PHYSICS (PRINCIPAL)   **9792/01**

Paper 1 Multiple Choice   **May/June 2018**

                                                             1 hour 30 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.

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International Examinations

[Turn over

Data

gravitational field strength close to Earth's surface	$g = 9.81 \, \text{N} \, \text{kg}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \, \text{C}$
speed of light in vacuum	$c = 3.00 \times 10^{8} \, \text{m} \, \text{s}^{-1}$
Planck constant	$h = 6.63 \times 10^{-34} \, \text{J} \, \text{s}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12} \, \text{F} \, \text{m}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \, \text{N} \, \text{m}^2 \, \text{kg}^{-2}$
electron mass	$m_e = 9.11 \times 10^{-31} \, \text{kg}$
proton mass	$m_p = 1.67 \times 10^{-27} \, \text{kg}$
unified atomic mass constant	$u = 1.66 \times 10^{-27} \, \text{kg}$
molar gas constant	$R = 8.31 \, \text{J} \, \text{K}^{-1} \, \text{mol}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \, \text{mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \, \text{J} \, \text{K}^{-1}$
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \, \text{W} \, \text{m}^{-2} \, \text{K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
	$s = \left(\frac{u+v}{2}\right)t$
heating	$\Delta E = mc\Delta\theta$

change of state	$\Delta E = mL$
refraction	$n = \dfrac{\sin\theta_1}{\sin\theta_2}$
	$n = \dfrac{v_1}{v_2}$

diffraction	
single slit, minima	$n\lambda = b \sin\theta$
grating, maxima	$n\lambda = d \sin\theta$
double slit interference	$\lambda = \dfrac{ax}{D}$
Rayleigh criterion	$\theta \approx \dfrac{\lambda}{b}$
photon energy	$E = hf$
de Broglie wavelength	$\lambda = \dfrac{h}{p}$
simple harmonic motion	$x = A \cos\omega t$
	$v = -A\omega \sin\omega t$
	$a = -A\omega^2 \cos\omega t$
	$F = -m\omega^2 x$
	$E = \frac{1}{2}mA^2\omega^2$
energy stored in a capacitor	$W = \frac{1}{2}QV$
capacitor discharge	$Q = Q_0 e^{-\frac{t}{RC}}$
electric force	$F = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
electrostatic potential energy	$W = \dfrac{Q_1 Q_2}{4\pi\varepsilon_0 r}$
gravitational force	$F = -\dfrac{Gm_1 m_2}{r^2}$
gravitational potential energy	$E = -\dfrac{Gm_1 m_2}{r}$
magnetic force	$F = BIl \sin\theta$
	$F = BQv \sin\theta$

electromagnetic induction	$E = -\dfrac{d(N\Phi)}{dt}$
Hall effect	$V = Bvd$
time dilation	$t' = \dfrac{t}{\sqrt{1 - \dfrac{v^2}{c^2}}}$
length contraction	$l' = l\sqrt{1 - \dfrac{v^2}{c^2}}$
kinetic theory	$\frac{1}{2}m\langle c^2 \rangle = \frac{3}{2}kT$
work done on/by a gas	$W = p\Delta V$
radioactive decay	$\dfrac{dN}{dt} = -\lambda N$
	$N = N_0 e^{-\lambda t}$
	$t_{\frac{1}{2}} = \dfrac{\ln 2}{\lambda}$
attenuation losses	$I = I_0 e^{-\mu x}$
mass-energy equivalence	$\Delta E = c^2 \Delta m$
hydrogen energy levels	$E_n = \dfrac{-13.6\,\text{eV}}{n^2}$
Heisenberg uncertainty principle	$\Delta p \Delta x \geqslant \dfrac{h}{2\pi}$
Wien's displacement law	$\lambda_{max} \propto \dfrac{1}{T}$
Stefan's law	$L = 4\pi\sigma r^2 T^4$
electromagnetic radiation from a moving source	$\dfrac{\Delta\lambda}{\lambda} \approx \dfrac{\Delta f}{f} \approx \dfrac{v}{c}$

1   The physical quantities mass, weight and density are all related to one another.

    Which quantities are scalars?

    A   mass, weight and density

    B   mass and density only

    C   mass only

    D   weight only

2   On a stationary ship a golf ball is struck so that it flies off horizontally from the edge of the deck of the ship at a speed of $72\,\text{m}\,\text{s}^{-1}$.

    The deck is 46 m vertically above the sea. Ignore air resistance.

    What is the horizontal distance the ball travels before landing in the sea?

    A   74 m   **B**   160 m   **C**   220 m   **D**   680 m

3   A particle X has initial momentum p. It collides with a stationary particle Y. The particle X is deflected through angle θ and its momentum is p_X. The particle Y moves off at angle α to the original direction of motion of particle X with momentum p_Y as shown.
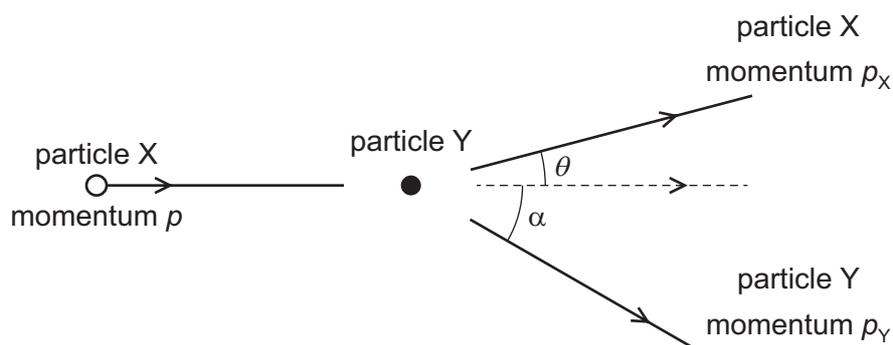
    Which equation is a correct statement for momentum in this collision?

    A $p_X \cos\theta = p_Y \cos\alpha$

    B $p_X \sin\theta = p_Y \sin\alpha$

    C $p = p_X + p_Y$

    D $p = p_X \sin\theta + p_Y \sin\alpha$

4 Close to the surface of the Earth the gravitational field strength is uniform. A pair of unequal masses are joined by a light, stiff horizontal bar and suspended by a string from their centre of gravity as shown.
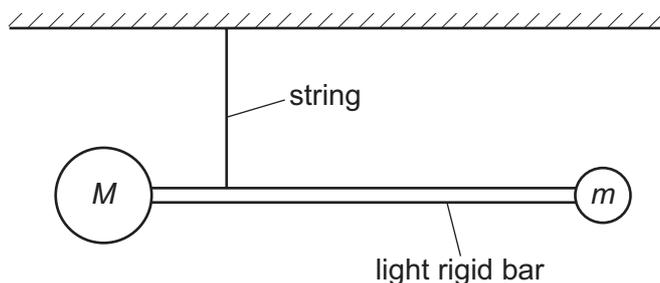
The supporting string is now cut and the system begins to fall. Air resistance is negligible.

Which statement is correct?

A The bar will remain horizontal as it falls.

B The bar will rotate as it falls.

C The resultant gravitational force will act at the centre of *M*.

D The resultant gravitational force will act half-way between the centres of the two masses.

5 A student performs an experiment to determine the Young modulus for steel.

The student hangs various weights on a steel wire and measures the extension. The graph shows the student's results.
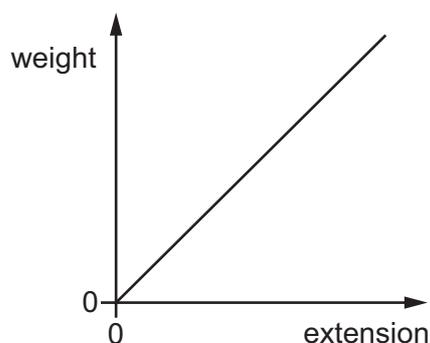
The wire has cross-sectional area *A* and original length l.

Which calculation correctly determines the Young modulus?

A $\dfrac{\text{gradient of graph} \times l}{A}$

B $\dfrac{\text{gradient of graph} \times A}{l}$

C $\text{gradient of graph} \times A \times l$

D $\dfrac{\text{gradient of graph}}{A \times l}$

6 The table gives data for the yield stress and breaking stress of copper and aluminium.

	yield stress / MPa	breaking stress / MPa
copper	70	220
aluminium	241	300

A force of 140 N is applied to a copper wire of cross-sectional area 0.50 mm². The same force is then applied to an aluminium wire of the same cross-sectional area.

Which statement about the two wires is correct?

A Both wires will be permanently deformed but neither will break.

B Both wires will break.

C The copper wire will be permanently deformed but the aluminium wire will not.

D The copper wire will break and the aluminium wire will be permanently deformed.

7 The Moon is held in a circular orbit by the gravitational force provided by the Earth. The strength of this gravitational force is 2.1×10^{20} N, and the radius of the circular orbit is 3.8×10^5 km.

What is the total work done on the Moon by the Earth's gravitational force during one complete orbit?

A 0 **B** 8.0×10^{25} J **C** 5.0×10^{26} J **D** 5.0×10^{29} J

8 A groundsman pulls a roller along using a force of 250 N at an angle of 25° above the horizontal.
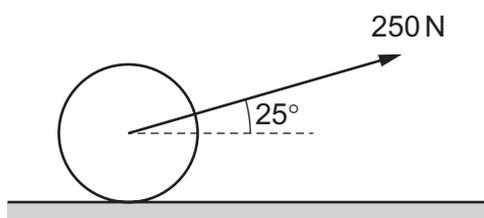
The roller is moving at a constant speed of $2.0\,\mathrm{m\,s^{-1}}$.

What is the rate at which friction is producing heat in this situation?

A 0 **B** $210\,\mathrm{J\,s^{-1}}$ **C** $450\,\mathrm{J\,s^{-1}}$ **D** $500\,\mathrm{J\,s^{-1}}$

9   A copper saucepan has a mass of 2.0 kg and is at a temperature of 20 °C. 2.0 kg of hot water at 80 °C is poured into the saucepan.

Copper has a specific heat capacity of 390 J kg^{-1}K^{-1}.

Water has a specific heat capacity of 4200 J kg^{-1}K^{-1}.

Assume that there are no energy losses to the surroundings.

What is the final temperature of the saucepan and water?

A   25 °C   B   50 °C   C   75 °C   D   80 °C

10 The graphs show how the charge Q on a capacitor varies with time t in four different experiments.

Which experiment has a constant, non-zero current?
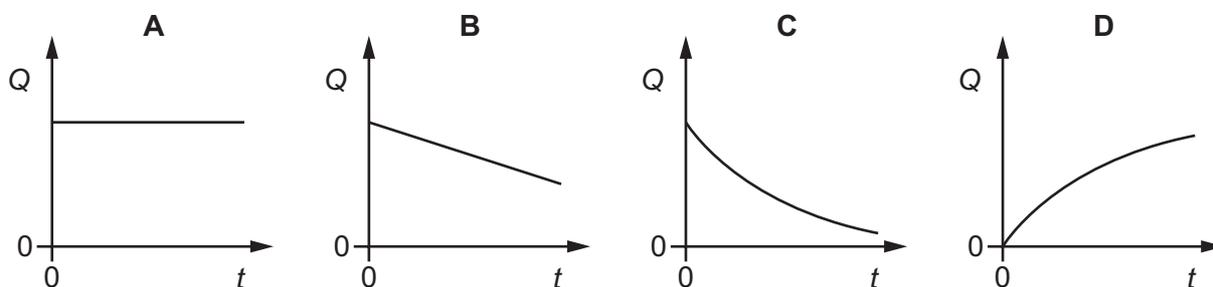
11 The diagram shows a network formed by five identical 2.0 Ω resistors.
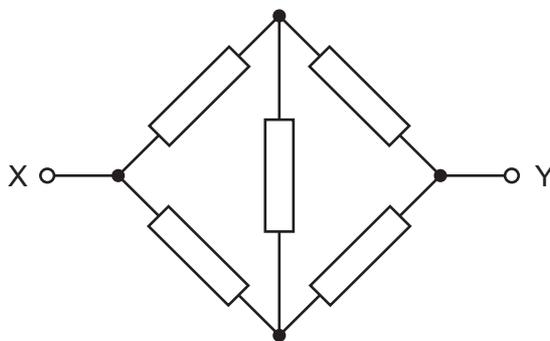
A potential difference of 10 V is applied across XY.

What current flows between X and Y?

A   2.0 A   B   2.5 A   C   4.0 A   D   5.0 A

12 A cell of electromotive force E and internal resistance r is connected in series with a resistor of resistance R. The potential difference across the terminals of the cell is V.

Which statement is **not** correct?

A power dissipated in cell $= r\left(\dfrac{E}{R+r}\right)^2$

B power dissipated in $r = \dfrac{V^2}{r}$

C power dissipated in $R = \dfrac{V^2}{R}$

D power dissipated in whole circuit $= \dfrac{E^2}{R+r}$

13 The table lists some properties of longitudinal waves.

Which row is correct?

	polarisation	direction of vibrations
A	can be polarised	parallel to velocity of wave
B	can be polarised	perpendicular to velocity of wave
C	cannot be polarised	parallel to velocity of wave
D	cannot be polarised	perpendicular to velocity of wave

14 A ray of light is incident at the boundary between two transparent materials X and Y.
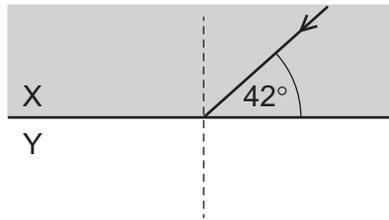
The ray in material X is incident at an angle 42° to the boundary.

The speed of light in X is $2.0 \times 10^8 \, \text{m s}^{-1}$ and the speed of light in Y is $2.3 \times 10^8 \, \text{m s}^{-1}$.

What is the angle of refraction of the ray in Y?

A 36°   **B** 40°   **C** 50°   **D** 59°

15 Two identical water waves travel from two sources X and Y to meet at point P. The frequency of the waves is 0.40 Hz and the waves emitted are in phase.
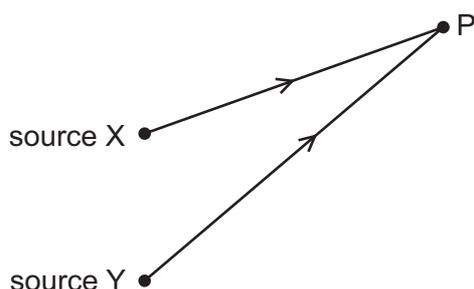
Waves from source X take 3.0 s to arrive at P.

Waves from source Y take 3.5 s to arrive at P.

What is the phase difference, in radians, between the two waves at P?

A $\dfrac{\pi}{5}$ **B** $\dfrac{2\pi}{5}$ **C** $\dfrac{5\pi}{2}$ **D** 5π

16 The diagram shows a string with its ends P and Q fixed.
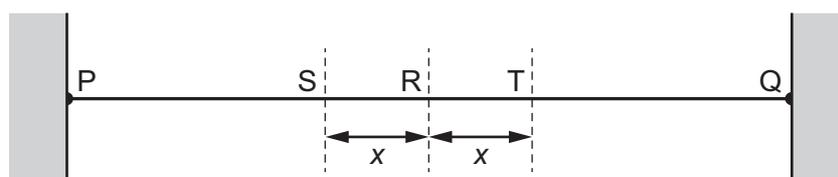
The string is made to vibrate transversely so that P, Q and R are the only points of the string which are nodes.

S and T are two points equal distances x from R.

Which statement about the vibrations of the two points S and T, shown on the string, is correct?

A They have different amplitudes and are in phase.

B They have different amplitudes and differ in phase by 180°.

C They have the same amplitude and are in phase.

D They have the same amplitude and differ in phase by 180°.

17 The α-particle scattering experiments conducted in the early 1900s were important in determining the nuclear model of the atom.

Which conclusion was deduced from the scattering experiments?

A The α-particles were scattered by the atomic electrons.

B The majority of the volume of the atom was empty space.

C The nucleus of the atom attracted the α-particle.

D The nucleus of the atom contained protons.

18 Nuclide X is radioactive with a half-life of 300 million years. It decays to form the stable nuclide Y.

A sample of rock is thought to have contained none of nuclide Y when it was formed, but now contains 15 atoms of Y to every atom of X.

How old are the rocks in this sample?

A much less than 300 million years

B 1200 million years

C 2400 million years

D 4500 million years

19 The graph shows how the stopping potential V_s for a particular metal depends on the frequency f of the light that falls on its surface.
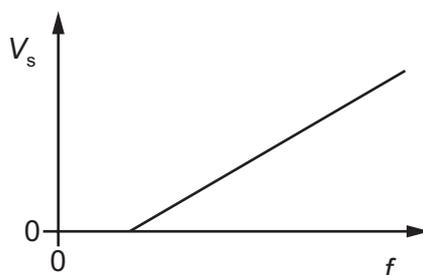
Which statement is correct?

A The gradient of the line is equal to the Planck constant h.

B The intercept on the f axis is equal to the threshold frequency of the metal.

C The intercept on the V_S axis is equal to the work function of the metal.

D The stopping voltage is directly proportional to the frequency.

20 An electron of mass m and charge e is accelerated from rest through a potential difference of V.

The speed of light is c and the Planck constant is h.

What is the frequency of a photon whose wavelength is equal to the de Broglie wavelength of this electron?

A $\dfrac{c\sqrt{2meV}}{h}$ **B** $\dfrac{h}{\sqrt{2meV}}$ **C** $\dfrac{hc}{eV}$ **D** $\dfrac{eV}{h}$

21 A solid sphere is rotating about a fixed axis passing through its centre.

Which quantity is the same for every point within the sphere that is **not** on this axis?

A acceleration

B angular velocity

C speed

D velocity

22 A proton travels in a circular path of radius 0.42 m in a magnetic field.

In a time of 7.3×10^{-8} s the proton travels through an angle of 60°.

path of proton

60°
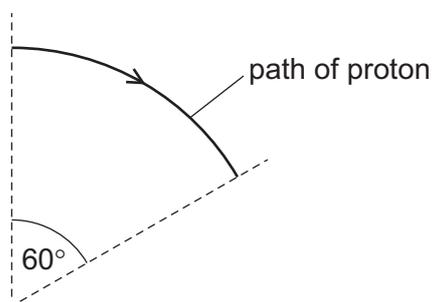
What is the resultant force acting on the proton?

A 7.9×10^{-17} N

B 2.8×10^{-15} N

C 1.4×10^{-13} N

D 5.2×10^{-12} N

23 An undamped oscillator is executing simple harmonic motion.

A graph of the displacement x against time t for this oscillator is shown.
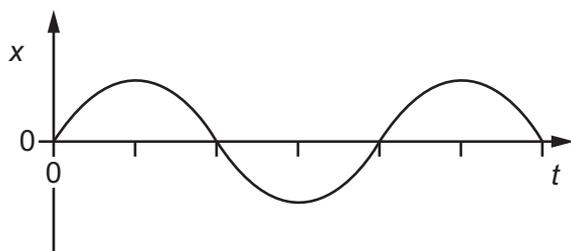
Which graph shows the variation of the kinetic energy E of the oscillator with time t?

A

B

C

D
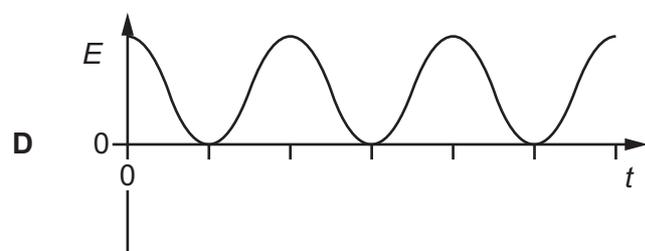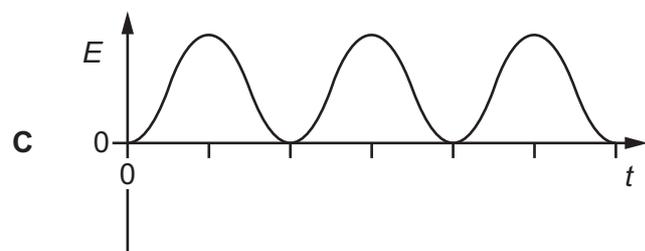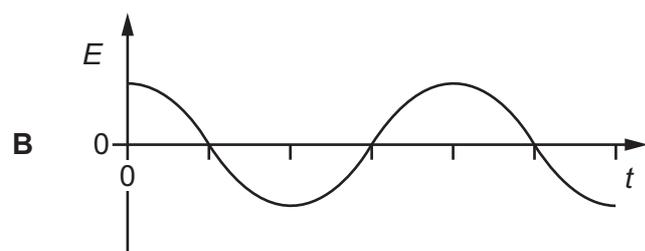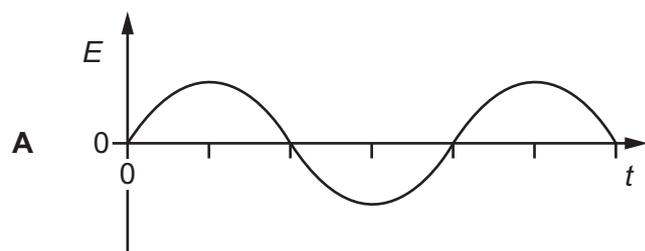
24 The graph shows how the amplitude of a simple pendulum decays with time from an initial amplitude of 5.0 cm.
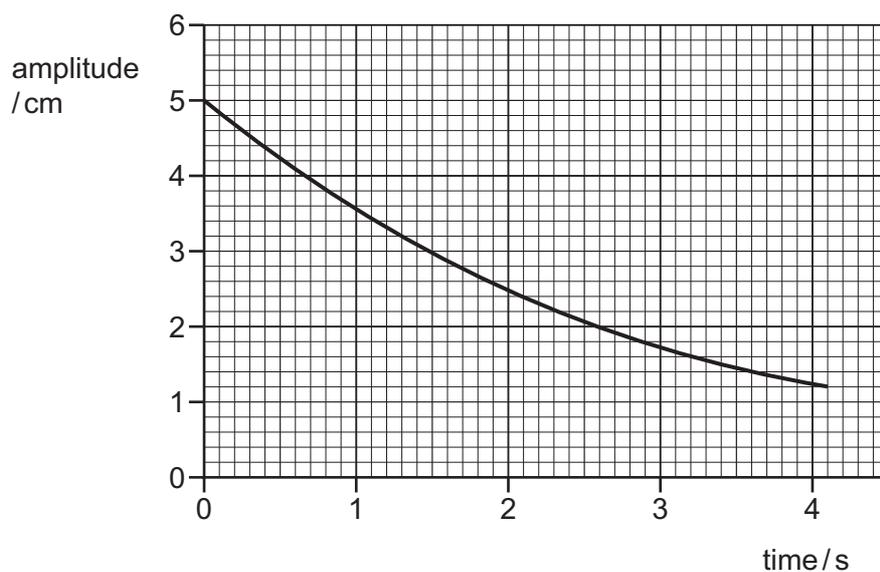
What is the fraction of the initial energy that has been lost in the first 4.0 s?

A $\dfrac{1}{16}$ **B** $\dfrac{1}{4}$ **C** $\dfrac{3}{4}$ **D** $\dfrac{15}{16}$

25 A charged oil drop is held stationary between two oppositely charged horizontal plates.
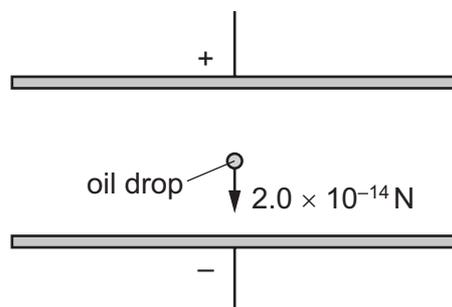
The weight of the oil drop is 2.0×10^{-14} N.

The potential difference between the plates is 400 V.

The potential difference between the plates is now increased to 600 V and the polarities of the plates reversed.

What is the magnitude of the resultant force acting on the oil drop?

A 1.0×10^{-14} N

B 2.0×10^{-14} N

C 3.0×10^{-14} N

D 5.0×10^{-14} N

26 A capacitor of capacitance $4.8\,\mu F$ is discharged through a resistor of resistance $6.3\,k\Omega$.

The initial potential difference (p.d.) across the capacitor was $12\,V$.

What is the time taken for the p.d. across the capacitor to fall to $0.12\,V$?

A $30\,ms$ **B** $60\,ms$ **C** $140\,ms$ **D** $1200\,ms$

27 A dipole molecule can be modelled as a pair of point charges $+Q$ and $-Q$ separated by a distance $2r$ as shown.
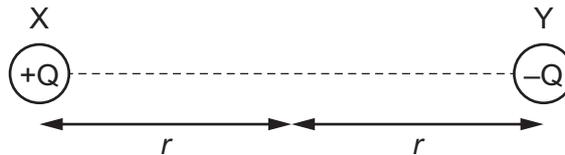
Which expression gives the magnitude of the electric field strength half way between the two charges?

A $\dfrac{Q}{\pi\varepsilon_0 r^2}$ **B** $\dfrac{Q}{2\pi\varepsilon_0 r^2}$ **C** $\dfrac{Q}{4\pi\varepsilon_0 r^2}$ **D** $\dfrac{Q}{8\pi\varepsilon_0 r^2}$

28 A space probe is used to measure the gravitational field strength g of a planet at a distance r from its centre.

A graph of g against $\dfrac{1}{r^2}$ for this planet produces a straight line graph through the origin.

Which quantity can be determined from the gradient of the straight line graph?

A   the density of the planet

B   the mass of the planet

C   the radius of the planet

D   the volume of the planet

29 A satellite of mass 500 kg is being put into orbit around the Earth. It changes position from X to Y, as shown. The Earth can be treated as a point mass.
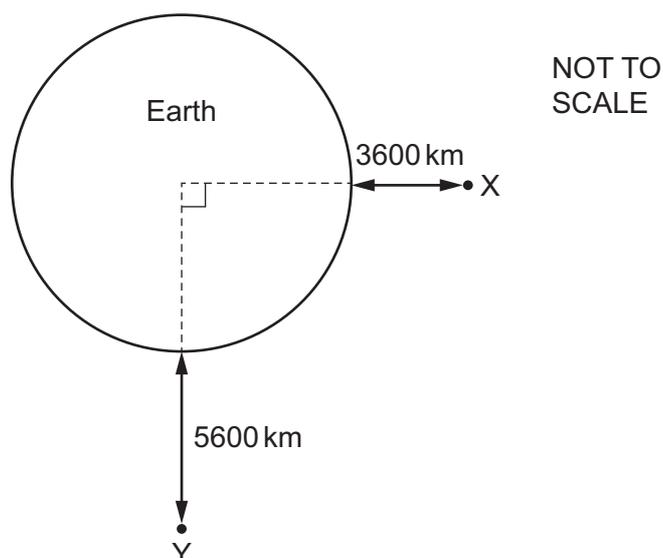
The mass of the Earth is 6.0×10^{24} kg.

The radius of the Earth is 6400 km.

What is the change in gravitational potential energy for the satellite?

A 3.3×10^{9} J   **B** 1.3×10^{10} J   **C** 2.0×10^{10} J   **D** 1.0×10^{11} J

30 A rectangular wire loop RSTU with sides of length x and y carries a current I.
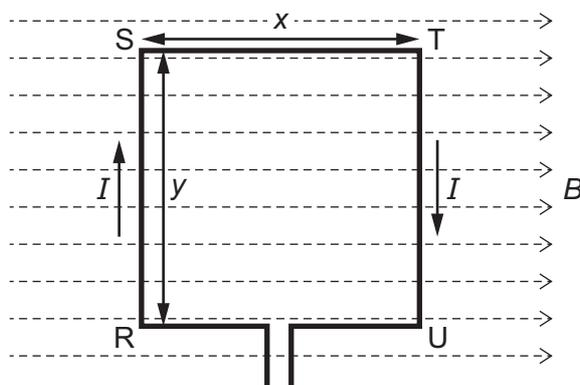
A magnetic field of flux density B lies within the plane of the loop perpendicular to SR.

Which statement is **not** correct?

A The force on SR is equal to BIy.

B The force on SR is in the opposite direction to the force on TU.

C The force on ST is equal to BIx.

D The moment on the loop is $BIxy$.

31 Two coils of wire, X and Y, are wound on a soft iron core, as shown.

soft iron
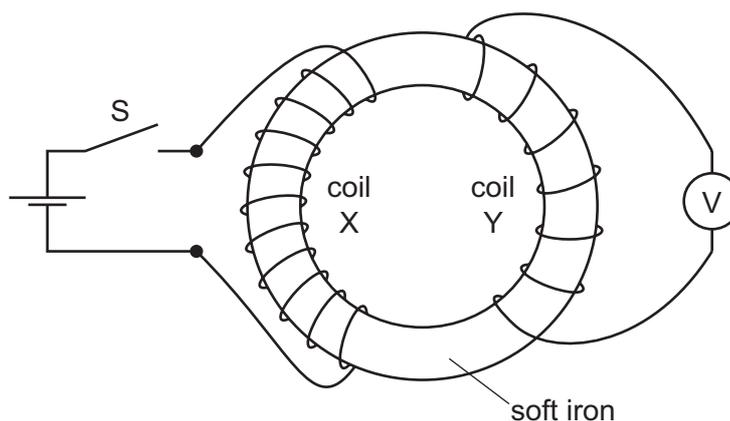
Switch S is closed and then opened.

Which graph best represents how the electromotive force (e.m.f.) *V* across coil Y varies with time?

A

current in   current in
coil X   coil X
switched **on** switched **off**

B

current in   current in
coil X   coil X
switched **on** switched **off**

C

current in   current in
coil X   coil X
switched **on** switched **off**

D

current in   current in
coil X   coil X
switched **on** switched **off**
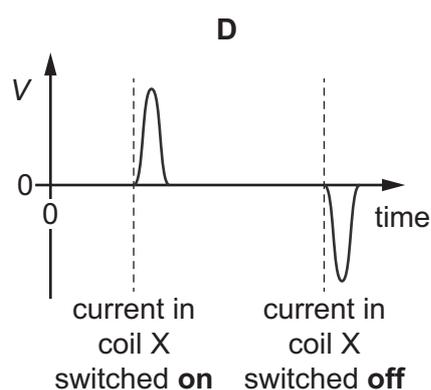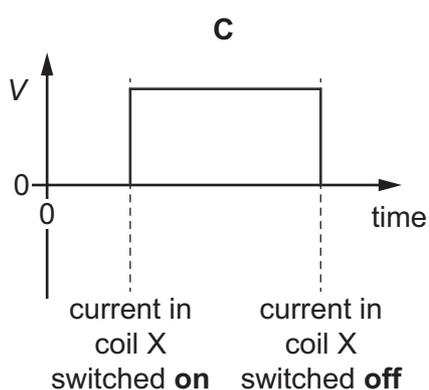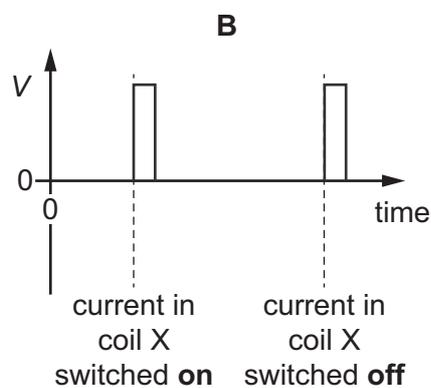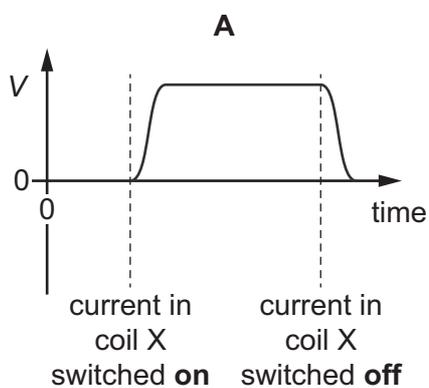
32 An electric current passes through a semiconductor material.

The slice is placed into a uniform magnetic field of flux density B directed into the page and a Hall voltage develops across the slice. The charge carriers in this semiconductor are negatively charged.
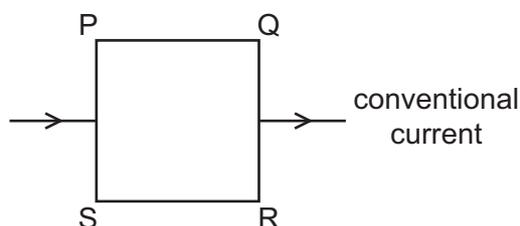
What describes the polarity of the different sides correctly?

A   PQ positive and RS negative

B   PQ negative and RS positive

C   PS positive and QR negative

D   PS negative and QR positive

33 A cylinder contains 575 g of oxygen.

The volume of the cylinder is $0.0300 \, m^3$ and the temperature of the oxygen is 22.0 °C.

The mass of one mole of oxygen is 32 g. Assume the oxygen behaves as an ideal gas.

What is the pressure of the oxygen?

A   1.3 kPa   **B**   4.6 kPa   **C**   0.11 MPa   **D**   1.5 MPa

34 A sealed tank of gas contains a mixture of nitrogen and oxygen. The tank is at room temperature.

What is the same for the particles of nitrogen and oxygen in the tank?

A   internal energy

B   mean kinetic energy

C   mean speed

D   root mean square speed

35 The current in a semiconductor is directly proportional to the Boltzmann factor $e^{-\frac{E}{kT}}$. Each electron requires energy of 5.6×10^{-20} J to become a conduction electron.

The temperature of the semiconductor is increased from 40 °C to 80 °C.

What is the value of the ratio $\dfrac{\text{current in the semiconductor at 80°C}}{\text{current in the semiconductor at 40°C}}$?

A   0.23   **B**   1.1   **C**   2.0   **D**   4.3

36 The rest mass of an up quark is $\frac{1}{400}$ of the rest mass of a proton.

What is the minimum energy required to create an up-anti-up ($u\bar{u}$)quark pair?

A 1.3×10^{-21} J

B 2.5×10^{-21} J

C 3.8×10^{-13} J

D 7.5×10^{-13} J

37 The standard model classifies matter into three families.

What are the names of the families?

A baryons, leptons and antimatter

B neutrons, protons and electrons

C nucleons, electrons and antineutrinos

D quarks, leptons and force carriers

38 The diagram shows the lowest four energy levels in the hydrogen atom. The energy levels of the hydrogen atom are given by $E_n = \dfrac{-13.6\ \text{eV}}{n^2}$.

The electron transitions X and Y result in the emission of two photons.
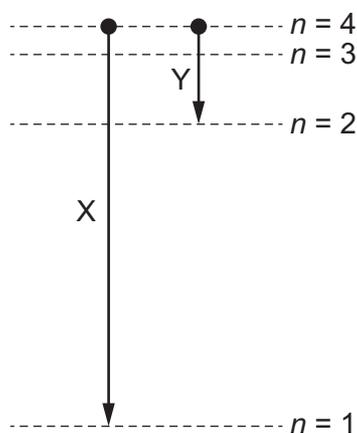
What is the ratio $\dfrac{\text{wavelength of photon due to X}}{\text{wavelength of photon due to Y}}$?

A $\dfrac{1}{5}$ **B** $\dfrac{1}{4}$ **C** 4   **D** 5

39 Standard candles are used to help determine distances to galaxies.

Which property is known about a standard candle?

A its distance from the Earth

B its luminosity

C its luminous flux on Earth

D its radius

40 Two stars, X and Y, are compared. Star X has four times the luminosity of star Y and the wavelength corresponding to the peak of the stellar spectrum of X is half the wavelength at the peak of the stellar spectrum of star Y.

The radius of star Y is R.

What is the radius of star X?

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

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