MINISTRY OF EDUCATION, SINGAPORE
in collaboration with
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION
General Certificate of Education Advanced Level
Higher 2

# PHYSICS

**9749/01**

Paper 1 Multiple Choice

**October/November 2020**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Centre number and index number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE ON ANY BARCODES.

There are **thirty** 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 rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

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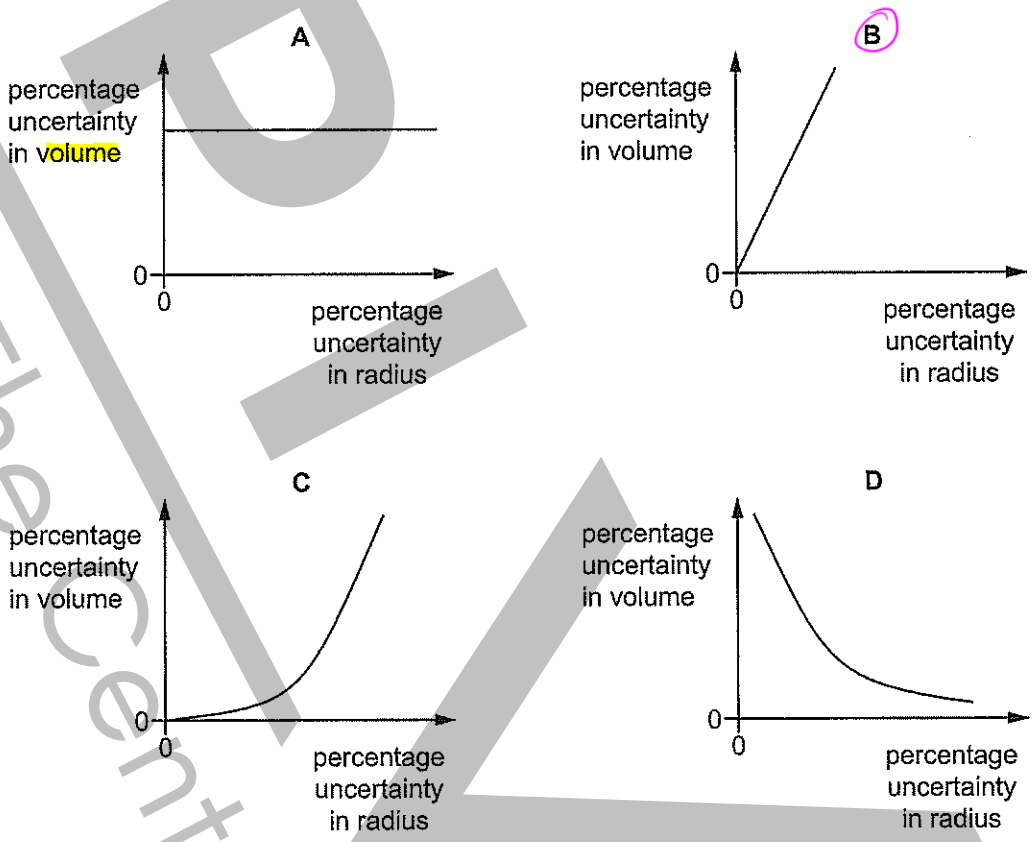
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1 A spherical balloon is gradually inflated. The radius of the balloon is measured at regular intervals and the uncertainty of the measurement is estimated. The radius of the balloon is used to calculate the volume of the balloon at each stage.

Which graph shows how the percentage uncertainty in the volume of the balloon varies with the percentage uncertainty in the radius of the balloon?




2 What is **not** an example of Newton's third law of motion?

**A** the force backwards by a car on the ground and the force forwards by the ground on the tyres of a car

**B** the force backwards by a propeller on water and the force forwards by the water on the propeller of a boat

**C** air molecules pushing backwards on a moving car and the car pushing forwards on the air molecules

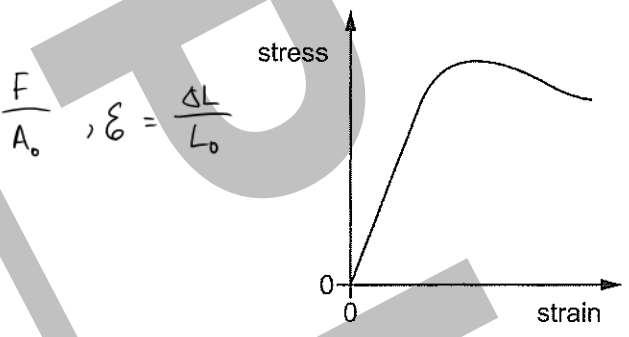
**D** the weight of a car downwards and the normal contact force upwards on the car

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3 When a metal wire is stretched, the elastic potential energy stored in the wire increases. A quantity called stress can be calculated by dividing the stretching force by the cross-sectional area of the wire. A quantity called strain can be calculated by dividing the extension of the wire by the original length of the wire.

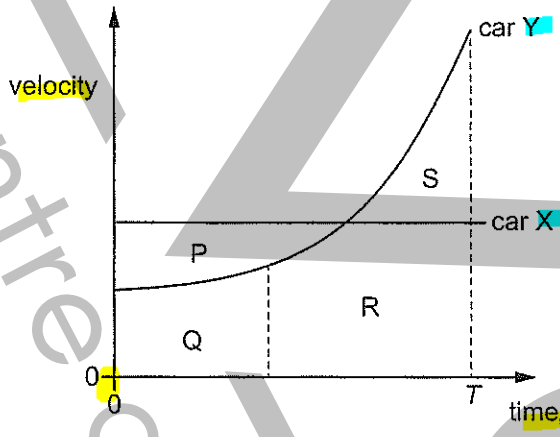
A graph of stress–strain for a metal wire is shown.




What is the unit of the quantity that represents the area under the stress–strain graph?

**A** J **B** $Jm^{-1}$ **C** $Jm^{-2}$ **D** $Jm^{-3}$

4 The velocity–time graph shows car X travelling with a constant velocity and car Y travelling with increasing acceleration. Car X overtakes car Y at time $t = 0$.




Four areas P, Q, R and S are labelled on the graph.

Car Y overtakes car X at time $t = T$.

Which relationship must be correct?

**A** P = S **B** R = S **C** P + Q = R **D** Q + R = P + S

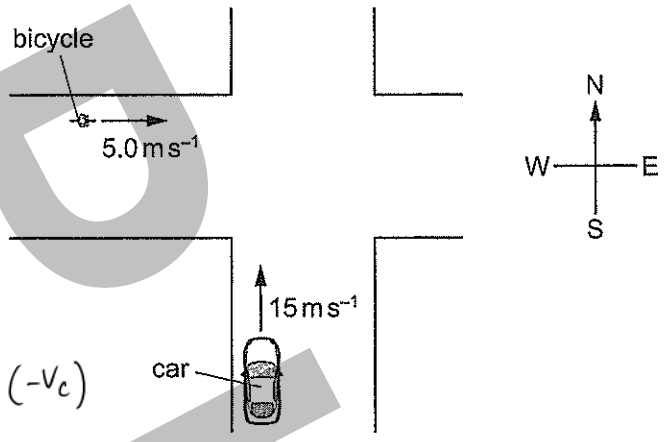
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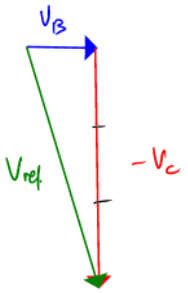
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**5** A car and a bicycle are equal distances from a crossroads. The car is travelling north with a speed of $15\,m\,s^{-1}$.

The bicycle is travelling east with a speed of $5.0\,m\,s^{-1}$.




$V_{B\,rel\,C} = V_B - V_C = V_B + (-V_C)$




At this instant, which arrow represents the velocity of the bicycle relative to the car?

A B C D

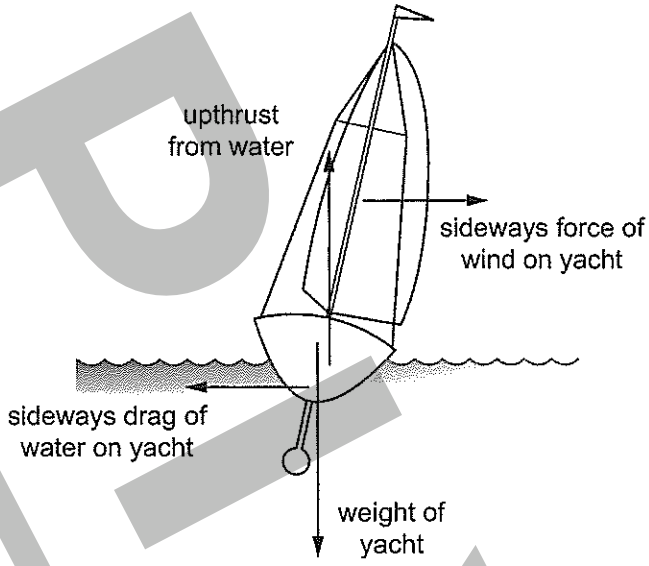


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6 A yacht that is in equilibrium has two vertical and two horizontal forces acting on it.




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

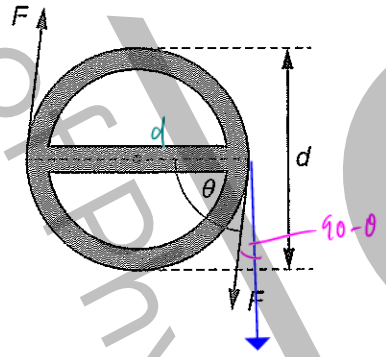
A The sideways drag from the water on the yacht is equal and opposite to the sideways force of the wind on the yacht.

B The resultant of all four forces is zero.

C The torque provided by the vertical forces is equal to the torque provided by the horizontal forces.

D The upthrust from the water is equal and opposite to the weight of the yacht.

7 A motorist applies two parallel forces, each of value $F$, to a steering wheel of diameter $d$, as shown.




$C = F\cos(90-\theta)\cdot d$

Both forces are at angle $\theta$ to the diameter.

What is the torque of the pair of forces?

A $Fd\cos\theta$ B $Fd\sin\theta$ C $2Fd\cos\theta$ D $2Fd\sin\theta$

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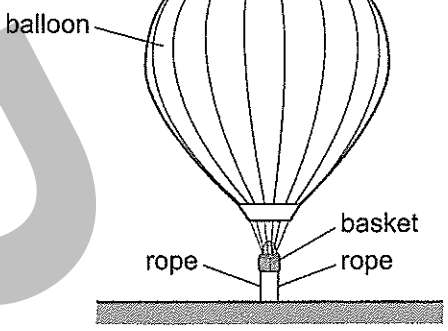
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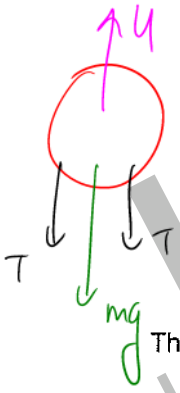
$2T + 700 + \rho_{hotair} V_{balloon} g = \rho_{Coldair} V_{balloon} g$

**8** A hot-air balloon is tied to the ground by two ropes, as shown.

$\therefore 2T = (1.204)(2800)(9.81) - 700(9.81) - (0.898)(2800)(9.81)$

$\therefore T = 769.1\,N$




The balloon is filled with hot air at 120 °C. The ropes are in tension and vertical.

The atmospheric air temperature is 20 °C.

mass of basket and balloon (not inflated) = 700 kg

volume of balloon when filled with hot air = 2800 $m^3$

density of air at 20 °C = 1.204 kg $m^{-3}$

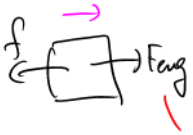
density of air at 120 °C = 0.898 kg $m^{-3}$

What is the magnitude of the tension force in each rope when the balloon is filled with hot air?

**A** 0.770 kN **B** 1.54 kN **C** 7.62 kN **D** 13.1 kN

**9** At a particular time, the driving force applied by the driving wheels of a car is 1.6 kN. This force does useful work on the car to keep it moving at a constant speed of 22 m $s^{-1}$ on level ground. The total thermal energy produced by the burning of fuel in the engine is 3.3 MJ per minute.

22 m/s →




1600 N

What is the efficiency of the car in converting the thermal energy into useful work done on the car to keep it moving at the constant speed of 22 m $s^{-1}$ on level ground?

0.055 MJ/s

**A** 22% **B** 36% **C** 39% **D** 64%

$\eta = \frac{P_{out}}{P_{in}} = \frac{(1600)(22)}{0.055\,MW} = 0.64$

**10** The orbit of the Moon around the Earth is circular with a radius of $3.85 \times 10^8$ m. The time for one orbit is 27.3 days.

What is the centripetal acceleration of the Moon?

**A** $1.84 \times 10^{-20}$ m $s^{-2}$

**B** $2.73 \times 10^{-3}$ m $s^{-2}$

**C** $1.03 \times 10^{3}$ m $s^{-2}$

**D** $1.57 \times 10^{3}$ m $s^{-2}$

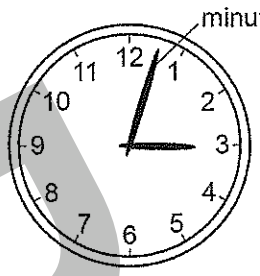
$a_c = r\omega^2 = r\left(\frac{2\pi}{T}\right)^2 = (3.85 \times 10^8)\left(\frac{2\pi}{27.3 \times 24 \times 3600}\right)^2$

$= 2.73 \times 10^{-3}$

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**11** The minute hand of a large clock is 3.00 m long.




What is the magnitude of its angular velocity?

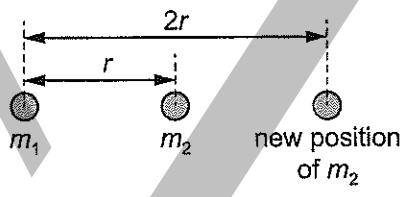
**A** $1.39 \times 10^{-4}$ rad s$^{-1}$

**B** $1.75 \times 10^{-3}$ rad s$^{-1}$

**C** $5.24 \times 10^{-3}$ rad s$^{-1}$

**D** $1.05 \times 10^{-1}$ rad s$^{-1}$

**12** Two objects are separated by a distance $r$. The objects can be considered to be point masses of mass $m_1$ and $m_2$. The object of mass $m_1$ is fixed in position. The object of mass $m_2$ is moved so that the separation of the two objects is $2r$.




What is the increase in gravitational potential energy of the object of mass $m_2$?

**A** $\frac{Gm_1m_2}{2r}$ **B** $\frac{-Gm_1m_2}{2r}$ **C** $\frac{3Gm_1m_2}{4r^2}$ **D** $\frac{-3Gm_1m_2}{4r^2}$

**13** A black hole has a mass of $2.0 \times 10^{31}$ kg.

What would be the gravitational field strength due to this black hole at a distance of 150 million km?

**A** $5.9 \times 10^{-2}$ N kg$^{-1}$

**B** $5.9 \times 10^{4}$ N kg$^{-1}$

**C** $8.8 \times 10^{9}$ N kg$^{-1}$

**D** $8.8 \times 10^{12}$ N kg$^{-1}$

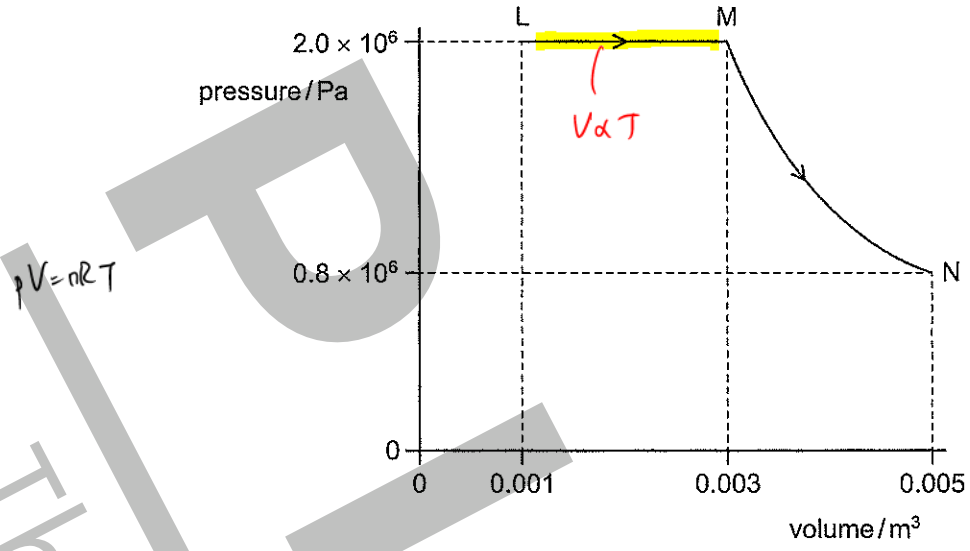
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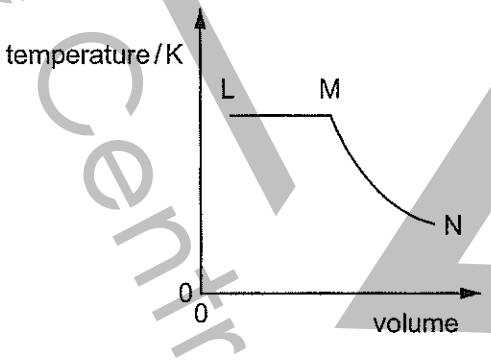
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**14** A fixed mass of ideal gas undergoes changes of pressure and volume starting at L, as shown.

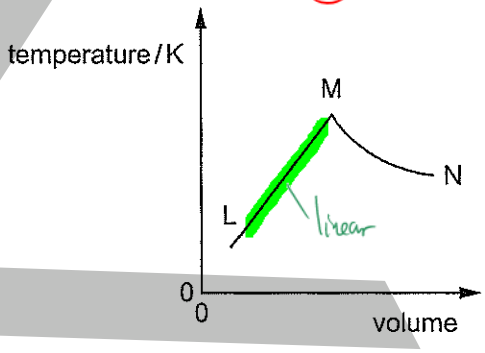



Which graph shows how temperature (measured in kelvin) changes with volume?

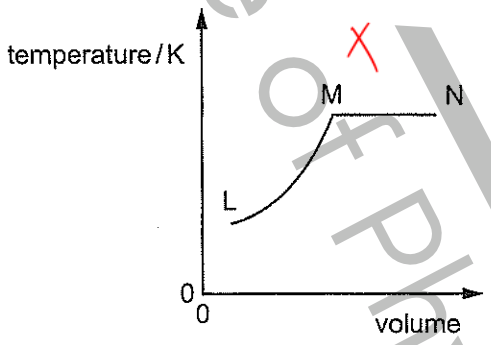
**A**



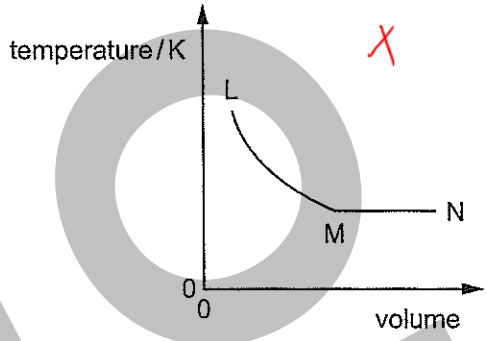

**B**




**C**




**D**



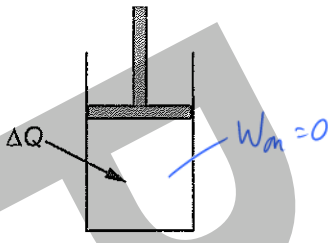

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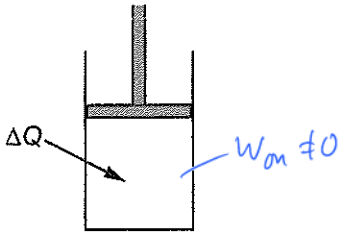


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**15** Two experiments are carried out using a fixed mass of gas.




experiment 1
gas at constant volume




experiment 2
gas at constant pressure

In experiment 1, an amount of heat energy $\Delta Q$ is supplied to a fixed mass of gas at constant volume. In experiment 2, the same amount of heat energy $\Delta Q$ is supplied to the same mass of gas at constant pressure.

Which statement about these two experiments is correct?

**A** The work done by the gas in experiment 1 is greater than $\Delta Q$.

**B** The increase in internal energy of the gas in experiment 1 is equal to $\Delta Q$.

**C** The work done by the gas in experiment 2 is greater than $\Delta Q$.

**D** The increase in internal energy of the gas in experiment 2 is equal to $\Delta Q$.

**16** A pendulum consists of a small object on the end of a light string.

When the object is set in motion it oscillates with simple harmonic motion with negligible damping.

The maximum potential energy of the object at maximum displacement $x$ is $E$.

The pendulum is stopped and then started again.

Now the maximum potential energy of the object is reduced by $\frac{E}{4}$.

What is the change in the amplitude of the oscillation?

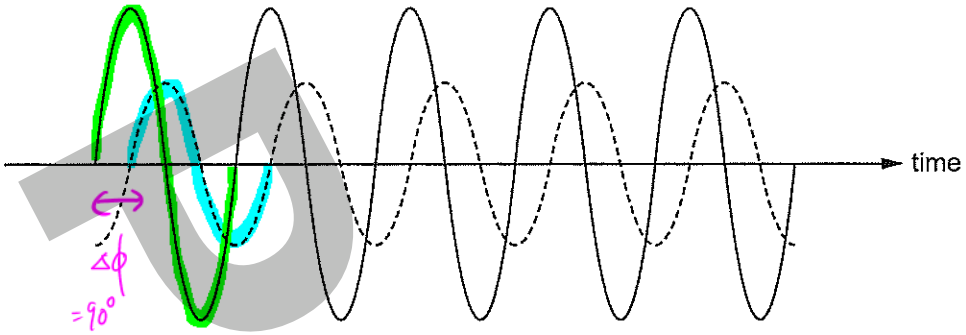
**A** 0.134 $x$ **B** 0.250 $x$ **C** 0.500 $x$ **D** 0.866 $x$

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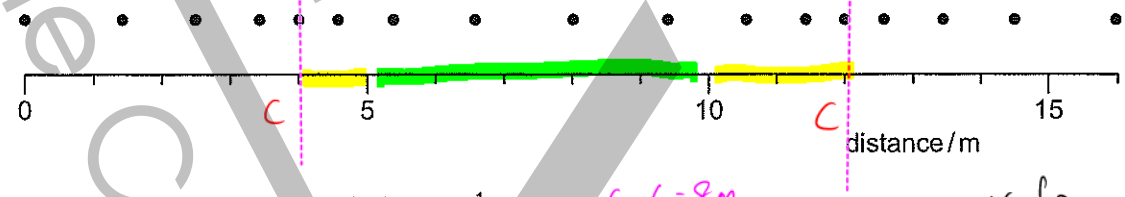
**17** Two waves of the same frequency are displayed on a screen.




What is the phase difference between the waves?

**A** $\frac{1}{4}$ rad **B** $\frac{\pi}{4}$ rad **C** $\frac{\pi}{2}$ rad **D** $\frac{3\pi}{4}$ rad

**18** The diagram illustrates the position of particles along a longitudinal wave at an instant in time.

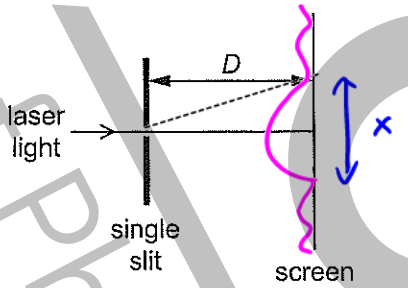



The wave travels at a speed of 12 m s$^{-1}$.

What is the wave frequency?

**A** 0.33 Hz **B** 0.67 Hz **C** 1.5 Hz **D** 3.0 Hz

**19** Laser light of frequency $f$ passes through a single slit. The resulting diffraction pattern is observed on a screen. The width of the central maximum is $x$. The distance $D$ between the single slit and the screen is much greater than the slit width.




What is the correct expression for the slit width?

**A** $\frac{cx}{2Df}$ **B** $\frac{cx}{Df}$ **C** $\frac{cD}{fx}$ **D** $\frac{2cD}{fx}$

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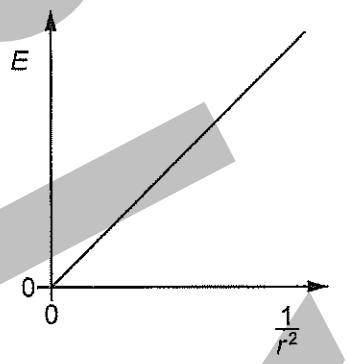
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**20** The electric potential due to a point charge at distance $d$ from the charge is $V$.

What is the electric potential at distance $\frac{d}{2}$ from the point charge?

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

**21** The variation of the electric field strength $E$ with distance from a point charge is shown.




Which expression, using the gradient of the graph, is equal to the magnitude of the charge?

**A** $4\pi\varepsilon_0 \times$ gradient

**B** $\frac{4\pi\varepsilon_0}{\text{gradient}}$

**C** $4\pi\varepsilon_0 \times \sqrt{\text{gradient}}$

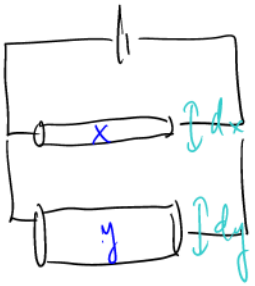
**D** $\frac{4\pi\varepsilon_0}{\sqrt{\text{gradient}}}$

**22** Two heating elements X and Y of a domestic fan heater are made of wire of the same resistivity and length. They are connected in parallel to a power supply. Element X transfers energy at a rate of 1.0 kW and element Y transfers energy at a rate of 1.5 kW.

The diameters of the wire of the heating elements are $d_x$ and $d_y$.

What is the value of the ratio $\frac{d_x}{d_y}$?

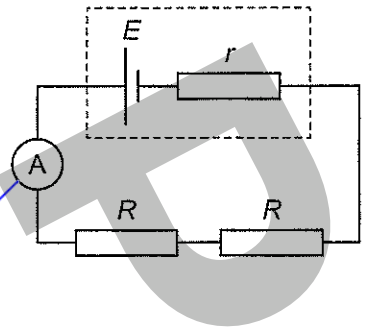
**A** 0.67 **B** 0.82 **C** 1.2 **D** 1.5



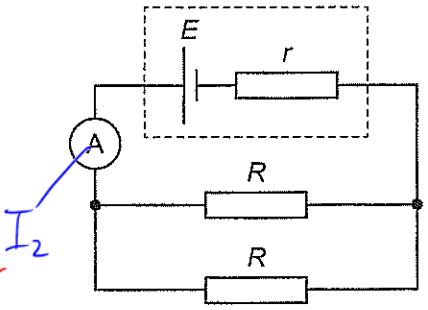

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**23** Two resistors, each of resistance $R$, are connected in series and then in parallel with a d.c. supply of electromotive force (e.m.f.) $E$ and internal resistance $r$.




circuit 1




circuit 2

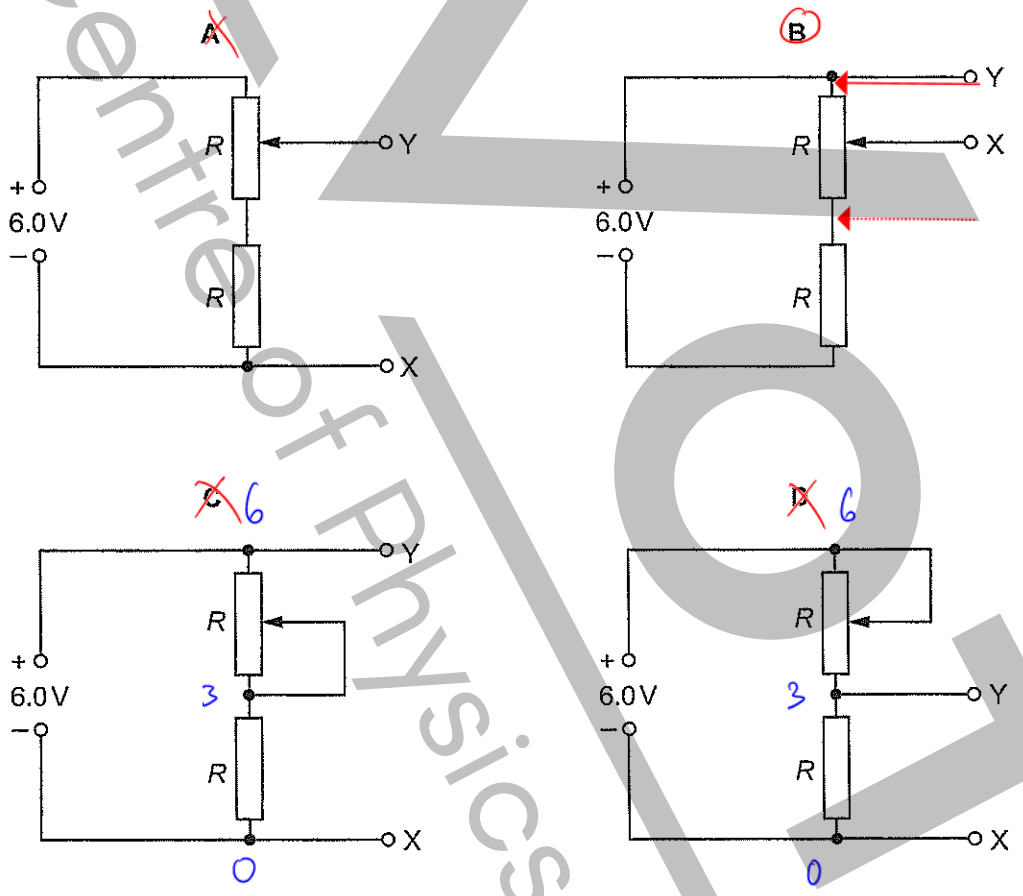
The ammeter reading in circuit 2 is three times the ammeter reading in circuit 1.

What is $r$?

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

**24** A potential divider has a constant supply of 6.0 V, as shown in the diagrams.

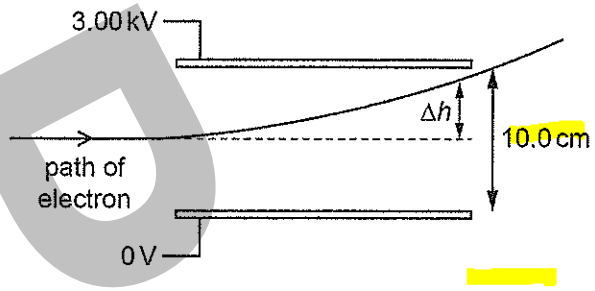
Which circuit will provide a potential difference between X and Y that can be varied between zero and 3.0 V?




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25 An electron, initially travelling horizontally at $1.97 \times 10^7\ \text{m s}^{-1}$, enters a uniform electric field at right angles to the field. The electric field is generated by applying a potential difference of 3.00 kV between two parallel conducting plates 10.0 cm apart.




What is the change in height $\Delta h$ of the electron during the first 5.00 cm of horizontal distance travelled into the field?

A $1.36 \times 10^{-4}$ m

B $1.70 \times 10^{-2}$ m

C $3.34 \times 10^{-2}$ m

D $1.36 \times 10^{-1}$ m

$s = ut + \frac{1}{2}at^2$ $\quad t = \frac{D}{v}$

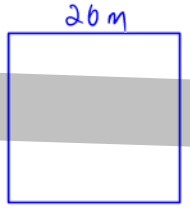
$\therefore \Delta h = 0 + \frac{1}{2}\left(\frac{q}{m}\cdot\frac{\Delta V}{\Delta d}\right)\left(\frac{D}{v}\right)^2 = \frac{1}{2}\left(\frac{1.6\times10^{-19}}{9.11\times10^{-31}}\right)\left(\frac{3000}{0.1}\right)\left(\frac{0.05}{1.97\times10^{7}}\right)^2$

$= 0.01697$

26 In an experiment to measure the strength of the Earth's magnetic field, a student makes a square coil of wire that measures 20 m by 20 m. The coil consists of 10 turns and rests horizontally on the ground.

The vertical component of the Earth's flux density is $2.1 \times 10^{-5}$ T.

What is the magnetic flux linkage enclosed by the coil?




A $8.4 \times 10^{-3}\ \text{T m}^{-2}$

B $8.4 \times 10^{-3}\ \text{T m}^{2}$

C $8.4 \times 10^{-2}\ \text{T m}^{-2}$

D $8.4 \times 10^{-2}\ \text{T m}^{2}$

$\Phi = BAN\cos\theta$

$= (2.1\times10^{-5})(400)(10)(\cos 0)$

$= 0.084\ \text{T m}^2$

27 A sinusoidal alternating current produces an average power $P$ in a resistor of resistance $R$.

What is the r.m.s. current in the resistor?

A $\sqrt{PR}$ B $\sqrt{\frac{2P}{R}}$ C $\sqrt{\frac{P}{R}}$ D $\sqrt{\frac{P}{2R}}$

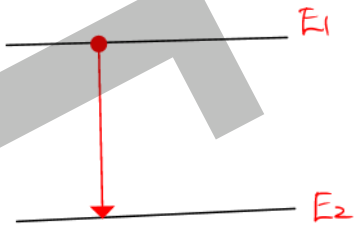
$P_{rms} = I_{rms}^2 R$

$\therefore P = I_{rms}^2 R$

28 An electron in a hydrogen atom makes a transition from an energy level $E_1$ to an energy level $E_2$ and a photon is emitted.

What is the wavelength of the photon?

A $\frac{h}{c}(E_1 - E_2)$ B $\frac{h}{c(E_1 - E_2)}$ C $hc(E_1 - E_2)$ D $\frac{hc}{(E_1 - E_2)}$




$E_1 - E_2 = \frac{hc}{\lambda}$

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**29** A neutron collides with a $^{235}_{92}U$ nucleus. The fission reaction that occurs splits the nucleus into $^{141}_{56}Ba$, $^{92}_{36}Kr$ and three neutrons, and energy is released.

The equation for this reaction is shown.

$$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n$$

The table shows the masses of the particles in the reaction.

| nucleus | mass/u |
|---|---|
| $^{235}_{92}U$ | 235.04 |
| $^{141}_{56}Ba$ | 140.91 |
| $^{92}_{36}Kr$ | 91.91 |
| $^{1}_{0}n$ | 1.01 |

$M_{LHS} = 235.04 + 1.01 = 236.05$

$M_{RHS} = 140.91 + 91.91 + 3(1.01)$

$= 235.85$

$\Delta m$ = mass defect = 0.24

$1u = 933.75\,MeV$

$\therefore 0.24u = 186.75\,MeV$

$= 2.988 \times 10^{-11}\,J$

What is the energy released in this fission reaction?

**A** $3.0 \times 10^{-11}$ J

**B** $1.8 \times 10^{-10}$ J

**C** $1.8 \times 10^{16}$ J

**D** $1.1 \times 10^{17}$ J

$1\,MeV \Rightarrow 1.6 \times 10^{-13}\,J$

**30** Thorium-228 has a decay constant of $1.15 \times 10^{-8}\,s^{-1}$.

A small sample of thorium-228 is prepared, containing $5.00 \times 10^{12}$ nuclei.

How long does it take for $3.00 \times 10^{12}$ of these nuclei to decay?

**A** $3.62 \times 10^{7}$ s **B** $4.44 \times 10^{7}$ s **C** $7.23 \times 10^{7}$ s **D** $7.97 \times 10^{7}$ s

$N = N_0 e^{-\lambda t}$

$2 \times 10^{12} = 5 \times 10^{12} e^{-(1.15 \times 10^{-8})(t)}$

$\therefore \ln\left(\frac{2}{5}\right) = -(1.15 \times 10^{-8})(t)$

and $t = 7.967 \times 10^{7}$ s #

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