

PHYSICS

9702/11

Paper 1 Multiple Choice

October/November 2019

1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

DO NOT WRITE IN ANY BARCODES.

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 separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any working should be done in this booklet.

Electronic calculators may be used.

This document consists of **20** printed pages.



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

1 For which quantity is the magnitude a reasonable estimate?

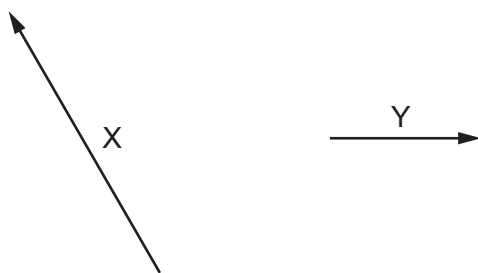
- A** frequency of a radio wave 500 pHz
B mass of an atom 500 μg
C the Young modulus of a metal 500 kPa
D wavelength of green light 500 nm

2 The speed of a wave in deep water depends on its wavelength L and the acceleration of free fall g .

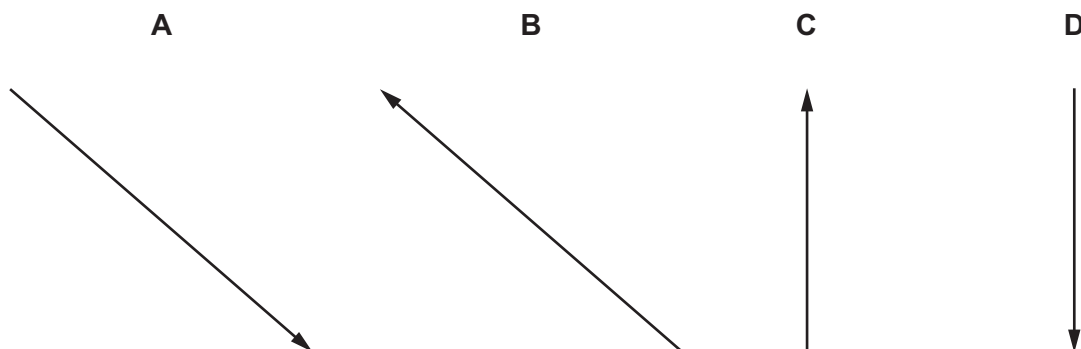
What is a possible equation for the speed v of the wave?

- A** $v = \sqrt{\left(\frac{gL}{2\pi}\right)}$ **B** $v = \frac{gL}{4\pi^2}$ **C** $v = 2\pi\sqrt{\left(\frac{g}{L}\right)}$ **D** $v = \frac{2\pi g}{L}$

3 The diagram shows two vectors X and Y , drawn to scale.



If $X = Y - Z$, which diagram best represents the vector Z ?



- 4 A student intends to measure accurately the diameter of a wire (known to be approximately 1 mm) and the internal diameter of a pipe (known to be approximately 2 cm).

What are the most appropriate instruments for the student to use to make these measurements?

	wire	pipe
A	calipers	calipers
B	calipers	micrometer
C	micrometer	calipers
D	micrometer	micrometer

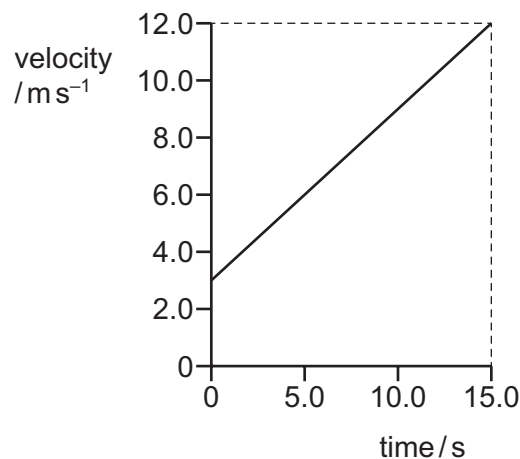
- 5 The power P dissipated in a resistor of resistance R is calculated using the expression

$$P = \frac{V^2}{R}$$

where V is the potential difference (p.d.) across the resistor. The percentage uncertainty in V is 5% and in R is 2%.

What is the percentage uncertainty in P ?

- A** 3% **B** 7% **C** 8% **D** 12%
- 6 The velocity-time graph for an object of mass 2.5 kg is shown.



What is the resultant force acting on the object?

- A** 0.60 N **B** 0.80 N **C** 1.5 N **D** 2.0 N

- 7 Which statement follows directly from Newton's first law?
- A A body remains at constant velocity unless acted upon by a resultant force.
 - B A satellite in circular motion about the Earth has a constant velocity.
 - C A water drop leaving a spinning umbrella travels at a constant velocity.
 - D The force acting on an object is equal to its change in momentum.

- 8 A resultant force causes an object to accelerate.

What is equal to the resultant force?

- A the acceleration of the object per unit mass
 - B the change in kinetic energy of the object per unit time
 - C the change in momentum of the object per unit time
 - D the change in velocity of the object per unit time
- 9 A skydiver falls from an aircraft that is moving horizontally.

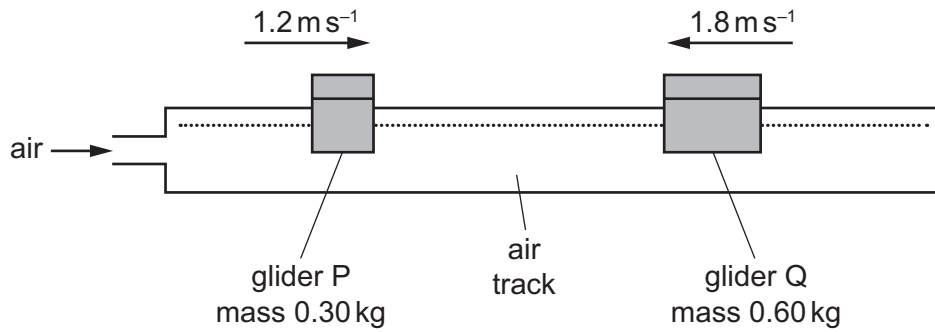
The vertical component of the velocity of the skydiver is v .

The vertical component of the acceleration of the skydiver is a .

Which row describes v and a during the first few seconds after the skydiver leaves the aircraft?

	v	a
A	constant	constant
B	constant	decreasing
C	increasing	constant
D	increasing	decreasing

- 10 Two gliders are travelling towards each other on a horizontal air track. Glider P has mass 0.30 kg and is moving with a constant speed of 1.2 m s^{-1} . Glider Q has mass 0.60 kg and is moving with a constant speed of 1.8 m s^{-1} .

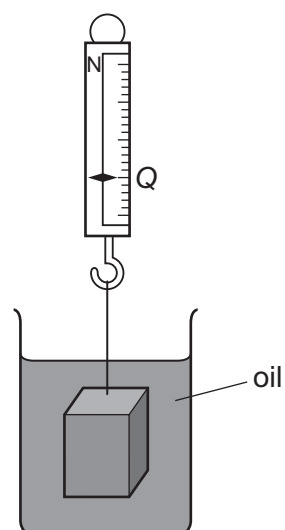
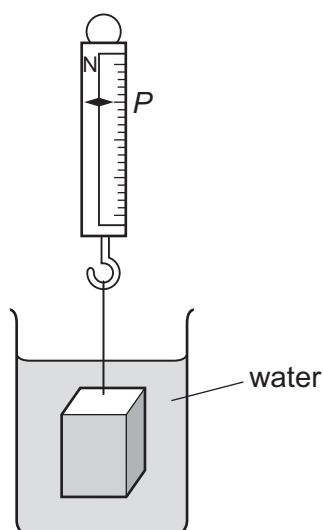


The gliders have a perfectly elastic collision.

What are the speeds of the two gliders after the collision?

	speed of P $/\text{m s}^{-1}$	speed of Q $/\text{m s}^{-1}$
A	1.2	0.6
B	2.0	1.4
C	2.8	0.2
D	3.6	0.6

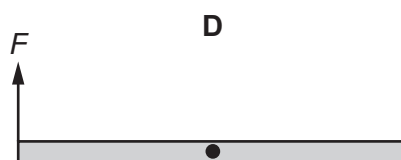
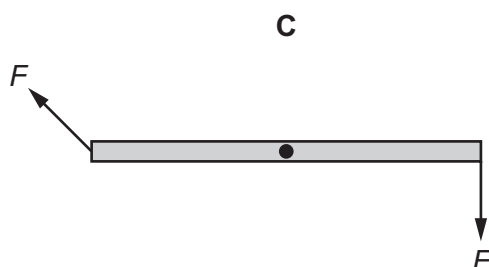
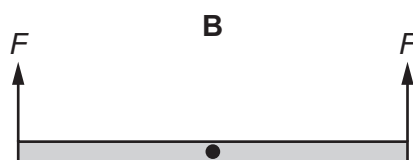
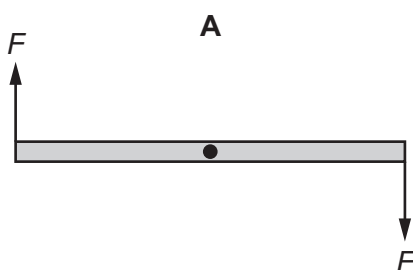
- 11 An object of weight W is suspended from a newton meter. When the object is completely immersed in water, the newton meter reads P . When the object is completely immersed in oil, the newton meter reads Q .



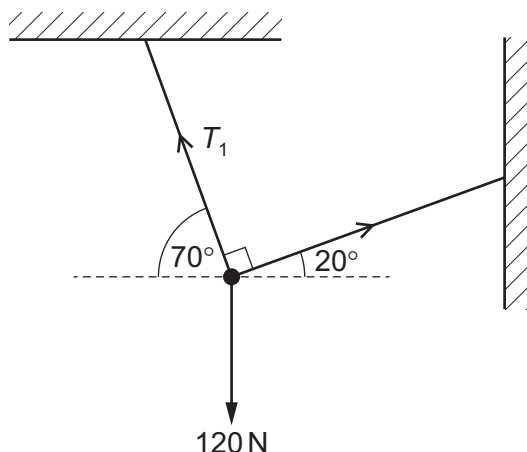
What is the ratio $\frac{\text{density of oil}}{\text{density of water}}$?

- A $\frac{W-P}{Q-P}$ B $\frac{Q-P}{W-P}$ C $\frac{W-P}{W-Q}$ D $\frac{W-Q}{W-P}$

- 12 Which diagram shows a couple?



- 13** An object of weight 120 N is supported in equilibrium by two strings as shown.



What is the tension T_1 in the left-hand string?

- A** 41 N **B** 77 N **C** 113 N **D** 128 N
- 14** In a large container in an oil refinery, three oils of different densities are mixed. No chemical activity occurs.

The mixture consists of:

1200 kg of oil of density 1100 kg m^{-3}

1500 kg of oil of density 860 kg m^{-3}

4000 kg of oil of density 910 kg m^{-3} .

What is the density of the mixture?

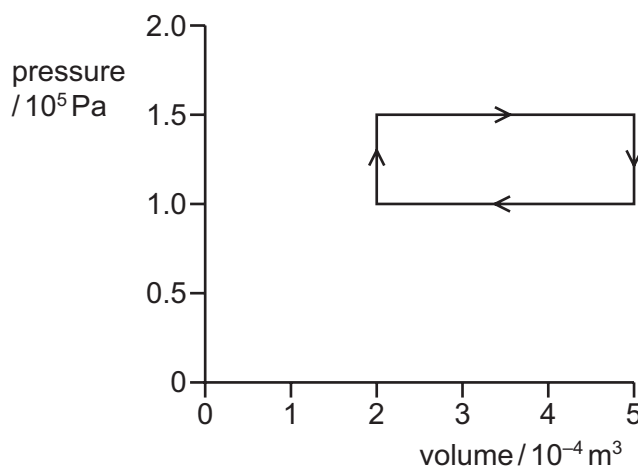
- A** 927 kg m^{-3} **B** 933 kg m^{-3} **C** 957 kg m^{-3} **D** 1045 kg m^{-3}
- 15** An electric motor produces 120 W of useful mechanical output power. The efficiency of the motor is 60%.

Which row is correct?

	electrical power input / W	waste heat power output / W
A	72	48
B	192	72
C	200	72
D	200	80

- 16** A fixed amount of a gas undergoes a series of changes to its pressure and volume.

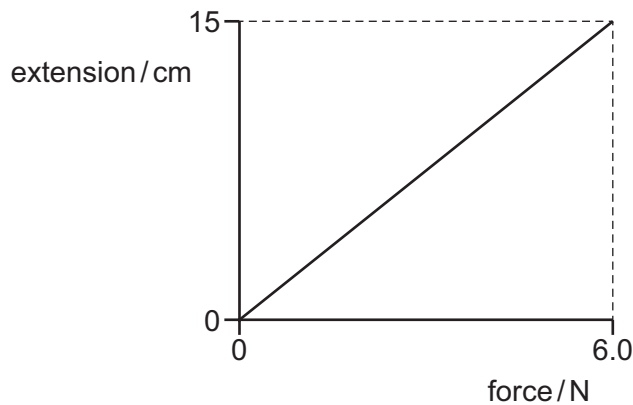
In two of the changes, no work is done by or on the gas. In one change work is done by the gas on its surroundings. In another change work is done on the gas by its surroundings.



During the change when work is done on the gas by its surroundings, how much work is done on the gas?

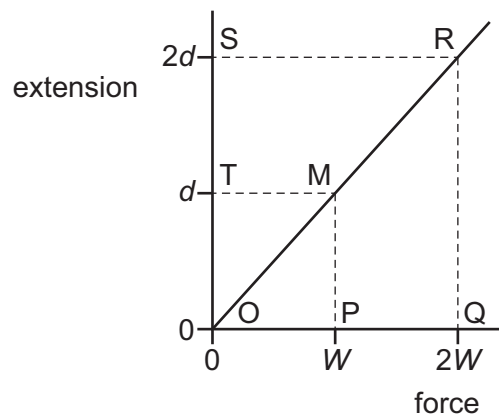
- A** 15 J **B** 25 J **C** 30 J **D** 45 J
- 17** An object travelling with a speed of 10 m s^{-1} has kinetic energy 1500 J.
- The speed of the object is increased to 40 m s^{-1} .
- What is the new kinetic energy of the object?
- A** 4500 J **B** 6000 J **C** 24 000 J **D** 1 350 000 J
- 18** The engine of a car exerts a force of 600 N in moving the car 1.0 km in 150 seconds.
- What is the average useful output power of the engine?
- A** 4.0 W **B** 4.0 kW **C** 90 kW **D** 90 MW

- 19 An extension–force graph for a spring is shown.



What is the spring constant of the spring?

- A** 0.025 N m^{-1} **B** 0.40 N m^{-1} **C** 2.5 N m^{-1} **D** 40 N m^{-1}
- 20 A wire is extended by a force. The graph shows how the extension of the wire varies with the force applied.



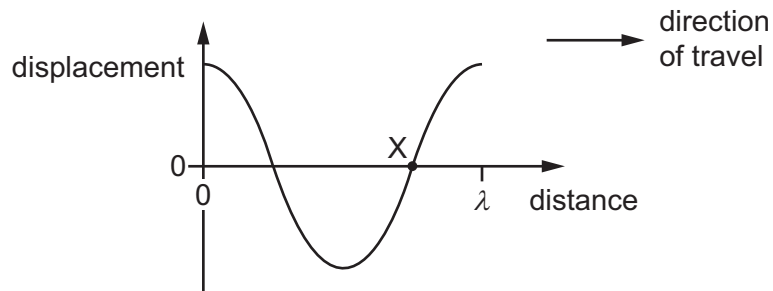
Initially a force W gives an extension d . The force is then increased to $2W$. This increases the extension to $2d$.

Which area of the graph represents the work done by the force when the force increases from W to $2W$?

- A** ORQ **B** OQRS **C** ORS **D** TMRS

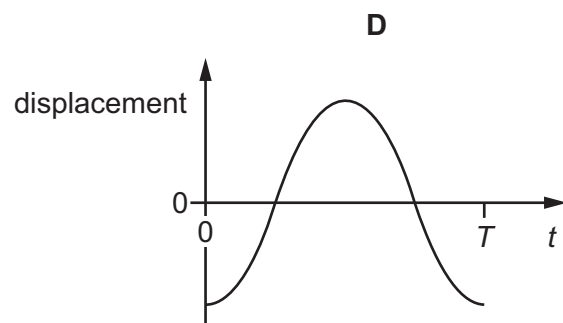
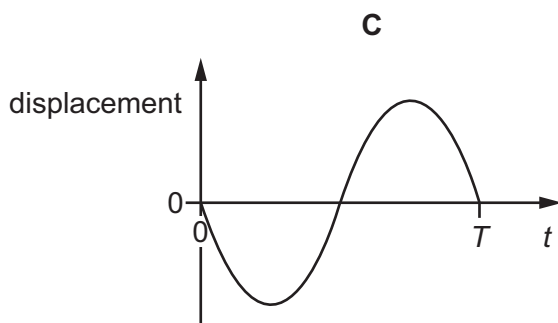
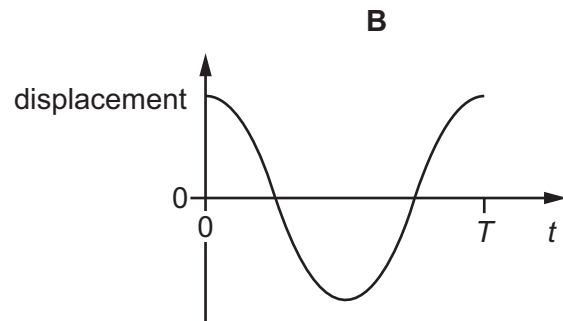
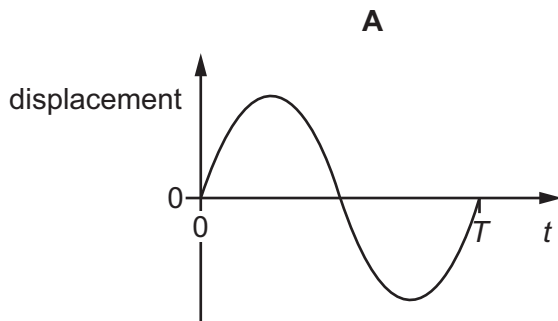
- 21** A transverse wave on a rope has wavelength λ and period T .

The graph shows the variation of the displacement of the particles of the rope with distance in the direction of travel of the wave at time $t = 0$.



A particle X is labelled.

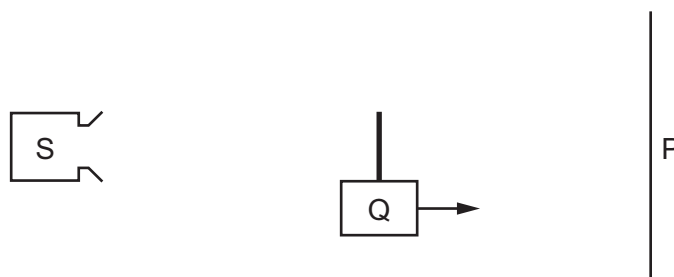
Which graph shows the variation of the displacement of particle X with time t ?



- 22** Which statement about all types of transverse waves is correct?

- A** They all have the same speed.
- B** They all have vibrations that are parallel to the direction of propagation of energy.
- C** They can all form stationary waves.
- D** They can all travel through a vacuum.

- 23 Source S emits microwaves with a constant amplitude. The microwaves hit a metal screen P and are reflected. A stationary wave is formed between S and P. The wavelength of the microwaves is much smaller than the distance between S and P.



A detector Q is moved at a slow, constant speed from S to P.

What happens to the amplitude of the signal detected by Q?

- A decreases steadily
 - B increases and decreases regularly
 - C increases steadily
 - D remains constant
- 24 The siren of a moving police car emits a sound wave with a frequency of 440 Hz. A stationary observer hears sound of frequency 494 Hz. The speed of sound in the air is 340 m s^{-1} .

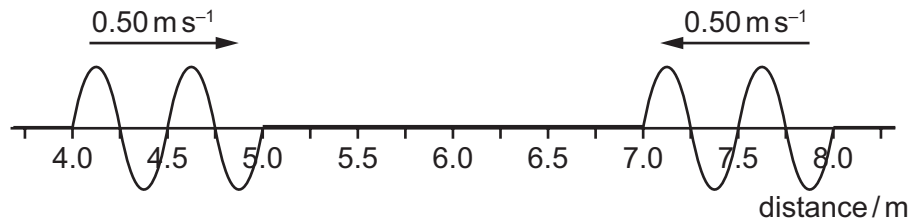
What could be the speed and the direction of movement of the car?

- A 37 m s^{-1} directly towards the observer
 - B 37 m s^{-1} directly away from the observer
 - C 42 m s^{-1} directly towards the observer
 - D 42 m s^{-1} directly away from the observer
- 25 An electromagnetic wave has a wavelength of 138 pm in a vacuum.

To which region of the electromagnetic spectrum does this wave belong?

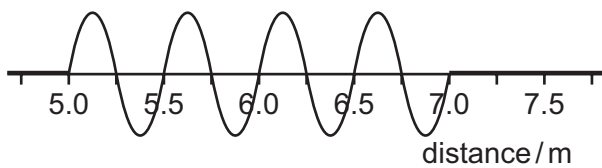
- A radio wave
- B microwave
- C visible light
- D X-ray

- 26 Two wave pulses are travelling towards each other on a long rope. The pulses have the same amplitude and wavelength and are travelling at a speed of 0.50 m s^{-1} . The diagram shows the rope at time $t = 0$.

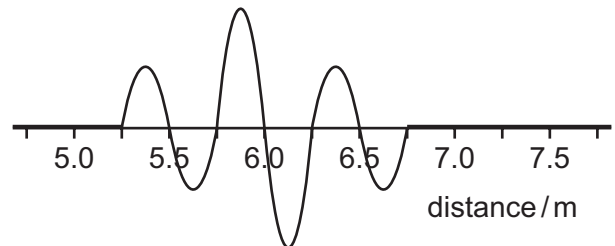


Which diagram shows the rope at time $t = 3.0 \text{ s}$?

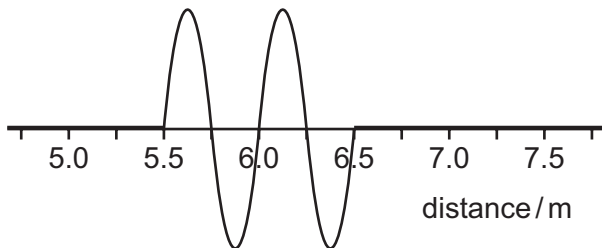
A



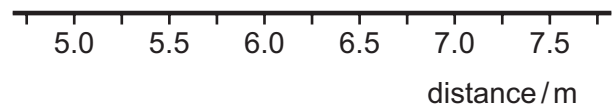
B



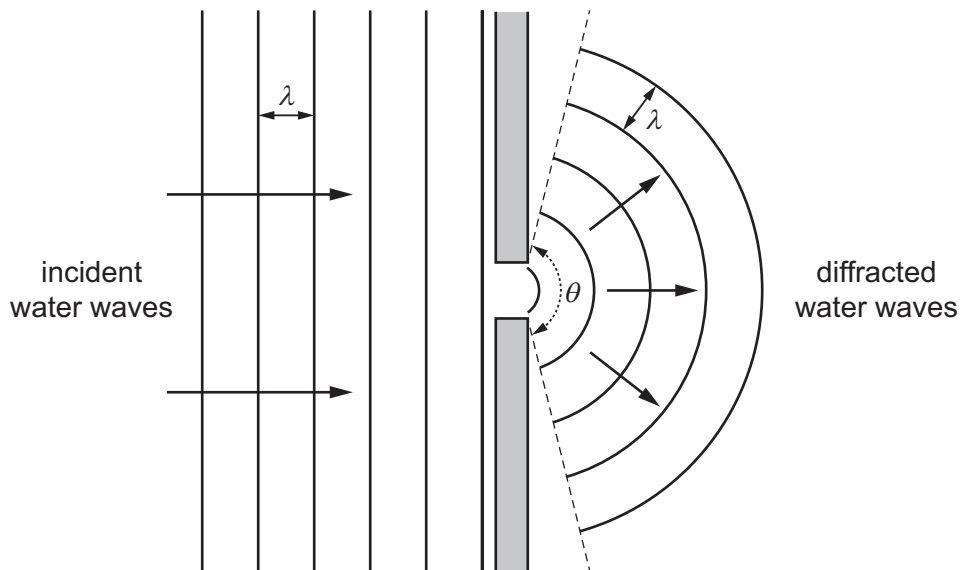
C



D



- 27 Water waves of wavelength λ are incident normally on an obstacle with a narrow gap. The width of the gap is equal to λ . The waves from the gap emerge over an angle θ as shown.



The gap is slowly widened.

Which changes, if any, occur to θ and to the wavelength of the emerging waves?

	θ	wavelength
A	decreases	remains the same
B	increases	remains the same
C	remains the same	decreases
D	remains the same	increases

- 28 Light of wavelength 720 nm from a laser X is incident normally on a diffraction grating and a diffraction pattern is observed. Light from a laser Y is then also incident normally on the same grating. The third-order maximum due to laser Y is seen at the same place as the second-order maximum due to laser X.

What is the wavelength of the light from laser Y?

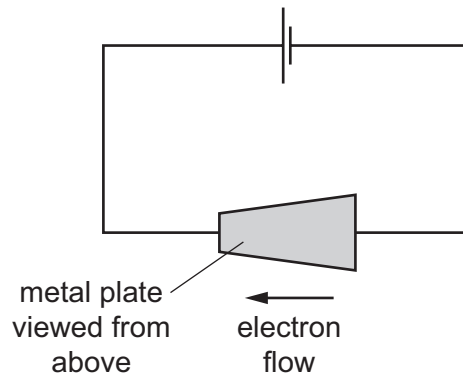
- A** 480 nm **B** 540 nm **C** 720 nm **D** 1080 nm

- 29 Monochromatic light of frequency f is incident on a diffraction grating of line spacing d . The speed of light is c .

Which expression can be used to determine the highest order of intensity maximum produced by the grating?

- A** $n = \frac{d}{cf}$ **B** $n = \frac{df}{c}$ **C** $n = \frac{dc}{f}$ **D** $n = \frac{c}{df}$

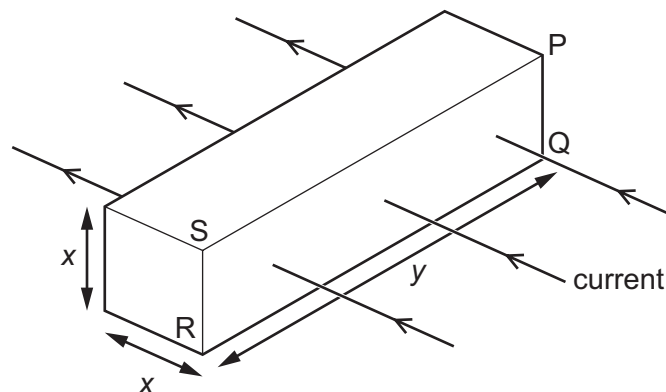
- 30 A metal plate of uniform thickness is connected to a cell as shown.



Electrons move clockwise around the circuit.

Which statement about the metal plate is correct?

- A The average drift speed of the conduction electrons decreases as they move from right to left through the plate.
 - B The average drift speed of the conduction electrons increases as they move from right to left through the plate.
 - C The number density of the conduction electrons decreases from right to left through the plate.
 - D The number density of the conduction electrons increases from right to left through the plate.
- 31 The diagram shows the direction of the current in a metal block. The charge carriers enter the block through the face PQRS and leave the block through the opposite face.



The number density of charge carriers is n . Each charge carrier has charge e . The average drift speed of the charge carriers is v .

Which expression gives the current in the block?

- A $envx^2$
- B $envxy$
- C $envx^3y^2$
- D $envx^4y$

32 What could **not** be used as a unit of potential difference?

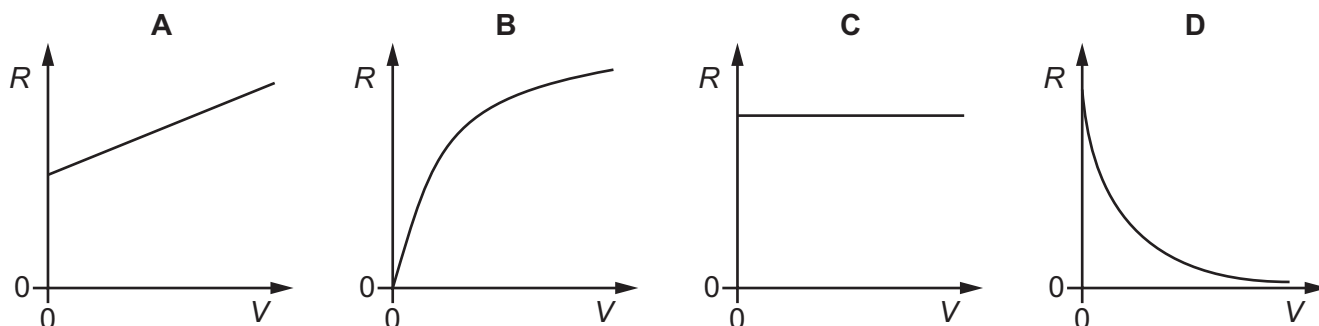
A $A\Omega$

B $Nm^{-1}C^{-1}$

C WA^{-1}

D $(\Omega W)^{\frac{1}{2}}$

33 Which graph could show how the resistance R of a filament lamp varies with the applied potential difference (p.d.) V , as V is increased to the normal operating p.d.?

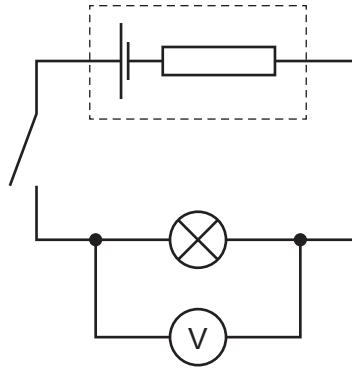


34 Kirchhoff's two laws for electric circuits can be derived by using conservation laws.

On which conservation laws do Kirchhoff's laws depend?

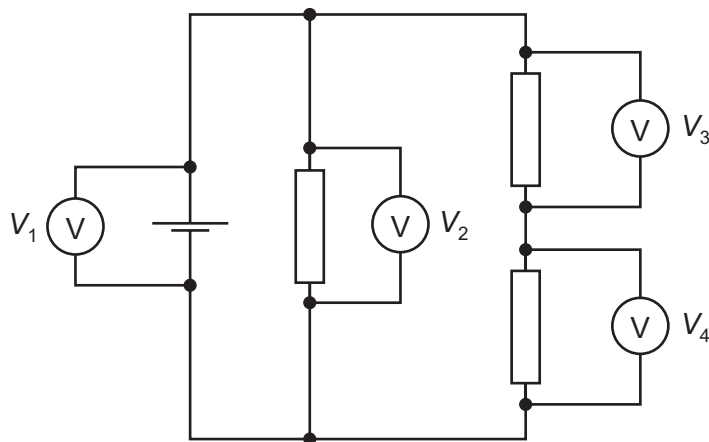
	Kirchhoff's first law	Kirchhoff's second law
A	charge	current
B	charge	energy
C	current	mass
D	energy	current

35 The diagram shows a circuit.



Which statement about the circuit is **not** correct?

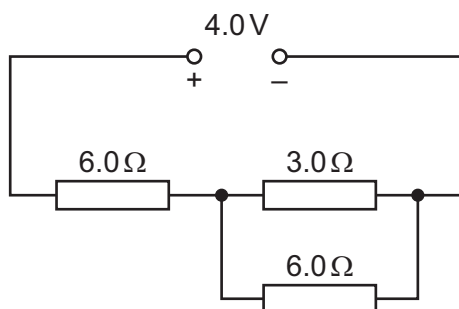
- A Electromotive force is the energy transferred per unit charge.
 - B Energy is transferred from chemical potential energy in the cell to other forms when the switch is closed.
 - C The electromotive force of the cell is greater than the terminal potential difference when the switch is closed.
 - D When the switch is open, the voltmeter measures the electromotive force of the cell.
- 36 The diagram shows a circuit containing four voltmeters. The readings on the voltmeters are V_1 , V_2 , V_3 and V_4 . All the readings are positive.



Which equation relating the voltmeter readings is correct?

- A $V_1 = V_2 + V_4$
- B $V_1 = V_2 + V_3 + V_4$
- C $V_2 + V_3 = V_4$
- D $V_3 + V_4 - V_2 = 0$

- 37 A network consists of a $3.0\ \Omega$ resistor and two $6.0\ \Omega$ resistors, as shown.

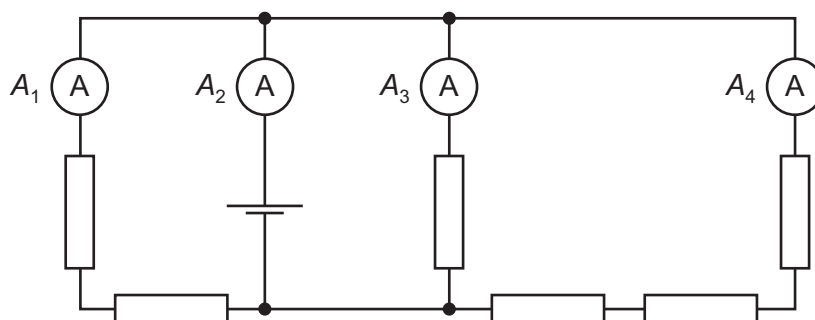


The potential difference (p.d.) across the network is 4.0 V .

What is the current through the $3.0\ \Omega$ resistor?

- A** 0.17 A **B** 0.25 A **C** 0.33 A **D** 1.3 A

- 38 In the circuit shown, all the resistors are identical and all the ammeters have negligible resistance.



The reading A_1 is 0.6 A .

What are the readings on the other ammeters?

	A_2/A	A_3/A	A_4/A
A	1.0	0.3	0.1
B	1.4	0.6	0.2
C	1.8	0.9	0.3
D	2.2	1.2	0.4

- 39 An unstable nucleus of an element decays by emitting an α -particle or a β^- particle to become a nucleus of a different element. This nucleus is also unstable and also emits an α -particle or a β^- particle. The process continues until an isotope of the original element is produced.

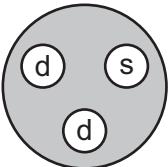
What is the minimum possible number of these particles emitted?

- A** 2 **B** 3 **C** 4 **D** 5

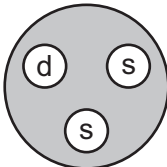
- 40 The diagrams show the quark composition of four different hadrons. One of the hadrons is a Σ^+ particle. It has a charge of $+e$, where e is the elementary charge.

Which hadron could be the Σ^+ particle?

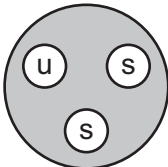
A



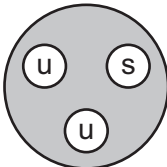
B



C



D



key

u = up quark

d = down quark

s = strange quark

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PHYSICS

9702/12

Paper 1 Multiple Choice

October/November 2019

1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet
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Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.

Any working should be done in this booklet.

Electronic calculators may be used.

This document consists of **18** printed pages and **2** blank pages.

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

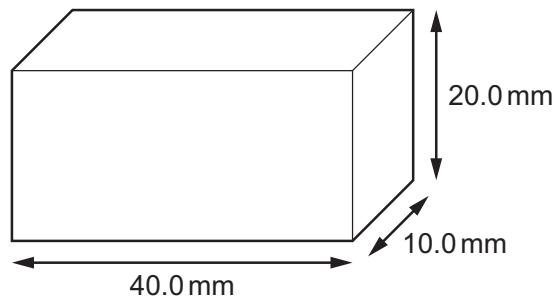
uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

- 1 A cyclist has a speed of 5 m s^{-1} and a small car has a speed of 12 m s^{-1} .

Which statement does **not** give a reasonable estimate?

- A The kinetic energy of the cyclist is $1 \times 10^3 \text{ J}$.
 - B The kinetic energy of the car is $7 \times 10^4 \text{ J}$.
 - C The momentum of the cyclist is $4 \times 10^2 \text{ kg m s}^{-1}$.
 - D The momentum of the car is $2 \times 10^5 \text{ kg m s}^{-1}$.
- 2 Which expression gives an SI base quantity?
- A charge per unit time
 - B force per unit area
 - C mass per unit volume
 - D work done per unit distance
- 3 Which list contains only scalar quantities?
- A area, length, displacement
 - B kinetic energy, speed, power
 - C potential energy, momentum, time
 - D velocity, distance, temperature
- 4 A micrometer is used to measure the 28.50 mm width of a plastic ruler. The micrometer reads to the nearest 0.01 mm.
- What is the correct way to record this reading?
- A $0.02850 \pm 0.01 \text{ m}$
 - B $0.0285 \pm 0.001 \text{ m}$
 - C $(2.850 \pm 0.001) \times 10^{-2} \text{ m}$
 - D $(2.850 \pm 0.001) \times 10^{-3} \text{ m}$

- 5 The sides of a wooden block are measured with calipers. The lengths of the sides are measured as 20.0 mm, 40.0 mm and 10.0 mm.



The calipers can measure with an absolute uncertainty of ± 0.1 mm.

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

- A** 0.3% **B** 1.8% **C** 3.8% **D** 30%
- 6 A ball is thrown vertically upwards from ground level and reaches a maximum height of 12.7 m before falling back to ground level.

Assume air resistance is negligible.

What is the total time for which the ball is in the air?

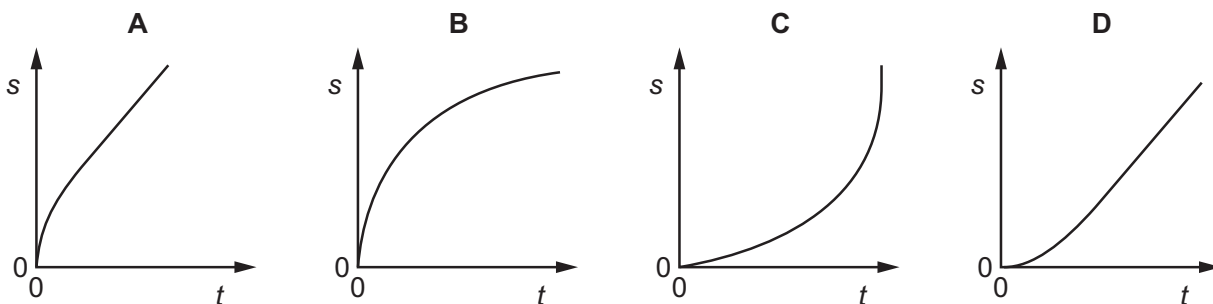
- A** 1.61 s **B** 3.22 s **C** 3.88 s **D** 5.18 s
- 7 A snooker ball has a mass of 200 g. It hits the cushion of a snooker table and rebounds along its original path.

The ball arrives at the cushion with a speed of 14.0 ms^{-1} and then leaves it with a speed of 7.0 ms^{-1} . The ball and the cushion are in contact for a time of 0.60 s.

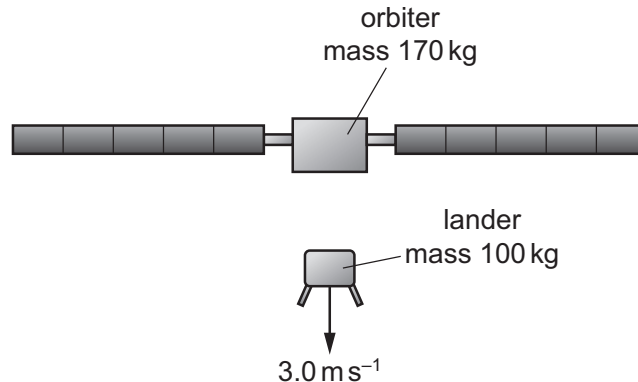
What is the average force exerted on the ball by the cushion?

- A** 1.4 N **B** 2.3 N **C** 4.2 N **D** 7.0 N
- 8 A tennis ball is released from rest at time $t = 0$ and falls through air for a long time.

Which graph of its displacement s against time t best represents the motion of the ball?



- 9 The space probe Rosetta was designed to investigate a comet. The probe consisted of an orbiter and a lander. The orbiter had a mass of 170 kg and the lander had a mass of 100 kg. When the two parts separated, the lander was pushed towards the surface of the comet so that its change in velocity towards the comet was 3.0 m s^{-1} .



Assume that the orbiter and lander were an isolated system.

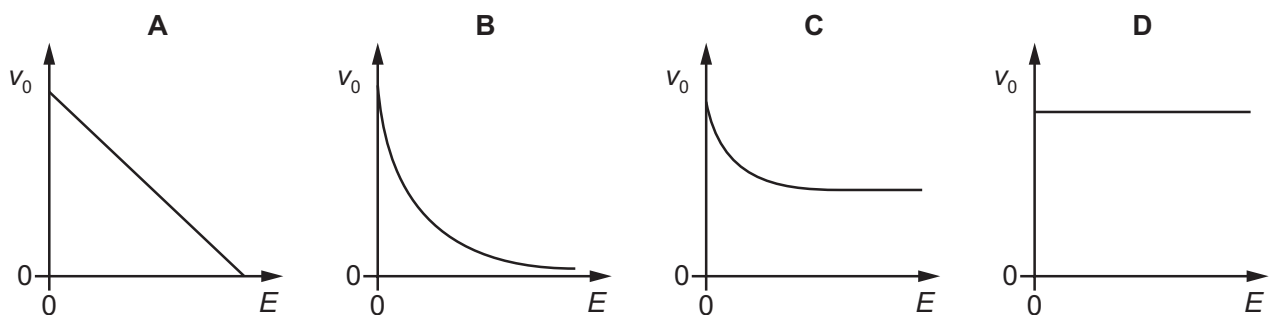
The orbiter moved away from the comet during the separation.

What was the change in the speed of the orbiter?

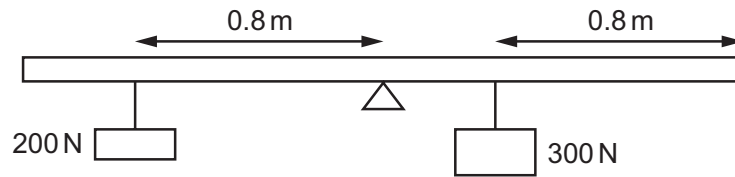
- A** 1.8 m s^{-1} **B** 2.3 m s^{-1} **C** 3.0 m s^{-1} **D** 5.1 m s^{-1}
- 10 A positively charged oil droplet falls in air in a uniform electric field that is vertically upwards. The droplet has a constant terminal speed v_0 and the electric field strength is E .

The magnitude of the force due to air resistance acting on the droplet is proportional to the speed of the droplet.

Which graph shows the variation with E of v_0 ?



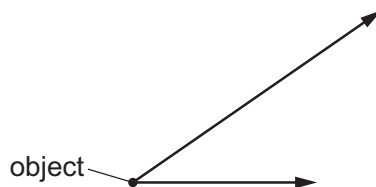
- 11 A rigid uniform bar of length 2.4 m is pivoted horizontally at its midpoint.



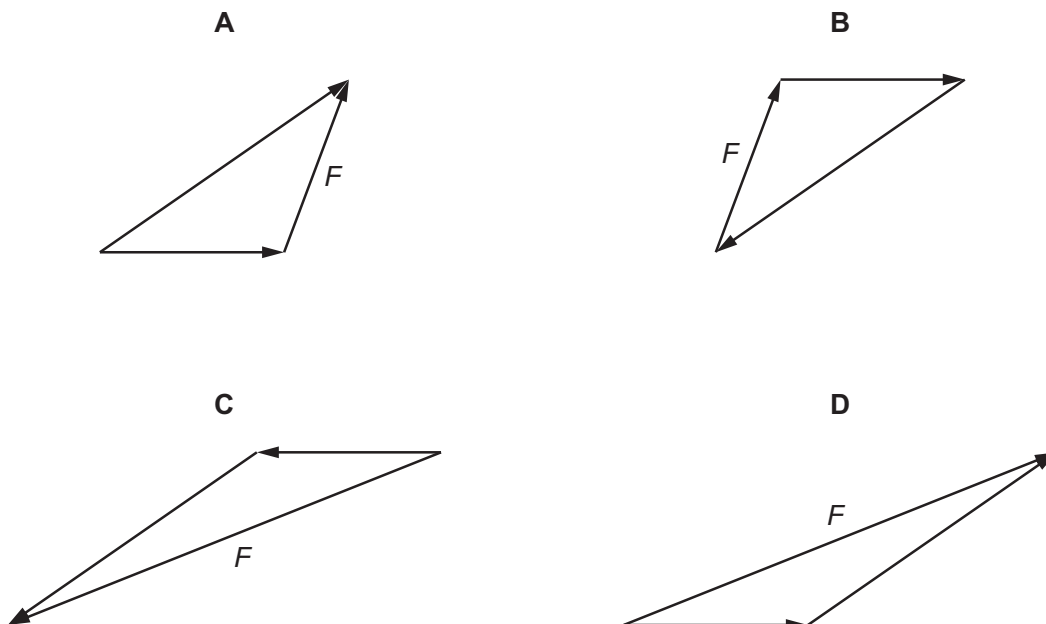
Weights are hung from two points on the bar as shown in the diagram. To maintain equilibrium, a couple is applied to the bar.

What is the torque and direction of this couple?

- A 40 N m clockwise
 - B 40 N m anticlockwise
 - C 80 N m clockwise
 - D 80 N m anticlockwise
- 12 Two coplanar forces act on an object as shown.

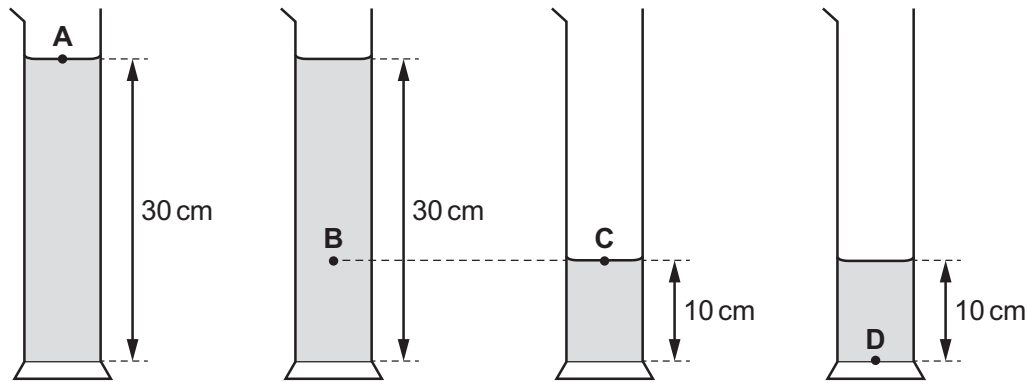


Which diagram shows the resultant F of these two forces?

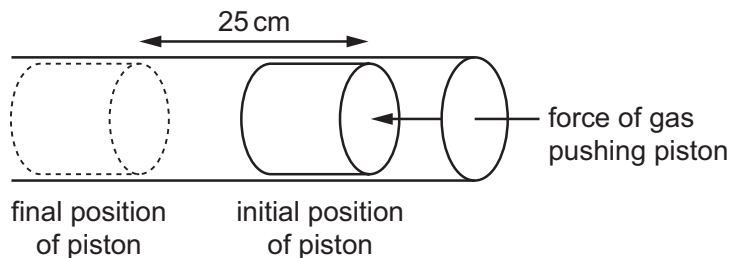


- 13 Four measuring cylinders are filled with the same liquid to the heights shown.

At which position is the pressure the greatest?



- 14 The gas in an engine does work on a piston of cross-sectional area 80 cm^2 . The pressure on the piston has a constant value of $4.6 \times 10^5 \text{ Pa}$.



How much work is done by the gas on the piston when it moves through a distance of 25 cm?

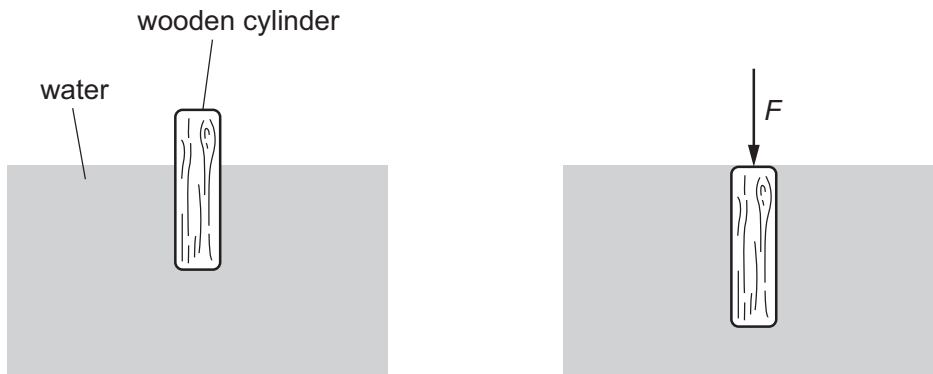
- A $9.2 \times 10^2 \text{ J}$ B $9.2 \times 10^4 \text{ J}$ C $9.2 \times 10^6 \text{ J}$ D $9.2 \times 10^8 \text{ J}$
- 15 A power station using coal as fuel has an average power output of 3000 MW. Coal is supplied by 20 trains each day. The efficiency of the station in converting the thermal energy released from the coal to electrical energy is 26%.

A mass of 1.0 kg of coal will release 33 MJ of thermal energy when burnt.

Which mass of coal does each train bring?

- A $2.5 \times 10^4 \text{ kg}$ B $6.3 \times 10^4 \text{ kg}$ C $1.5 \times 10^6 \text{ kg}$ D $3.0 \times 10^7 \text{ kg}$

- 16 A wooden cylinder floats partially submerged in a bath of water. A force F is applied to the cylinder until it is just fully submerged.

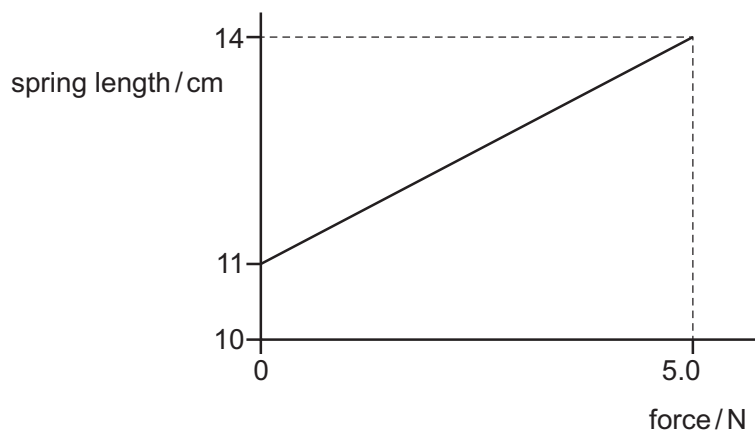


Which statement is **not** correct?

- A Some of the water gains gravitational potential energy.
 - B The cylinder loses gravitational potential energy.
 - C Work is done by force F on the cylinder.
 - D Work is done by the upthrust on the cylinder.
- 17 The motor of a crane lifts a load of mass 600 kg. The load rises vertically at a constant speed of 12 m per minute.

What is the useful power output of the motor?

- A 0.12 kW
 - B 1.2 kW
 - C 7.2 kW
 - D 71 kW
- 18 The graph shows the effect of applying a force of up to 5.0 N to a spring.

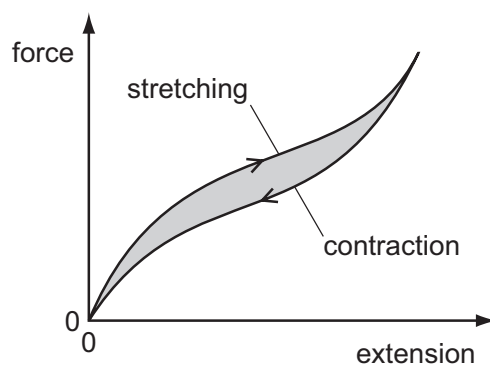
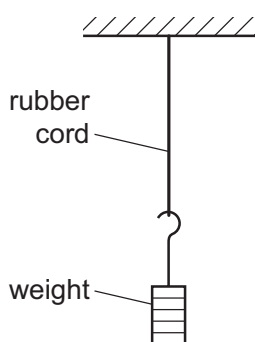


The spring obeys Hooke's law for forces up to 7.0 N.

What is the total extension of the spring produced by a 7.0 N force?

- A 4.2 cm
- B 5.6 cm
- C 15 cm
- D 20 cm

- 19 A rubber cord hangs from a rigid support. A weight attached to its lower end is gradually increased from zero, and then gradually reduced to zero.

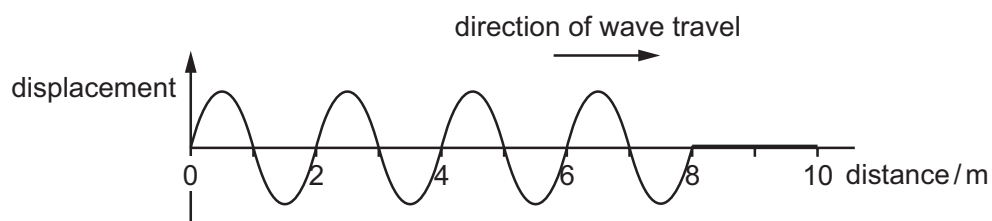


The force–extension curve for contraction is below the force–extension curve for stretching.

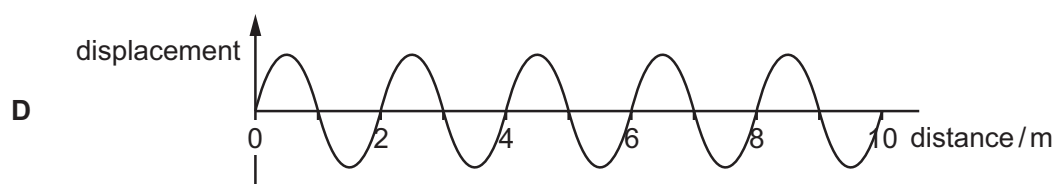
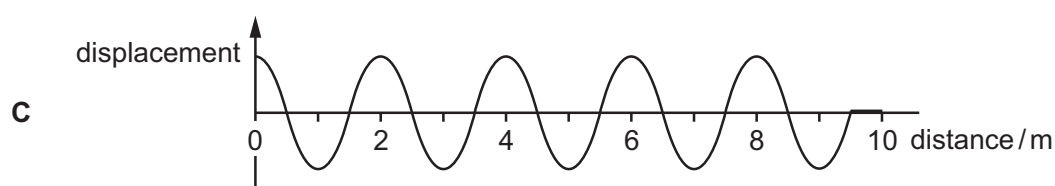
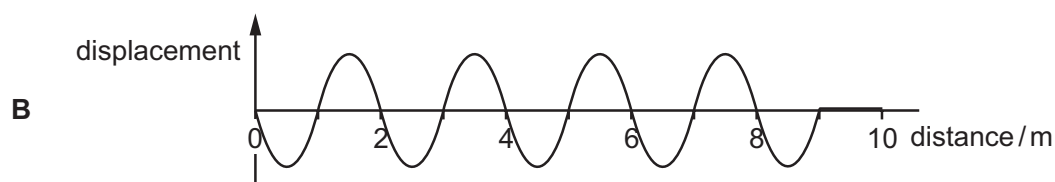
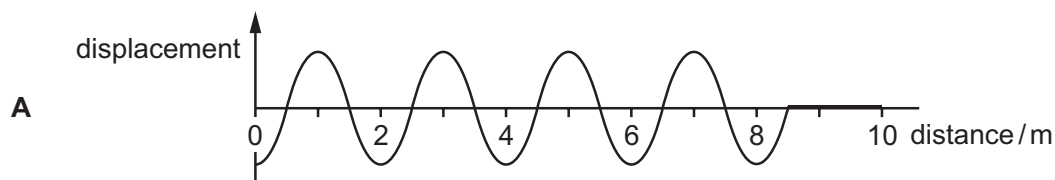
What does the shaded area between the curves represent?

- A the elastic potential energy stored in the rubber cord
- B the thermal energy dissipated in the rubber cord
- C the work done on the rubber cord during stretching
- D the work done by the rubber cord during contraction

- 20** A transverse wave is travelling along a rope. The frequency of the wave is 2.0 Hz . The graph shows the variation with distance of the displacement of the wave at time $t = 0$.

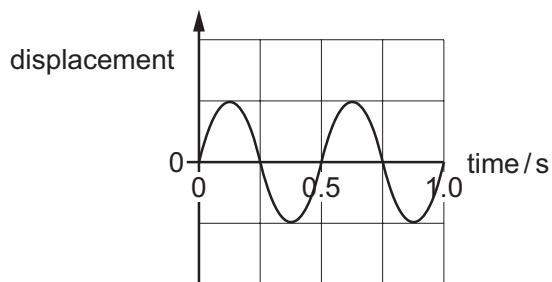


Which diagram shows the position of the wave at time $t = 0.5\text{ s}$?

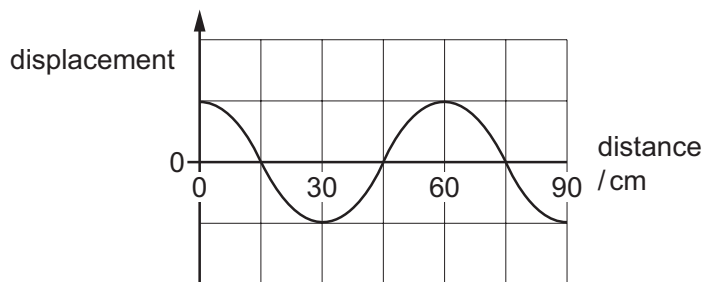


- 21** The two graphs represent the same wave.

Graph 1 shows the variation with time of the displacement at a particular distance. Graph 2 shows the variation with distance of the displacement at one instant.



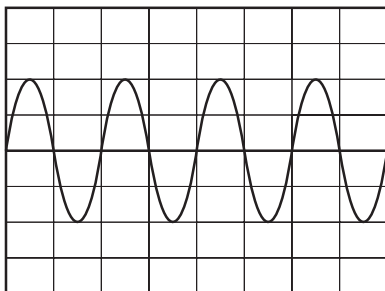
graph 1



graph 2

What is the speed of the wave?

- A** 22.5 cm s^{-1} **B** 30.0 cm s^{-1} **C** 90.0 cm s^{-1} **D** 120 cm s^{-1}
- 22** A microphone is connected to a cathode-ray oscilloscope (CRO). When a tuning fork is struck and then held next to the microphone, the following waveform is shown on the display of the CRO.



The time-base setting on the CRO is 2.00 ms per division.

What is the best estimate of the frequency of the sound produced by the tuning fork?

- A** 63 Hz **B** 170 Hz **C** 250 Hz **D** 500 Hz
- 23** A loudspeaker emitting a constant frequency of 2000 Hz is swung in a horizontal circle with a speed of 15.0 m s^{-1} .

A stationary observer is level with the loudspeaker and situated a long distance from the loudspeaker. The observer hears a sound of varying frequency. The maximum frequency heard is 2097 Hz .

What is the speed of the sound in the air?

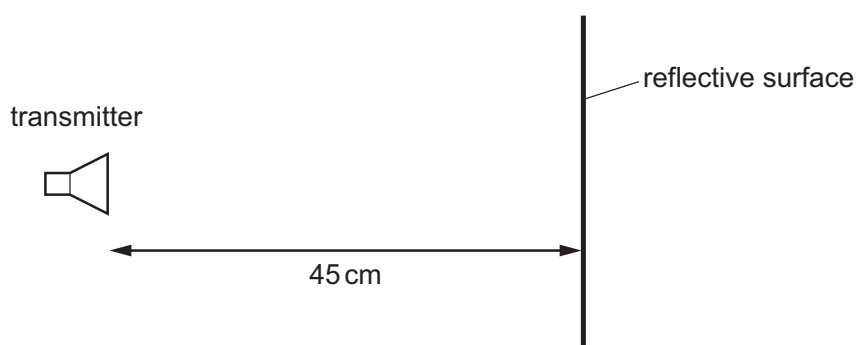
- A** 294 m s^{-1} **B** 309 m s^{-1} **C** 324 m s^{-1} **D** 330 m s^{-1}

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

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

- 25 A transmitter of electromagnetic waves is placed 45 cm from a reflective surface.



The emitted waves have a frequency of 1.00 GHz. A stationary wave is produced with a node at the transmitter and a node at the surface.

How many antinodes are in the space between the transmitter and the surface?

- A** 1 **B** 2 **C** 3 **D** 4
- 26 Which statement about a light wave and a sound wave is correct?

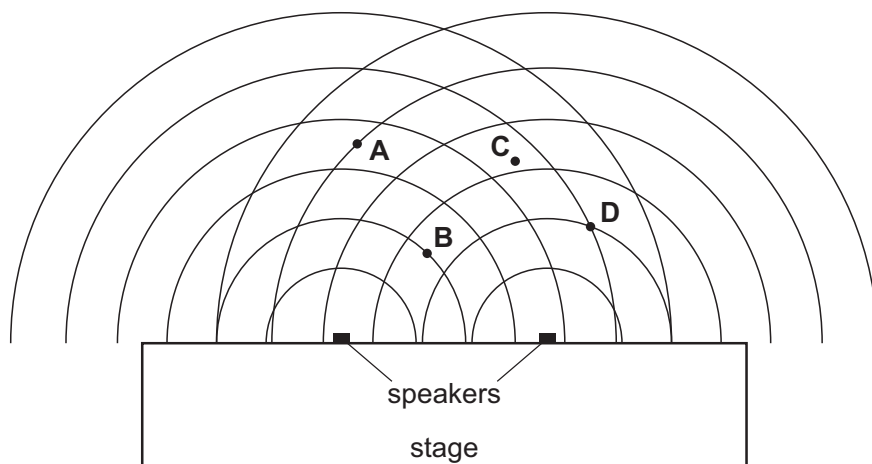
- A** Both can travel through free space.
B Both have a frequency inversely proportional to their wavelength.
C Both have an intensity proportional to their amplitude.
D Both have oscillations perpendicular to the direction of energy transfer.

- 27** An outdoor concert has two large speakers beside the stage for broadcasting music.

In order to test the speakers, they are made to emit sound of the same wavelength and the same amplitude.

The curved lines in the diagram represent wavefronts.

Where is the loudest sound heard?



- 28** An electromagnetic wave is incident normally on a diffraction grating.

A second-order maximum is produced at an angle of 30° to a normal to the grating.

The grating has 5000 lines per cm.

What is the wavelength of the wave?

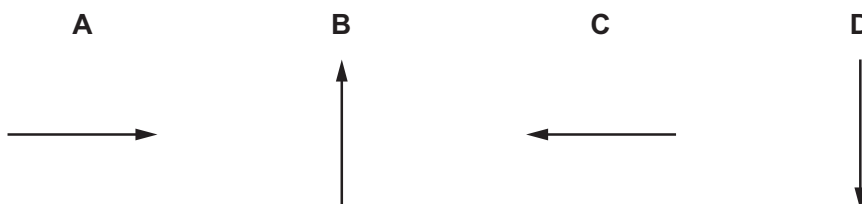
- A** $2.5 \times 10^{-7} \text{ m}$ **B** $5.0 \times 10^{-7} \text{ m}$ **C** $1.0 \times 10^{-6} \text{ m}$ **D** $5.0 \times 10^{-5} \text{ m}$

- 29** P is a point near to charge X as shown.

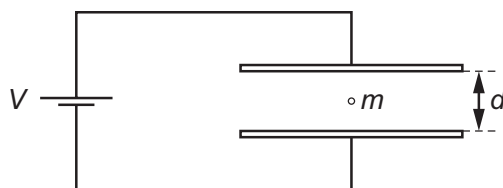


When a negatively charged test charge is placed at point P, it is found to experience a force of repulsion from X that is radially away from X.

Which arrow correctly shows the direction of the electric field at point P due to the charge X?



- 30 A charged oil drop of mass m , with n excess electrons, is held stationary in the uniform electric field between two horizontal plates separated by a distance d .



The voltage between the plates is V , the elementary charge is e and the acceleration of free fall is g .

What is the value of n ?

- A $\frac{eV}{mgd}$ B $\frac{mgd}{eV}$ C $\frac{meV}{gd}$ D $\frac{gd}{meV}$

- 31 When the current in a wire is 5.0 A , the average drift speed of the conduction electrons in the wire is $7.4 \times 10^{-4}\text{ m s}^{-1}$.

Which row gives a possible cross-sectional area and number of conduction electrons per unit volume for this wire?

	cross-sectional area / m^2	number of conduction electrons per unit volume / m^{-3}
A	7.2×10^{-7}	1.2×10^{28}
B	7.2×10^{-7}	5.9×10^{28}
C	2.3×10^{-6}	7.3×10^{26}
D	2.3×10^{-6}	3.7×10^{27}

- 32 A fixed resistor of resistance 12Ω is connected to a battery. There is a current of 0.20 A in the resistor. The current is now doubled.

What is the new power dissipated in the resistor?

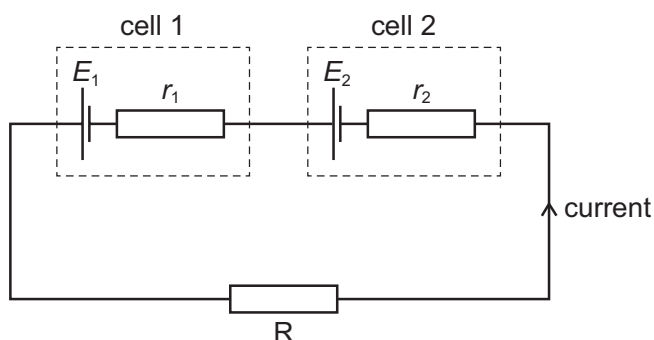
- A 0.48 W B 0.96 W C 1.9 W D 4.8 W

- 33 There is a current in a resistor for an unknown time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

- A the current in the resistor and the potential difference across the resistor
 B the resistance of the resistor and the current in the resistor
 C the total charge passing through the resistor and the potential difference across the resistor
 D the total charge passing through the resistor and the resistance of the resistor

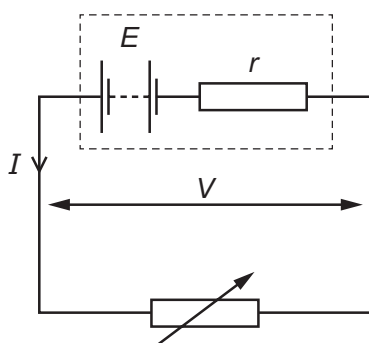
- 34 Two cells with electromotive forces E_1 and E_2 and internal resistances r_1 and r_2 are connected to a resistor R as shown.



The terminal potential difference across cell 1 is zero.

Which expression gives the resistance of resistor R ?

- A $\frac{E_2 r_1 - E_1 r_2}{E_1}$ B $\frac{E_2 r_1 - E_1 r_2}{E_2}$ C $\frac{E_1 r_2 - E_2 r_1}{E_1}$ D $\frac{E_1 r_2 - E_2 r_1}{E_2}$
- 35 A battery has an electromotive force (e.m.f.) E and internal resistance r . The battery delivers a current I to a variable resistor and the potential difference (p.d.) across its terminals is V .

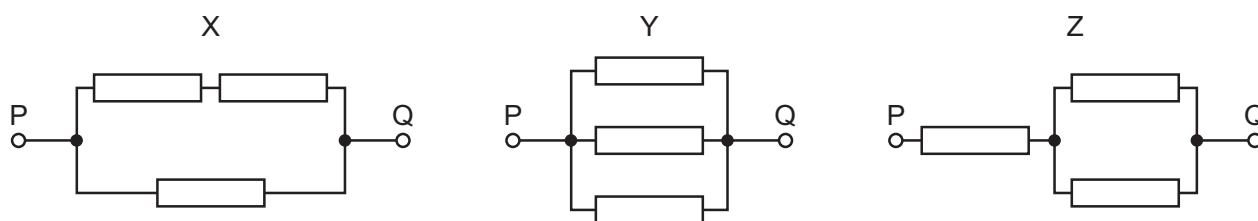


The variable resistor is adjusted so that I increases.

Why does V decrease?

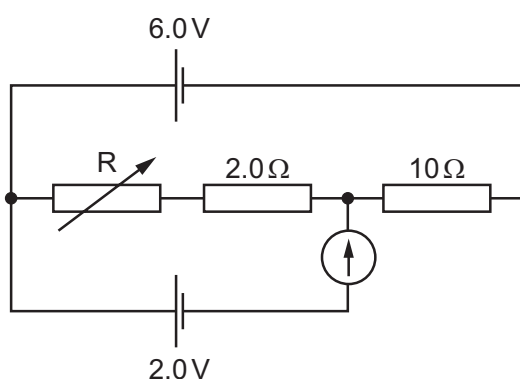
- A The e.m.f. E decreases.
 B The internal resistance r increases.
 C The p.d. across r increases.
 D The resistance of the variable resistor increases.

- 36** Three identical resistors are connected between terminals P and Q in different networks X, Y and Z as shown.



What is the order of increasing combined resistance between P and Q (lowest first)?

- A** $X \rightarrow Y \rightarrow Z$
B $X \rightarrow Z \rightarrow Y$
C $Y \rightarrow X \rightarrow Z$
D $Y \rightarrow Z \rightarrow X$
- 37** The diagram shows a variable resistor R and two fixed resistors connected in series in a circuit to act as a potential divider.



The cell of electromotive force (e.m.f.) 6.0 V has negligible internal resistance. A cell of e.m.f. 2.0 V and a galvanometer are connected into the potential divider. The resistance of R is varied until the galvanometer reads zero.

What is the resistance of resistor R ?

- A** 3.0 Ω **B** 5.0 Ω **C** 8.0 Ω **D** 18 Ω

38 The table gives some data relating to four neutral (uncharged) atoms W, X, Y and Z.

	W	X	Y	Z
nucleon (mass) number	16	17	17	18
total number of particles (protons, neutrons and electrons) in the atom	24	26	25	28

Two of the atoms are isotopes of the same element.

What is the proton number of this element?

- A** 7 **B** 8 **C** 9 **D** 10

39 What is **not** a fundamental particle?

- A** electron
B neutrino
C neutron
D positron

40 An unstable nucleus decays and emits a β^- particle.

Which changes, if any, occur to the quark composition of the nucleus?

	quark changes	
	up quarks	down quarks
A	+1	0
B	+1	-1
C	-1	+1
D	0	+1

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PHYSICS

9702/13

Paper 1 Multiple Choice

October/November 2019

1 hour 15 minutes

Additional Materials: Multiple Choice Answer Sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, centre number and candidate number on the Answer Sheet in the spaces provided unless this has been done for you.

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

1 Which quantity with its unit is correct?

- A acceleration of a bicycle = 1.4 m s^{-1}
- B electric current in a lamp = 0.25 A s^{-1}
- C electric potential difference across a battery = 8.0 J C^{-1}
- D kinetic energy of a car = 4500 N m^{-1}

2 Which two units are **not** equivalent to each other?

- A Nm and $\text{kg m}^2 \text{s}^{-2}$
- B Ns and kg m s^{-1}
- C Js^{-1} and $\text{kg m}^2 \text{s}^{-3}$
- D Pa and kg m s^{-2}

3 The arrow represents a vector R.



Which diagram does **not** represent R as two perpendicular components?

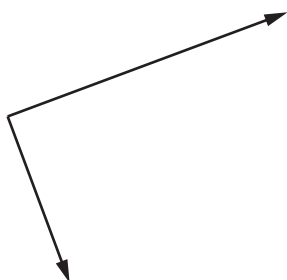
A



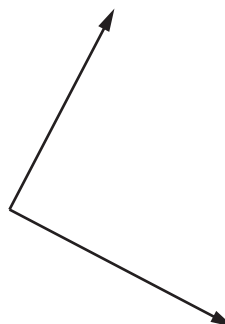
B



C



D



4 What could reduce systematic errors?

- A averaging a large number of measurements
- B careful calibration of measuring instruments
- C reducing the sample size
- D repeating measurements

5 The power loss P in a resistor is calculated using the formula $P = \frac{V^2}{R}$.

The percentage uncertainty in the potential difference V is 3% and the percentage uncertainty in the resistance R is 2%.

What is the percentage uncertainty in P ?

- A 4% B 7% C 8% D 11%

6 A lead sphere is released from rest at point X, a long way above the surface of a planet. The sphere falls in a vacuum. After a time of 4.0 s, it has fallen through a vertical distance of 3.0 m. Assume the acceleration of free fall is constant.

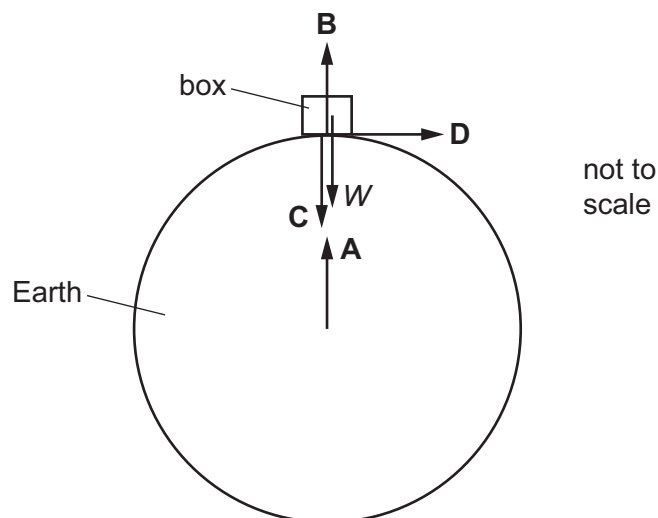
How far will the sphere have fallen from point X at a time of 20 s after its release?

- A 15 m B 75 m C 80 m D 2000 m

7 A box rests on the Earth, as shown.

Newton's third law describes how forces of the same type act in pairs. One of the forces of a pair is the weight W of the box.

Which arrow represents the other force of this pair?



- 8 A snowflake is falling from the sky on a still day. Its weight acts vertically downwards and air resistance acts vertically upwards. As the snowflake falls, air resistance increases until it is equal to the weight and there is no resultant force acting on the snowflake.



When the forces become equal, which statement is correct?

- A The snowflake accelerates.
 - B The snowflake decelerates.
 - C The snowflake is stationary.
 - D The snowflake moves at a constant velocity.
- 9 Two objects X and Y in an isolated system undergo a perfectly elastic collision. The velocities of the objects before and after the collision are shown.



What is the speed v of Y after the collision?

- A 2.0 ms^{-1}
- B 18 ms^{-1}
- C 22 ms^{-1}
- D 24 ms^{-1}

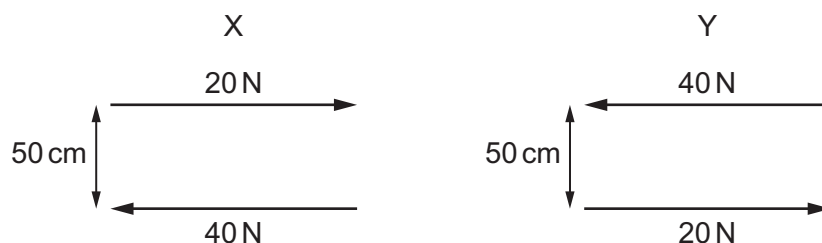
- 10** A solid sphere, which is less dense than water, is held completely immersed in water a few metres below the surface. The density of the water is uniform.

The sphere is released. Immediately after release, the sphere rises.

Which row correctly describes the changes in the upthrust on the sphere and the resultant force on the sphere?

	upthrust on the sphere	resultant force on the sphere
A	constant	increasing
B	constant	decreasing
C	decreasing	increasing
D	decreasing	decreasing

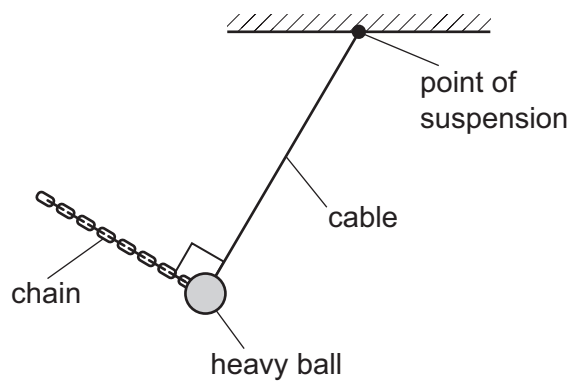
- 11** The diagram shows two pairs X and Y of parallel forces.



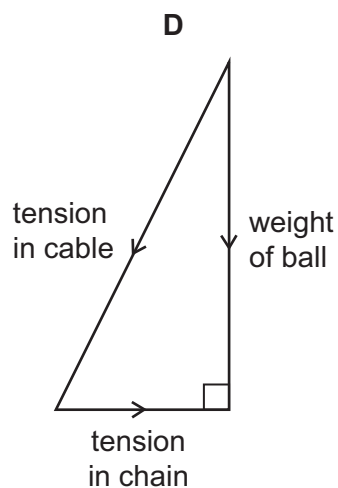
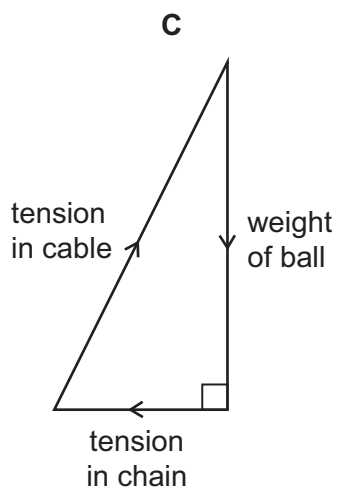
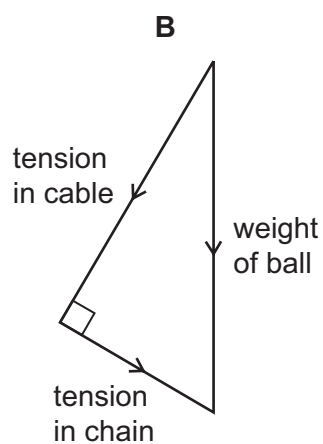
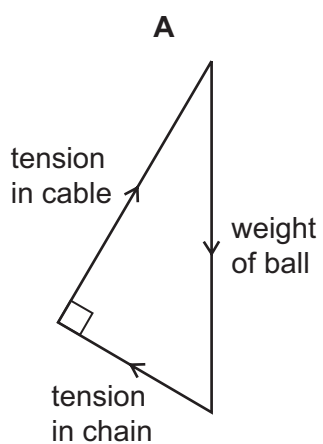
Which statement is correct?

- A** X is equivalent to a clockwise torque of 10 N m and a force of 20 N to the left.
B X is equivalent to a clockwise torque of 20 N m only.
C Y is equivalent to an anticlockwise torque of 30 N m and a force of 20 N to the left.
D Y is equivalent to an anticlockwise torque of 30 N m only.

12 A heavy ball hanging from a cable is held in equilibrium by a chain, as shown.



Which vector diagram shows the three forces acting on the ball?



- 13 At sea level, atmospheric pressure is 100 kPa and the density of air is 1.3 kg m^{-3} .

Assume that the density of air decreases linearly with height above sea level.

What is an estimate of the total height of the atmosphere based on this information?

- A** 7.8 km **B** 16 km **C** 77 km **D** 150 km

- 14 Trains supply coal to a power station. The table shows quantities describing the operation of the power station.

	symbol	unit
power station average output	P	W
number of trains per day	N	
mass of coal on a train	M	kg
energy from 1 kg of coal	E	J
number of seconds in one day	S	

Which expression gives the efficiency of the power station?

- A** $\frac{PS}{NME}$ **B** $\frac{PSN}{ME}$ **C** $\frac{NME}{PS}$ **D** $\frac{NM}{PSE}$

- 15 A piston in a gas supply pump has an area of 500 cm^2 and it moves a distance of 30 cm.

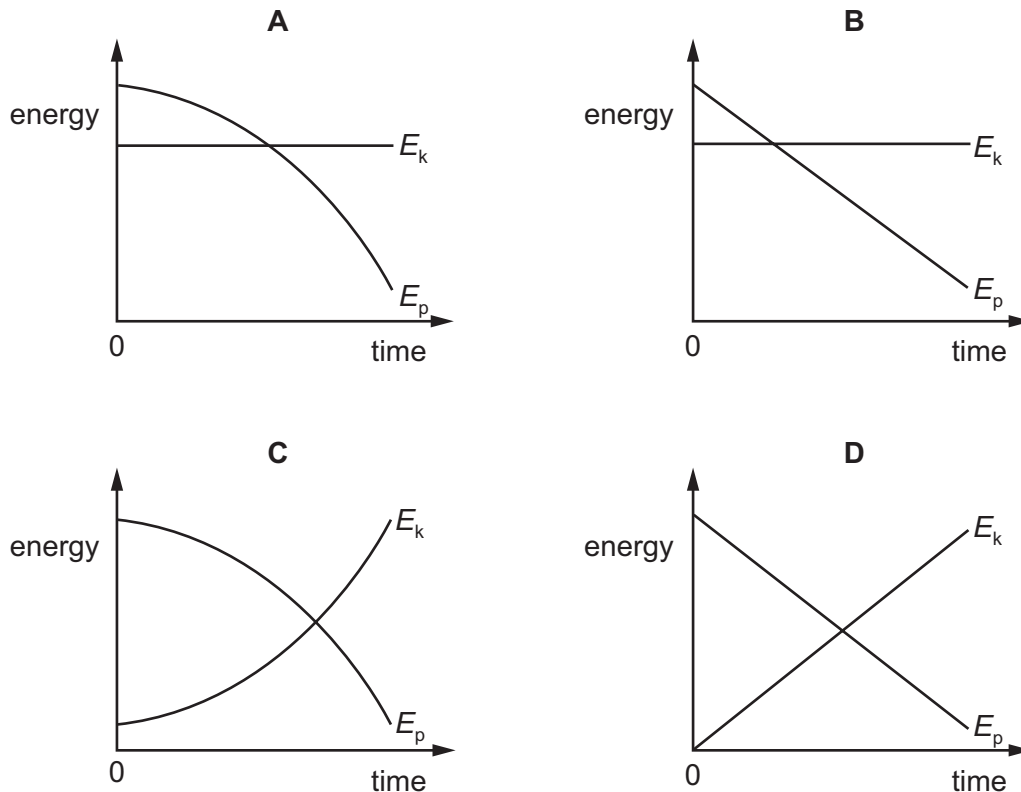
The pump moves the gas against a fixed pressure of 4000 Pa.

How much work is done by the piston?

- A** 60 J **B** $6.0 \times 10^3 \text{ J}$ **C** $6.0 \times 10^5 \text{ J}$ **D** $6.0 \times 10^7 \text{ J}$

- 16 A steel ball is falling at constant speed in oil.

Which graph shows the variation with time of the gravitational potential energy E_p and the kinetic energy E_k of the ball?



- 17 The maximum useful output power of a car travelling on a horizontal road is P . The total resistive force acting on the car is kv^2 , where v is the speed of the car and k is a constant.

Which equation is correct when the car is travelling at maximum speed?

A $v^3 = \frac{P}{k}$
 B $v^2 = \frac{P}{k}$
 C $v = \left(\frac{P}{k}\right)^2$
 D $v = \left(\frac{P}{k}\right)^3$

- 18 Initially, four identical uniform blocks, each of mass m and thickness h , are spread on a table.

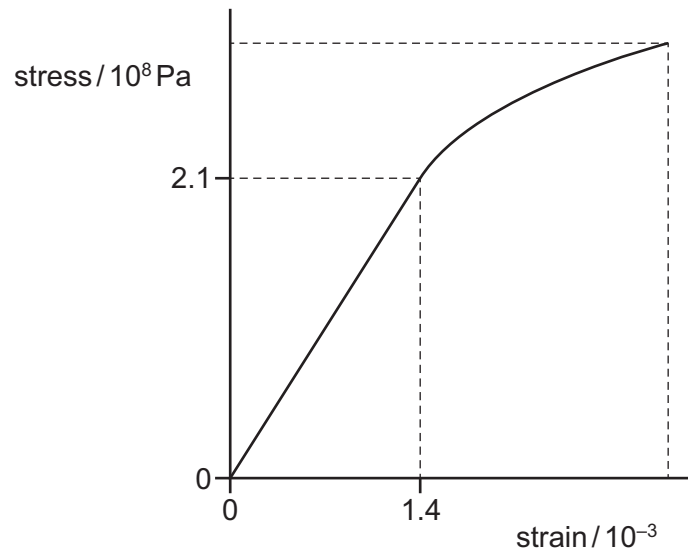


The acceleration of free fall is g .

How much work is done on the blocks in stacking them on top of one another?

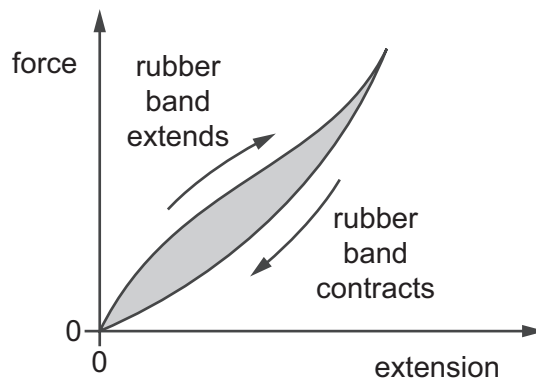
A $3mgh$
 B $6mgh$
 C $8mgh$
 D $10mgh$

- 19 The stress–strain graph for a wire is shown.



What is the Young modulus of the material of the wire?

- A $6.7 \times 10^{-12} \text{ Pa}$
 - B $6.7 \times 10^{-9} \text{ Pa}$
 - C $1.5 \times 10^8 \text{ Pa}$
 - D $1.5 \times 10^{11} \text{ Pa}$
- 20 The diagram shows a force–extension graph for a rubber band as the band is extended and then the stretching force is decreased to zero.



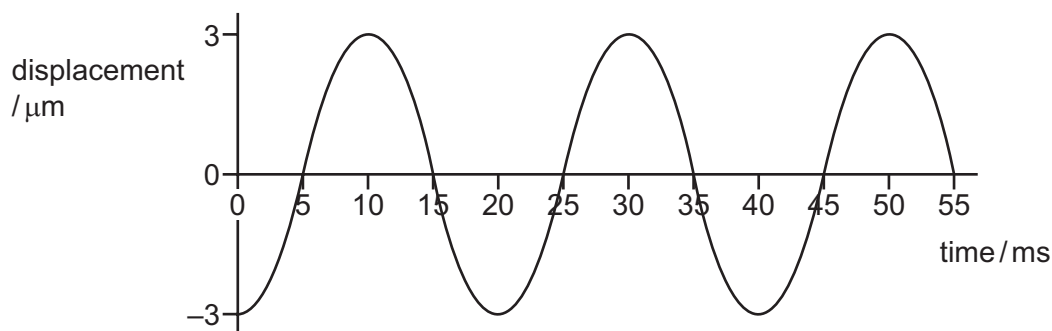
What can be deduced from the graph?

- A The rubber band does not return to its original length when the force is decreased to zero.
- B The rubber band obeys Hooke's law for the extensions shown.
- C The rubber band remains elastic for the extensions shown.
- D The shaded area represents the work done in extending the rubber band.

21 Which statement about light waves and sound waves is **not** correct?

- A Light waves and sound waves can both demonstrate the Doppler effect.
- B Light waves are transverse waves and sound waves are longitudinal waves.
- C Light waves can be diffracted but sound waves cannot.
- D Light waves can travel in a vacuum but sound waves cannot.

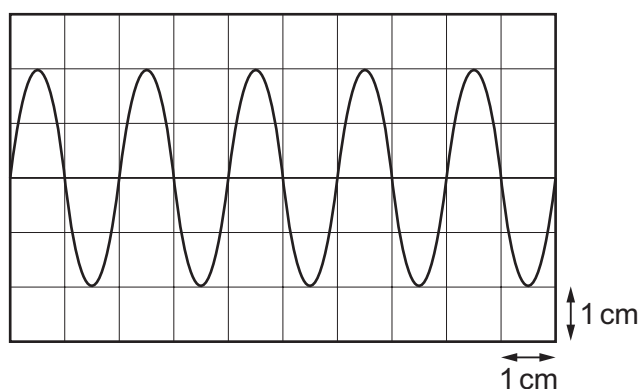
22 The graph represents a sound wave.



Which statement is correct?

- A The wave is longitudinal and has a period of 25 ms.
- B The wave is longitudinal and has a frequency of 50 Hz.
- C The wave is transverse and has an amplitude of $3\ \mu\text{m}$.
- D The wave is transverse and has a wavelength of 20 ms.

23 A cathode-ray oscilloscope (CRO) is used to display a wave of frequency $5.0\ \text{kHz}$. The display is shown.



What is the time-base setting of the CRO?

- A $10\ \mu\text{s cm}^{-1}$
- B $100\ \mu\text{s cm}^{-1}$
- C $10\ \text{ms cm}^{-1}$
- D $100\ \text{ms cm}^{-1}$

- 24** A siren emits sound of frequency 1000 Hz. The siren moves at 20 m s^{-1} towards an observer who is standing still.

The speed of sound in the air is 330 m s^{-1} .

Which expression would correctly give the frequency heard by the observer?

- A** $\frac{1000 \times 330}{330 + 20}$
- B** $\frac{1000 \times 330}{330 - 20}$
- C** $\frac{1000 (330 + 20)}{330}$
- D** $\frac{1000 (330 - 20)}{330}$

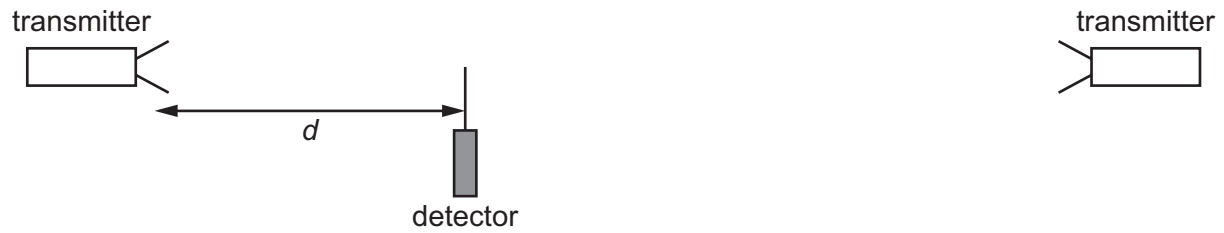
- 25** A source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

$$I = \frac{P}{4\pi r^2}.$$

How does the amplitude a of the vibrating air molecules vary with the distance r from the source?

- A** $a \propto \frac{1}{r}$ **B** $a \propto \frac{1}{r^2}$ **C** $a \propto r$ **D** $a \propto r^2$

- 26 In an experiment to demonstrate a stationary wave, two microwave transmitters, emitting waves of wavelength 4 cm, are set facing each other, as shown.



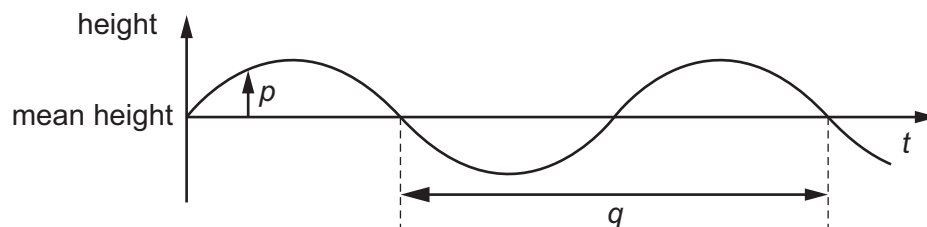
A detector is moved along a straight line between the transmitters. It detects positions of maximum and minimum signal. The detector is a distance d from the left-hand transmitter.

Assume that both transmitters are at antinodes of the stationary wave.

Which row gives a value of d for a maximum and for a minimum?

	value of d for a maximum / cm	value of d for a minimum / cm
A	46	48
B	47	48
C	48	47
D	49	47

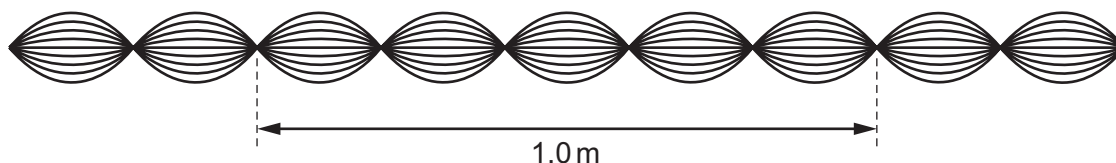
- 27 The graph shows how the height of the water surface at a point in a harbour varies with time t as waves pass the point.



What are p and q ?

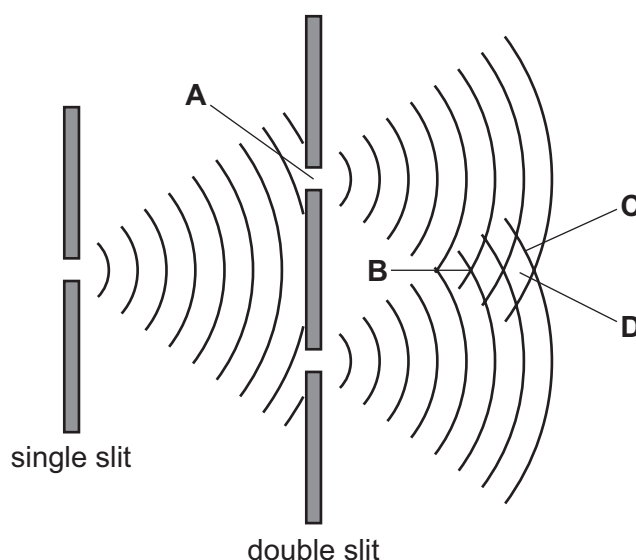
	p	q
A	displacement	period
B	displacement	wavelength
C	amplitude	period
D	amplitude	wavelength

- 28 The diagram shows a sketch of a wave pattern over a short period of time.



Which description of this wave is correct?

- A The wave is longitudinal, has a wavelength of 20 cm and is stationary.
 - B The wave is transverse, has a wavelength of 20 cm and is stationary.
 - C The wave is transverse, has a wavelength of 40 cm and is progressive.
 - D The wave is transverse, has a wavelength of 40 cm and is stationary.
- 29 The double-slit experiment demonstrates interference between two coherent sources of light waves. In the diagram, the curved lines represent wavefronts.

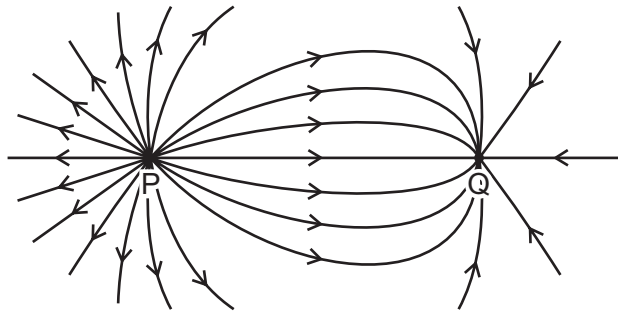


- 30 Light of wavelength 567 nm is incident normally on a diffraction grating. The grating has 400 lines per mm. A number of diffraction maxima are observed on the far side of the grating.

What is the angle between the second-order maximum and the third-order maximum?

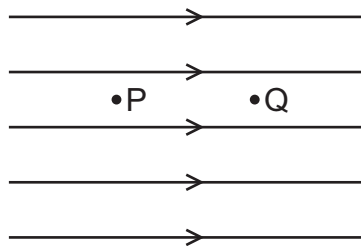
- A 13.1°
- B 13.9°
- C 15.9°
- D 27.0°

- 31 The diagram shows the electric field pattern between two opposite and unequal point charges P and Q.



Which statement about the charges is correct?

- A P is negatively charged and has a smaller charge than Q.
 - B P is negatively charged and has a greater charge than Q.
 - C P is positively charged and has a smaller charge than Q.
 - D P is positively charged and has a greater charge than Q.
- 32 A uniform electric field is represented by five horizontal field lines.



P and Q are two points in the field. The field causes a positively charged particle in a vacuum to move from P to Q.

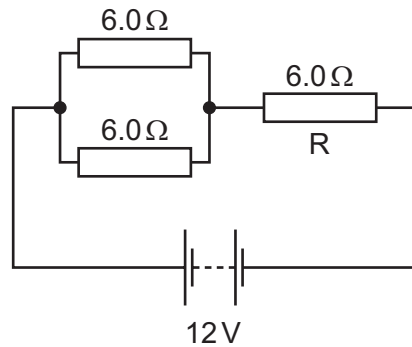
Which statement must be correct?

- A The acceleration of the particle between P and Q is increasing.
 - B The kinetic energy of the particle at P is the same as the kinetic energy of the particle at Q.
 - C The force on the particle at Q is greater than the force on the particle at P.
 - D Work is done on the particle as it moves from P to Q.
- 33 A metal electrical conductor has a resistance of $5.6\text{ k}\Omega$. A potential difference (p.d.) of 9.0 V is applied across its ends.

How many electrons pass a point in the conductor in one minute?

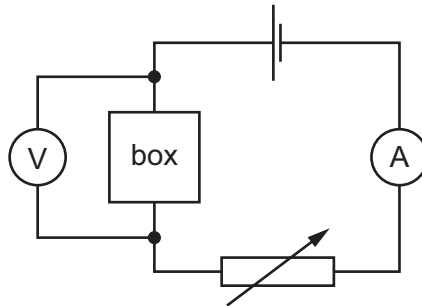
- A 6.0×10^{20}
- B 1.0×10^{19}
- C 6.0×10^{17}
- D 1.0×10^{16}

- 34 A battery of electromotive force (e.m.f.) 12 V and negligible internal resistance is connected to three resistors, each of resistance $6.0\ \Omega$, as shown.

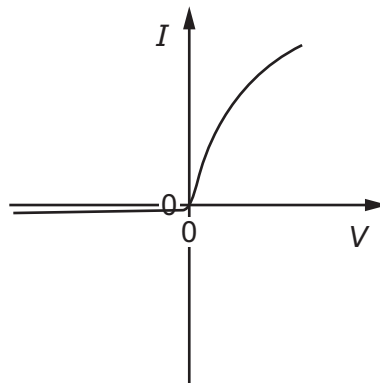


What is the power dissipated in resistor R?

- A 2.7 W B 6.0 W C 11 W D 24 W
- 35 A box containing two electrical components is connected into a circuit.



The variable resistor is adjusted and measurements are taken to determine the I – V characteristic for the box, as shown.



Which arrangement of two electrical components in the box would create the best fit to the measured I – V characteristic?

- A a filament lamp and a fixed resistor in parallel
 B a filament lamp and a fixed resistor in series
 C a semiconductor diode and a filament lamp in parallel
 D a semiconductor diode and a filament lamp in series

- 36** A cell of internal resistance 0.5Ω is connected to a fixed resistor of resistance 10Ω .

The resistance of the resistor is changed to 20Ω .

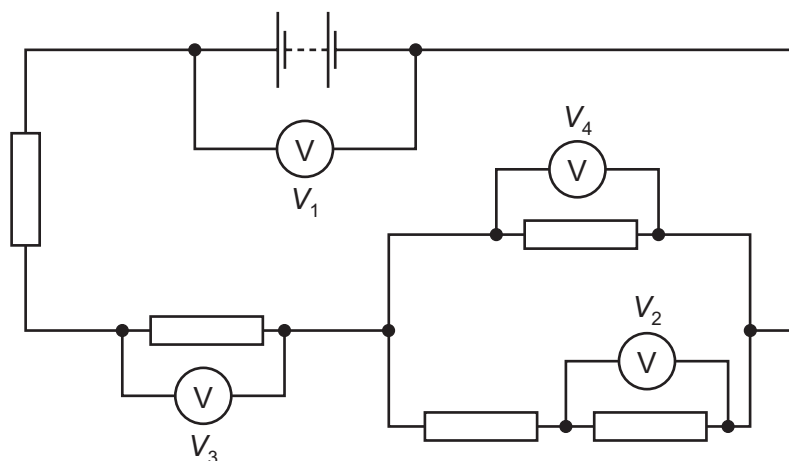
Which statement is **not** correct?

- A** The current in the circuit will halve.
- B** The e.m.f. of the cell will remain constant.
- C** The power dissipated by the fixed resistor will decrease.
- D** The terminal p.d. of the cell will increase.

- 37** Which row correctly describes Kirchhoff's laws?

	Kirchhoff's first law	physics principle applied for first law	Kirchhoff's second law	physics principle applied for second law
A	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy
B	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge
C	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of energy	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of charge
D	The sum of the e.m.f.s around any closed loop in a circuit equals the sum of the p.d.s around the same loop.	conservation of charge	The sum of the currents entering a junction equals the sum of the currents leaving the junction.	conservation of energy

38 In the circuit shown, all the resistors are identical.



The reading V_1 is 8.0 V and the reading V_2 is 1.0 V.

What are the readings on the other voltmeters?

	V_3 /V	V_4 /V
A	1.5	1.0
B	3.0	2.0
C	4.5	3.0
D	6.0	4.0

39 A radioactive nucleus emits an α -particle or a β^- particle, creating a product nucleus.

Which decay could create the product nucleus stated?

	radioactive nucleus	decay	product nucleus
A	${}^{226}_{88}\text{Ra}$	α	${}^{224}_{86}\text{Rn}$
B	${}^{238}_{92}\text{U}$	α	${}^{242}_{94}\text{Pu}$
C	${}^{228}_{88}\text{Ra}$	β^-	${}^{228}_{87}\text{Fr}$
D	${}^{231}_{90}\text{Th}$	β^-	${}^{231}_{91}\text{Pa}$

40 Which statement is correct?

- A** Electrons and neutrinos are fundamental particles.
- B** Electrons and neutrinos are hadrons.
- C** Protons and neutrons are leptons.
- D** Protons and neutrons are quarks.

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