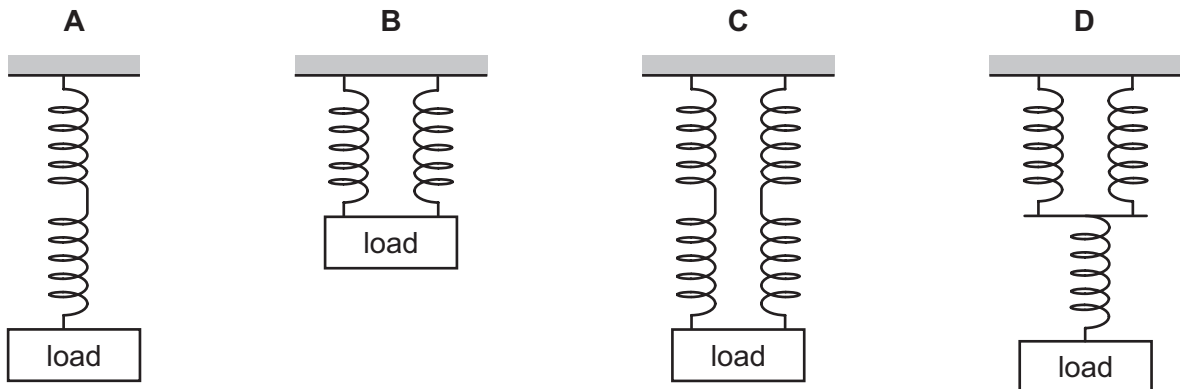
- 18** An alpha-particle has 2.2×10^{-13} J of kinetic energy.

What is the speed of the alpha-particle?

- A** $4.1 \times 10^6 \text{ m s}^{-1}$
B $5.8 \times 10^6 \text{ m s}^{-1}$
C $8.1 \times 10^6 \text{ m s}^{-1}$
D $1.2 \times 10^7 \text{ m s}^{-1}$

- 19** Identical springs are joined in four arrangements.

Which arrangement has the same spring constant as a single spring?



- 20** An unstretched spring has a length of 2.0 cm.

The spring is then stretched within its limit of proportionality by a tensile force of 1.5 N so that the elastic potential energy stored in the spring is 0.045 J.

What is the stretched length of the spring?

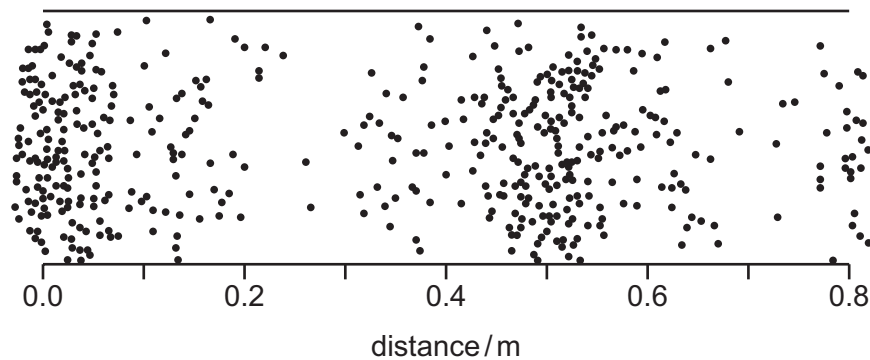
- A** 3.0 cm **B** 5.0 cm **C** 6.0 cm **D** 8.0 cm

- 21 A signal generator, amplifier and loudspeaker are used to produce different sound waves in the air of a room. The relationships between the properties of these waves are investigated.

Which relationship is **not** correct?

- A Amplitude is proportional to wavelength.
- B Frequency is inversely proportional to wavelength.
- C Intensity is proportional to amplitude squared at a given frequency.
- D Period is equal to the reciprocal of frequency.

- 22 When a guitar string is plucked, it causes a longitudinal sound wave in the air, as shown.



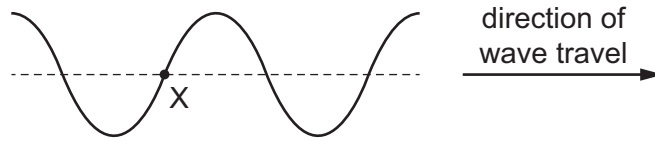
The speed of sound in the air is 340 m s^{-1} .

What is the approximate frequency of the sound wave shown?

- A 430 Hz
- B 680 Hz
- C 1100 Hz
- D 1400 Hz

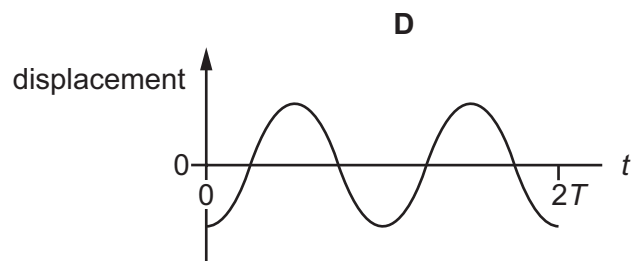
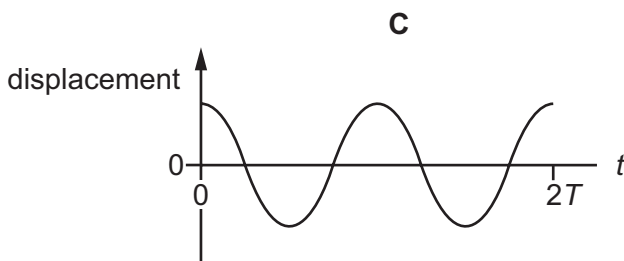
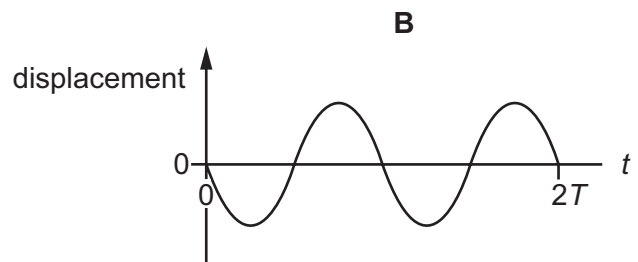
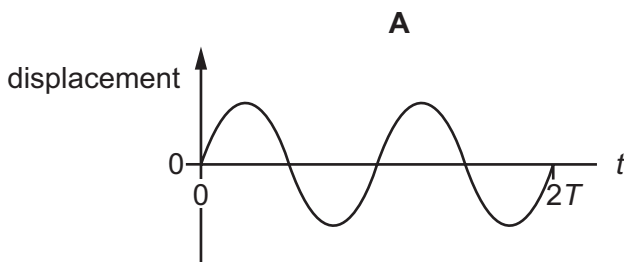
- 23** A transverse wave travels along a rope. The diagram shows the rope at time $t = 0$.

The wave is travelling from left to right. The period of the wave is T .



One particle of the rope is labelled X.

Which graph shows the variation with time of the displacement of particle X between $t = 0$ and $t = 2T$?



- 24** A jet aircraft travels at a speed of $0.80v$, where v is the speed of sound. The aircraft directly approaches a stationary observer. The frequency of sound emitted by the aircraft is 100 Hz.

Which frequency does the observer hear?

- A** 56 Hz **B** 180 Hz **C** 400 Hz **D** 500 Hz

- 25** A telescope detects and analyses some electromagnetic radiation of wavelength 2 cm.

Which type of telescope is it?

- A** microwave telescope
B optical telescope
C radio telescope
D X-ray telescope

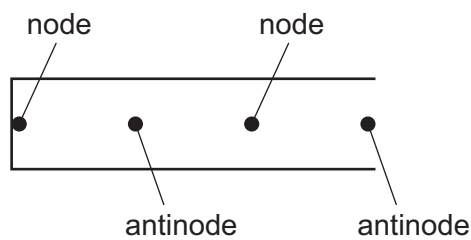
- 26 Two waves of the same type overlap.

When does the principle of superposition apply?

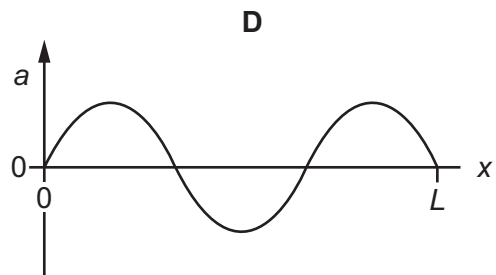
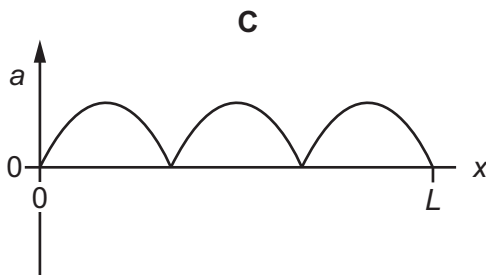
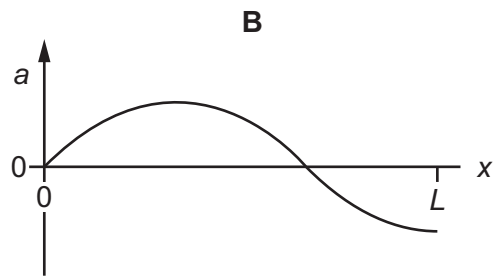
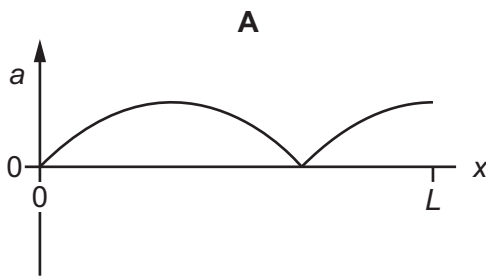
- A always
- B only when the waves have the same amplitude
- C only when the waves have the same frequency
- D only when the waves travel in opposite directions

- 27 A stationary sound wave is formed in a tube of length L that is closed at one end.

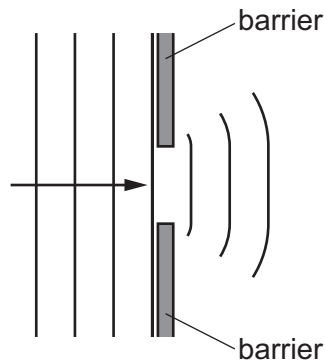
The diagram shows the positions of the nodes and antinodes of the stationary wave.



Which graph shows the variation of the amplitude a of the wave with distance x measured from the closed end of the tube?



- 28 A wave on the surface of water passes through a gap between two barriers and is diffracted, as shown.



What happens when the frequency of the wave is halved?

- A Less diffraction is observed.
 - B More diffraction is observed.
 - C There is no diffraction.
 - D The same amount of diffraction is observed.
- 29 Observable interference fringes are produced using light from a double slit. The intensity of the light emerging from each slit is initially the same.

The intensity of the light emerging from one of the slits is now reduced.

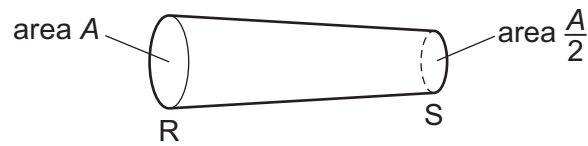
How does this affect the interference pattern?

- A The bright fringes and the dark fringes all become brighter.
 - B The bright fringes and the dark fringes all become darker.
 - C The bright fringes become brighter and the dark fringes become darker.
 - D The bright fringes become darker and the dark fringes become brighter.
- 30 A diffraction grating has 4.00×10^5 lines per metre. A beam of light of wavelength 589×10^{-9} m is incident normally on the diffraction grating.

What is the angle between the second-order maximum and the direction of the incident beam of light?

- A 13.6°
- B 27.3°
- C 28.1°
- D 56.2°

- 31 A length of wire RS has a circular cross-section.



At end R of the wire, the cross-sectional area is A .

At end S of the wire, the cross-sectional area is $\frac{A}{2}$.

Charge Q takes time t to pass through end R of the wire. There is a constant electric current in the wire.

How much charge will pass through end S in a time interval of $\frac{t}{4}$?

- A** $\frac{Q}{8}$ **B** $\frac{Q}{4}$ **C** $\frac{Q}{2}$ **D** Q

- 32 A power supply is connected to a component by connecting wires of total resistance 4.9Ω .

The power supply has an output power of 3.6 W and a terminal potential difference of 12 V .

How much thermal energy is dissipated in the connecting wires in a time of 1.0 hour ?

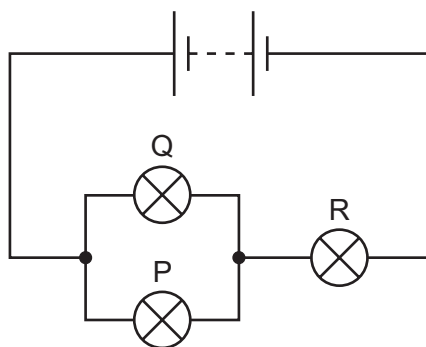
- A** 0.44 J **B** 29 J **C** 1.6 kJ **D** 11 kJ

- 33 A copper wire is to be replaced by an aluminium alloy wire of the same length and resistance. Copper has half the resistivity of the alloy.

What is the ratio $\frac{\text{diameter of alloy wire}}{\text{diameter of copper wire}}$?

- A** $\sqrt{2}$ **B** 2 **C** $2\sqrt{2}$ **D** 4

- 34** Three identical filament lamps, P, Q and R, are connected to a battery of negligible internal resistance, as shown.



The filament wire in lamp Q breaks so that it no longer conducts.

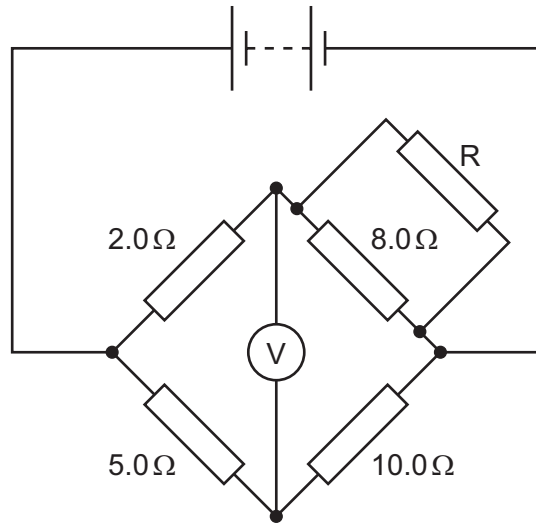
What are the changes in the brightness of lamps P and R?

	lamp P	lamp R
A	brighter	brighter
B	brighter	dimmer
C	dimmer	brighter
D	dimmer	dimmer

- 35** Which ratio has the same units as electromotive force (e.m.f.)?

- A** charge per unit energy transferred
- B** charge per unit time
- C** energy transferred per unit charge
- D** energy transferred per unit time

- 36 A circuit consists of a battery, a voltmeter and five fixed resistors, as shown.

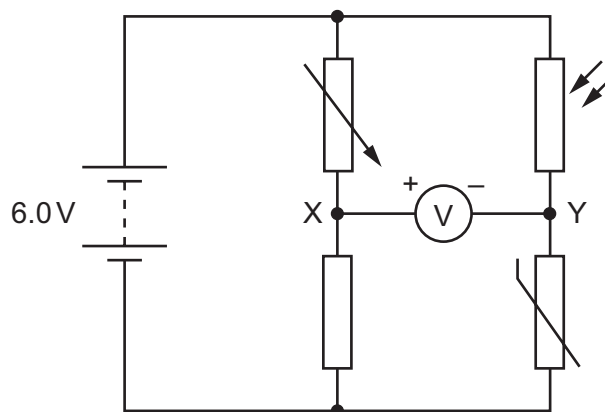


The voltmeter reading is zero.

What is the resistance of resistor R?

- A** $1.1\ \Omega$ **B** $2.1\ \Omega$ **C** $4.0\ \Omega$ **D** $8.0\ \Omega$
- 37 A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to a voltmeter and four other components, as shown.

The voltmeter is connected between points X and Y. The positive terminal of the voltmeter is connected to X and the negative terminal of the voltmeter is connected to Y.



Initially, the resistance of each of the four components is $1.0\text{ k}\Omega$.

Which change, on its own, will cause the voltmeter to show a positive reading?

- A** Decrease the temperature of the thermistor.
B Increase the resistance of the variable resistor.
C Reduce the intensity of light incident on the light-dependent resistor (LDR).
D Replace the fixed resistor with a $500\ \Omega$ resistor.

- 38 An α -particle passes close to a gold nucleus and is deflected through an angle greater than 90° .

Which property of the α -particle changes as a result of the deflection?

- A charge
- B momentum
- C nucleon number
- D proton number

- 39 A nucleus of ${}_{92}^{238}\text{U}$ decays in stages by emitting α -particles and β^- particles, eventually forming a nucleus of ${}_{82}^{206}\text{Pb}$.

How many α -particles and how many β^- particles are emitted during the decay chain?

	α -particles	β^- particles
A	8	6
B	8	10
C	16	6
D	16	22

- 40 Which list of particles contains **only** fundamental particles?

- A antineutrino, beta, meson
- B baryon, neutrino, positron
- C electron, neutrino, alpha
- D lepton, quark, positron

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resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

1 Which quantity is a physical quantity?

- A flavour
- B kelvin
- C minute
- D potential difference

2 What is a power of 3.7 MW when expressed in kilowatts?

- A $3.7 \times 10^{-3} \text{ kW}$
- B $3.7 \times 10^{-3} \text{ KW}$
- C $3.7 \times 10^3 \text{ kW}$
- D $3.7 \times 10^3 \text{ KW}$

3 A spring is suspended from a fixed point and a force is applied. The position of a pointer attached to the bottom of the spring against a vertical ruler is recorded.

Before the force is applied, the position of the pointer is $(225 \pm 2) \text{ mm}$.

After the force is applied, the position of the pointer is $(250 \pm 2) \text{ mm}$.

The extension of the spring is determined.

What is the percentage uncertainty in the extension?

- A 1.6% B 1.8% C 8.0% D 16%

4 What is the difference between a scalar quantity and a vector quantity?

- A A scalar quantity has direction but a vector quantity does not.
- B A scalar quantity has magnitude but a vector quantity does not.
- C A vector quantity has direction but a scalar quantity does not.
- D A vector quantity has magnitude but a scalar quantity does not.

- 5 A toy car travels on a circular track at a constant speed of 0.50 m s^{-1} . It passes a point on the track at time $t = 0$ and takes a time of 40 s to travel once around the track.

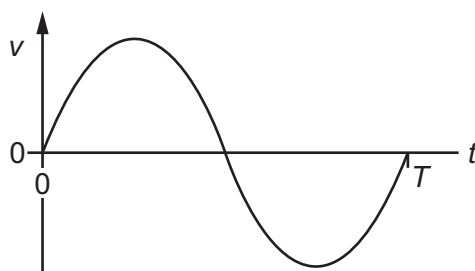
The magnitude of the average velocity of the car between $t = 0$ and $t = 20 \text{ s}$ is v_{20} .

The magnitude of the average velocity of the car between $t = 0$ and $t = 40 \text{ s}$ is v_{40} .

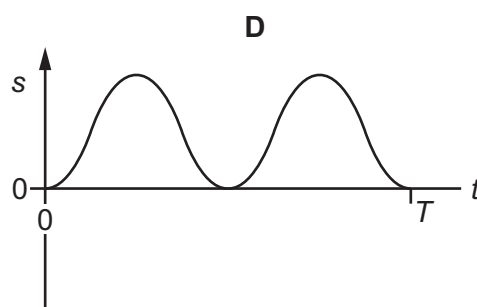
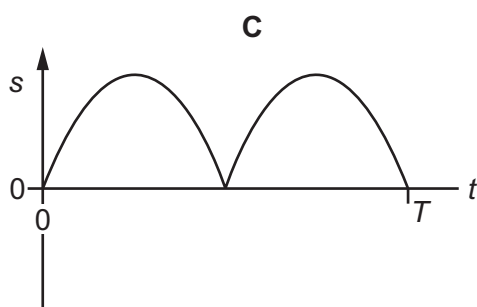
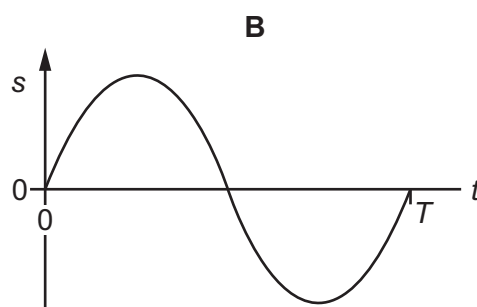
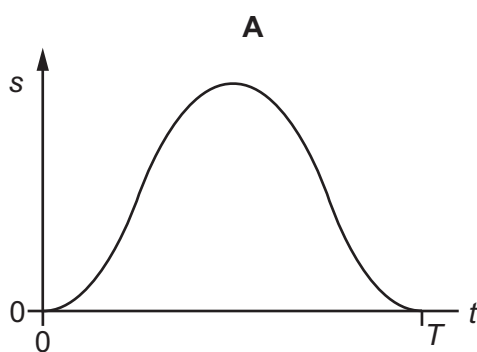
What are v_{20} and v_{40} ?

	$v_{20} / \text{m s}^{-1}$	$v_{40} / \text{m s}^{-1}$
A	0.32	0
B	0.32	0.32
C	0.50	0
D	0.50	0.50

- 6 The graph shows how the velocity v of an object moving in a straight line varies with time t from $t = 0$ to $t = T$.



Which graph could represent the displacement s of the object from time $t = 0$ to $t = T$?



- 7 A goods train passes through a station at a steady speed of 10 m s^{-1} at time $t = 0$. An express train is at rest at the station. The express train leaves the station with a uniform acceleration of 0.5 m s^{-2} just as the goods train goes past. Both trains move in the same direction on straight, parallel tracks.

At which time t does the express train overtake the goods train?

- A 6 s B 10 s C 20 s D 40 s

- 8 A constant resultant force F acts on an object of mass m for time t .

What is the change in momentum of the object?

- A $\frac{F}{t}$ B $\frac{Ft}{m}$ C Ft D $\frac{F}{mt}$

- 9 The acceleration of free fall on the surface of planet P is one-tenth of that on the surface of planet Q.

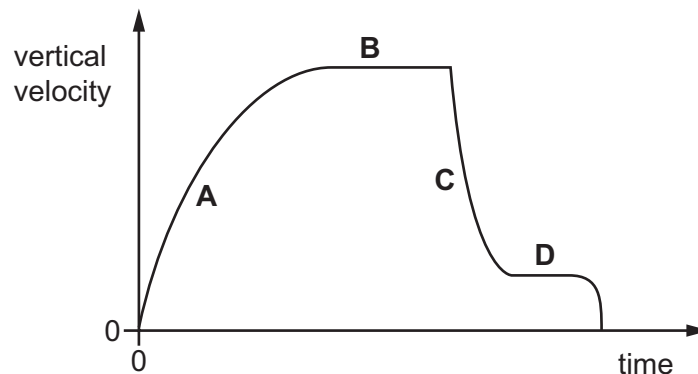
On the surface of P, an object has a mass of 1.0 kg and a weight of 1.0 N .

What are the mass and the weight of the same object on the surface of planet Q?

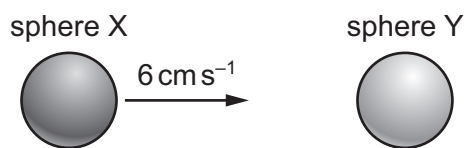
	mass on Q/kg	weight on Q/N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

- 10 A parachutist falls from rest from a balloon. The variation with time of the vertical velocity of the parachutist is shown.

In which region is the force due to air resistance much greater than the weight of the parachutist?



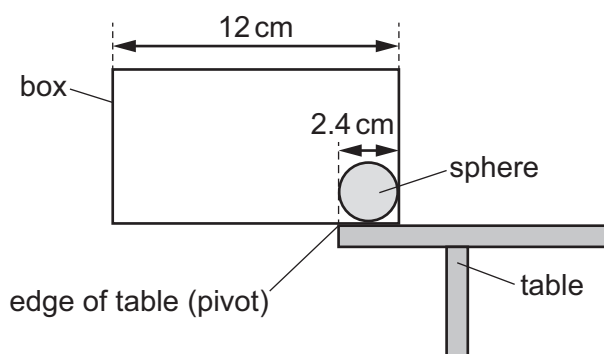
- 11 Two solid spheres form an isolated system. Sphere X moves with speed 6 cm s^{-1} in a straight line directly towards a stationary sphere Y, as shown.



The spheres have a perfectly elastic collision. After the collision, sphere X moves with speed 2 cm s^{-1} in the same direction as before the collision.

What is the speed of sphere Y?

- A 2 cm s^{-1} B 4 cm s^{-1} C 6 cm s^{-1} D 8 cm s^{-1}
- 12 What is **not** a necessary requirement of the forces in a couple?
- A They act in opposite directions.
 B They act along different lines.
 C They have the same magnitude.
 D They produce a resultant force.
- 13 A box of length 12 cm and weight 0.43 N is placed on a horizontal table, with the greater part of its length overhanging the edge of the table. The edge of the table acts as a pivot. The centre of gravity of the box is at its geometric centre.

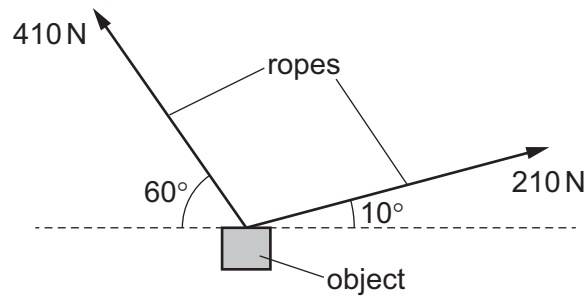


Assume that the forces acting on the box are in the plane of the diagram.

What is the minimum mass of the sphere that is needed to maintain the system in equilibrium?

- A 0.066 kg B 0.13 kg C 0.22 kg D 1.3 kg

- 14 An object is suspended by two ropes. One rope has a tension of 410 N at an angle of 60° to the horizontal. The other rope has a tension of 210 N at an angle of 10° to the horizontal.



The object is in equilibrium.

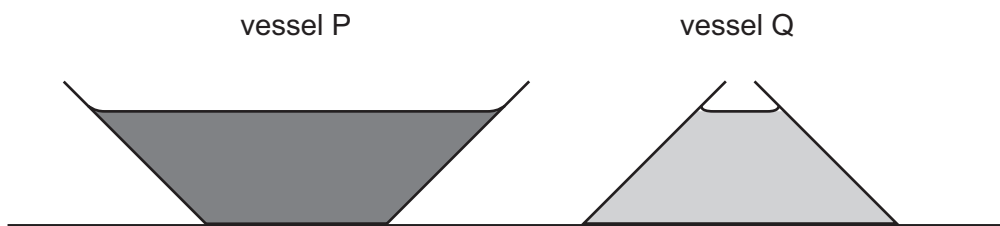
What is the mass of the object?

- A 40 kg B 42 kg C 390 kg D 410 kg
- 15 A solid cube is floating in equilibrium in liquid mercury. The cube is made of iron of density 7900 kg m^{-3} .

The cube floats with 42% of its volume above the surface of the mercury.

What is the density of the mercury?

- A 3300 kg m^{-3}
 B 4600 kg m^{-3}
 C $14\,000 \text{ kg m}^{-3}$
 D $19\,000 \text{ kg m}^{-3}$
- 16 The diagram shows two vessels, P and Q, both with sides inclined at 45° to the horizontal.



Vessel P tapers outwards and vessel Q tapers inwards, as shown.

Both vessels contain a liquid. The depth of the liquid in the vessels is the same. The liquid in vessel P is twice as dense as the liquid in vessel Q.

What is the ratio $\frac{\text{pressure due to the liquid on the base of P}}{\text{pressure due to the liquid on the base of Q}}$?

- A $\frac{2}{1}$ B $\frac{\sqrt{2}}{1}$ C $\frac{1}{\sqrt{2}}$ D $\frac{1}{2}$

- 17 A motor is used to lift a load vertically upwards.

The load has weight W .

The motor produces useful power output P .

The load is lifted at constant velocity v .

Which expression gives the time taken for the motor to lift the load vertically upwards through a distance d ?

- A $\frac{P}{Wd}$ B $\frac{Wv}{P}$ C $\frac{Wd}{P}$ D $\frac{Pv}{W}$

- 18 A lamp is switched on for 2.0 hours. The power input to the lamp is 1.0 W. The energy given out by the lamp as light is 7.0×10^3 J.

How much energy is converted to other forms by the lamp?

- A 120 J B 200 J C 3400 J D 7200 J

- 19 An object of mass m is dropped onto the surface of two planets, X and Y, which have no atmosphere.

The height from which the object is dropped and the change in gravitational potential energy of the object, for each planet, are given in the table.

	height / m	change in gravitational potential energy
planet X	3	ΔE
planet Y	4	$4\Delta E$

The acceleration of free fall near the surface of planet X is g_x .

What is the acceleration of free fall near the surface of planet Y?

- A $\frac{3}{4}g_x$ B $\frac{4}{3}g_x$ C $3g_x$ D $4g_x$

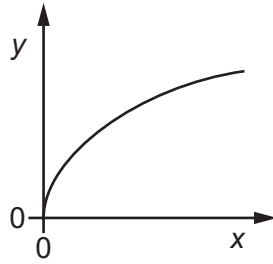
- 20 A known tensile force acts on a metal wire. The wire does not exceed its limit of proportionality.

Which two measurements enable the strain of the wire to be calculated?

- A the unstretched length of the wire and the cross-sectional area of the wire
 B the unstretched length of the wire and the extension of the wire
 C the Young modulus of the metal and the extension of the wire
 D the Young modulus of the metal and the unstretched length of the wire

21 A wire is extended by different forces. The wire obeys Hooke's law.

A graph is plotted to show the variation of a quantity y with a quantity x .



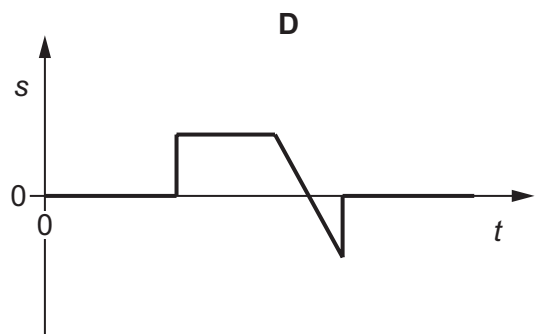
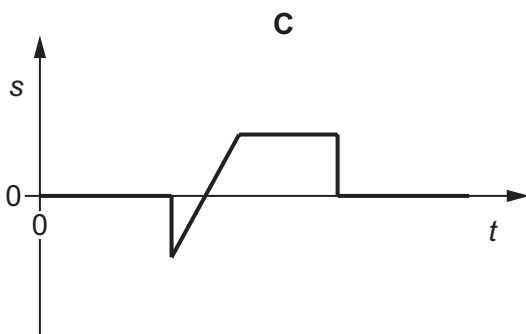
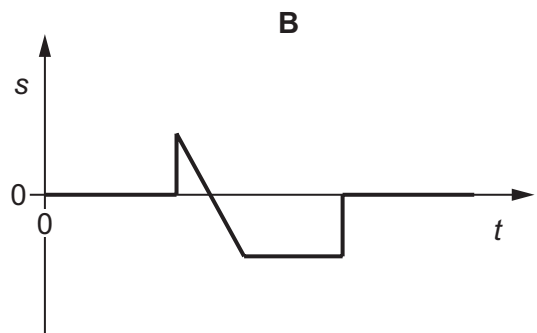
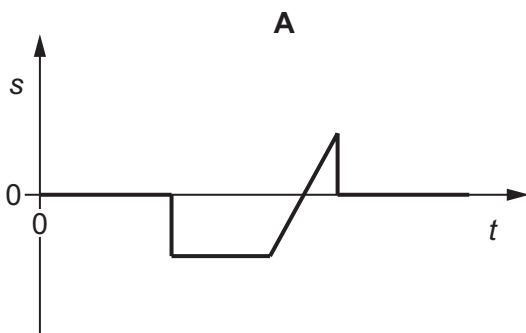
What could x and y represent?

	x	y
A	elastic potential energy	extension
B	extension	force
C	force	extension
D	extension	elastic potential energy

22 A wave pulse moves along a stretched rope in the direction shown.



Which diagram shows the variation with time t of the displacement s of the particle P in the rope?



23 Which statement about progressive transverse and longitudinal waves is correct?

- A** Particles in a transverse wave have fixed equilibrium positions but those in longitudinal waves do not.
- B** Transverse waves can be polarised but longitudinal waves cannot.
- C** Transverse waves transfer energy but longitudinal waves do not.
- D** Two-source interference can be demonstrated with transverse waves but not with longitudinal waves.

24 A miniature loudspeaker, initially at rest, falls vertically from a window in a high building. When the speaker has fallen a distance of 10.0 m, it emits a very short pulse of sound of constant frequency 256 Hz in all directions. The pulse of sound, travelling at a speed of 330 ms^{-1} , is heard by a person leaning out of the window.

Air resistance is negligible.

What is the frequency of the pulse of sound heard by the person?

- A** 246 Hz **B** 249 Hz **C** 267 Hz **D** 313 Hz

25 Two electromagnetic waves have wavelengths of $5.0 \times 10^{-7} \text{ m}$ and $5.0 \times 10^{-2} \text{ m}$ in a vacuum.

Which row identifies the regions of the electromagnetic spectrum to which the waves belong?

	wavelength $5.0 \times 10^{-7} \text{ m}$	wavelength $5.0 \times 10^{-2} \text{ m}$
A	ultraviolet	infrared
B	visible	microwave
C	ultraviolet	microwave
D	visible	infrared

- 26** The wavelength of sound in air may be determined by using stationary waves.

In one experiment, a loudspeaker produces a sound wave of constant frequency which is reflected directly back along its original path by a metal plate approximately 1 m away. A microphone connected to a cathode-ray oscilloscope (CRO) is moved between the loudspeaker and plate to identify regions of high sound intensity ('loud' spots) and low sound intensity ('quiet' spots).

The wavelength of the sound is determined using the **least** possible number of measured quantities.

Which row shows the quantities that are needed?

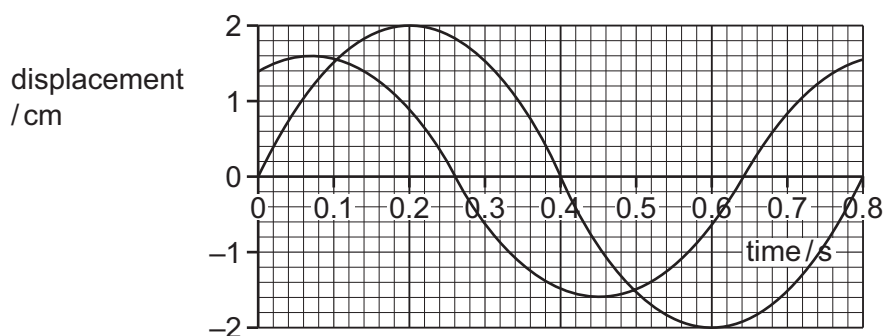
	frequency of sound	mean separation of 'quiet' spots	speed of sound in air
A	✓	✓	✗
B	✓	✗	✓
C	✓	✗	✗
D	✗	✓	✗

key

✓ = needed

✗ = not needed

- 27** Two progressive waves meet at a fixed point P. The variation with time of the displacement of each wave at point P is shown.



The two waves superpose at point P.

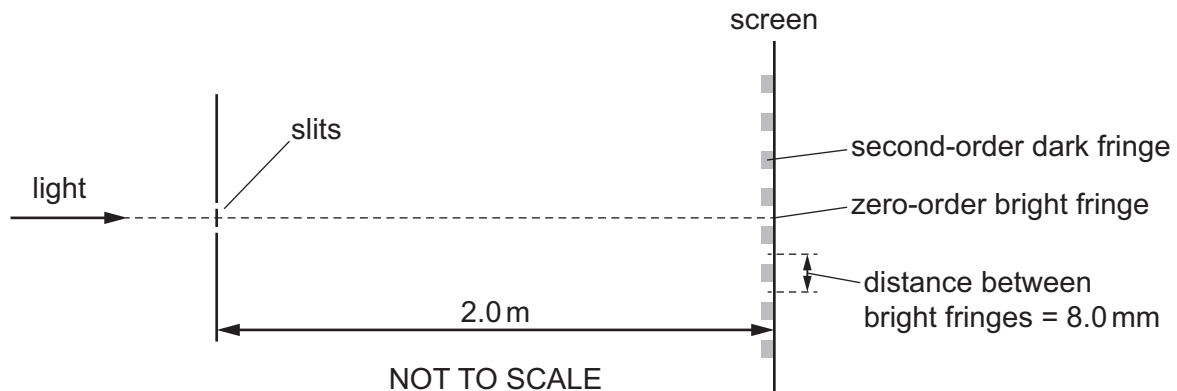
What is the resultant displacement at time 0.38 s?

- A** +1.0 cm **B** -1.0 cm **C** +1.8 cm **D** -1.8 cm

- 28** In which situation does diffraction occur?

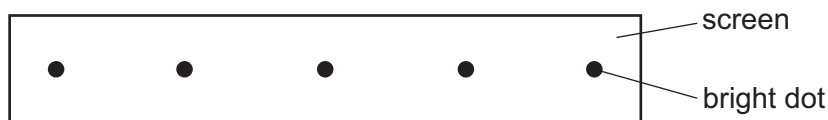
- A** A wave bounces back from a surface.
B A wave passes from one medium into another.
C A wave passes through a gap in a barrier.
D Waves from two identical sources are superposed.

- 29 Light of a single frequency is incident on a pair of narrow slits that are a distance of 0.10 mm apart. A series of bright and dark fringes is observed on a screen a distance of 2.0 m away. The distance between adjacent bright fringes is 8.0 mm.



What is the path difference of the light waves from the two slits that meet at the second-order **dark** fringe?

- A 2.0×10^{-7} m
 B 4.0×10^{-7} m
 C 6.0×10^{-7} m
 D 8.0×10^{-7} m
- 30 Red light of a single wavelength passes through a diffraction grating. Bright dots are formed on a screen, as shown.



The red light is replaced with white light.

Which diagram, drawn to the same scale, shows a possible pattern of bright light on the screen?

- A
- B
- C
- D

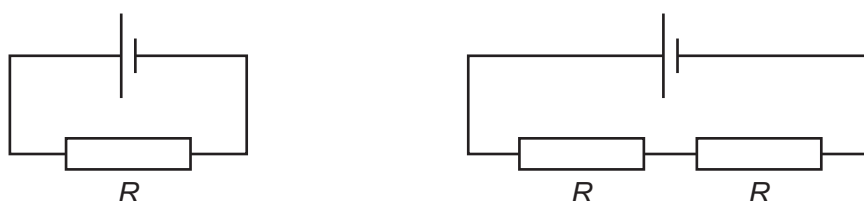
- 31** A nichrome wire has a resistance of 15Ω and a diameter of 3.0 mm. The number density of the free electrons in nichrome is $9.0 \times 10^{28} \text{ m}^{-3}$.

A potential difference (p.d.) of 6.0 V is applied between the ends of the wire.

What is the average drift speed of the free electrons in the wire?

- A** $9.8 \times 10^{-7} \text{ m s}^{-1}$
B $3.9 \times 10^{-6} \text{ m s}^{-1}$
C $6.1 \times 10^{-6} \text{ m s}^{-1}$
D $2.5 \times 10^{-5} \text{ m s}^{-1}$

- 32** The diagrams show two different circuits.



The cells in each circuit have the same electromotive force (e.m.f.) and negligible internal resistance. The three resistors each have the same resistance R .

In the circuit on the left, the power dissipated in the resistor is P .

What is the total power dissipated in the circuit on the right?

- A** $\frac{P}{4}$ **B** $\frac{P}{2}$ **C** P **D** $2P$

- 33** The potential difference (p.d.) across a filament lamp is increased.

Which statement is correct?

- A** The resistance of the lamp decreases because the temperature decreases.
B The resistance of the lamp decreases because the temperature increases.
C The resistance of the lamp increases because the temperature decreases.
D The resistance of the lamp increases because the temperature increases.

- 34** A metal wire has resistance R .

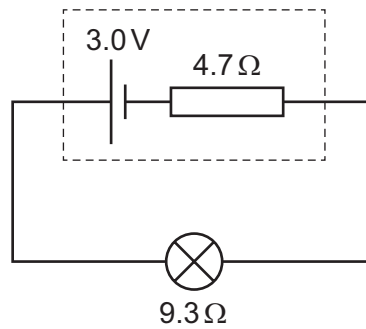
The wire is stretched so that its diameter decreases to 94.0% of the original diameter.

The volume of the wire is unchanged.

What is the resistance of the stretched wire?

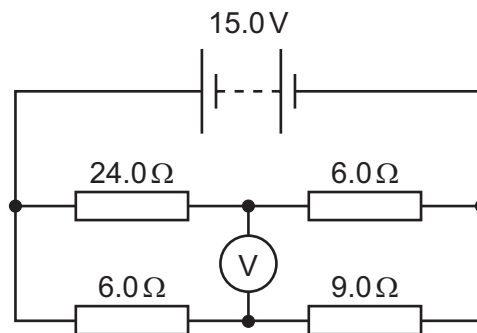
- A** $1.06R$ **B** $1.13R$ **C** $1.20R$ **D** $1.28R$

- 35** The diagram shows a cell of electromotive force (e.m.f.) 3.0 V and internal resistance $4.7\ \Omega$ connected across a lamp. The lamp has a resistance of $9.3\ \Omega$.



What is the power dissipated by the internal resistance of the cell?

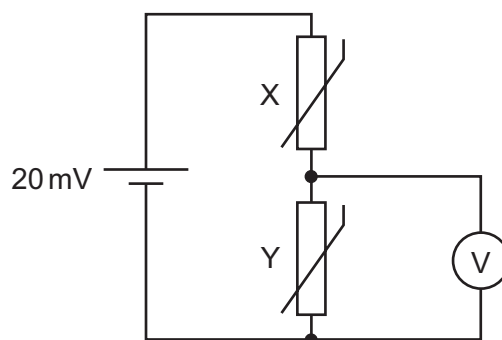
- A** 0.22 W **B** 0.43 W **C** 0.64 W **D** 1.0 W
- 36** A circuit consists of a battery, a high-resistance voltmeter and four fixed resistors, as shown. The battery has an electromotive force (e.m.f.) of 15.0 V and negligible internal resistance.



What is the reading on the voltmeter?

- A** 3.0 V **B** 6.0 V **C** 9.0 V **D** 12.0 V

- 37 A potential divider circuit is designed to detect the difference in temperature between two different places.



The cell has electromotive force (e.m.f.) 20 mV and negligible internal resistance.

Initially, thermistors X and Y are at the same temperature and have the same resistance. The voltmeter reads 10 mV. X is then placed in a cold environment and its resistance doubles. Y is placed in a warm environment and its resistance halves.

What is the new reading on the voltmeter?

- A** 4 mV **B** 5 mV **C** 15 mV **D** 16 mV
- 38 In the α -particle scattering experiment, a beam of α -particles is aimed at a thin gold foil. Most of the α -particles go straight through or are deflected by a small angle. A very small proportion are deflected by more than 90° , effectively rebounding towards the source of the α -particles.
- Which conclusion about the structure of atoms **cannot** be drawn from this experiment alone?
- A** Most of the atom is empty space.
B Most of the mass of an atom is concentrated in the nucleus.
C The nucleus contains both protons and neutrons.
D The nucleus is charged.
- 39 Which two particles have opposite charges?
- A** alpha-particle and helium nucleus
B antiproton and beta-plus particle
C beta-minus particle and electron
D positron and proton

40 Which particle is a lepton?

- A meson
- B positron
- C proton
- D quark

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Cambridge International AS & A Level

PHYSICS

9702/13

Paper 1 Multiple Choice

October/November 2022

1 hour 15 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.



Data

acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

- 1 A train of mass 600 000 kg moves with a speed of 100 km h^{-1} .

What is the order of magnitude of the kinetic energy of the train?

- A 10^6 J B 10^8 J C 10^{10} J D 10^{12} J

- 2 What are the SI base units of electromotive force (e.m.f.)?

A $\text{kg m}^2 \text{ s}^{-1} \text{ A}^{-1}$

B $\text{kg m}^2 \text{ s}^{-3} \text{ A}^{-1}$

C $\text{kg m}^2 \text{ s}^{-1} \text{ A}$

D $\text{kg m s}^{-3} \text{ A}^{-1}$

- 3 A digital meter is used to measure the current in an electric circuit.

The reading on the meter fluctuates (varies) between 3.04 A and 3.08 A. The readings on the meter have an accuracy of $\pm 1\%$.

What is the true value of the current, with its uncertainty?

A $(3.06 \pm 0.02) \text{ A}$

B $(3.06 \pm 0.04) \text{ A}$

C $(3.06 \pm 0.05) \text{ A}$

D $(3.06 \pm 0.07) \text{ A}$

- 4 Which quantity is a vector quantity?

A density

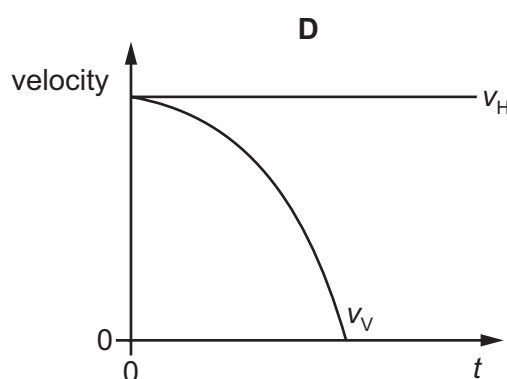
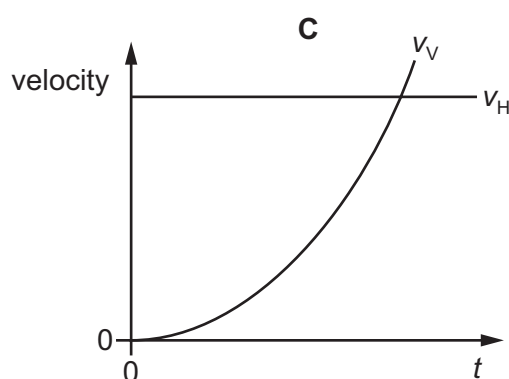
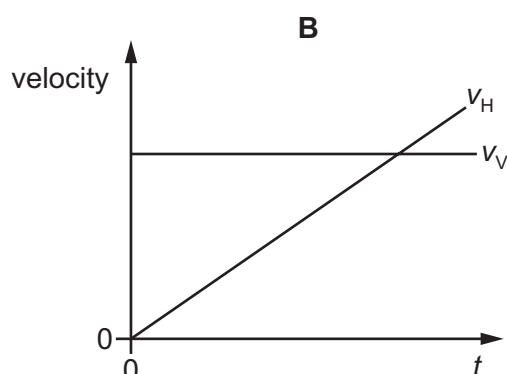
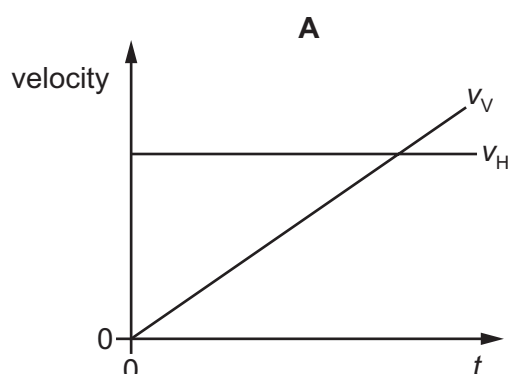
B mass

C volume

D weight

- 5 A stone is projected horizontally at time $t = 0$ and falls. Air resistance is negligible. The stone has a horizontal component of velocity v_H and a vertical component of velocity v_V .

Which graph shows how v_H and v_V vary with time t ?



- 6 On the Earth, an object takes time T_E to fall from rest through a vertical distance h .
On the Moon, the same object takes time T_M to fall from rest through the same vertical distance h .

The ratio $\frac{\text{acceleration of free fall on the Earth}}{\text{acceleration of free fall on the Moon}}$ is equal to 6.

Air resistance is negligible for the object on the Earth and on the Moon.

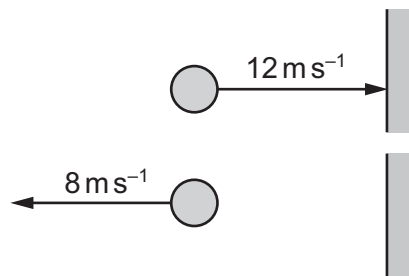
What is the ratio $\frac{T_E}{T_M}$?

- A** $\frac{1}{6}$ **B** $\frac{1}{\sqrt{6}}$ **C** $\sqrt{6}$ **D** 6

- 7 A cyclist in still air pedals as hard as she can. She reaches a maximum speed. However, after a certain time her maximum speed increases.

What could be a possible cause for this?

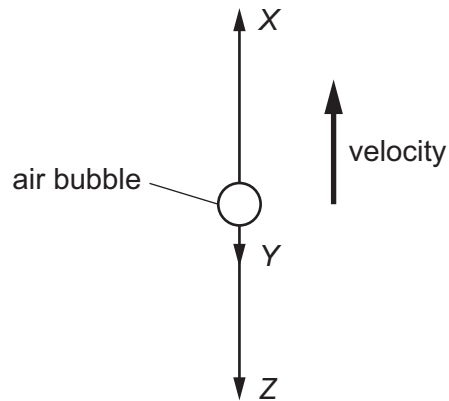
- A She cycles into a wind.
 - B She cycles over rougher ground.
 - C She sits more upright on the bicycle.
 - D She starts to travel downhill.
- 8 A ball of mass 0.5 kg hits a vertical wall at a speed of 12 m s^{-1} . It bounces back along its original path with a speed of 8 m s^{-1} . The collision lasts for 0.10 s .



What is the average force on the ball due to the collision?

- A 0.2 N B 1 N C 20 N D 100 N

- 9 An air bubble in a tank of water is rising with terminal (constant) velocity. The forces acting on the bubble are X , Y and Z , as shown.



The upthrust on the bubble is X .

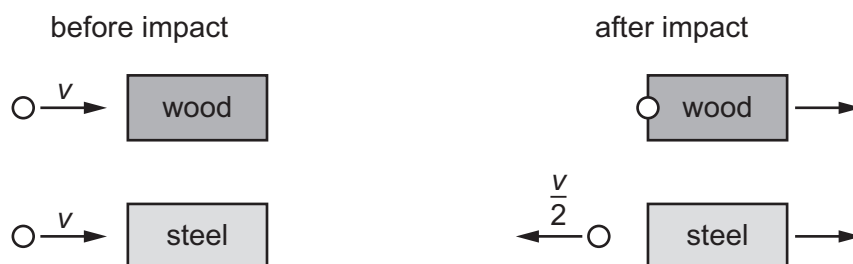
Which statement about the forces is correct?

- A** Z is the viscous force on the bubble, Y is the weight of the bubble and $X = Y + Z$.
- B** Z is the viscous force on the bubble, Y is the weight of the bubble and $X > Y + Z$.
- C** Z is the weight of the bubble, Y is the viscous force on the bubble and $X = Y + Z$.
- D** Z is the weight of the bubble, Y is the viscous force on the bubble and $X > Y + Z$.

- 10 Two blocks are at rest on a frictionless horizontal surface. One block is made of wood and the other block is made of steel.

A steel ball is fired horizontally with a speed v at the wooden block. The ball embeds itself in the block, and the ball and block move together after impact.

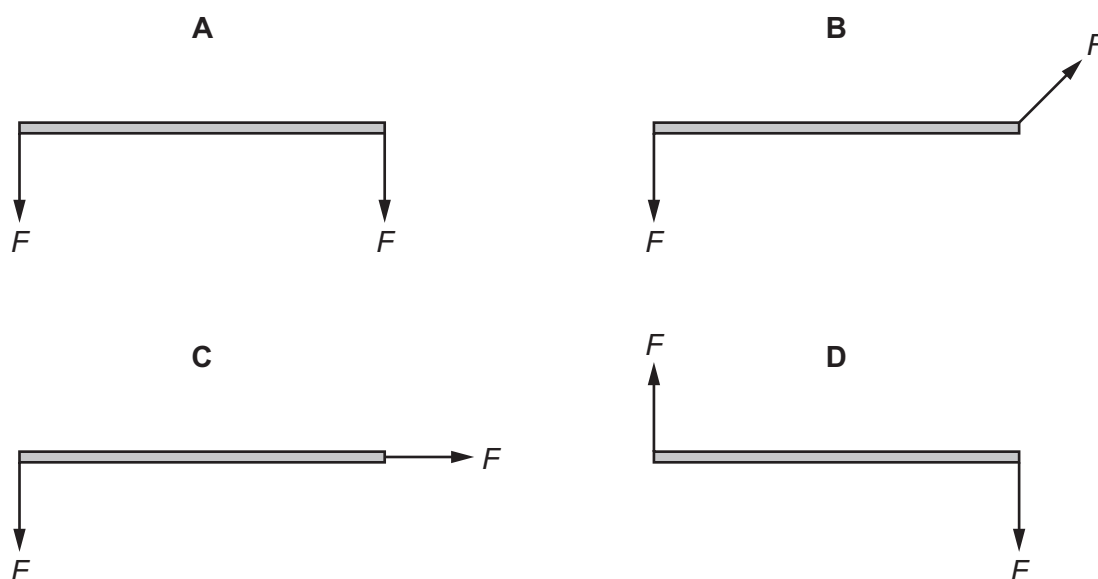
A second identical steel ball is fired horizontally with speed v at the steel block. The steel ball then rebounds back along its original path with speed $\frac{v}{2}$.



The wooden block and the steel block have equal mass.

Which statement about the blocks immediately after the collisions is correct?

- A Both blocks must travel with the same speed.
 - B The steel block must travel faster than the wooden block.
 - C The wooden block must travel faster than the steel block.
 - D The masses of the blocks and the steel ball are needed to determine which block travels faster.
- 11 Which diagram shows a couple formed by two forces, each of magnitude F , acting on a rod?



12 A student states that:

'If an object is in equilibrium, the sum of the clockwise moments about a point X is equal to the sum of the anticlockwise moments about a point Y.'

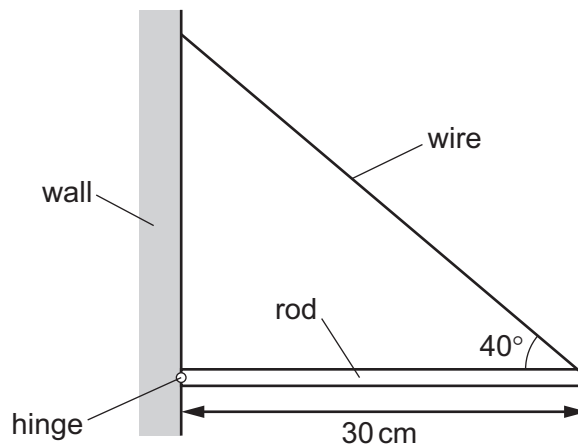
Which condition would make the student's statement correct?

- A Either X or Y is the centre of gravity of the object.
- B Either X or Y is the pivot of the object.
- C X and Y are at opposite ends of the object.
- D X and Y are the same point on the object.

13 A uniform rod of length 30 cm and weight 5.2 N is attached to a wall by a hinge at one end.

The other end of the rod is supported by a wire so that the rod is horizontal and in equilibrium.

The wire is at an angle of 40° to the horizontal.



What is the tension in the wire?

- A 3.4 N
- B 4.0 N
- C 6.8 N
- D 8.1 N

14 Water is pumped through a nozzle at the end of a hose. The nozzle has a circular cross-section of diameter 50 mm. A mass of 100 kg of water takes a time of 2.0 s to move through the nozzle. The density of water is 1000 kg m^{-3} .

What is the speed of the water in the nozzle?

- A 6.4 ms^{-1}
- B 13 ms^{-1}
- C 25 ms^{-1}
- D 51 ms^{-1}

- 15 A solid wooden cube rests on a horizontal surface.

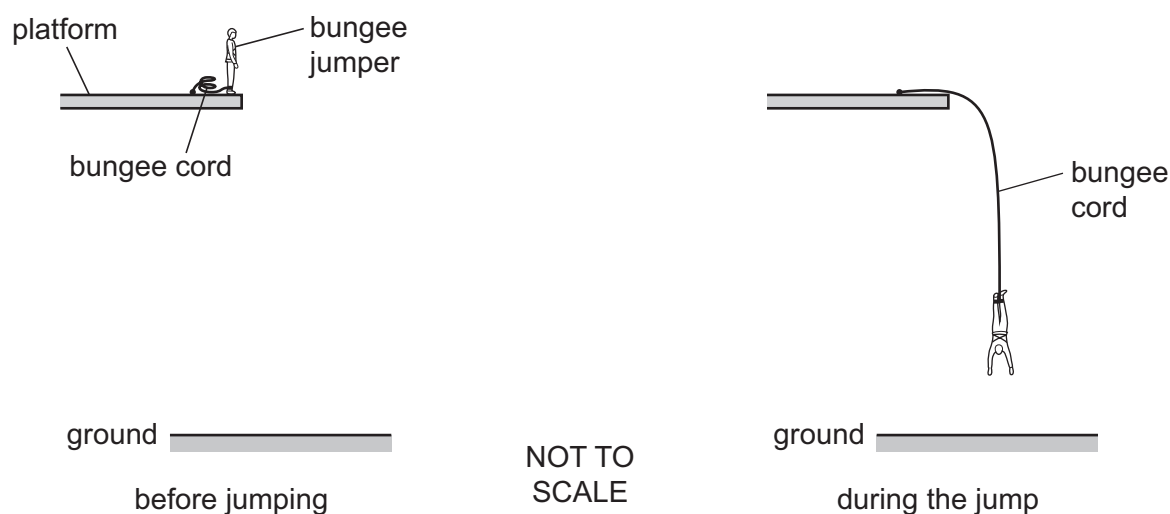
What gives the pressure exerted by the weight of the cube on the horizontal surface?

- A the product of the acceleration of free fall and the density of the cube
- B the product of the acceleration of free fall, the density and the side length of the cube
- C the product of the acceleration of free fall, the density and the area of one face of the cube
- D the product of the acceleration of free fall, the density and the volume of the cube

- 16 Which expression could be used to calculate power?

- A $\frac{(\text{current})^2}{\text{resistance}}$
- B $\frac{\text{force} \times \text{displacement}}{\text{time}}$
- C $\text{current} \times (\text{resistance})^2$
- D $\frac{\text{weight}}{\text{time}}$

- 17 A bungee jumper jumps from a platform and is decelerated by an elastic bungee cord, as shown.



When the jumper makes the jump, his initial gravitational potential energy is converted into his kinetic energy and into elastic potential energy in the cord.

At which part of the jump are all three types of energy non-zero?

- A on the platform before the jump
- B on the way down before the cord has started to extend
- C on the way down as he decelerates
- D at the bottom of the jump when he is stationary

- 18 An object is displaced horizontally to the right in a uniform vertical gravitational field.

Which statement describes the change in the gravitational potential energy of the object?

- A It decreases in direct proportion to the displacement.
- B It does not change with the displacement.
- C It increases in direct proportion to the displacement.
- D It increases in direct proportion to the square of the displacement.

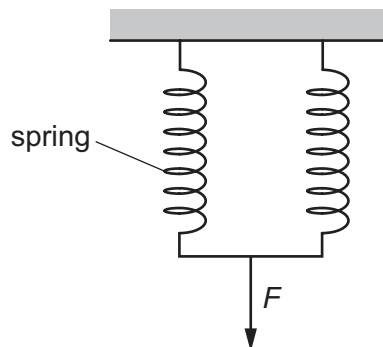
- 19 A copper wire of length 3.6 m and diameter 1.22 mm is stretched by a force of 37 N. The wire obeys Hooke's law. The Young modulus of copper is 1.17×10^{11} Pa.

Which extension is caused by this force?

- A 0.24 mm B 0.76 mm C 0.97 mm D 3.1 mm

- 20 A spring has spring constant k . The spring obeys Hooke's law and experiences extension x when a force F is applied to it. The resulting elastic potential energy of the spring is E_P .

The diagram shows two of these springs joined together in parallel and hanging from a fixed beam.

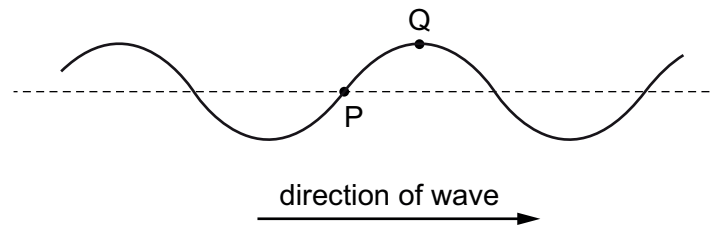


What is the extension and total elastic potential energy of this arrangement when the same force F is applied?

	extension	total elastic potential energy
A	$\frac{1}{2}x$	$\frac{1}{2}E_P$
B	$\frac{1}{2}x$	$\frac{1}{4}E_P$
C	x	$\frac{1}{2}E_P$
D	x	$\frac{1}{4}E_P$

- 21 The diagram shows a transverse wave on a rope. The wave is travelling from left to right.

At the instant shown, the points P and Q on the rope have zero displacement and maximum displacement respectively.



Which row describes the direction of motion, if any, of the points P and Q at this instant?

	point P	point Q
A	downwards	stationary
B	stationary	downwards
C	stationary	upwards
D	upwards	stationary

- 22 The period of an electromagnetic wave in a vacuum is 1.0 ns.

What are the frequency and wavelength of the wave?

	frequency / Hz	wavelength / m
A	1.0	3.0×10^8
B	1.0×10^6	300
C	1.0×10^9	0.30
D	1.0×10^{12}	3.0×10^{-4}

- 23 An observer is standing on a railway platform. A train passes the observer at constant speed while emitting sound of constant frequency f from its whistle.

What does the observer hear?

- A** sound of a decreasing frequency as the train approaches and of an increasing frequency as it moves away
- B** sound of a higher frequency than f as the train approaches and of a lower frequency than f as the train moves away
- C** sound of a lower frequency than f as the train approaches and of a higher frequency than f as the train moves away
- D** sound of an increasing frequency as the train approaches and as it moves away

24 Which microorganisms have a length that is equal to the wavelength in free space of an electromagnetic wave that is visible to the human eye?

- A** algae of length $0.5\ \mu\text{m}$
- B** bacteria of length $5.0\ \mu\text{m}$
- C** fungi of length $50\ \mu\text{m}$
- D** protozoa of length $100\ \mu\text{m}$

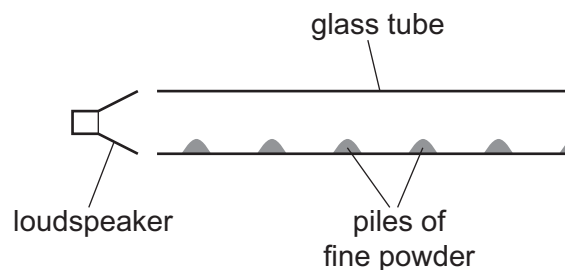
25 Two progressive waves overlap.

What is an essential condition for the two waves to form a stationary wave?

- A** The waves are longitudinal.
- B** The waves are polarised.
- C** The waves travel in opposite directions.
- D** The waves travel in the same direction.

26 In an experiment to produce a stationary sound wave in air, a fine powder is initially evenly distributed along the length of a horizontal glass tube which is closed at one end.

At the open end of the tube, a loudspeaker emits a sound wave of a constant wavelength. A stationary wave is formed and the powder accumulates in regularly spaced piles, as shown.



Which statement explains the positions of the piles of powder within the tube?

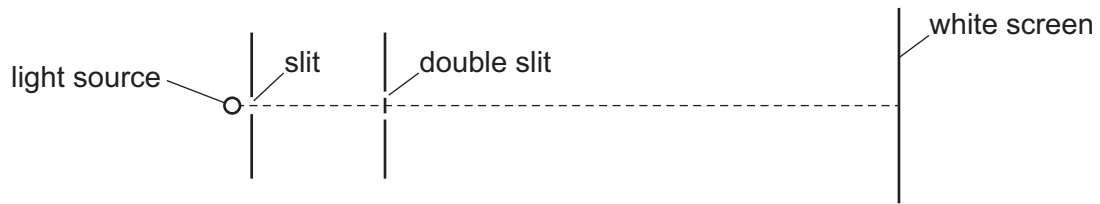
- A** The piles are where the air molecules vibrate with maximum amplitude.
- B** The piles are where the air molecules vibrate with minimum amplitude.
- C** The piles are where the air molecules vibrate with the highest frequency.
- D** The piles are where the air molecules vibrate vertically.

- 27** A sound wave of wavelength 0.50 m passes through a doorway of width 1.0 m between two rooms.

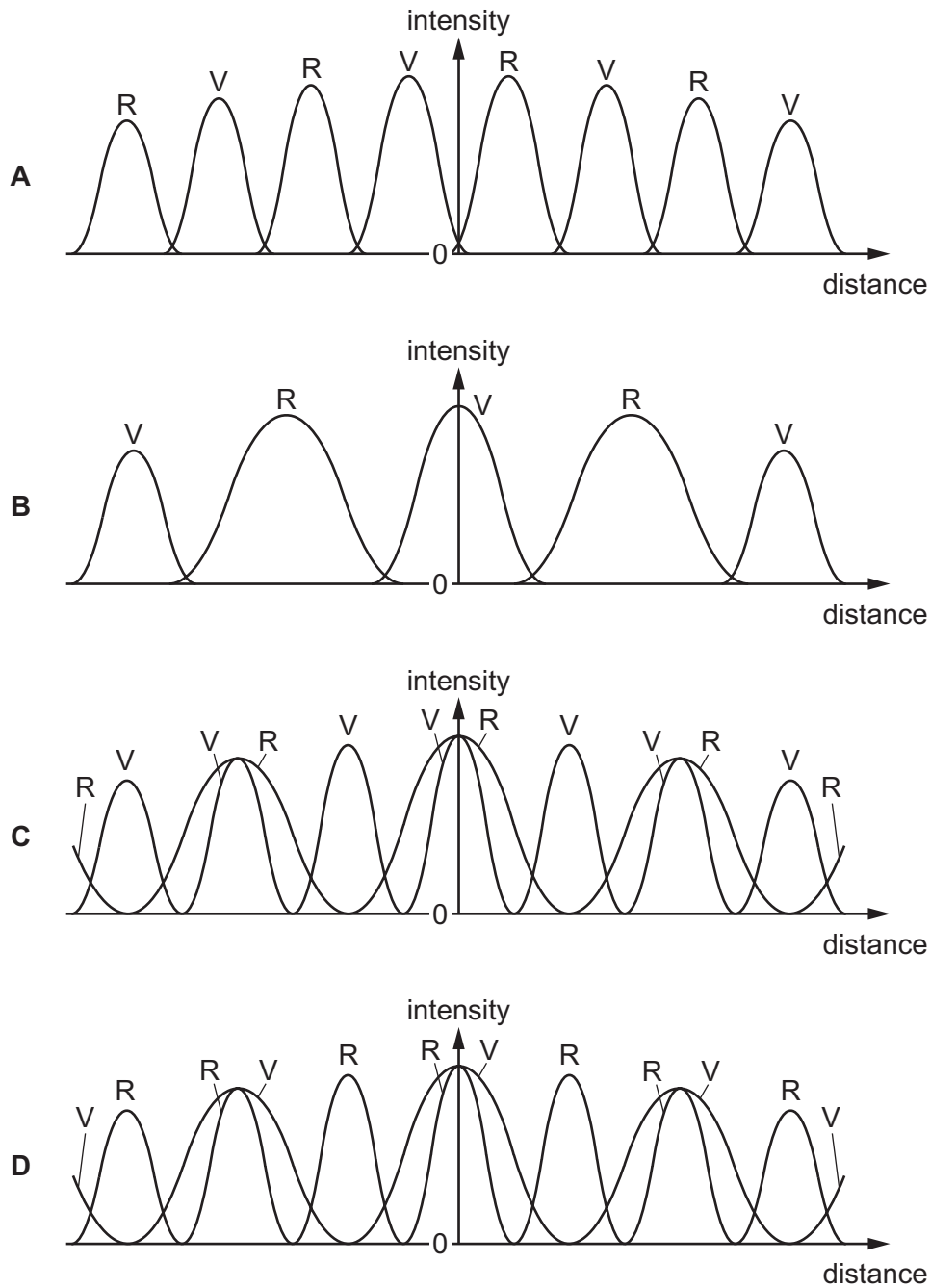
Which change increases the amount of diffraction that takes place?

- A** Double the amplitude of the sound wave.
- B** Double the width of the doorway.
- C** Halve the frequency of the sound wave.
- D** Halve the period of the sound wave.

- 28 A light source consists of a vertical slit illuminated by red light (R) and violet light (V). The wavelength of R is approximately twice the wavelength of V. A parallel vertical double slit is placed nearby. A white screen is placed so that fringes are formed on it.



Which graph best represents the interference fringes formed on the screen?



29 Which property of a light wave can be determined using a diffraction grating?

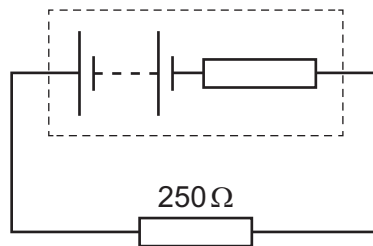
- A amplitude
- B intensity
- C speed
- D wavelength

30 There is an electric current in a copper wire.

Which statement describing the average drift speed of the charge carriers in the wire is correct?

- A It is nearly $3 \times 10^8 \text{ m s}^{-1}$.
- B It is proportional to the cross-sectional area of the wire.
- C It is proportional to the length of the wire.
- D It is proportional to the magnitude of the current.

31 A battery with a constant internal resistance is connected to a resistor of resistance 250Ω , as shown.

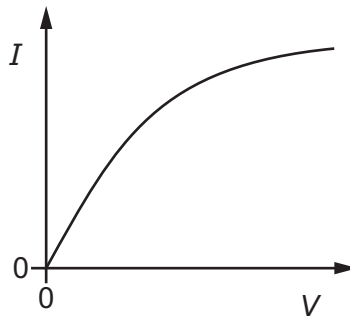


The current in the resistor is 40 mA for a time of 60 s . During this time 6.0 J of energy is dissipated by the internal resistance.

What is the energy supplied to the external resistor during the 60 s and the electromotive force (e.m.f.) of the battery?

	energy / J	e.m.f. / V
A	30	2.5
B	30	7.5
C	24	10.0
D	24	12.5

32 Which component has the I – V graph shown?

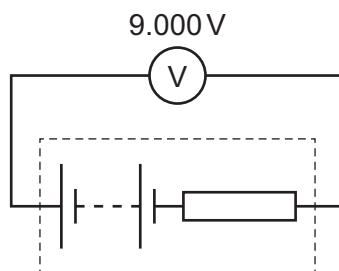


- A** filament lamp
B metallic conductor at constant temperature
C resistor of fixed resistance
D semiconductor diode
- 33 Two wires, P and Q, have the same resistance. Wire Q is made of material that has twice the resistivity of the material used to make wire P. The diameter of wire Q is twice the diameter of wire P.

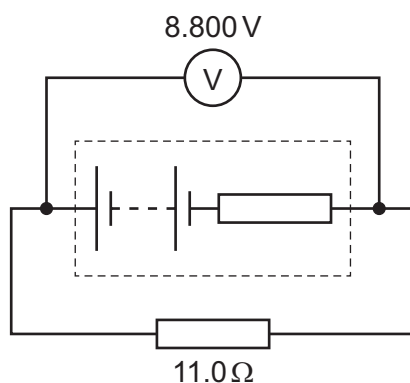
What is the ratio $\frac{\text{length of wire P}}{\text{length of wire Q}}$?

- A** $\frac{1}{8}$ **B** $\frac{1}{4}$ **C** $\frac{1}{2}$ **D** $\frac{2}{1}$

- 34 A voltmeter reads 9.000 V when it is connected across the terminals of a battery.



When a resistor of resistance $11.0\ \Omega$ is connected in parallel with the battery, the voltmeter reading changes to 8.800 V.



What is the internal resistance of the battery?

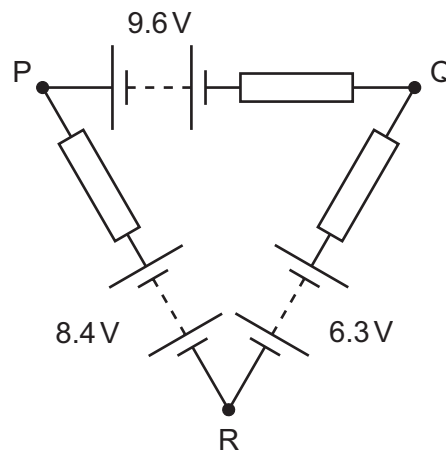
- A** $0.244\ \Omega$ **B** $0.250\ \Omega$ **C** $10.8\ \Omega$ **D** $11.3\ \Omega$

- 35 Each of Kirchhoff's laws is linked to the conservation of a physical quantity.

Which conserved physical quantities are used in the derivation of Kirchhoff's first law and of Kirchhoff's second law?

	Kirchhoff's first law	Kirchhoff's second law
A	energy	charge
B	energy	momentum
C	charge	energy
D	momentum	energy

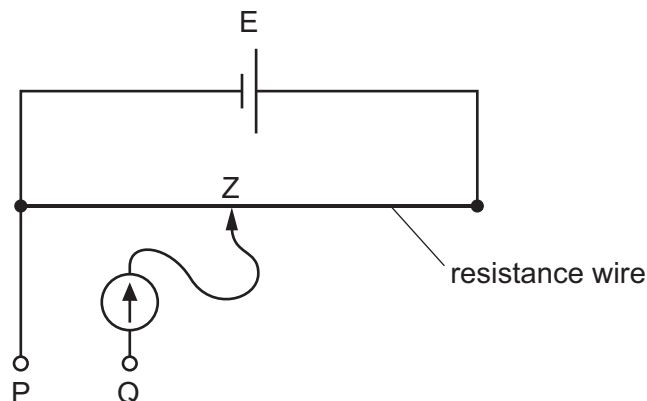
- 36 Three batteries and three identical resistors are connected in a circuit PQR, as shown.



The batteries have negligible internal resistance.

What is the potential difference between points P and Q?

- A** 1.5V **B** 2.1V **C** 7.1V **D** 12.1V
- 37 A cell E, of electromotive force (e.m.f.) 2V and negligible internal resistance, is connected to a uniform resistance wire of resistance 10Ω and length 1.0 m.



Z is a connection that may be made at any position along the resistance wire. A galvanometer is connected between Z and a point Q.

A new source of e.m.f. of approximately 8 mV is connected between points P and Q. The e.m.f. of the new source is determined by changing the position of Z until the reading on the galvanometer is zero.

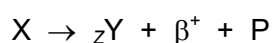
Which change to the circuit allows a much more precise value for the e.m.f. of the new source to be obtained?

- A** Add a resistor of resistance 0.1Ω in series with cell E.
B Add a resistor of resistance 1000Ω in series with cell E.
C Add a resistor of resistance 10Ω in series with the new source.
D Add a resistor of resistance 800Ω in series with the new source.

- 38 Which statement about the alpha-particle scattering experiment provides evidence for the existence of the nucleus?
- A A tiny proportion of the alpha-particles are deflected through large angles.
 - B Slower alpha-particles are deflected through larger angles.
 - C The kinetic energies of the deflected alpha-particles are unchanged.
 - D The number of alpha-particles deflected depends on the thickness of the foil.

- 39 A nucleus X undergoes β^+ decay.

The products are a nucleus Y with proton number Z, a β^+ particle and another particle P.



What is particle P and what is the proton number of nucleus X?

	P	proton number of nucleus X
A	antineutrino	$Z - 1$
B	antineutrino	$Z + 1$
C	neutrino	$Z - 1$
D	neutrino	$Z + 1$

- 40 A particle consists of two up quarks and a charm quark.

What is the charge of this particle, expressed in terms of the elementary charge e ?

- A $-2e$ B $-e$ C $+e$ D $+2e$

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