Cambridge International AS & A Level

**Cambridge International Examinations**
Cambridge International Advanced Subsidiary and Advanced Level

**PHYSICS** **9702/12**

Paper 1 Multiple Choice **May/June 2016**

**1 hour 15 minutes**

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

*0353395208*

**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 **21** printed pages and **3** blank pages.


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**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 | $\varepsilon_0 = 8.85 \times 10^{-12}\,\text{F m}^{-1}$ |
| | $\left(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\text{m F}^{-1}\right)$ |
| 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 | $m_\text{e} = 9.11 \times 10^{-31}\,\text{kg}$ |
| rest mass of proton | $m_\text{p} = 1.67 \times 10^{-27}\,\text{kg}$ |
| molar gas constant | $R = 8.31\,\text{J K}^{-1}\,\text{mol}^{-1}$ |
| the Avogadro constant | $N_\text{A} = 6.02 \times 10^{23}\,\text{mol}^{-1}$ |
| 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 | $g = 9.81\,\text{m s}^{-2}$ |

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**Formulae**

| | |
|---|---|
| uniformly accelerated motion | $s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ |
| 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. | $v = v_0 \cos \omega t$<br>$v = \pm\omega\sqrt{(x_0^2 - x^2)}$ |
| Doppler effect | $f_o = \frac{f_s v}{v \pm v_s}$ |
| electric potential | $V = \frac{Q}{4\pi\varepsilon_0 r}$ |
| capacitors in series | $1/C = 1/C_1 + 1/C_2 + \ldots$ |
| capacitors in parallel | $C = C_1 + C_2 + \ldots$ |
| energy of charged capacitor | $W = \frac{1}{2}QV$ |
| electric current | $I = Anvq$ |
| resistors in series | $R = R_1 + R_2 + \ldots$ |
| resistors in parallel | $1/R = 1/R_1 + 1/R_2 + \ldots$ |
| Hall voltage | $V_H = \frac{BI}{ntq}$ |
| alternating current/voltage | $x = x_0 \sin \omega t$ |
| radioactive decay | $x = x_0 \exp(-\lambda t)$ |
| decay constant | $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$ |

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**[Turn over**

**1** Which quantity with its unit is correct?

**A** acceleration of a bicycle = $1.4\,\text{m}\,\text{s}^{-1}$

**B** electric current in a lamp = $0.25\,\text{A}\,\text{s}^{-1}$

**C** electric potential difference across a battery = $8.0\,\text{J}\,\text{C}^{-1}$

**D** kinetic energy of a car = $4500\,\text{N}\,\text{m}^{-1}$

**2** The luminosity $L$ of a star is given by

$$L = 4\pi r^2 \sigma T^4$$

where

$r$ is the radius of the star,

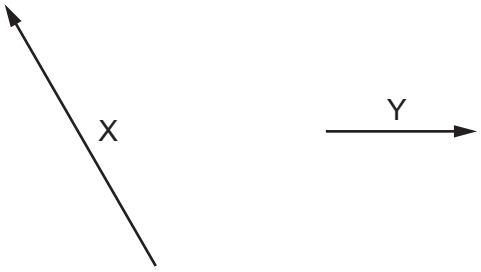
$T$ is the temperature of the star,

$\sigma$ is a constant with units $\text{W}\,\text{m}^{-2}\,\text{K}^{-4}$.

What are the SI base units of $L$?

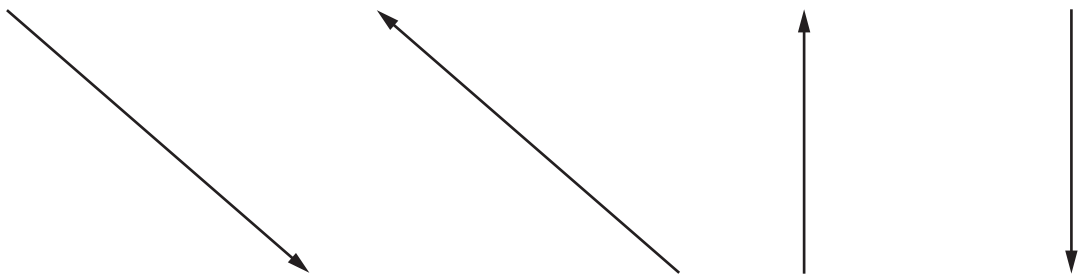
**A** $\text{kg}\,\text{m}^2\,\text{s}^{-1}$ **B** $\text{kg}\,\text{m}^2\,\text{s}^{-2}$ **C** $\text{kg}\,\text{m}^2\,\text{s}^{-3}$ **D** $\text{kg}\,\text{m}^2\,\text{s}^{-4}$

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

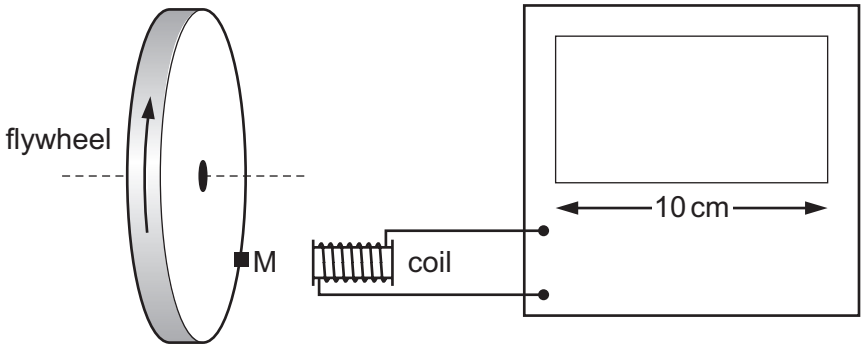



If X = Y – Z, which diagram best represents the vector Z?

**A** **B** **C** **D**



**4** The diagram shows a cathode-ray oscilloscope (c.r.o.) being used to measure the rate of rotation of a flywheel.




The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at 3000 revolutions per minute.

Which time-base setting will display clearly separate pulses on the screen?

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

**5** A student determines the density $\rho$ of steel by taking measurements from a steel wire.

mass $m = 6.2 \pm 0.1\,\text{g}$

length $l = 25.0 \pm 0.1\,\text{cm}$

diameter $d = 2.00 \pm 0.01\,\text{mm}$

He uses the equation $\rho = \dfrac{4m}{\pi d^2 l}$.

What is the percentage uncertainty in his calculated value of density?

**A** 1.1% **B** 1.8% **C** 2.5% **D** 3.0%

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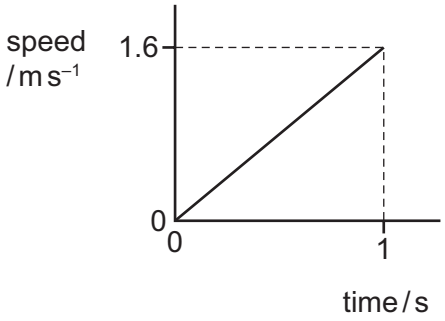
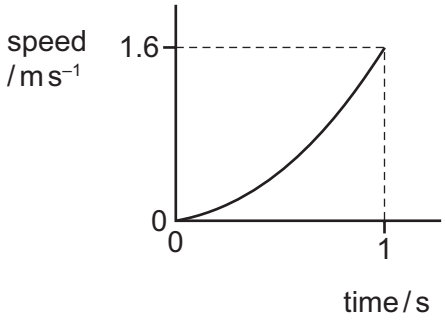
**6** The acceleration of free fall on the Moon is $1.6\,m\,s^{-2}$. The Moon has no atmosphere. An astronaut standing on the surface of the Moon drops a feather.

Which graph shows the variation with time of the speed of the feather during the first second of its fall?

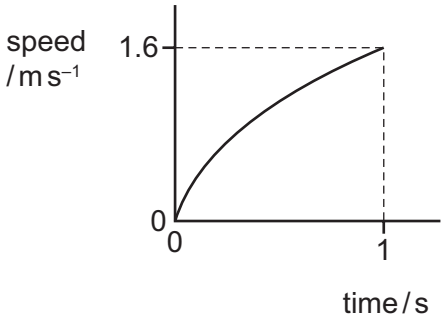
**A**



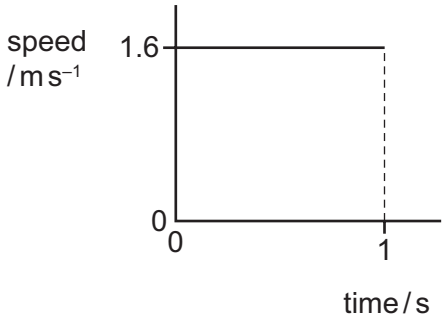

**B**




**C**




**D**

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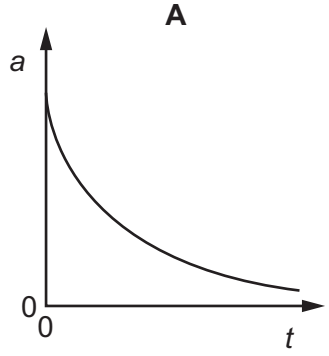
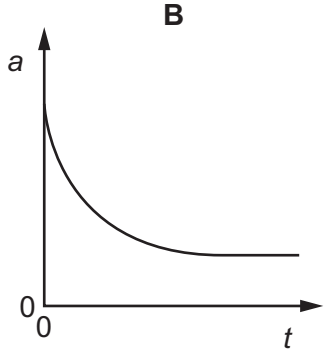
**7** A tennis ball is released from rest at the top of a tall building.

Which graph best represents the variation with time $t$ of the acceleration $a$ of the ball as it falls, assuming that the effect of air resistance is **not** negligible?

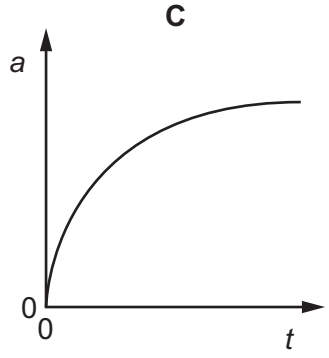
**A**



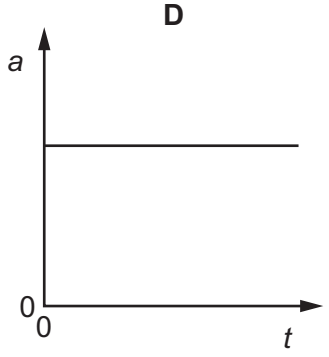

**B**



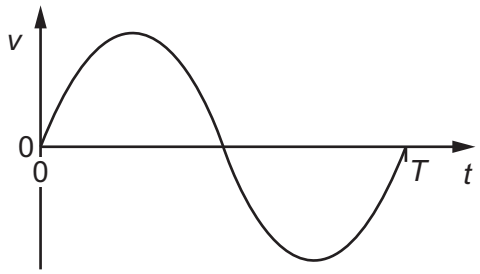

**C**




**D**

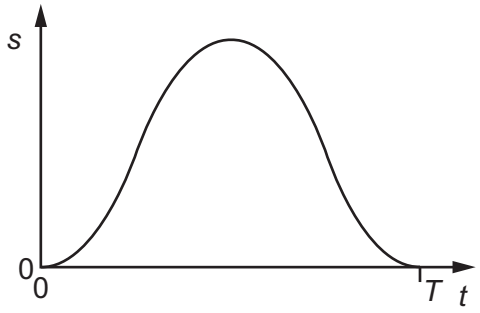


**8** The graph shows how the velocity $v$ of an object moving in a straight line varies with time $t$ from $t = 0$ to $t = T$.

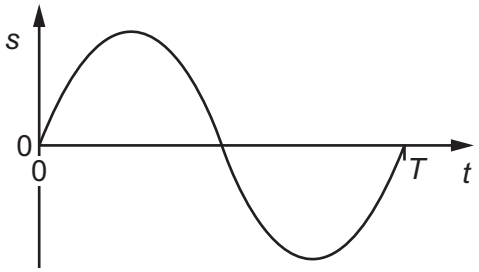



Which graph represents the displacement $s$ of the object in the time $t = 0$ to $t = T$?

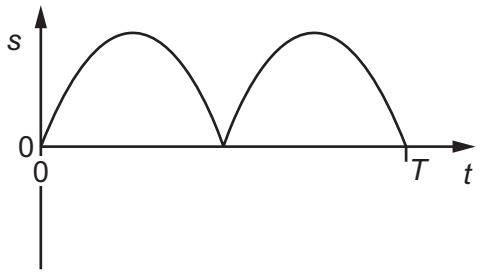
**A**



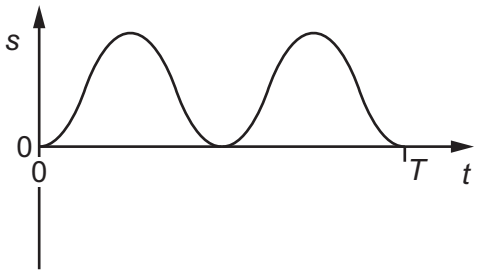

**B**




**C**




**D**

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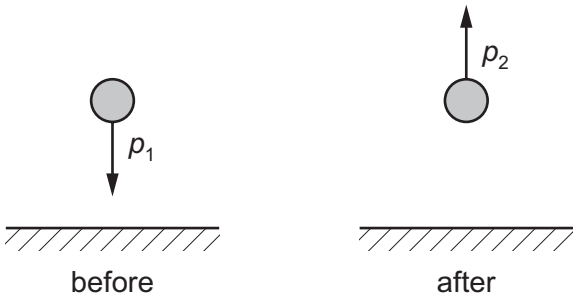
**9** A ball falls vertically onto horizontal ground and rebounds, as shown.




The ball has momentum $p_1$ downwards just before hitting the ground. After rebounding, the ball leaves the ground with momentum $p_2$ upwards. The ball is in contact with the ground for 0.020 s. During this time interval, an average resultant force of 25 N acts on the ball.

What is a possible combination of values for $p_1$ and $p_2$?

| | $p_1$ / kg m s$^{-1}$ | $p_2$ / kg m s$^{-1}$ |
|---|---|---|
| **A** | 0.15 | 0.65 |
| **B** | 0.20 | 0.30 |
| **C** | 0.30 | 0.20 |
| **D** | 0.65 | 0.15 |

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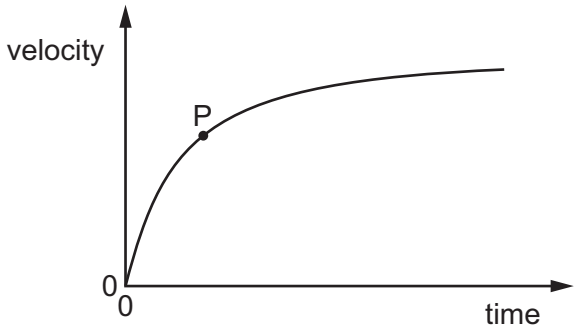
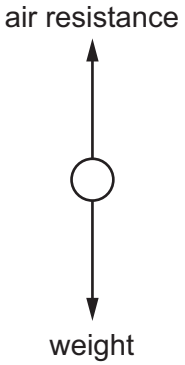
**10** A sphere falls from rest through the air. The graph shows the variation with time of the sphere's velocity.




Which diagram shows the forces acting on the sphere when it is at the velocity corresponding to point P on the graph?

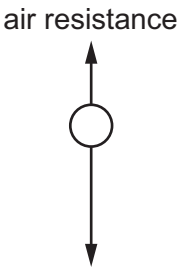
**A**



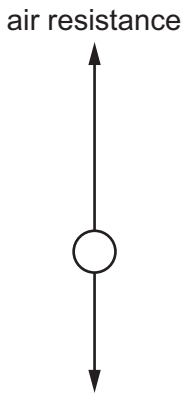

**B**




**C**




**D**

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**11** A ball of mass $m$ travelling at velocity $u$ collides with a stationary ball of mass $M$. After collision the two balls travel at velocities $v$ and $V$ respectively, in the directions shown.

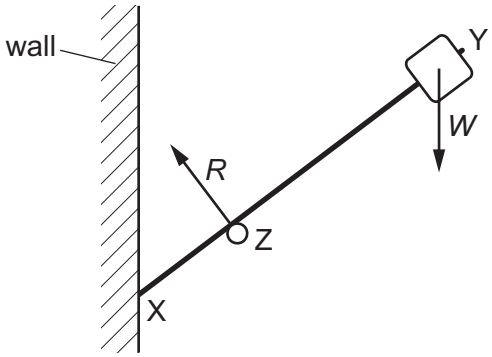



A student writes three equations relating to the collision.

Which row in the table indicates the correct and incorrect equations?

| | $mu = MV + mv$ | $mv \sin 30° = MV \sin 40°$ | $mu = mv \cos 30° + MV \cos 40°$ |
|---|---|---|---|
| **A** | correct | correct | correct |
| **B** | incorrect | correct | incorrect |
| **C** | correct | incorrect | incorrect |
| **D** | incorrect | correct | correct |

**12** A light rigid rod XY has an object of weight $W$ fixed at one end. The rod is in equilibrium, resting on a roller at Z and a vertical wall at X. The roller exerts a force $R$ on the rod as shown. The diagram shows the directions, but not the magnitudes, of the forces $R$ and $W$.




What is the direction of the force on the rod at X?

**A** **B** **C** **D**



**13** 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$^{-3}$,

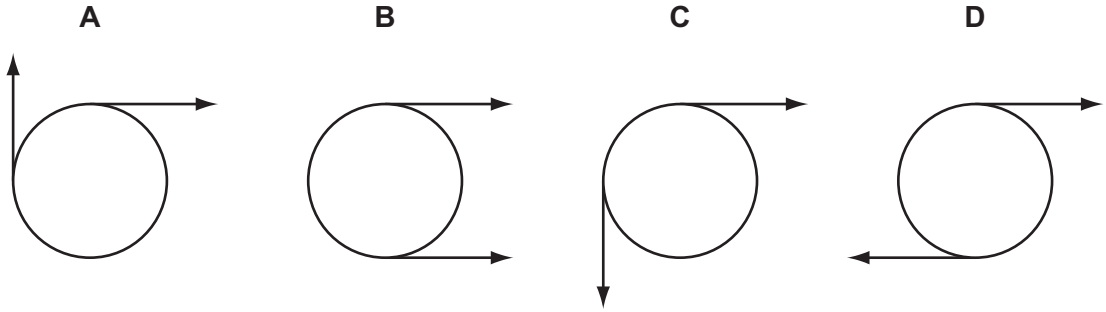
4000 kg of oil of density 910 kg m$^{-3}$.

What is the density of the mixture?

**A** 927 kg m$^{-3}$ **B** 957 kg m$^{-3}$ **C** 1010 kg m$^{-3}$ **D** 1080 kg m$^{-3}$

**14** Two coplanar forces act on the rim of a wheel. The forces are equal in magnitude.

Which arrangement of forces provides only a couple?




**15** The density of air on the Earth decreases almost linearly with height from 1.22 kg m$^{-3}$ at sea level to 0.74 kg m$^{-3}$ at an altitude of 5000 m.

Atmospheric pressure at the Earth's surface on a particular day is 100 000 Pa. The value of $g$ between the Earth's surface and an altitude of 5000 m can be considered to have a constant value of 9.7 m s$^{-2}$.

What will be the atmospheric pressure at an altitude of 5000 m?

**A** 36 000 Pa **B** 48 000 Pa **C** 52 000 Pa **D** 59 000 Pa

**16** A parachutist is falling at constant (terminal) velocity.

Which statement is **not** correct?

**A** Gravitational potential energy is converted into kinetic energy of the air.

**B** Gravitational potential energy is converted into kinetic energy of the parachutist.

**C** Gravitational potential energy is converted into thermal energy of the air.

**D** Gravitational potential energy is converted into thermal energy of the parachutist.

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**17** A boy on a bicycle starts from rest and rolls down a hill inclined at 30° to the horizontal.

The boy and bicycle have a combined mass of 25 kg.

There is a frictional force of 30 N, which is independent of the velocity of the bicycle.

What is the kinetic energy of the boy and the bicycle after rolling 20 m down the slope?

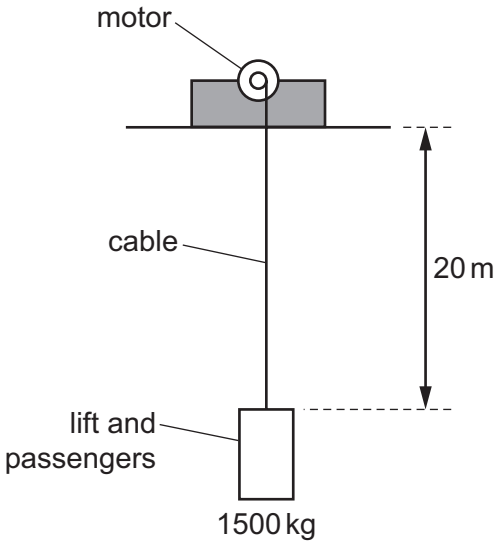
**A** 1850 J **B** 2450 J **C** 3050 J **D** 3640 J

**18** An escalator in an underground station has 250 people standing on it and is moving with a velocity of 4.3 m s$^{-1}$. The average mass of a person is 78 kg and the angle of the escalator to the horizontal is 40°.

What is the minimum power required to lift these people?

**A** 54 kW **B** 64 kW **C** 530 kW **D** 630 kW

**19** An electric motor operating a lift has an output power of 20 kW.




The lift and passengers have a combined mass of 1500 kg. The motor raises the lift through a distance of 20 m.

How long does it take?

**A** 6 s **B** 15 s **C** 30 s **D** 60 s

**20** A spring balance consists of a spring of length 20.0 cm with a hook attached.

When a fish of mass 3.0 kg is suspended from the hook, the new length of the spring is 27.0 cm.

What is the spring constant of the spring?

**A** 4.2 N m$^{-1}$ **B** 43 N m$^{-1}$ **C** 110 N m$^{-1}$ **D** 420 N m$^{-1}$

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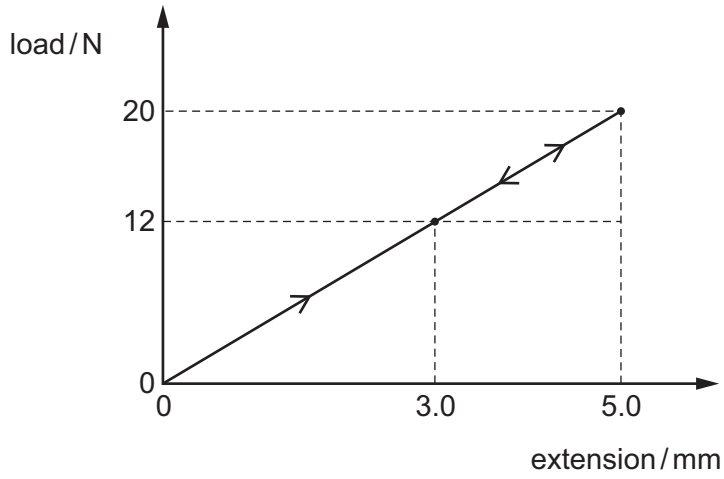
**21** A metal wire is attached at one end to a fixed point and a load is hung from the other end so that the wire hangs vertically. The load is increased from zero to 20 N. This causes the wire to extend elastically by 5.0 mm. The load is then reduced to 12 N and the extension decreases to 3.0 mm.




How much strain energy is released during the unloading process?

**A** $0.8 \times 10^{-2}$ J **B** $1.8 \times 10^{-2}$ J **C** $2.4 \times 10^{-2}$ J **D** $3.2 \times 10^{-2}$ J

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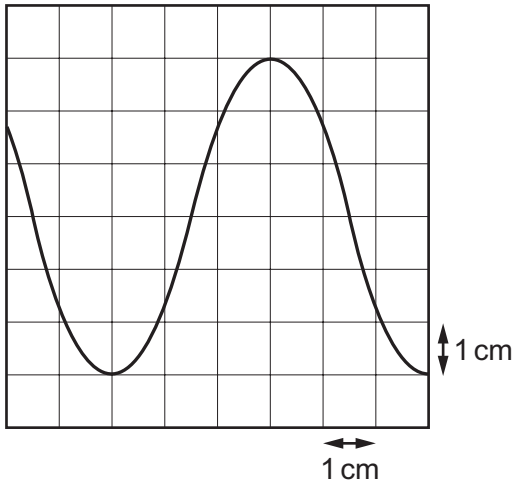
**22** A microphone connected to the Y-plates of a cathode-ray oscilloscope (c.r.o.) is placed in front of a loudspeaker. The trace on the screen of the c.r.o. is shown.




The time-base setting is 0.5 ms cm$^{-1}$ and the Y-plate sensitivity is 0.2 mV cm$^{-1}$.

What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the c.r.o.?

| | frequency / Hz | amplitude / mV |
|---|---|---|
| **A** | 330 | 0.6 |
| **B** | 330 | 1.2 |
| **C** | 670 | 0.6 |
| **D** | 670 | 1.2 |

**23** A source of sound of frequency 1000 Hz moves away from a stationary observer at a speed of 30.0 m s$^{-1}$. The speed of sound is 330 m s$^{-1}$.

What is the frequency of the sound heard by the observer?

**A** 909 Hz **B** 917 Hz **C** 1090 Hz **D** 1100 Hz

**24** Each of the principal radiations of the electromagnetic spectrum has a range of wavelengths.

Which wavelength is correctly linked to its radiation?

| | wavelength / m | radiation |
|---|---|---|
| **A** | $10^{-9}$ | gamma ray |
| **B** | $10^{-5}$ | microwave |
| **C** | $10^{-8}$ | ultraviolet |
| **D** | $10^{-14}$ | X-ray |

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**25** A stationary wave is set up on a stretched string.

The diagram shows the string at two instants of time when it has maximum displacement.




The oscillations of point P on the string have amplitude $A$.

What is the distance moved by P from the position shown in the diagram after half a time period of the wave?

**A** 0 **B** $A$ **C** $2A$ **D** $4A$

**26** Which statement is an example of the diffraction of light?

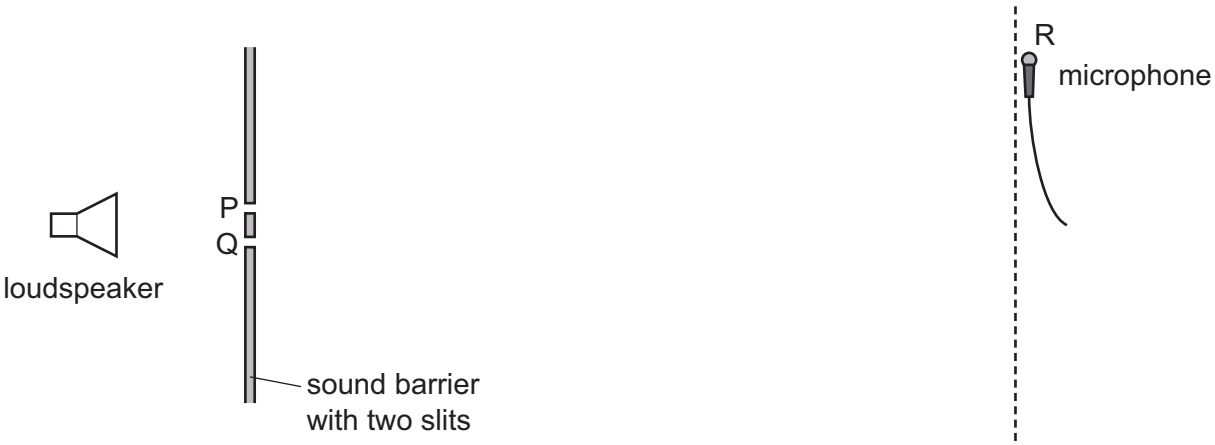
**A** the addition of the amplitudes of two beams of light which are in phase

**B** the change in direction of a beam of light when passing from air into water

**C** the separation of a beam of white light into a spectrum of colours using a prism

**D** the spreading of a beam of light as it passes through a small hole

**27** Sound waves of wavelength $\lambda$ are emitted by a loudspeaker and pass through two slits P and Q. Two sound waves from the slits meet at R.




What is the condition for an intensity maximum (loud sound) to be detected by a microphone at R?

**A** The amplitudes of the two waves at R must be the same.

**B** The distance PQ must be smaller than the wavelength $\lambda$.

**C** The two waves from the slits must have travelled the same distance to R.

**D** The two waves must be in phase at R.

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**28** Coherent light passes through a double slit, producing bright and dark fringes on a screen placed parallel to the plane of the double slit. The intensity of the light from each of the slits is initially the same.

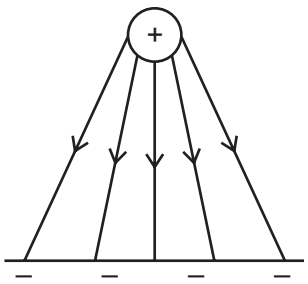
The intensity of the light passing through one of the slits in the double slit is now increased. The frequency of the light remains constant.

What is the effect on the appearance of the fringes on the screen?

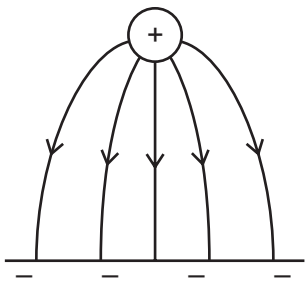
| | separation of fringes | maximum intensity of dark fringes |
|---|---|---|
| **A** | decreases | no change |
| **B** | increases | greater |
| **C** | no change | greater |
| **D** | no change | no change |

**29** Which diagram shows the pattern of the electric field between a positively charged metal sphere and a negatively charged metal plate?

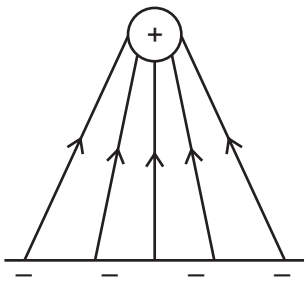
**A**



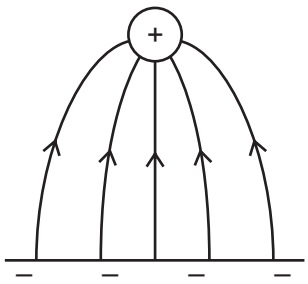
**B**



**C**



**D**



**30** Before a thunderstorm, the hairs on your head sometimes stand on end.

A hair with mass 0.50 mg and charge 1.0 pC is supported by a force due to an electric field. Ignore any forces other than the weight of the hair and the electric force.

What is the electric field strength?

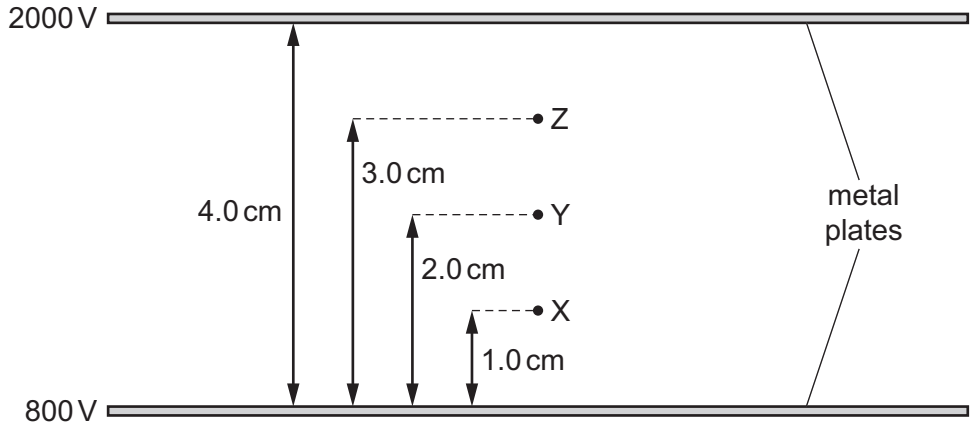
**A** $4.9 \times 10^{3}\,\text{N C}^{-1}$

**B** $4.9 \times 10^{5}\,\text{N C}^{-1}$

**C** $4.9 \times 10^{6}\,\text{N C}^{-1}$

**D** $4.9 \times 10^{9}\,\text{N C}^{-1}$

**31** Two parallel metal plates, 4.0 cm apart, are at electric potentials of 800 V and 2000 V. Points X, Y and Z are situated in the space between the plates at distances of 1.0 cm, 2.0 cm and 3.0 cm from the lower plate.




What is the electric field strength, in $\text{V m}^{-1}$, at X, Y and Z?

| | X | Y | Z |
|---|---|---|---|
| **A** | 300 | 600 | 900 |
| **B** | 1100 | 1400 | 1700 |
| **C** | $3.0 \times 10^{4}$ | $3.0 \times 10^{4}$ | $3.0 \times 10^{4}$ |
| **D** | $5.0 \times 10^{4}$ | $5.0 \times 10^{4}$ | $5.0 \times 10^{4}$ |

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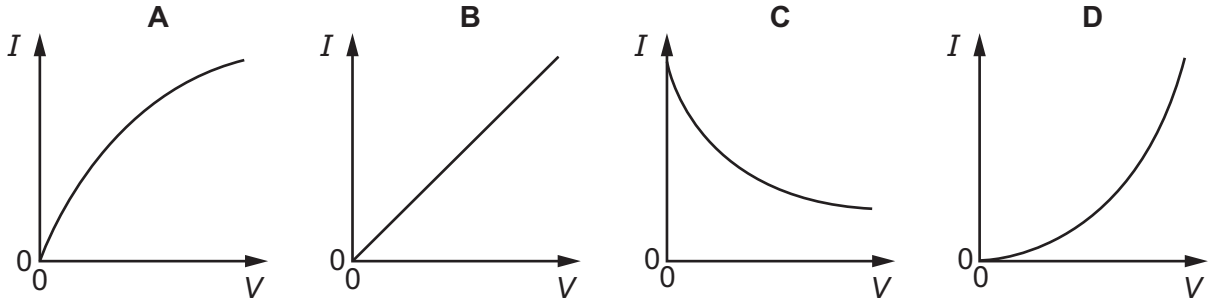
**32** The potential difference $V$ across a filament lamp is slowly raised from zero to its normal operating value.

Which graph represents the variation with $V$ of the current $I$ in the lamp?




**33** Two lamps are connected in series to a 250 V power supply. One lamp is rated 240 V, 60 W and the other is rated 10 V, 2.5 W.

Which statement most accurately describes what happens?

**A** Both lamps light at less than their normal brightness.

**B** Both lamps light at their normal brightness.

**C** Only the 240 V lamp lights.

**D** The 10 V lamp blows.

**34** Which equation is used to define resistance?

**A** energy = $(\text{current})^2 \times$ resistance $\times$ time

**B** potential difference = current $\times$ resistance

**C** power = $(\text{current})^2 \times$ resistance

**D** resistivity = resistance $\times$ area $\div$ length

**35** The charge that a fully charged 12 V car battery can supply is 100 kC. The starter motor of the car requires a current of 200 A for an average period of 2.0 s. The battery does not recharge because of a fault.

What is the maximum number of times the starter motor of the car can be used?

**A** 21 **B** 25 **C** 42 **D** 250

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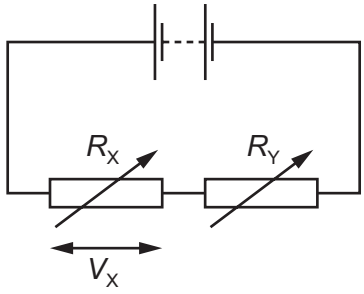
**36** A potential divider circuit is formed by connecting a battery of negligible internal resistance in series with two variable resistors, as shown.



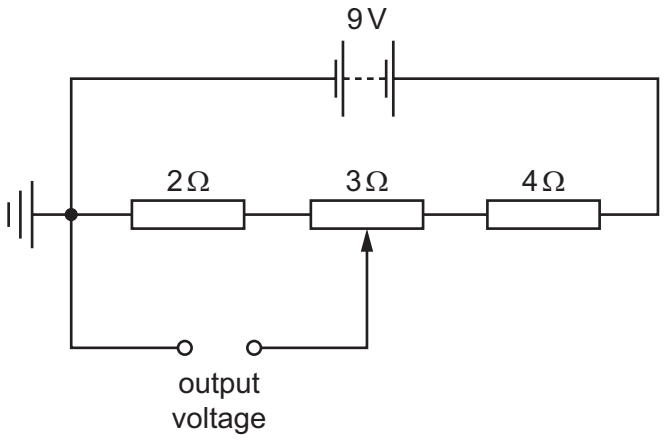

The variable resistors have resistances $R_X$ and $R_Y$.
$V_X$ is the potential difference across resistance $R_X$.

$R_X$ and $R_Y$ are both changed at the same time.

Which combination of changes **must** cause $V_X$ to increase?

| | $R_X$ | $R_Y$ |
|---|---|---|
| **A** | larger | larger |
| **B** | larger | smaller |
| **C** | smaller | larger |
| **D** | smaller | smaller |

**37** In the circuit shown, contact may be made at any point along the 3 Ω resistor (potentiometer).




The battery has e.m.f. 9 V and negligible internal resistance.

What is the maximum range of the output voltage?

**A** 0–2 V **B** 0–5 V **C** 2–3 V **D** 2–5 V

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**38** The gold nucleus $^{185}_{79}Au$ undergoes alpha decay.

What are the nucleon number and proton number of the nucleus formed by this decay?

| | nucleon number | proton number |
|---|---|---|
| **A** | 183 | 79 |
| **B** | 183 | 77 |
| **C** | 181 | 77 |
| **D** | 181 | 75 |

**39** Which row gives the correct classification of protons, electrons and neutrinos?

| | protons | electrons | neutrinos |
|---|---|---|---|
| **A** | hadrons | leptons | hadrons |
| **B** | hadrons | leptons | leptons |
| **C** | leptons | hadrons | hadrons |
| **D** | leptons | hadrons | leptons |

**40** Which equation represents $\beta^+$ decay?

**A** neutron $\rightarrow$ proton + positron + antineutrino

**B** neutron $\rightarrow$ proton + positron + neutrino

**C** proton $\rightarrow$ neutron + positron + antineutrino

**D** proton $\rightarrow$ neutron + positron + neutrino

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