

PHYSICS

9702/11

Paper 1 Multiple Choice

October/November 2017

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 **19** printed pages and **1** blank page.



Data

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

Formulae

uniformly accelerated motion

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

work done on/by a gas

$$W = p\Delta V$$

gravitational potential

$$\phi = -\frac{Gm}{r}$$

hydrostatic pressure

$$p = \rho gh$$

pressure of an ideal gas

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

simple harmonic motion

$$a = -\omega^2 x$$

velocity of particle in s.h.m.

$$v = v_0 \cos \omega t$$

$$v = \pm \omega \sqrt{(x_0^2 - x^2)}$$

Doppler effect

$$f_o = \frac{f_s v}{v \pm v_s}$$

electric potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

capacitors in series

$$1/C = 1/C_1 + 1/C_2 + \dots$$

capacitors in parallel

$$C = C_1 + C_2 + \dots$$

energy of charged capacitor

$$W = \frac{1}{2} QV$$

electric current

$$I = Anvq$$

resistors in series

$$R = R_1 + R_2 + \dots$$

resistors in parallel

$$1/R = 1/R_1 + 1/R_2 + \dots$$

Hall voltage

$$V_H = \frac{BI}{ntq}$$

alternating current/voltage

$$x = x_0 \sin \omega t$$

radioactive decay

$$x = x_0 \exp(-\lambda t)$$

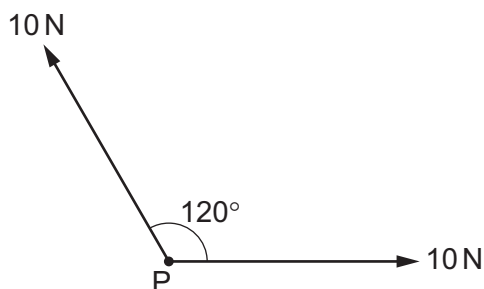
decay constant

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

1 Which SI unit, expressed in base units, is **not** correct?

- A unit of force, kg m s^{-2}
- B unit of momentum, kg m s^{-1}
- C unit of pressure, $\text{kg m}^{-2} \text{s}^{-2}$
- D unit of work, $\text{kg m}^2 \text{s}^{-2}$

2 Two forces, each of 10 N, act at a point P as shown. The angle between the directions of the forces is 120° .



What is the magnitude of the resultant force?

- A 5 N B 10 N C 17 N D 20 N

3 An ion is accelerated in a vacuum by a series of electrodes. A graph of the power supplied to the ion is plotted against time.

What is represented by the area under the graph between two times?

- A the average force on the ion
- B the change in kinetic energy of the ion
- C the change in momentum of the ion
- D the change in velocity of the ion

4 What is a typical value of the wavelength of a microwave travelling in a vacuum?

- A 3 000 000 pm
- B 30 nm
- C 30 000 μm
- D 3000 mm

- 5 A double-slit interference experiment is used to determine the wavelength of light from a monochromatic source.

The following measurements are used.

$$\text{slit separation } a = 0.50 \pm 0.02 \text{ mm}$$

$$\text{fringe separation } x = 1.7 \pm 0.1 \text{ mm}$$

$$\text{distance between slits and screen } D = 2.000 \pm 0.002 \text{ m}$$

What is the percentage uncertainty in the calculated wavelength?

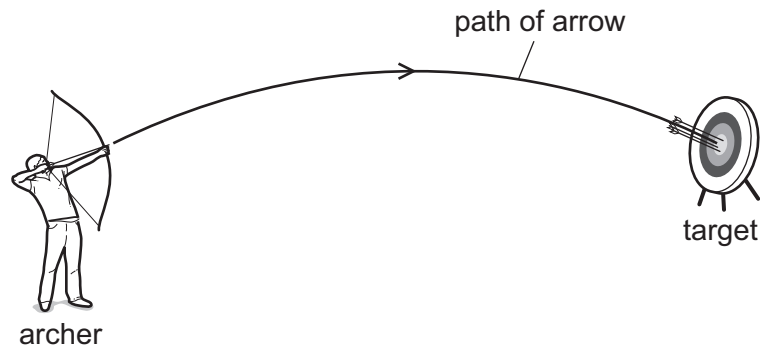
- A** 0.1% **B** 1% **C** 6% **D** 10%

- 6 In still air, a bird can fly at a speed of 10 m s^{-1} . The wind is blowing from the east at 8.0 m s^{-1} .

In which direction must the bird fly in order to travel to a destination that is due north of the bird's current location?

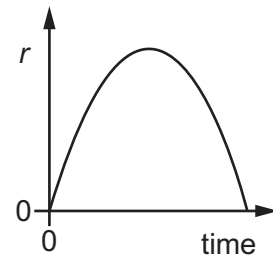
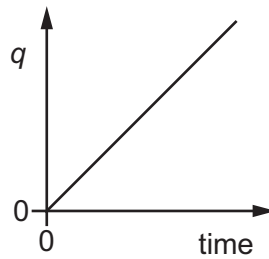
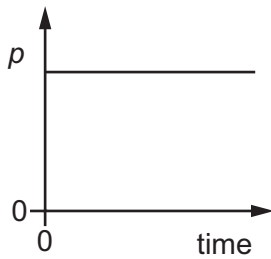
- A** 37° east of north
B 37° west of north
C 53° east of north
D 53° west of north

- 7 An archer shoots an arrow at a target. The diagram shows the path of the arrow.



Air resistance is assumed to be negligible.

The graphs show how three different quantities p , q and r , relating to the motion of the arrow, vary with time.



Which quantity is the horizontal component of displacement and which quantity is the vertical component of displacement of the arrow?

	horizontal component of displacement	vertical component of displacement
A	p	q
B	q	r
C	r	p
D	r	q

- 8 The three forces acting on a hot-air balloon that is moving vertically are its weight, the force due to air resistance and the upthrust force.

The hot-air balloon descends vertically at constant speed. The force of air resistance on the balloon is F .

Which weight of material must be released from the balloon so that it ascends vertically at the same constant speed?

- A** F **B** $2F$ **C** $3F$ **D** $4F$

- 9 A car is moving at constant speed in a straight line with the engine providing a driving force equal to the resistive force F .

When the engine is switched off, the car is brought to rest in a distance of 100 m by the resistive force.

It may be assumed that F is constant during the deceleration.

The process is then repeated for the same car with the same initial speed but with a constant resistive force of $0.800 F$.

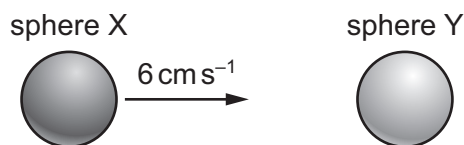
How far will the car travel while decelerating?

- A 120 m B 125 m C 156 m D 250 m

- 10 What is a statement of the principle of conservation of momentum?

- A In an elastic collision momentum is constant.
B Momentum is the product of mass and velocity.
C The force acting on a body is proportional to its rate of change of momentum.
D The momentum of an isolated system is constant.

- 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.



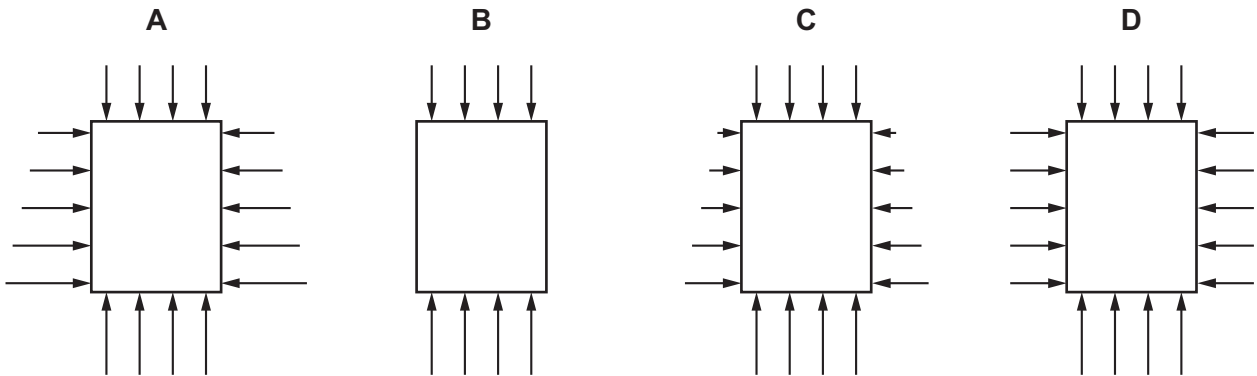
The spheres have a perfectly elastic collision. After the collision, sphere X moves with speed 2 cm s^{-1} in the same direction as before the collision.

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}

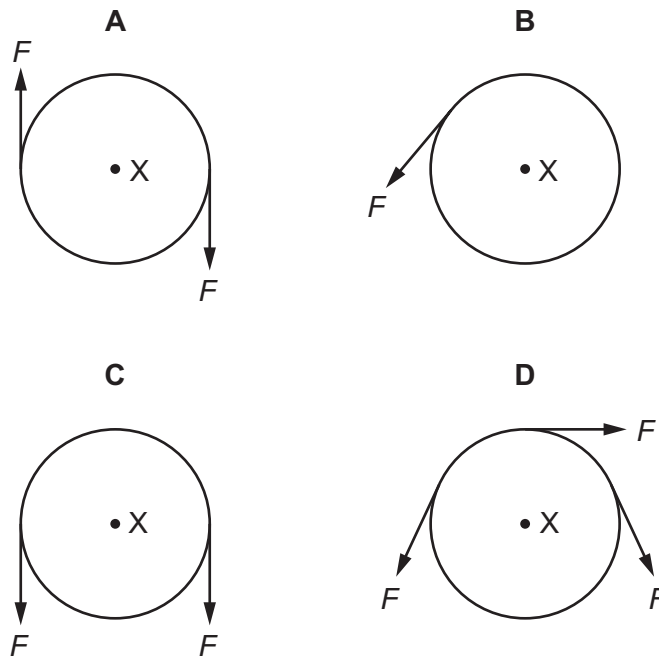
- 12 A block is submerged vertically in a liquid. The four diagrams show, to scale, the forces exerted by the liquid on the block.

Which diagram correctly shows a possible situation as viewed from the side?

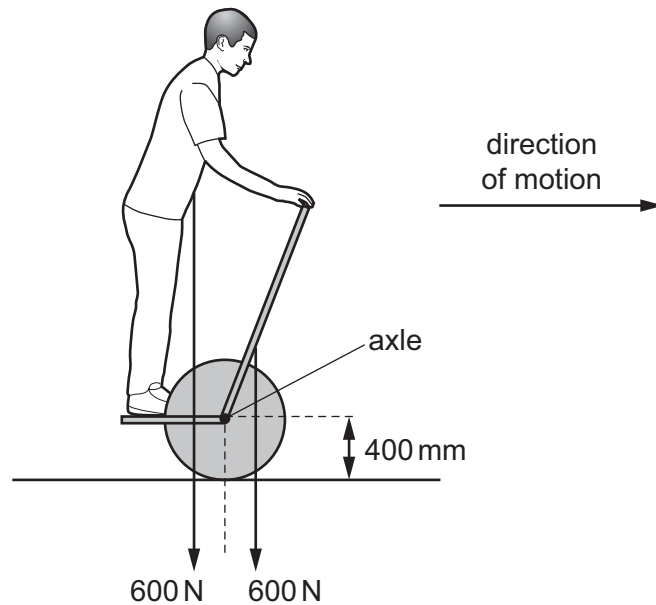


- 13 A rigid circular disc of radius r has its centre at X . A number of forces of equal magnitude F act at the edge of the disc. All the forces are in the plane of the disc.

Which arrangement of forces provides a moment of magnitude $2Fr$ about X ?



- 14 The diagram shows a motorised vehicle for carrying one person.



The vehicle has two wheels on one axle. The passenger stands on a platform between the wheels.

The weight of the machine is 600 N. Its centre of mass is 200 mm in front of the axle. The wheel radius is 400 mm.

When stationary, a passenger of weight 600 N stands with his centre of mass 200 mm behind the axle to balance the machine.

The motor is now switched on to provide a horizontal force of 90 N at the ground to move the vehicle forwards.

How far and in which direction must the passenger move his centre of mass to maintain balance?

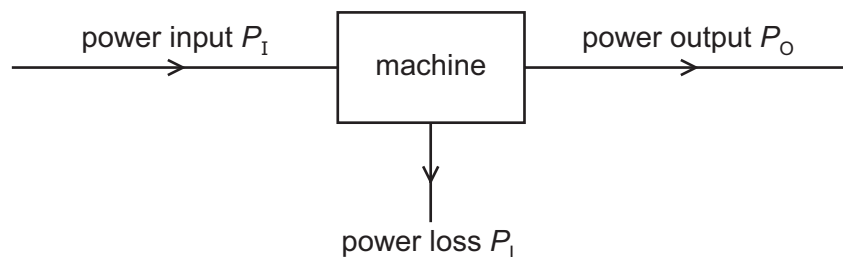
- A 60 mm backwards
- B 60 mm forwards
- C 140 mm backwards
- D 140 mm forwards

- 15 The derivation of the pressure equation $\Delta p = \rho g \Delta h$ uses a number of relationships between quantities.

Which relationship is **not** used in the derivation of this equation?

- A density = $\frac{\text{mass}}{\text{volume}}$
- B potential energy = mass $\times$ acceleration of free fall $\times$ height
- C pressure = $\frac{\text{force}}{\text{area}}$
- D weight = mass $\times$ acceleration of free fall

- 16 Power is transferred through a machine as shown.



What is the efficiency of the machine?

- A $\frac{P_I}{P_O + P_L}$ B $\frac{P_L}{P_I}$ C $\frac{P_L}{P_O}$ D $\frac{P_O}{P_I}$

- 17 A piston in a gas supply pump has an area of 400 cm^2 . The pump moves the gas against a fixed pressure of 3000 Pa .

During part of its stroke, the piston moves a distance of 25 cm in one direction. How much work is done by the piston during this movement?

- A 30 J B $3.0 \times 10^3 \text{ J}$ C $3.0 \times 10^5 \text{ J}$ D $3.0 \times 10^7 \text{ J}$

- 18 A stone is projected vertically upwards from the ground at an initial speed of 15 ms^{-1} . Air resistance is negligible.

What is the maximum height reached by the stone?

- A 0.76 m B 11 m C 23 m D 110 m

- 19 A turbine at a hydroelectric power station is situated 30 m below the level of the surface of a large lake. The water passes through the turbine at a rate of 340 m^3 per minute.

The overall efficiency of the turbine and generator system is 90% .

What is the output power of the power station? (The density of water is 1000 kg m^{-3} .)

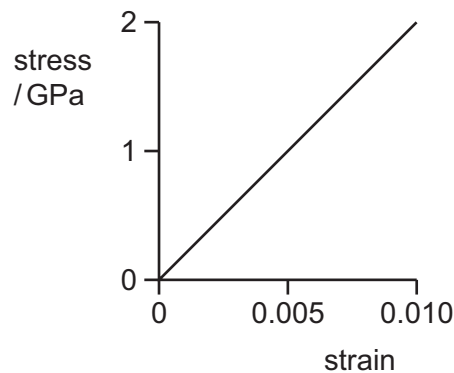
- A 0.15 MW B 1.5 MW C 1.7 MW D 90 MW

- 20** A spring is loaded with weights. When the weights are removed, the spring returns to its original length.

The spring is then loaded with heavier weights. When the weights are removed, the spring is longer than it was originally.

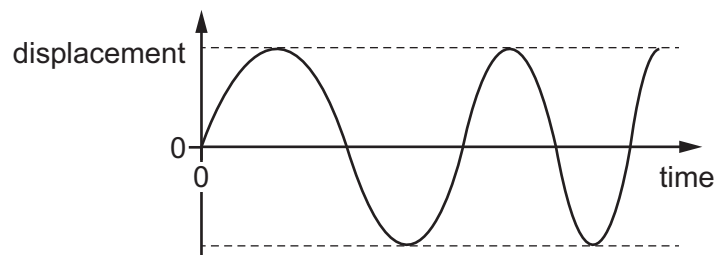
Which types of deformation are shown by this experiment?

- A** both elastic and plastic deformation
 - B** elastic deformation only
 - C** neither elastic nor plastic deformation
 - D** plastic deformation only
- 21** The stress-strain graph for a metal is shown.



What is the strain energy per unit volume of a rod made from this metal when the strain of the rod is 0.010?

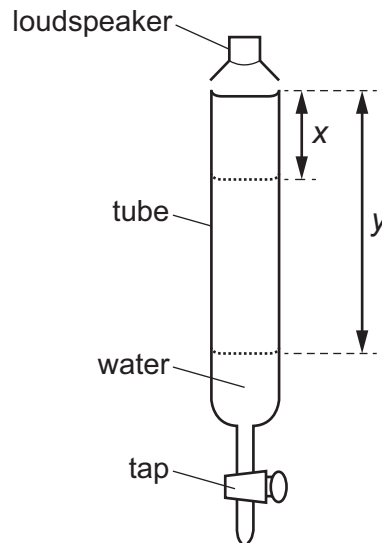
- A** 10 kJ m^{-3}
 - B** 100 kJ m^{-3}
 - C** 1.0 MJ m^{-3}
 - D** 10 MJ m^{-3}
- 22** The displacement-time graph for a layer of air in the path of a sound wave is shown.



Which wave quantity is increasing?

- A** amplitude
- B** frequency
- C** period
- D** wavelength

- 23** A loudspeaker emits a sound wave into a tube initially full of water.



A tap at the bottom of the tube is opened so that water slowly leaves the tube. For some lengths of the air column in the tube, the sound heard is much louder.

The first loud sound is heard when the air column in the tube has length x .

The next time that a loud sound is heard is when the air column in the tube has length y .

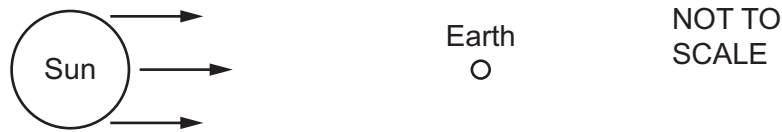
What is the wavelength of the sound wave from the loudspeaker?

- A** $2x$ **B** $4y$ **C** $2(y - x)$ **D** $4(y - x)$
- 24** Diffraction can be observed when a wave passes an obstruction. The diffraction effect is greatest when the wavelength and the obstruction are similar in size.

For waves travelling through air, what is the combination of wave and obstruction that could best demonstrate diffraction?

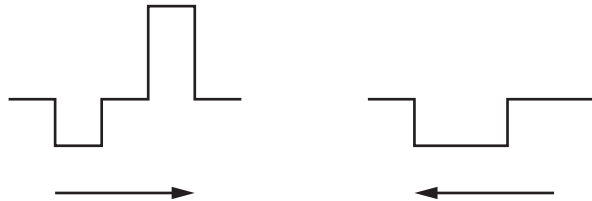
- A** microwaves passing a steel post
B radio waves passing a copper wire
C sound waves passing a human hair
D visible light waves passing a gate post

- 25** Light of a particular wavelength λ_s is emitted from the Sun. At any instant, a band of wavelengths ranging from less than λ_s to more than λ_s is observed on the Earth. This is caused by the Doppler effect.



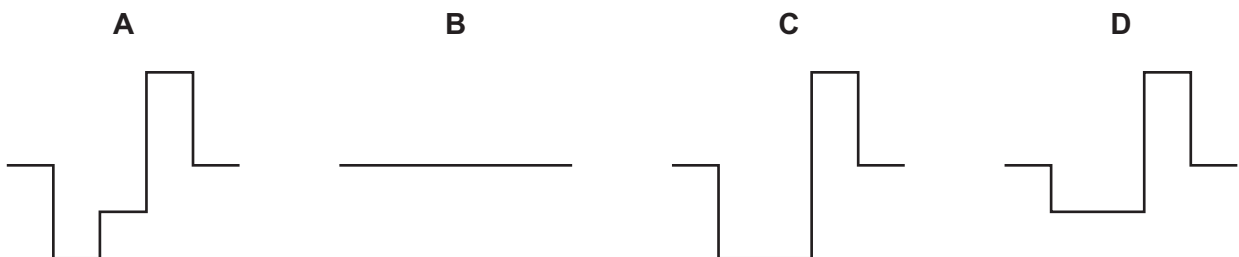
What could be the explanation for this Doppler effect?

- A** The Sun is moving at right-angles to a line joining the Sun and the Earth.
B The Sun is moving away from the Earth.
C The Sun is moving towards the Earth.
D The Sun is rotating.
- 26** What is the order of magnitude of the frequencies of electromagnetic waves in the visible spectrum?
- A** 10^{10} Hz **B** 10^{12} Hz **C** 10^{14} Hz **D** 10^{16} Hz
- 27** Two signals approach each other, as shown.

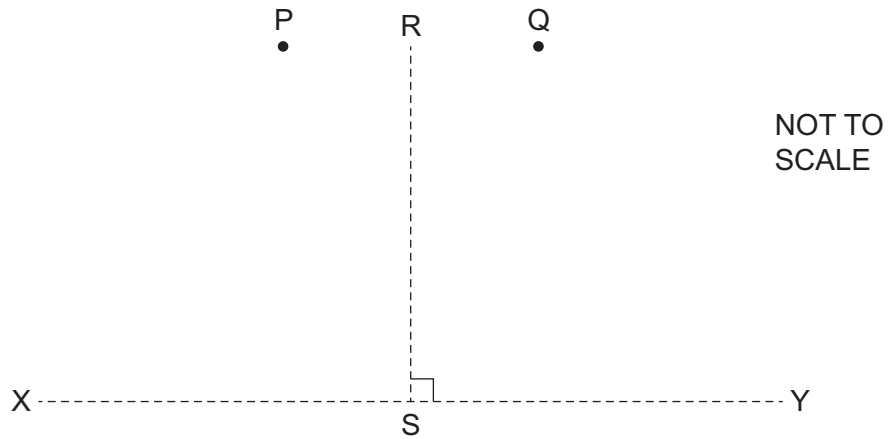


At one instant, the signals completely overlap.

According to the principle of superposition, what is the shape of the resulting signal at this instant?



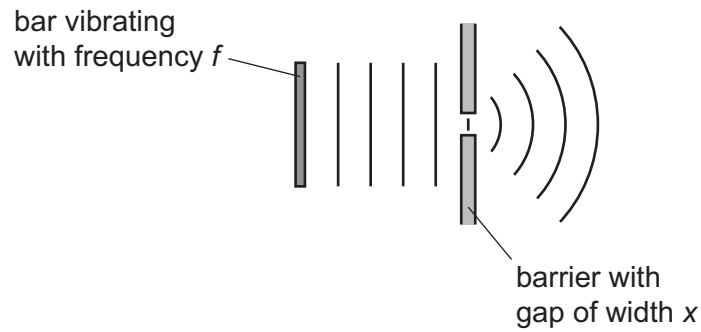
- 28 Coherent waves are produced at P and at Q and travel outwards in all directions. The line RS is half-way between P and Q and perpendicular to the line joining P and Q. The distance RS is much greater than the distance PQ.



Along which of the lines shown is an interference pattern observed?

- A both RS and XY
- B RS only
- C XY only
- D neither RS nor XY

- 29 A bar vibrates with frequency f to produce water waves in a ripple tank.

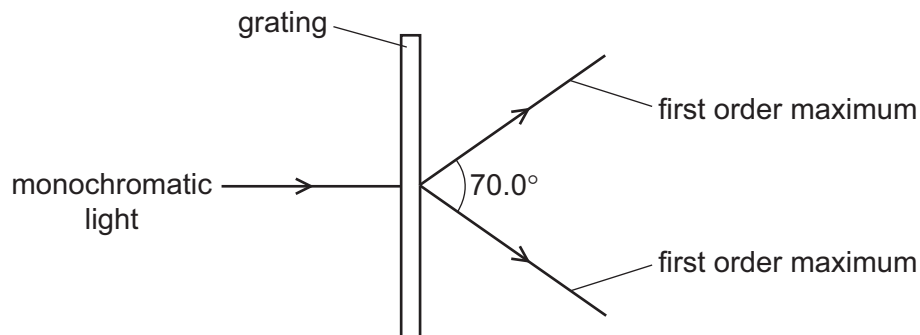


The waves pass through a gap of width x in a barrier so that diffraction occurs.

Which combination of vibration frequency and gap width will produce the smallest angle of diffraction?

	vibration frequency	gap width
A	$\frac{f}{2}$	$\frac{x}{2}$
B	$\frac{f}{2}$	$2x$
C	$2f$	$\frac{x}{2}$
D	$2f$	$2x$

- 30 A diffraction grating is used to measure the wavelength of monochromatic light, as shown in the diagram.

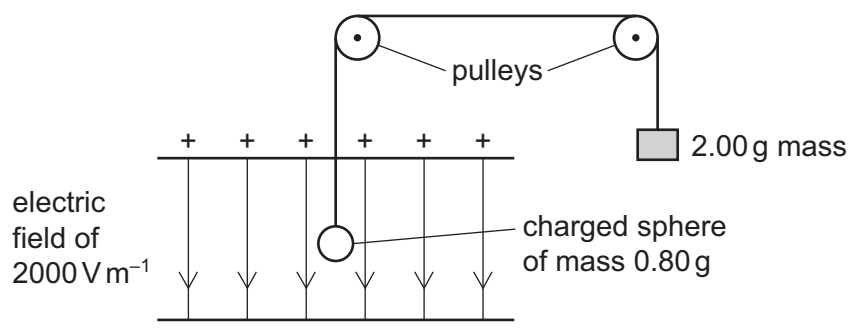


The spacing of the slits in the grating is $1.00 \times 10^{-6} \text{ m}$. The angle between the first order diffraction maxima is 70.0° .

What is the wavelength of the light?

- A** 287 nm **B** 470 nm **C** 574 nm **D** 940 nm

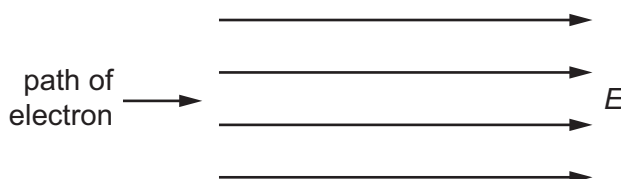
- 31 A small charged sphere of mass 0.80 g hangs from a light thread inside a vertical uniform electric field of strength 2000 V m^{-1} . The thread passes over two frictionless pulleys and a mass of 2.00 g hangs on the other end.



The sphere is in equilibrium.

What is the charge on the sphere?

- A** $-5.9\text{ }\mu\text{C}$ **B** $+0.60\text{ }\mu\text{C}$ **C** $+5.9\text{ }\mu\text{C}$ **D** $+9.8\text{ }\mu\text{C}$
- 32 An electron enters a region of space where there is a uniform electric field E as shown.

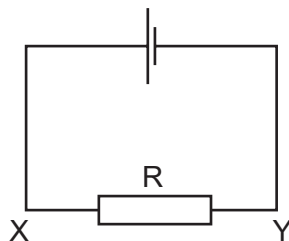


Initially, the electron is moving parallel to, and in the direction of, the electric field.

What is the subsequent path and change of speed of the electron caused by the electric field?

	path of electron	speed of electron
A	curved	decreases
B	curved	increases
C	linear	decreases
D	linear	increases

- 33 The current in the circuit shown is 3.2 mA.



What are the direction of flow and the rate of flow of electrons through the resistor R?

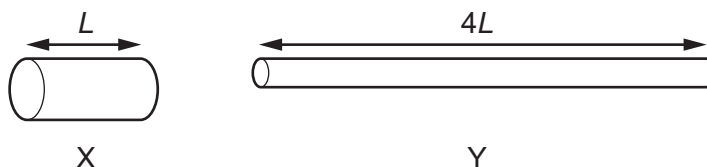
	direction of flow	rate of flow / s ⁻¹
A	X to Y	2.0×10^{16}
B	X to Y	5.1×10^{-22}
C	Y to X	2.0×10^{16}
D	Y to X	5.1×10^{-22}

- 34 A filament lamp has a resistance of $180\ \Omega$ when the current in it is 500 mA.

What is the power dissipated in the lamp?

- A** 45 W **B** 90 W **C** 290 W **D** 360 W

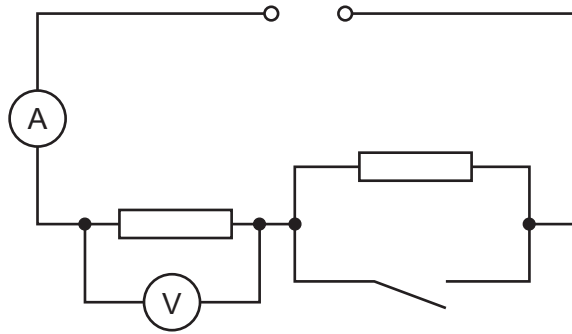
- 35 Two copper wires X and Y have the same volume. Wire Y is four times as long as wire X.



What is the ratio $\frac{\text{resistance of wire Y}}{\text{resistance of wire X}}$?

- A** 1 **B** 4 **C** 8 **D** 16

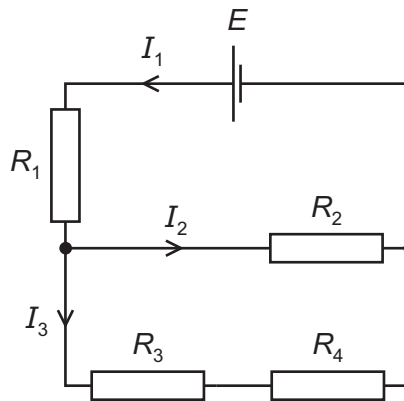
- 36 In the circuit shown, the ammeter reading is I and the voltmeter reading is V .



When the switch is closed, which row describes what happens to I and to V ?

	I	V
A	decreases	decreases
B	increases	increases
C	increases	stays the same
D	stays the same	increases

- 37 A cell of electromotive force E and negligible internal resistance is connected to a network of resistors of resistances R_1 , R_2 , R_3 and R_4 as shown.

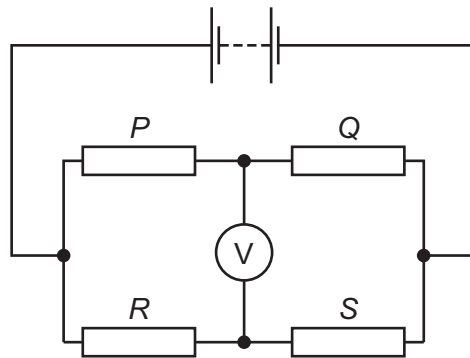


The branches of the circuit have currents I_1 , I_2 and I_3 .

Which equation is correct?

- A** $I_1 R_1 + I_2 R_2 = I_3 R_3 + I_3 R_4$
B $I_2 R_2 - I_3 R_4 - I_3 R_3 = 0$
C $E = I_1 R_1 + I_2 R_2 + I_3 R_3 + I_3 R_4$
D $E = I_1 R_1 + I_2 R_2 - I_3 R_3 - I_3 R_4$

- 38 The circuit diagram shows four resistors of different resistances P , Q , R and S connected to a battery.



The voltmeter reading is zero.

Which equation is correct?

- A** $P - Q = R - S$
B $P - S = Q - R$
C $PQ = RS$
D $PS = QR$
- 39 An astatine nucleus has a nucleon number of 218 and a proton number of 85. It decays to form a polonium nucleus, emitting a β^- particle and an α -particle in the process.

What are the nucleon number and the proton number of this polonium nucleus?

	nucleon number	proton number
A	214	83
B	214	84
C	215	83
D	216	82

- 40 What is the quark composition of a hydrogen-3 nucleus, ${}^3_1\text{H}$?

	number of quarks	
	up	down
A	4	5
B	5	4
C	5	7
D	7	5

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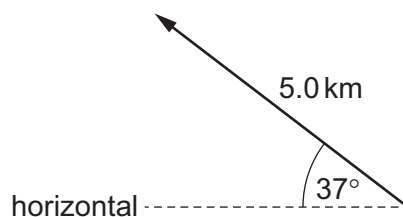
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gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
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 pair of units are **not** the same when expressed in SI base units?

- A ms^{-2} and N kg^{-1}
- B Ns and kg ms^{-1}
- C Pa and Nm^{-2}
- D Vm^{-2} and NC^{-1}

2 What is the vertical component of this displacement vector?



- A 3.0 km
- B 3.8 km
- C 4.0 km
- D 5.0 km

3 The units of specific heat capacity are $\text{J kg}^{-1} \text{K}^{-1}$.

What are the SI base units of specific heat capacity?

- A $\text{ms}^{-2} \text{K}^{-1}$
- B $\text{ms}^{-1} \text{K}^{-1}$
- C $\text{m}^2 \text{s}^{-2} \text{K}^{-1}$
- D $\text{m}^2 \text{s}^{-1} \text{K}^{-1}$

4 A quantity y is to be determined from the equation shown.

$$y = \frac{px}{q^2}$$

The percentage uncertainties in p , x and q are shown.

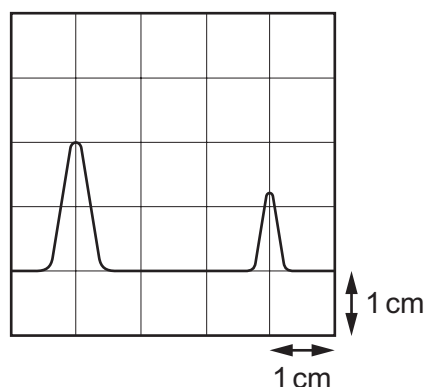
	percentage uncertainty
p	6%
x	2%
q	4%

What is the percentage uncertainty in y ?

- A 0.5%
- B 0.75%
- C 12%
- D 16%

- 5 A transmitter emits a pulse of electromagnetic waves towards a reflector. The pulse is reflected and returns to the transmitter.

A detector is located at the transmitter. The emitted pulse and the reflected pulse are displayed on a cathode-ray oscilloscope (c.r.o.) as shown.



The pulse takes $6.3 \mu\text{s}$ to travel from the transmitter to the reflector.

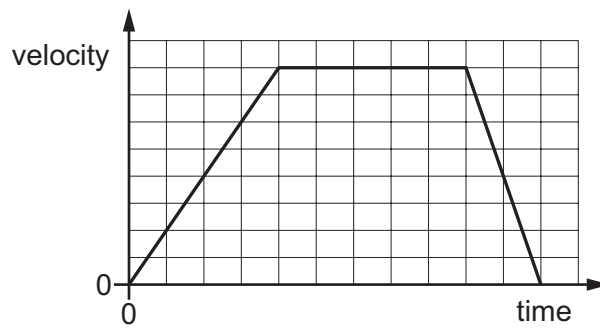
What is the time-base setting of the c.r.o.?

- A** $2.1 \mu\text{s cm}^{-1}$ **B** $3.2 \mu\text{s cm}^{-1}$ **C** $4.2 \mu\text{s cm}^{-1}$ **D** $6.3 \mu\text{s cm}^{-1}$
- 6 A hot-air balloon is moving vertically upwards with a constant speed of 3.00 m s^{-1} . A sandbag is dropped from the balloon. It takes 5.00 s for the sandbag to fall to the ground.

What was the height of the balloon when the sandbag was released?

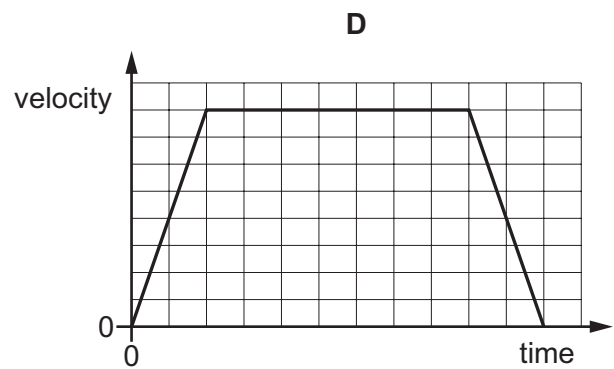
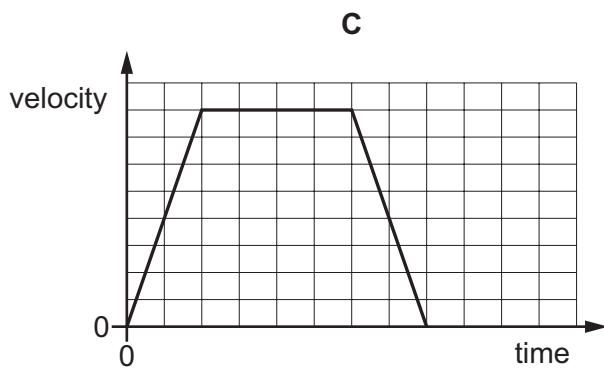
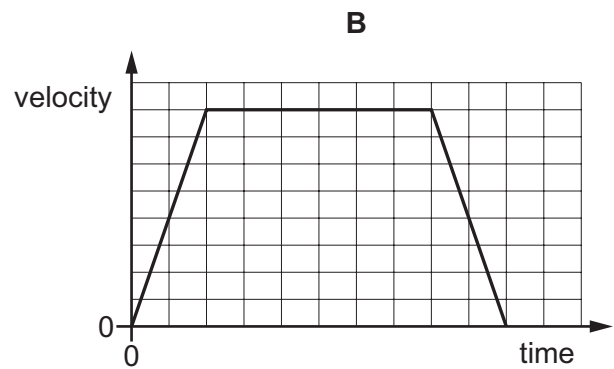
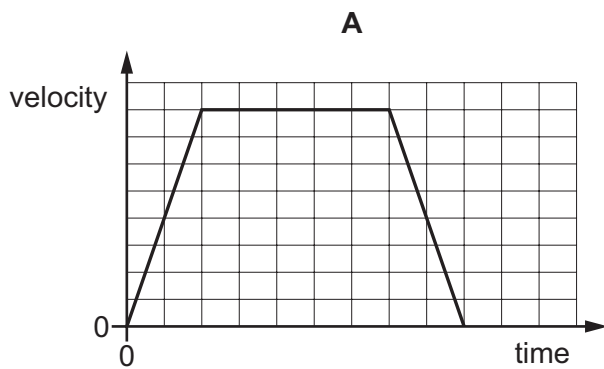
- A** 29 m **B** 108 m **C** 123 m **D** 138 m

- 7 The velocity-time graph for a train starting at one station and stopping at the next is shown.



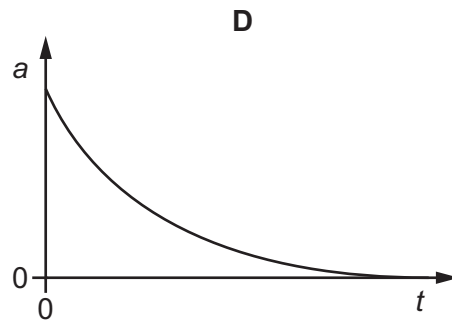
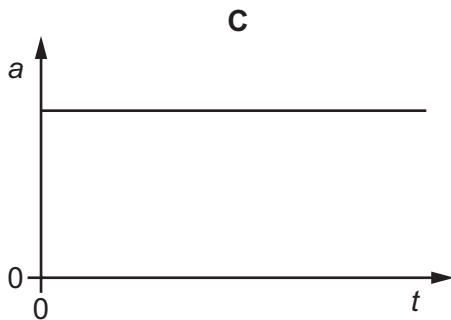
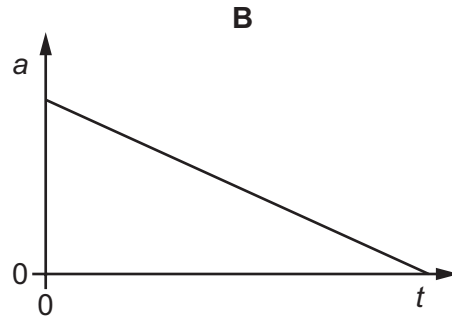
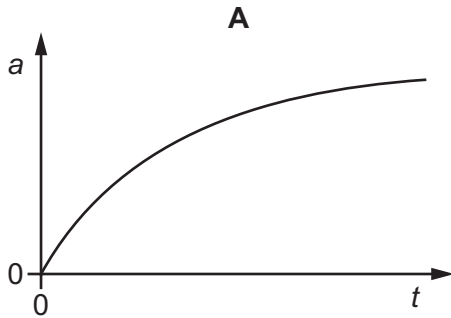
Another train has double the acceleration but the same maximum speed and the same deceleration.

Which velocity-time graph, on the same scale, shows the motion of this train between the same stations?



- 8 A stone is released from rest and falls a long distance in air.

Which graph could show the variation with time t of the acceleration a of the stone?

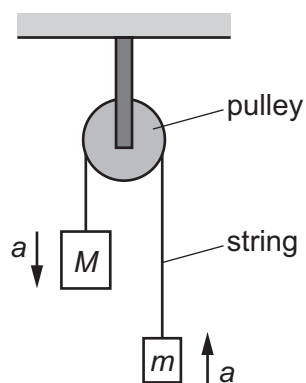


- 9 A slow vehicle and a fast vehicle travel towards each other in a straight line and then collide.

Which outcome is **never** possible, regardless of the masses of the vehicles?

- A** Both vehicles stop.
- B** Only one vehicle stops.
- C** The fast vehicle's speed increases.
- D** The slow vehicle's speed increases.

- 10 Two blocks of masses M and m are joined by a thin string which passes over a frictionless pulley, as shown.

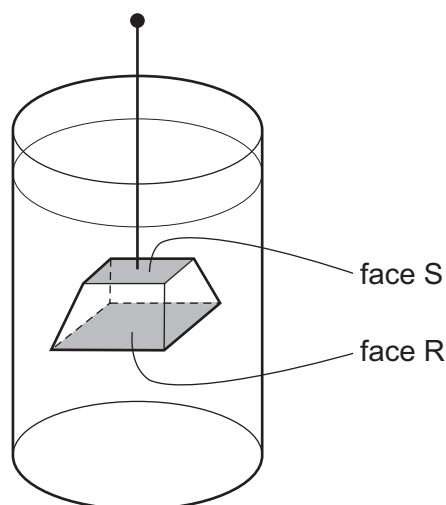


The acceleration of free fall is g .

What is the acceleration a of the two blocks?

- A $\frac{(M+m)}{(M-m)}g$ B $\frac{(M-m)}{(M+m)}g$ C $\frac{M}{m}g$ D $\frac{m}{M}g$

- 11 The diagram shows a block of copper suspended in water.

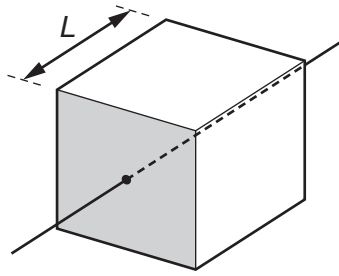


The block experiences an upthrust from the water.

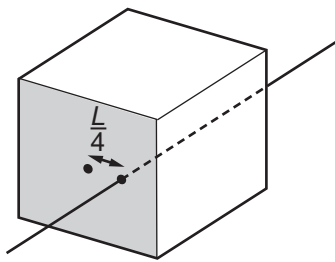
Which statement is the basis of an explanation for this upthrust?

- A Copper is more dense than water.
 B The area of face R is greater than the area of face S.
 C The density of water increases with depth.
 D The pressure of water increases with depth.

- 12 The diagram shows a solid cube with weight W and sides of length L . It is supported at rest by a frictionless spindle that passes through the centres of two opposite vertical faces. One of these faces is shaded.



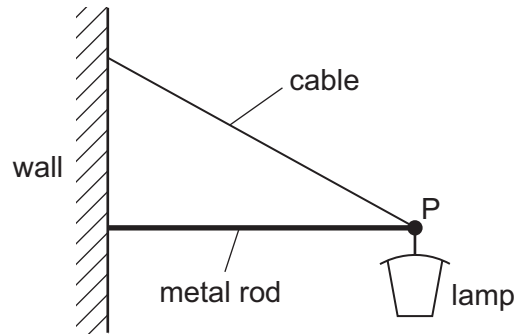
The spindle is now removed and replaced at a distance $\frac{L}{4}$ to the right of its original position.



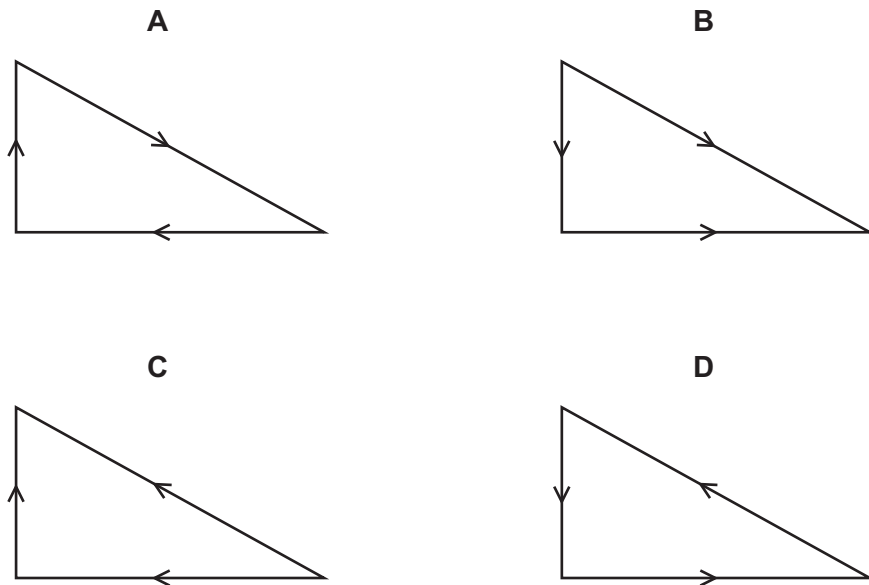
When viewing the shaded face, what is the torque of the couple that will now be needed to keep the cube at rest?

- A $\frac{WL}{4}$ anticlockwise
- B $\frac{WL}{4}$ clockwise
- C $\frac{WL}{2}$ anticlockwise
- D $\frac{WL}{2}$ clockwise

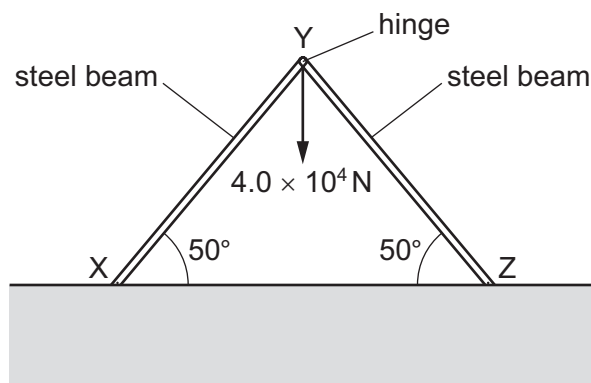
- 13 A street lamp is fixed to a wall by a metal rod and a cable.



Which vector triangle could represent the forces acting at point P?



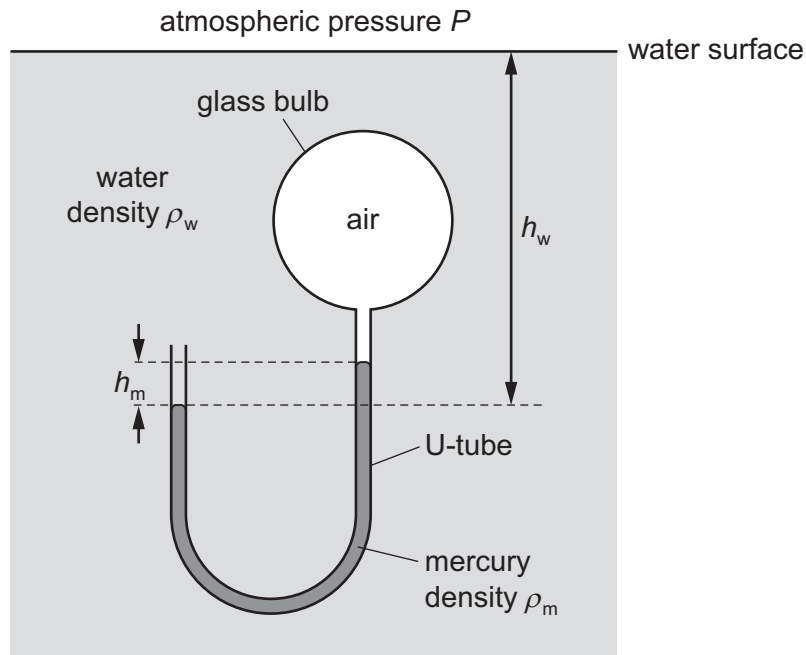
- 14 Two rigid steel beams XY and YZ are fixed at their lower ends and are hinged at Y. Each beam is inclined at 50° to the horizontal, as shown. A weight of $4.0 \times 10^4 \text{ N}$ hangs from Y. The structure is in equilibrium.



What is the force exerted by each beam on the hinge at Y?

- A** $2.6 \times 10^4 \text{ N}$ **B** $3.1 \times 10^4 \text{ N}$ **C** $5.2 \times 10^4 \text{ N}$ **D** $6.2 \times 10^4 \text{ N}$

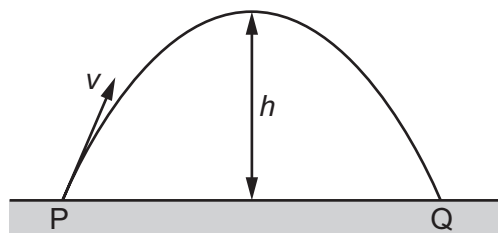
- 15 Air is trapped inside a glass bulb which is immersed in water and attached to a U-tube containing mercury. The densities of water and mercury are ρ_w and ρ_m respectively. The surface of the water is open to the atmosphere where atmospheric pressure is P .



The acceleration of free fall is g .

What is the pressure of the air in the glass bulb?

- A $P + g\rho_w h_w + g\rho_m h_m$
 B $P + g\rho_w h_w - g\rho_m h_m$
 C $g\rho_w h_w + g\rho_m h_m$
 D $g\rho_w h_w - g\rho_m h_m$
- 16 A ball of mass m is thrown up to height h in air with an initial velocity v , as shown.

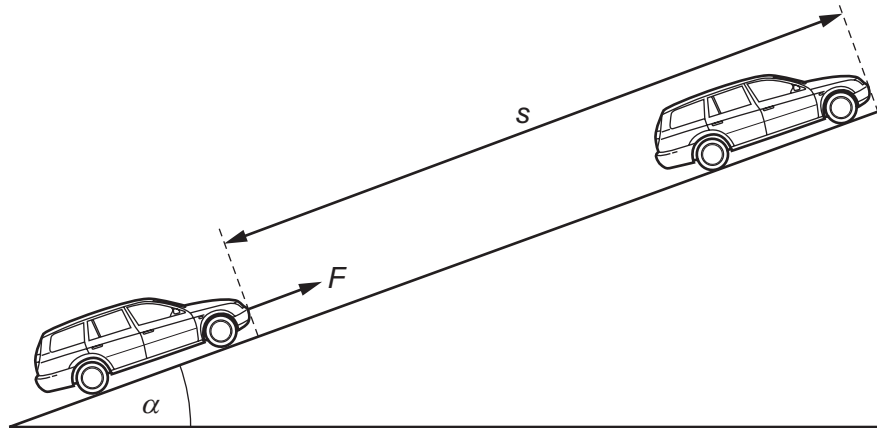


Air resistance is negligible. The acceleration of free fall is g .

What is the **total** work done by the gravitational force on the ball during its flight from P to Q?

- A zero B $\frac{1}{2}mv^2$ C mgh D $2mgh$

- 17 A constant force F , acting on a car of mass m , moves the car up a slope through a distance s at constant velocity v . The angle of the slope to the horizontal is α .



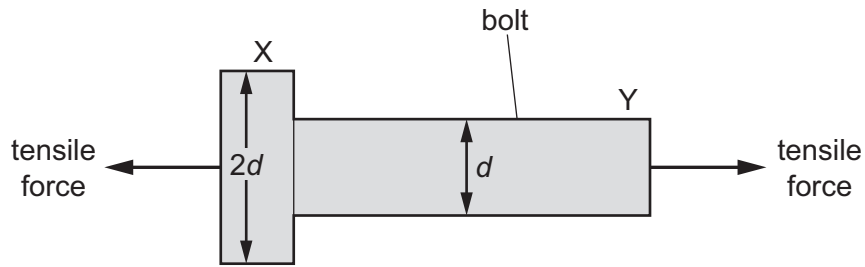
What is the ratio $\frac{\text{gravitational potential energy gained by car}}{\text{work done by force } F}$?

- A $\frac{mgs \sin \alpha}{Fv}$ B $\frac{mv}{Fs}$ C $\frac{mv^2}{2Fs}$ D $\frac{mg \sin \alpha}{F}$
- 18 Car X is travelling at half the speed of car Y. Car X has twice the mass of car Y.
- Which statement is correct?
- A Car X has half the kinetic energy of car Y.
- B Car X has one quarter of the kinetic energy of car Y.
- C Car X has twice the kinetic energy of car Y.
- D The two cars have the same kinetic energy.
- 19 During refuelling, a petrol car receives 50 litres of fuel in 90 seconds. The petrol has 34 MJ of energy per litre.

For an electric car to receive the same amount of energy in the same time from a 230 V supply, what is the minimum current required?

- A 2700 A B 8.2×10^4 A C 7.4×10^6 A D 6.6×10^8 A

- 20 A bolt is subjected to a tensile force, as shown.



The bolt has a circular cross-section. At end X the diameter is $2d$. At end Y the diameter is d .

What is the ratio $\frac{\text{stress at Y}}{\text{stress at X}}$?

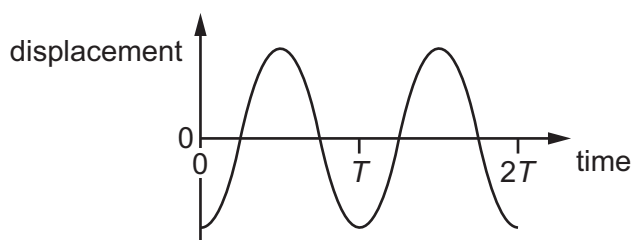
- A** 0.25 **B** 0.50 **C** 2.0 **D** 4.0
- 21 A rectangular block of steel supporting a very large component of a bridge has a height of 15 cm and a cross-section of $20\text{ cm} \times 12\text{ cm}$. It is designed to compress 1 mm when under maximum, evenly distributed, load.

The Young modulus of steel is $2.0 \times 10^{11} \text{ N m}^{-2}$.

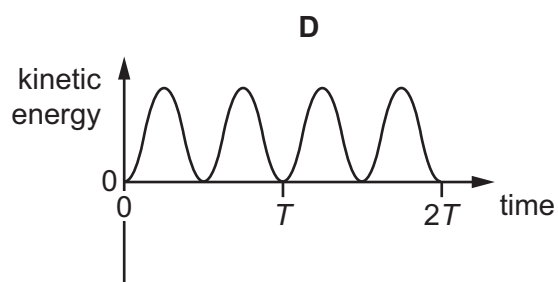
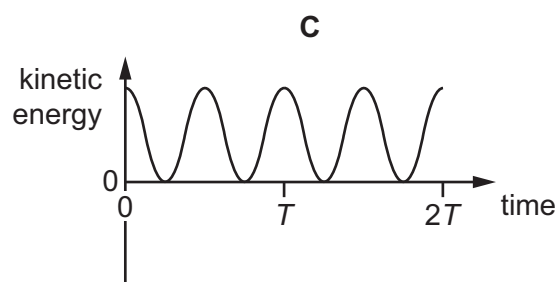
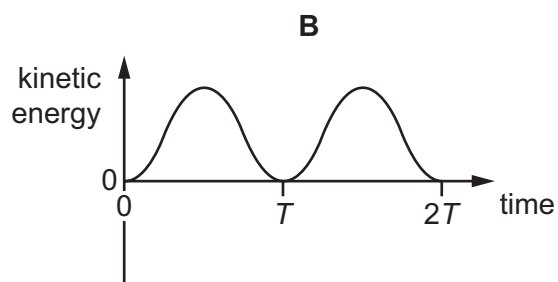
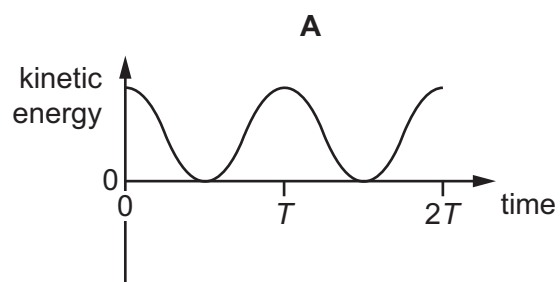
What is the maximum load it can support?

- A** 32 MN **B** 56 GN **C** 720 GN **D** 32 TN

- 22** When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.



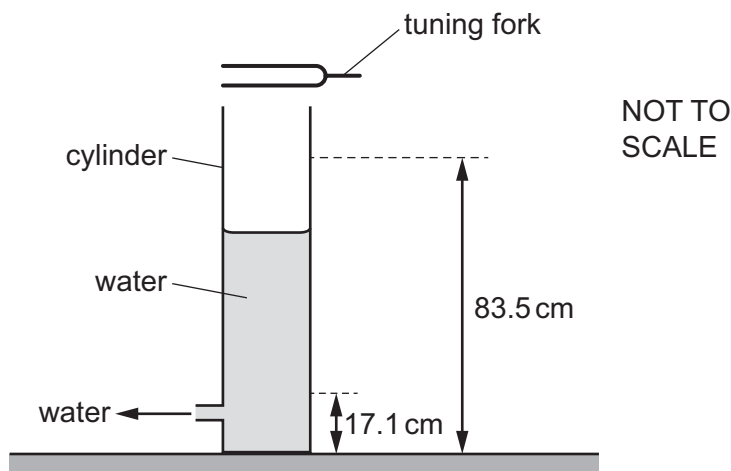
Which graph best shows how the kinetic energy of the air particle varies with time?



- 23** Which wave is a longitudinal wave?

- A** a light wave travelling through air
- B** a radio wave from a broadcasting station
- C** a ripple on the surface of water
- D** a sound wave travelling through air

- 24** A vibrating tuning fork is held above a glass cylinder filled to the top with water. The water level is steadily lowered. A loud sound is first heard when the water level is 83.5 cm above the bench. The next loud sound is heard when the water level is 17.1 cm above the bench.



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

What is the frequency of the tuning fork?

- A** 128 Hz **B** 256 Hz **C** 384 Hz **D** 512 Hz

- 25** A train that is moving in a straight line along a railway track has a whistle that continuously emits sound of frequency f .

A woman standing by the side of the track hears sound of frequency $0.85f$.

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

What is the velocity of the train?

- A** 51 m s^{-1} away from the woman
B 51 m s^{-1} towards the woman
C 60 m s^{-1} away from the woman
D 60 m s^{-1} towards the woman

- 26** Orange light in a vacuum has a wavelength of 600 nm.

What is the frequency of this light?

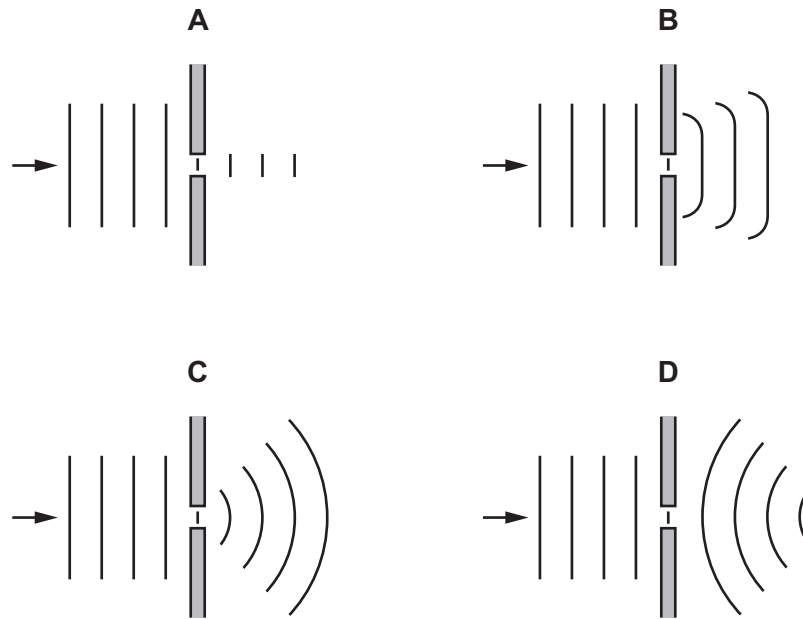
- A** 180 Hz **B** $5.0 \times 10^5 \text{ Hz}$ **C** $1.8 \times 10^{11} \text{ Hz}$ **D** $5.0 \times 10^{14} \text{ Hz}$

- 27** A stationary sound wave has a series of nodes. The distance between the first and the sixth node is 30.0 cm.

What is the wavelength of the sound wave?

- A** 5.0 cm **B** 6.0 cm **C** 10.0 cm **D** 12.0 cm

28 Which diagram shows the diffraction of water waves in a ripple tank?



29 A hill stands between a radio transmitter and a house, as shown.



The radio transmitter cannot be seen from the house, but radio waves from the transmitter are received at the house.

Why is this?

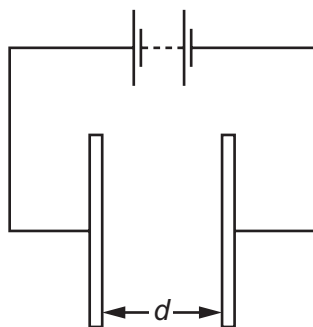
- A** The wavelength of light is longer than the wavelength of radio waves so there is more diffraction of light over the hill.
- B** The wavelength of light is shorter than the wavelength of radio waves so there is more diffraction of light over the hill.
- C** The wavelength of radio waves is longer than the wavelength of light so there is more diffraction of radio waves over the hill.
- D** The wavelength of radio waves is shorter than the wavelength of light so there is more diffraction of radio waves over the hill.

- 30 In an experiment to demonstrate double-slit interference using light, the distance from the slits to the screen is doubled and the slit separation is halved. The wavelength of the light is kept constant.

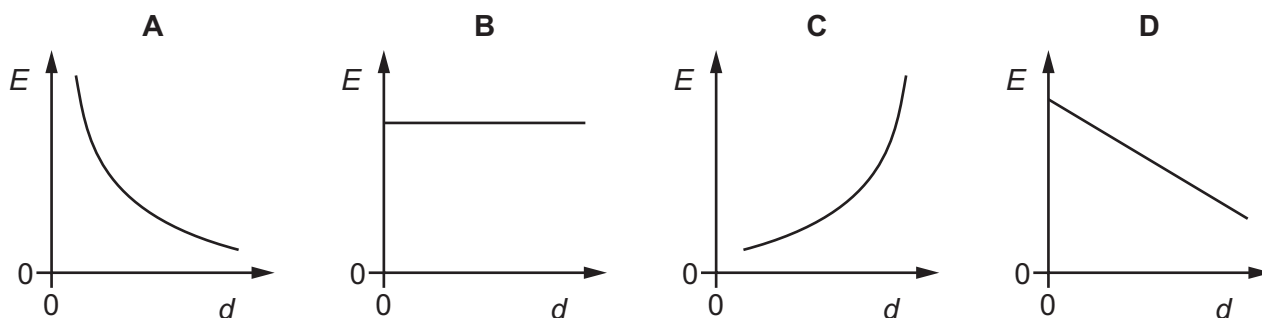
By which factor does the separation of adjacent bright fringes change?

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

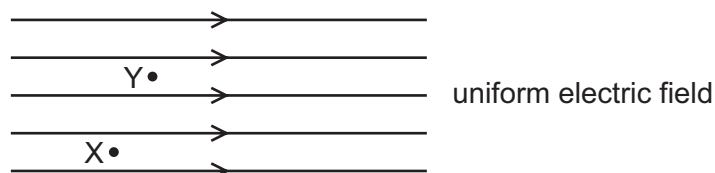
- 31 The diagram shows two metal plates connected to a constant high voltage.



Which graph shows the variation of the electric field strength E midway between the two plates as the distance d between the two plates is increased?



- 32 An electron moves between two points X and Y in a uniform electric field, as shown.



The distance between X and Y is 4.0 cm and the line XY is at an angle of 60° to the direction of the field.

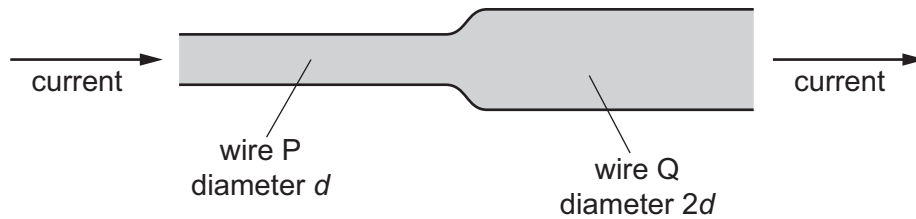
The field exerts the only force on the electron.

The field strength is 100 NC^{-1} .

What is the change in the kinetic energy of the electron as it moves from X to Y?

- A -4 eV B -2 eV C $+2 \text{ eV}$ D $+4 \text{ eV}$

- 33 Two copper wires are joined together and carry a current, as shown.

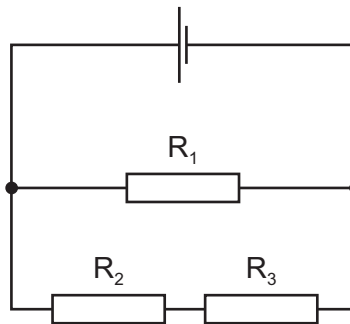


Wire P has diameter d and wire Q has diameter $2d$.

What is the ratio $\frac{\text{average drift speed of the free electrons in wire P}}{\text{average drift speed of the free electrons in wire Q}}$?

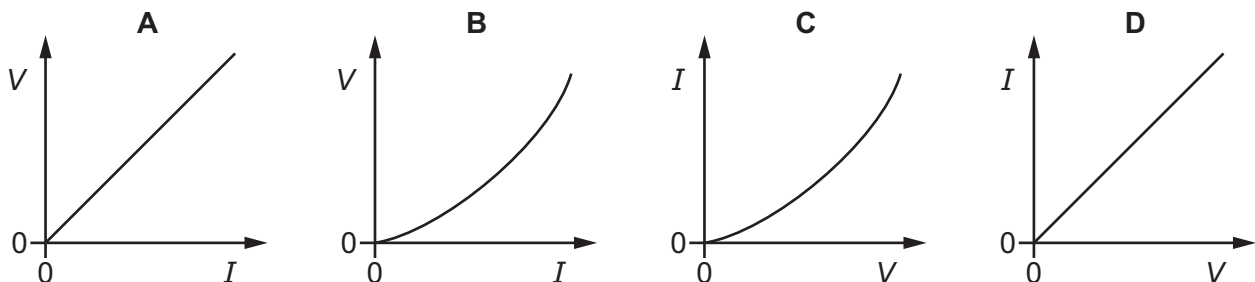
- A $\frac{1}{4}$ B $\frac{1}{2}$ C 2 D 4

- 34 A cell of negligible internal resistance is connected to resistors R_1 , R_2 and R_3 , as shown. The cell provides power to the circuit and power is dissipated in the resistors.



Which word equation **must** be correct?

- A power loss in R_1 = power loss in R_2 + power loss in R_3
 B power loss in R_2 = power loss in R_3
 C power output of cell = power loss in R_1 + power loss in R_2 + power loss in R_3
 D power output of cell = power loss in R_1
- 35 Which graph represents a metallic conductor, where the resistance of the conductor is given by the gradient of the graph?

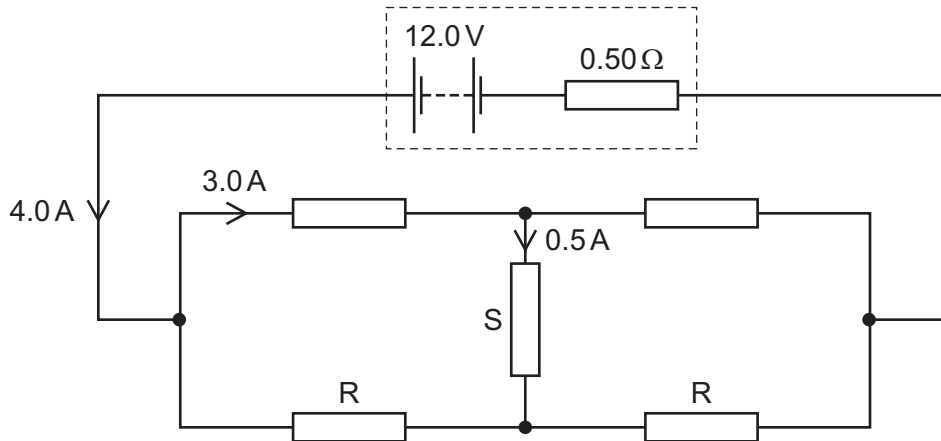


- 36 A typical mobile phone battery has an e.m.f. of 5.0 V and an internal resistance of 200 m Ω .

What is the terminal p.d. of the battery when it supplies a current of 500 mA?

- A 4.8 V B 4.9 V C 5.0 V D 5.1 V

- 37 The circuit shown contains a resistor S that is neither in series nor in parallel with the other resistors.

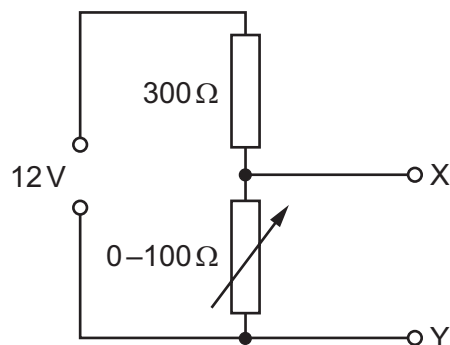


Kirchhoff's laws can be used with the data in the diagram to deduce the resistance of each of the two identical resistors labelled R.

What is the resistance of each resistor R?

- A 3.0 Ω B 4.0 Ω C 4.8 Ω D 5.0 Ω

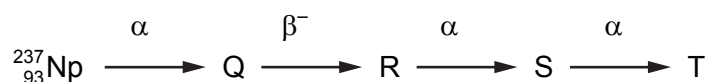
- 38 The diagram shows a potential divider connected to a 12 V supply of negligible internal resistance.



Which range of voltages can be obtained between X and Y?

- A 0 to 3 V B 0 to 4 V C 0 to 8 V D 0 to 9 V

- 39 The diagram shows a sequence of radioactive decays involving three α -particles and a β^- particle.



What is nuclide T?

- A** ${}_{88}^{225}\text{Ra}$
 B ${}_{88}^{231}\text{Ra}$
 C ${}_{90}^{225}\text{Th}$
 D ${}_{90}^{229}\text{Th}$
- A** u u u
 B u u d
 C u d d
 D d d d

- 40 Which combination of up (u) and down (d) quarks forms a neutron?

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PHYSICS

9702/13

Paper 1 Multiple Choice

October/November 2017

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 **19** printed pages and **1** blank page.



Data

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

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

- 1 How many cubic nanometres, nm^3 , are in a cubic micrometre, μm^3 ?

A 10^3 B 10^6 C 10^9 D 10^{12}

- 2 The maximum theoretical power P of a wind turbine is given by the equation

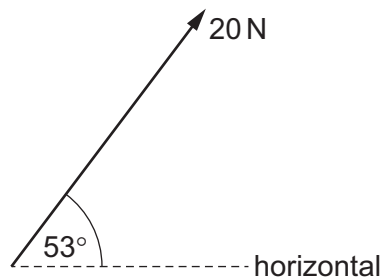
$$P = k\rho Av^n$$

where ρ is the density of air, A is the area swept by the turbine blades, v is the speed of the air and k is a constant with no units.

What is the value of n ?

A 1 B 2 C 3 D 4

- 3 What is the horizontal component of the force shown?



A 12 N B 16 N C 20 N D 27 N

- 4 A school has a piece of aluminium that it uses for radioactivity experiments. Its thickness is marked as 3.2 mm. A student decides to check this value. He has vernier calipers which give measurements to 0.1 mm and a micrometer which gives measurements to 0.01 mm.

Which statement **must** be correct?

- A The micrometer gives a more accurate measurement.
 B The micrometer gives a more precise measurement.
 C The vernier calipers give a more accurate measurement.
 D The vernier calipers give a more precise measurement.

5 Four possible sources of error in a series of measurements are listed.

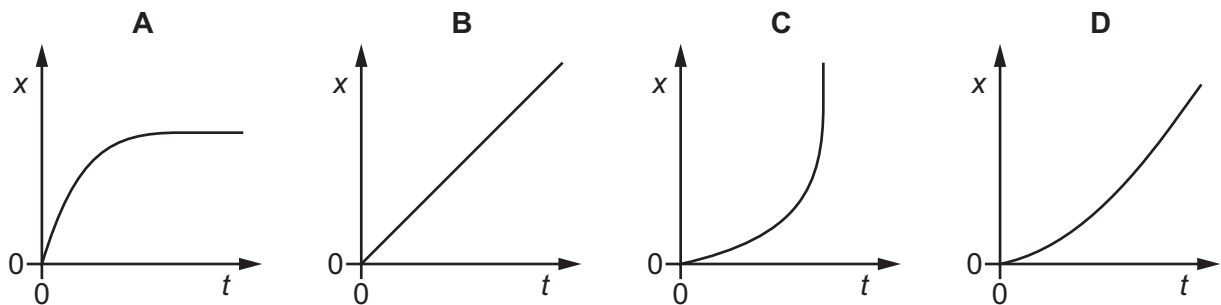
- 1 an analogue meter whose scale is read from different angles
- 2 a meter which always measures 5% too high
- 3 a meter with a needle that is not frictionless, so the needle sometimes sticks slightly
- 4 a meter with a zero error

Which errors are random and which are systematic?

	random error	systematic error
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 4	1 and 3
D	3 and 4	1 and 2

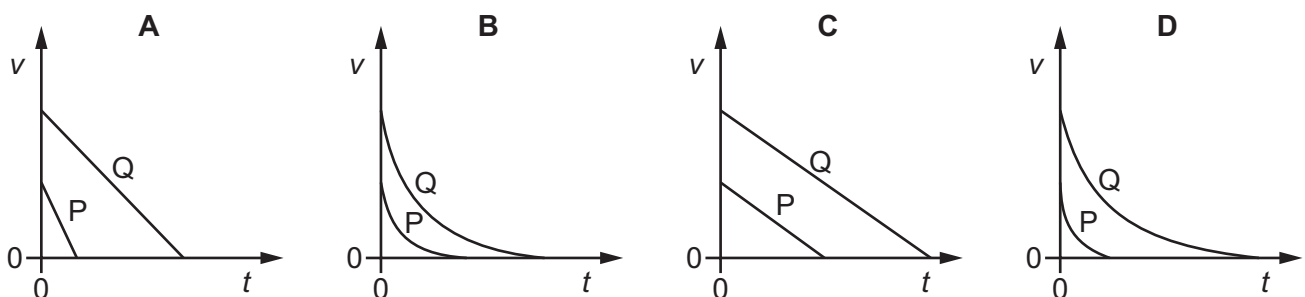
6 A football falls from the top of a tall building.

Which graph best represents the way in which the distance x fallen varies with time t ?

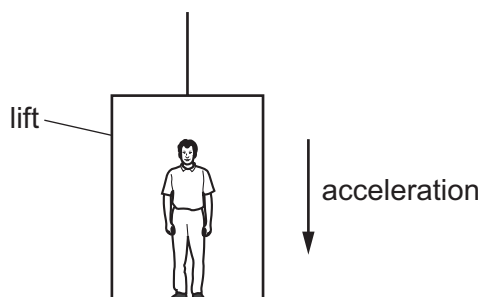


7 Two identical cars P and Q are travelling along a straight road. Car Q is travelling at twice the speed of car P. The brakes are applied to both cars, producing the same constant deceleration.

Which graph shows how the velocity v of each car varies with time t ?



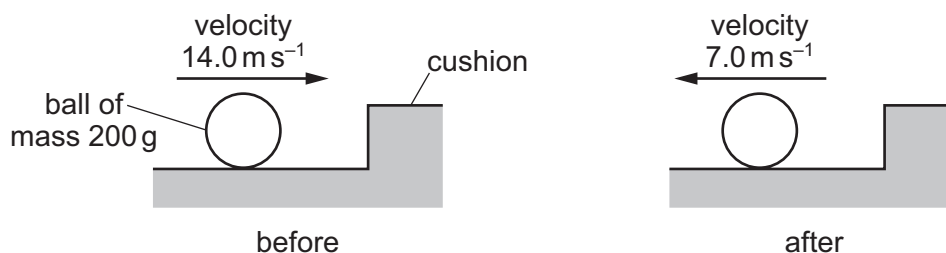
- 8 A man stands in a lift that is accelerating vertically downwards, as shown.



Which statement describes the force exerted by the man on the floor?

- A** It is equal to the weight of the man.
B It is greater than the force exerted by the floor on the man.
C It is less than the force exerted by the floor on the man.
D It is less than the weight of the man.
- 9 A snooker ball of mass 200 g hits the cushion of a snooker table at right-angles with a speed of 14.0 m s^{-1} .

The ball rebounds with half of its initial speed. The ball is in contact with the cushion for 0.60 s.



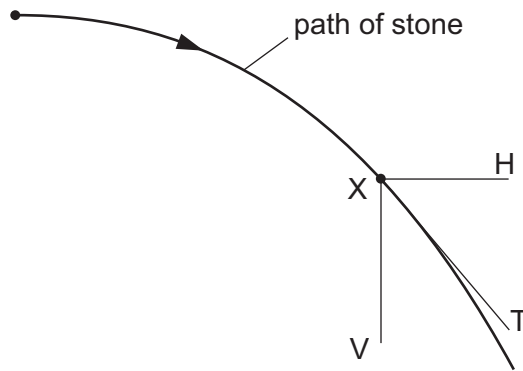
What is the average force exerted on the ball by the cushion?

- A** 2.3 N **B** 7.0 N **C** 2300 N **D** 7000 N
- 10 Two railway trucks of masses m and $3m$ move towards each other in opposite directions with speeds $2v$ and v respectively. These trucks collide and stick together.

What is the speed of the trucks after the collision?

- A** $\frac{v}{4}$ **B** $\frac{v}{2}$ **C** v **D** $\frac{5v}{4}$

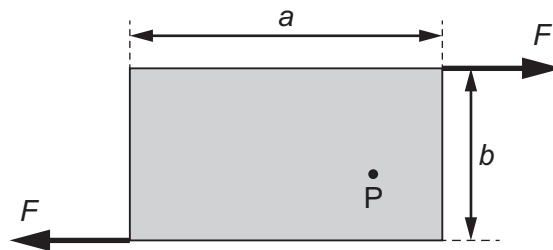
- 11 A stone is projected horizontally in a vacuum and moves along the path shown.



X is a point on this path. XV and XH are vertical and horizontal lines respectively through X. XT is the tangent to the path at X.

Along which directions do forces act on the stone at X?

- A XV and XH B XV only C XH only D XT only
- 12 Two forces, each of magnitude F , act along the edges of a rectangular metal plate, as shown.

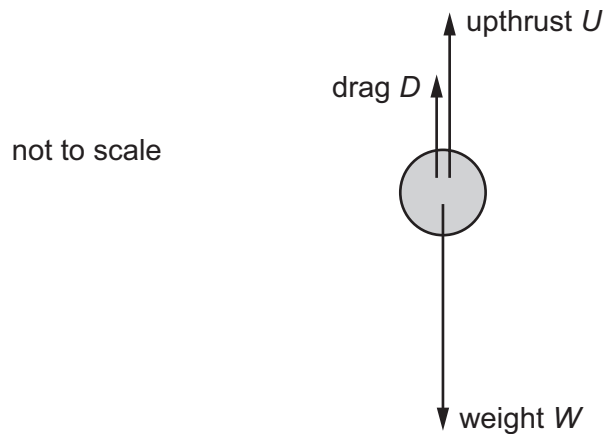


The plate has length a and width b .

What is the torque about point P?

- A Fa B Fb C $2Fa$ D $2Fb$

- 13 A solid sphere falls at constant (terminal) velocity in a liquid. The three forces acting on the sphere are shown in the diagram.



How are the three forces related?

- A $W + D = U$
 - B $W > U + D$
 - C $W - U = D$
 - D $W < D + U$
- 14 A thin horizontal plate of area 0.036 m^2 is beneath the surface of a liquid of density 930 kg m^{-3} . The force on one side of the plate due to the pressure of the liquid is 290 N .

What is the depth of the plate beneath the surface of the liquid?

- A 0.88 m
 - B 1.1 m
 - C 1.8 m
 - D 8.7 m
- 15 A ball is thrown vertically upwards. Air resistance is negligible.

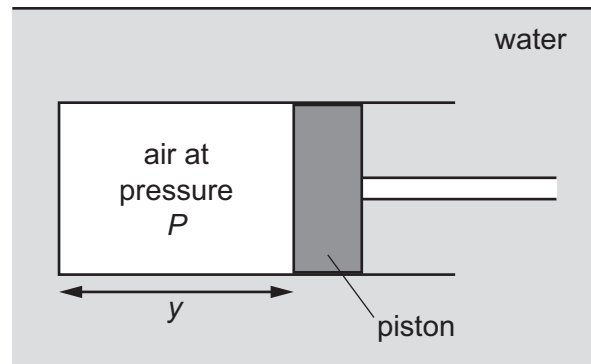
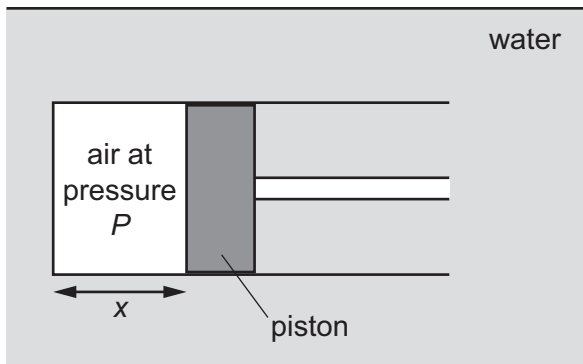
Which statement is correct?

- A By the principle of conservation of energy, the total energy of the ball is constant throughout its motion.
- B By the principle of conservation of momentum, the momentum of the ball is constant throughout its motion.
- C The kinetic energy of the ball is greatest at the greatest height attained.
- D The potential energy of the ball increases at a constant rate during its ascent.

- 16 A car of total mass 1560 kg is travelling with a constant speed of 32 m s^{-1} . The driving force provided by the car is 680 N . The kinetic energy of the car is 800 kJ and its momentum is $50\,000\text{ N s}$.

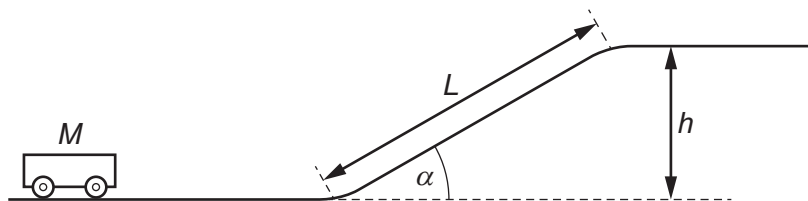
Which two items of data could be used to calculate the useful power output of the car?

- A driving force and momentum
 B kinetic energy and mass
 C mass and momentum
 D speed and driving force
- 17 A horizontal cylinder of cross-sectional area A is fitted with a frictionless piston and contains air at pressure P . It is immersed in hot water and the length of the air column increases from x to y . The pressure P is constant.



Which equation represents the work done by the trapped air during this process?

- A PAy B $-PAy$ C $PA(y - x)$ D $-PA(y - x)$
- 18 A trolley rolls along a horizontal surface and then travels up a slope before reaching a second horizontal surface. The slope is of length L . The trolley has mass M . The slope is at an angle α to the horizontal surface. The second horizontal surface is at height h above the first surface.



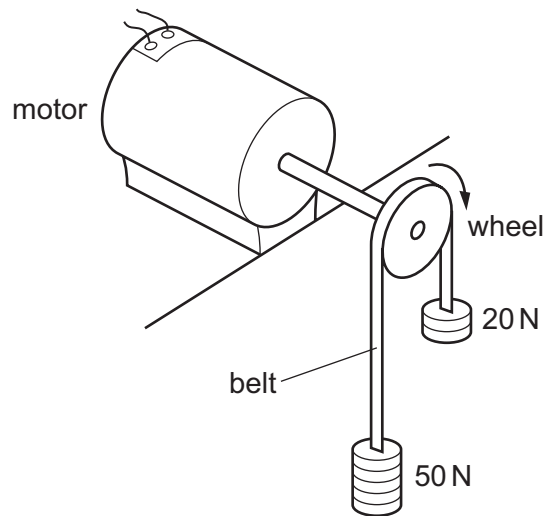
Assume negligible frictional forces. The acceleration of free fall is known.

In order to determine the minimum initial velocity of the trolley for it to reach the top of the slope, which additional values are needed?

- A h and M B M , L and h C α , L , M D h only

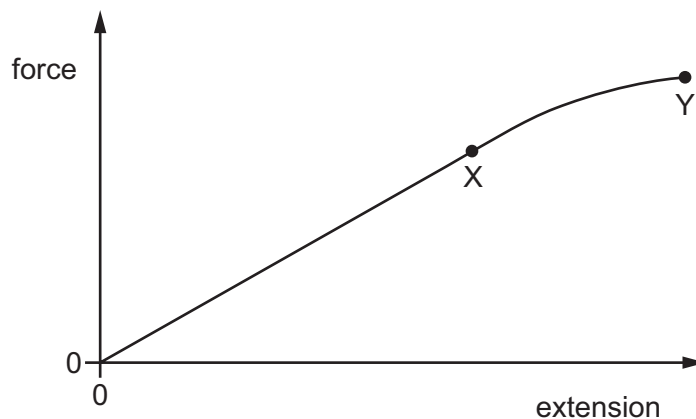
- 19 The diagram shows an arrangement used to find the output power of an electric motor.

The wheel attached to the motor's axle has a circumference of 0.5 m and the belt which passes over it is stationary when the weights have the values shown.



When the wheel is making 20 revolutions per second, what is the output power of the motor?

- A** 300 W **B** 500 W **C** 600 W **D** 700 W
- 20 A sample of metal is subjected to a force which increases to a maximum value and then decreases back to zero. A force-extension graph for the sample is shown.



When the sample contracts, it follows the same force-extension curve as when it was being stretched.

What is the behaviour of the metal between X and Y?

- A** both elastic and plastic
B not elastic and not plastic
C plastic but not elastic
D elastic but not plastic

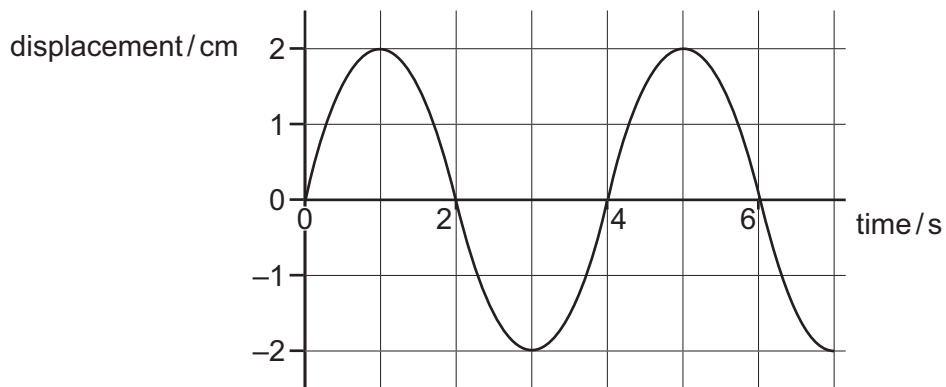
- 21** A load is hung from the end of a metal wire. The load is increased and the wire stretches elastically. The table shows the length of the wire for different loads.

load / kN	length / mm
0	500.0
1.0	502.0
2.0	504.0
3.0	506.0
4.0	508.0

When the load is 4.0 kN, what is the strain energy stored in the wire?

- A** 16 J **B** 32 J **C** 1.0 kJ **D** 2.0 kJ

- 22** The graph shows how the displacement of a particle in a wave varies with time.

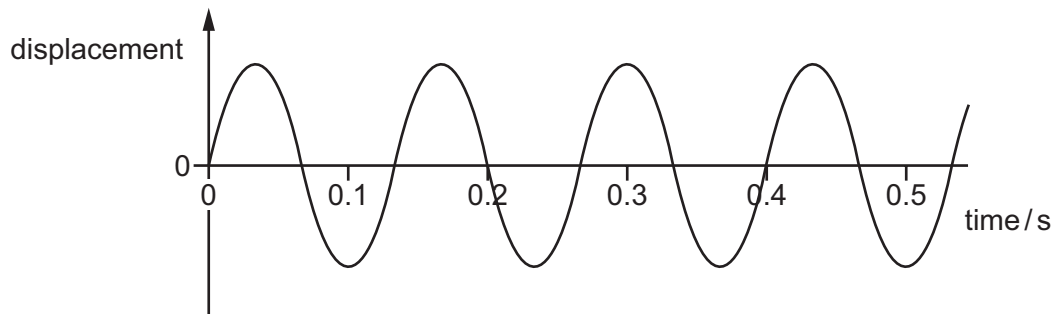


Which statement is correct?

- A** The wave has a period of 2 s and could be either transverse or longitudinal.
B The wave has a period of 2 s and must be transverse.
C The wave has a period of 4 s and could be either transverse or longitudinal.
D The wave has a period of 4 s and must be transverse.

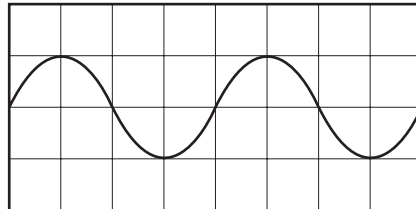
- 23** A wave travels along a coiled spring.

The graph shows the variation with time of the displacement of a point on the spring.



What is the frequency of the wave?

- A** 0.13 Hz **B** 0.20 Hz **C** 5.0 Hz **D** 7.5 Hz
- 24** An electrical signal is displayed on a cathode-ray oscilloscope (c.r.o.).



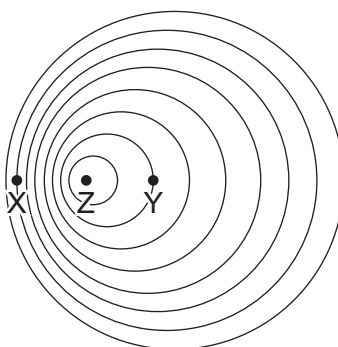
The time-base setting is 50 ms div^{-1} .

The Y-gain setting is 2 V div^{-1} .

What is the amplitude of the signal?

- A** 2 V **B** 4 V **C** 5 V **D** 10 V

- 25 A source of sound of frequency F at point Z is moving at a steady speed. The pattern of the emitted wavefronts is shown.



Which row describes the frequencies of the sound heard by stationary observers at X and Y?

	frequency heard at X	frequency heard at Y
A	$<F$	$<F$
B	$<F$	$>F$
C	$>F$	$<F$
D	$>F$	$>F$

- 26 A car travelling at a steady speed in a straight line passes close to a stationary observer. The observer measures the frequency of the sound from the engine.

As the car approaches, the observed frequency is 220 Hz. When the car moves away, the observed frequency is 180 Hz.

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

What is the speed of the car?

- A** 8.5 m s^{-1} **B** 31 m s^{-1} **C** 34 m s^{-1} **D** 38 m s^{-1}

- 27 Which frequency of electromagnetic radiation could be ultraviolet?

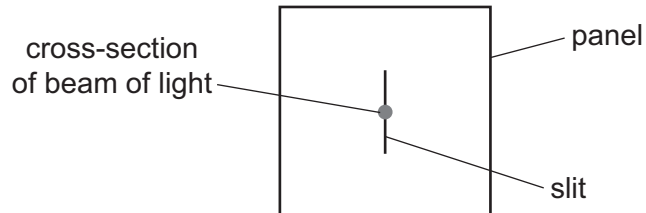
- A** $1.0 \times 10^6 \text{ Hz}$
B $1.0 \times 10^9 \text{ Hz}$
C $1.0 \times 10^{12} \text{ Hz}$
D $1.0 \times 10^{15} \text{ Hz}$

- 28** An electromagnetic wave travels in a straight line through a vacuum. The wave has a frequency of 6.0 THz.

What is the number of wavelengths in a distance of 1.0 m along the wave?

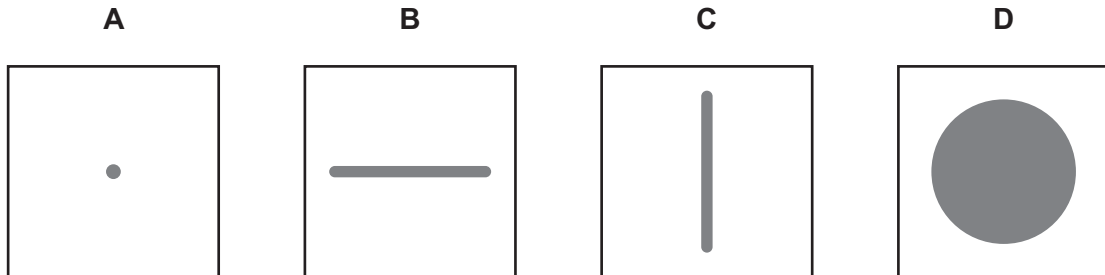
- A** 5.0×10^{-5} **B** 2.0×10^1 **C** 2.0×10^4 **D** 5.0×10^7

- 29** A beam of laser light is directed towards a narrow slit.



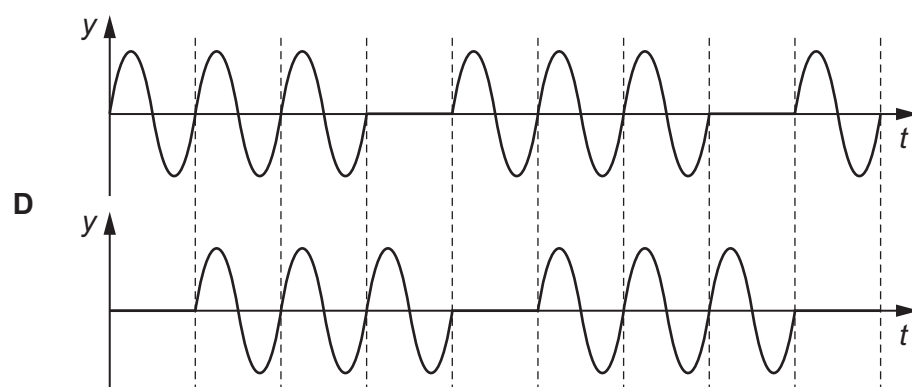
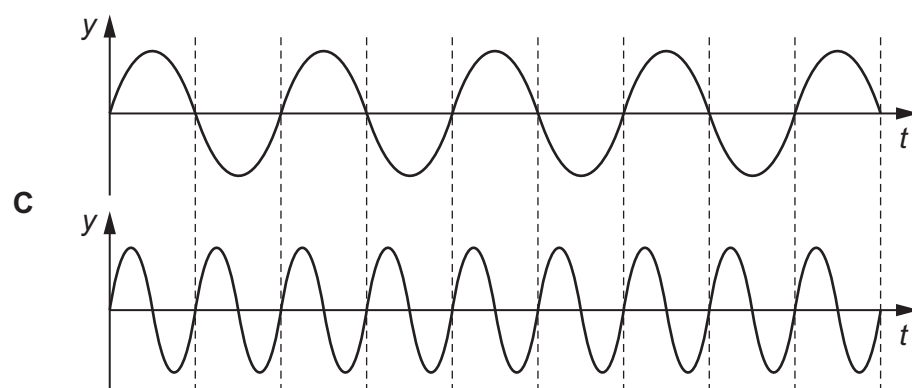
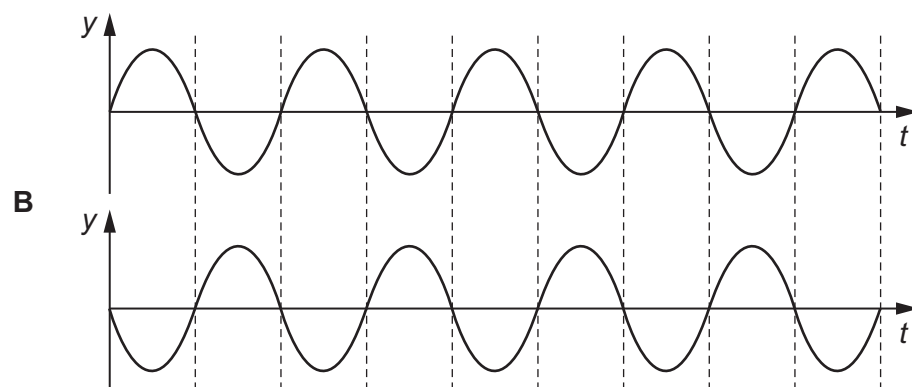
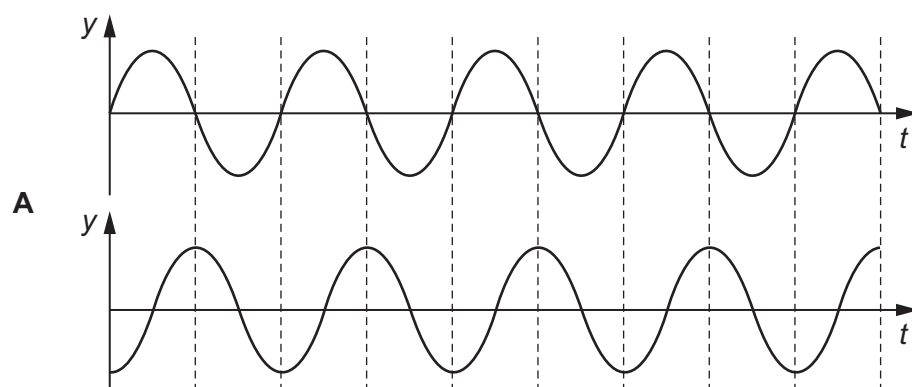
After emerging from the other side of the slit, the light then falls on a screen.

What is the pattern of light seen on the screen?



- 30 The diagrams show four pairs of waves. In each case the displacement y measured at a fixed point is plotted against time t .

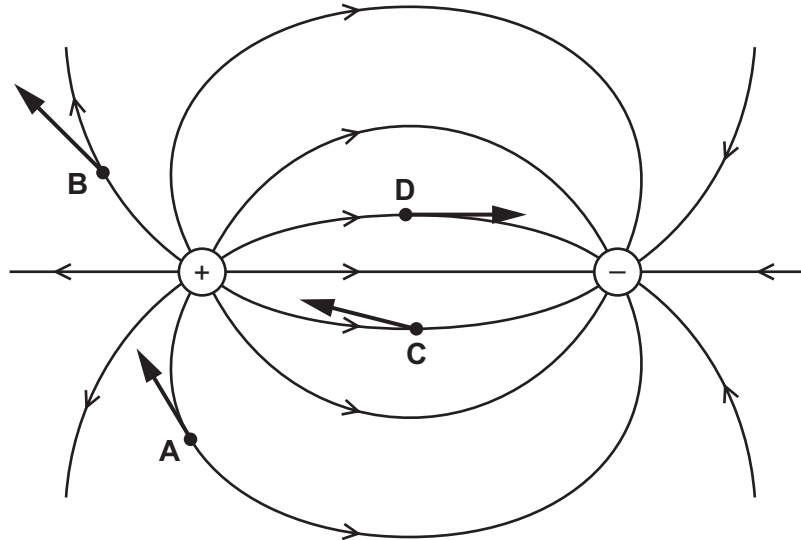
Which pair of waves is **not** coherent?



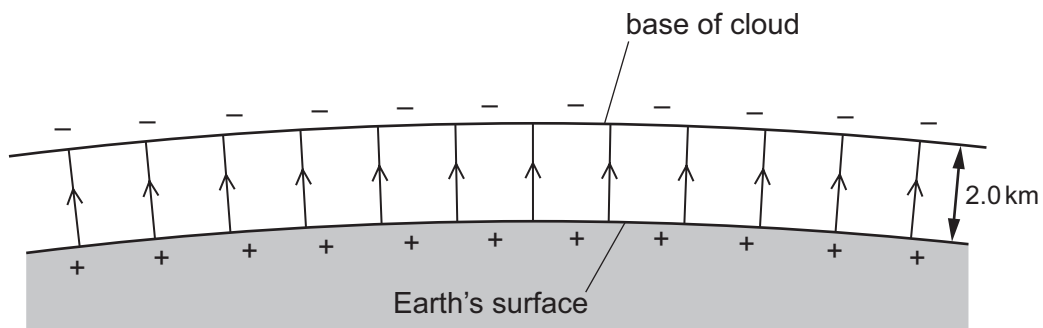
- 31 The diagram shows the electric field near a positively charged sphere and a negatively charged sphere.

Four electrons **A**, **B**, **C** and **D** are shown at different positions in the field.

On which electron is the direction of the force on the electron shown correctly?



- 32 Lightning can occur between a charged cloud and the Earth's surface when the electric field strength in the intervening atmosphere reaches 25 kNC^{-1} . The diagram shows the electric field between the base of a cloud and the Earth's surface.



What is the minimum potential difference between the Earth and the base of a cloud, 2.0 km high, for lightning to occur?

- A** 12.5 MV **B** 25 MV **C** 50 MV **D** 100 MV

- 33** The number density of conduction electrons in copper is $8.0 \times 10^{28} \text{ m}^{-3}$.

What is the average drift speed of electrons in a copper wire of diameter 0.42 mm when the current in the wire is 0.57 A?

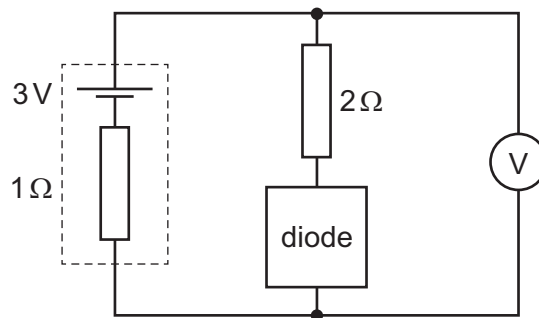
- A** $8.0 \times 10^{-11} \text{ m s}^{-1}$
- B** $3.2 \times 10^{-10} \text{ m s}^{-1}$
- C** $8.0 \times 10^{-5} \text{ m s}^{-1}$
- D** $3.2 \times 10^{-4} \text{ m s}^{-1}$

- 34** A simple circuit comprises a source of electromotive force (e.m.f.) connected to a load.

How does the output power P of the source depend on the internal resistance r of the source and the resistance R of the load?

- A** P is independent of both r and R .
- B** P depends on r but not on R .
- C** P depends on R but not on r .
- D** P depends on both r and R .

- 35** An ideal diode has zero resistance when forward biased and infinite resistance when reverse biased. The diode is connected in series with a 2Ω resistor across the terminals of a source having electromotive force (e.m.f.) 3 V and internal resistance 1Ω , as shown.

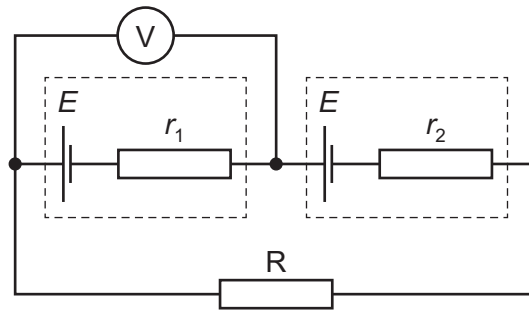


A high-resistance voltmeter is connected across the diode and resistor.

Which row gives the readings of the voltmeter for the two ways of connecting the diode?

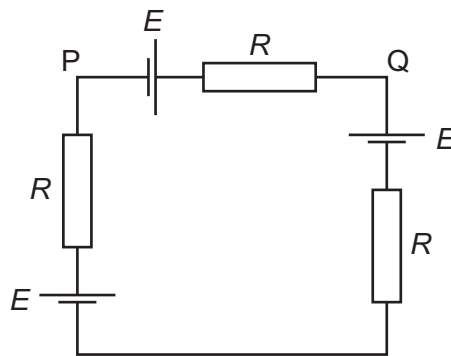
	forward biased	reverse biased
A	1 V	3 V
B	2 V	0 V
C	2 V	3 V
D	3 V	0 V

- 36 Two cells, each with electromotive force (e.m.f.) E , but different internal resistances r_1 and r_2 , are connected in series to a resistor R . The reading on the voltmeter is 0 V .



What is the resistance of R ?

- A 0 B $r_1 - r_2$ C $r_1 + r_2$ D $\frac{r_1 r_2}{r_1 + r_2}$
- 37 Three identical cells each have electromotive force (e.m.f.) E and negligible internal resistance. The cells are connected to three identical resistors, each of resistance R , as shown.

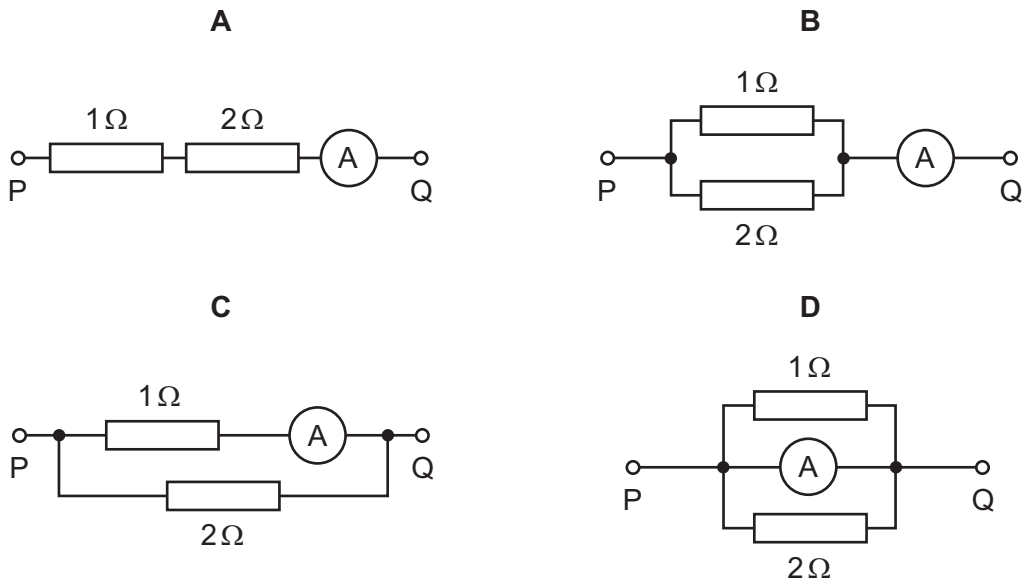


What is the potential difference between P and Q ?

- A 0 B $\frac{E}{3}$ C $\frac{2E}{3}$ D E

38 In each arrangement of resistors, the ammeter has a resistance of 2Ω .

Which arrangement gives the largest reading on the ammeter when the same potential difference is applied between points P and Q?



39 Each option shows the number of neutrons, protons and electrons in two atoms, some of which are ionised.

Which pair of atoms in the table are isotopes of the same element?

	neutron	proton	electron
A	20 20	17 19	20 20
B	28 28	23 24	23 24
C	34 36	29 29	29 28
D	40 42	32 31	32 32

40 Which combination of up (u) and down (d) quarks forms a proton?

- A** u u u **B** u u d **C** u d d **D** d d d

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