Cambridge Pre-U

PHYSICS **9792/01**

Paper 1 Multiple Choice **May/June 2023**

1 hour 30 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet
Soft clean eraser
Soft pencil (type B or HB is recommended)

INSTRUCTIONS
- 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 multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

INFORMATION
- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.

This document has **20** pages. Any blank pages are indicated.

[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	$m_\text{e} = 9.11 \times 10^{-31}\,\text{kg}$
proton mass	$m_\text{p} = 1.67 \times 10^{-27}\,\text{kg}$
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	$N_\text{A} = 6.02 \times 10^{23}\,\text{mol}^{-1}$
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	$s = ut + \frac{1}{2}at^2$	change of state	$\Delta E = mL$
	$v^2 = u^2 + 2as$	refraction	$n = \dfrac{\sin\theta_1}{\sin\theta_2}$
	$s = \left(\dfrac{u+v}{2}\right)t$		$n = \dfrac{v_1}{v_2}$
heating	$\Delta E = mc\Delta\theta$		

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 equation for the elastic strain energy E in a deformed material with an extension x is

$$E = \tfrac{1}{2} kx^2.$$

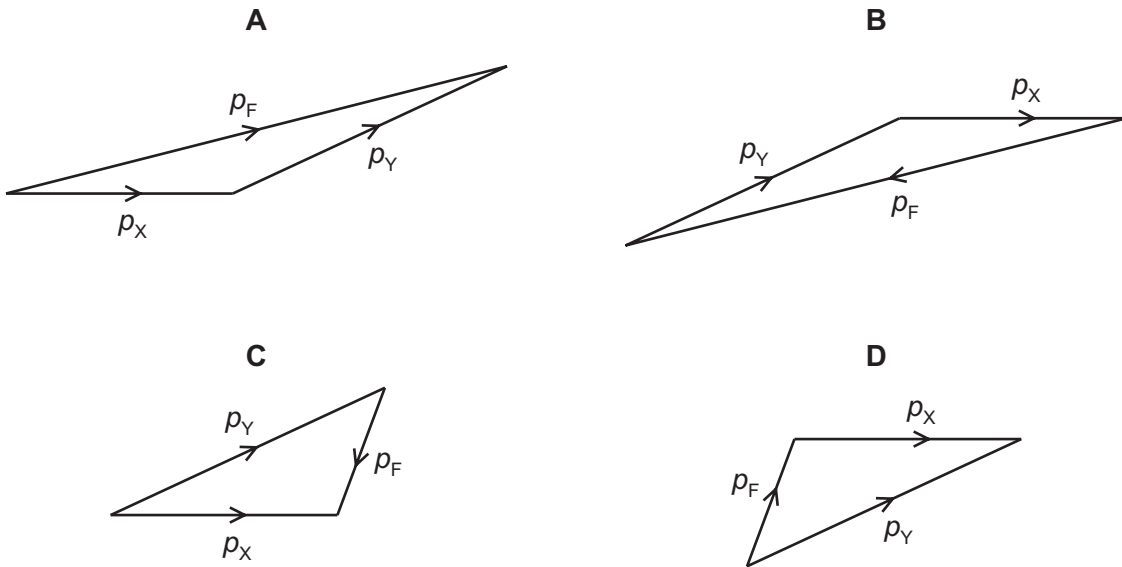What are the correct dimensions for the constant k?

A MT^{-2} **B** $ML^{-1}T^{-2}$ **C** ML^2T^{-2} **D** $ML^{-2}T^{-2}$

2   Two point masses, X and Y, have momentum p_X and p_Y respectively. p_X and p_Y are represented as shown.
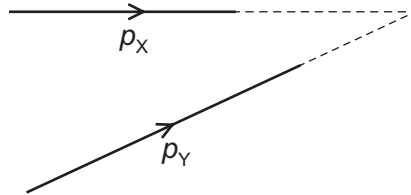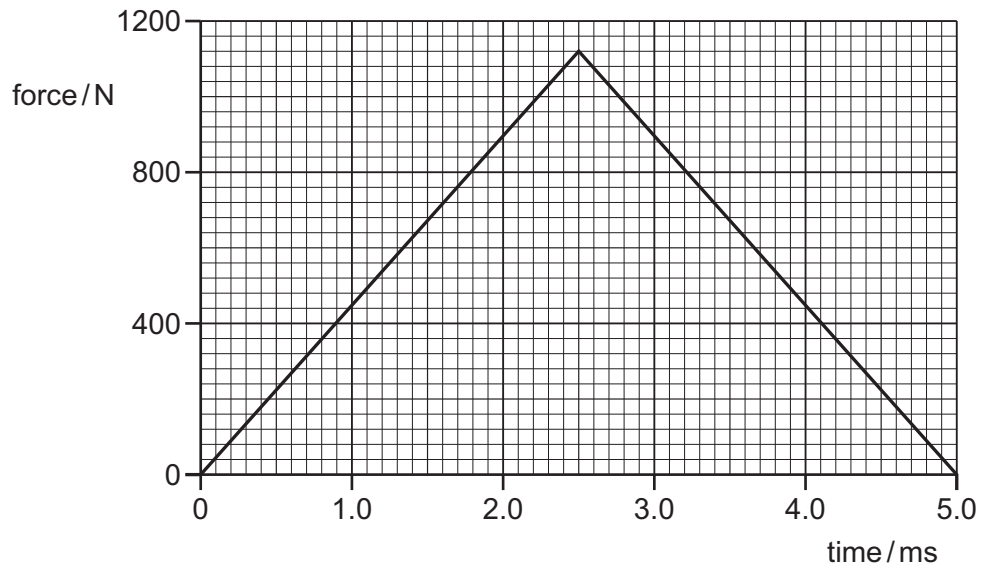

The point masses collide and move off together.
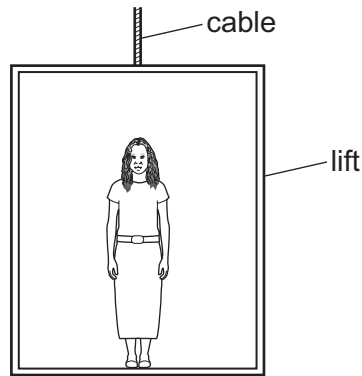
Which diagram shows the final momentum p_F of the combined masses?

3 A tennis ball of mass 56 g is struck by a tennis racquet. The graph shows how the force exerted on the ball by the racquet varies with time.
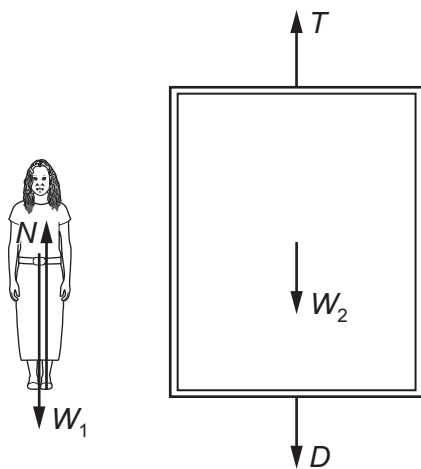

What is the change in the velocity of the tennis ball?

A $50\,\text{cm s}^{-1}$ **B** $100\,\text{cm s}^{-1}$ **C** $50\,\text{m s}^{-1}$ **D** $100\,\text{m s}^{-1}$

4 The diagram shows a woman standing in a lift.

cable

lift

The forces acting on the woman and the forces acting on the lift are shown.

N is the force from the lift floor on the woman.

W_1 is the weight of the woman.
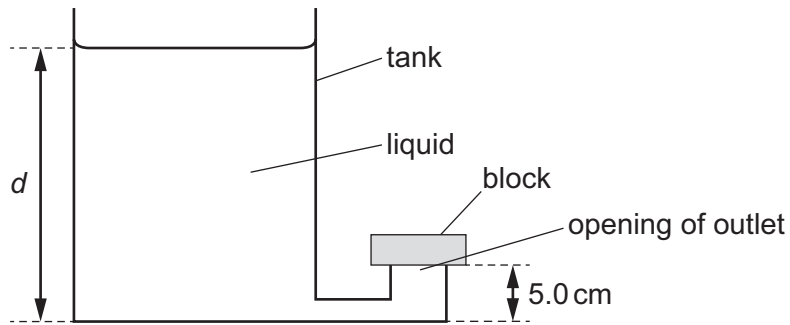
T is the tension in the lift cable.

W_2 is the weight of the lift.

D is the force from the woman on the lift floor.

Which statement is correct?

A N and W_1 are always equal and opposite.

B $(W_1 + W_2)$ is always equal to T.

C If $N = W_1$, the lift must be at rest.

D If $T = (D + W_2)$, the lift must have a constant velocity.

**5** A block seals a tank outlet 5.0 cm above the base of the tank.

The mass of the block is 0.20 kg and it seals an outlet area of $2.0 \times 10^{-4} \, m^2$.

The density of the liquid is $900 \, kg \, m^{-3}$.

The maximum depth of the liquid without the block lifting is d.

What is the value of d?

A 0.11 m   **B** 0.16 m   **C** 1.11 m   **D** 1.16 m

6 A space probe of mass 900 kg is on the surface of the planet Mars.

The gravitational field strength on the surface of the Earth is 2.6 times larger than the gravitational field strength on the surface of Mars.

What is the weight of the space probe on the surface of Mars?

A 900 N   **B** 3400 N   **C** 8800 N   **D** 23 000 N

7 The force F against extension x graphs for four materials are shown up to the breaking point.

Which graph best represents a material that is brittle?
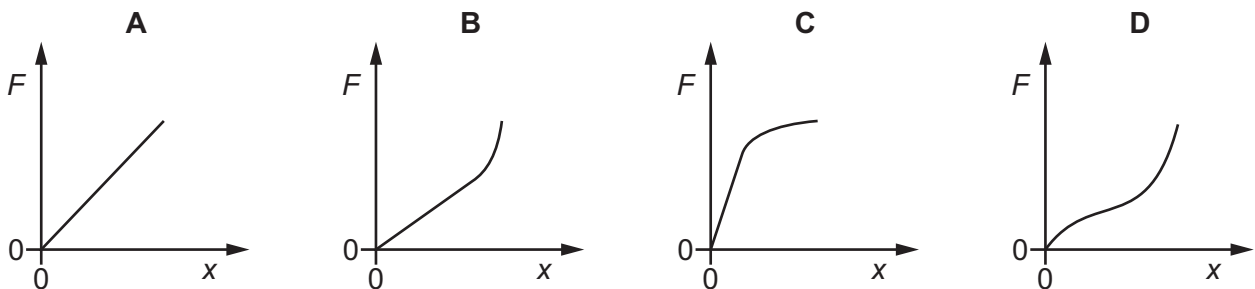
8 Students are investigating the breaking of aluminium strips. Each strip has a uniform rectangular cross-section.
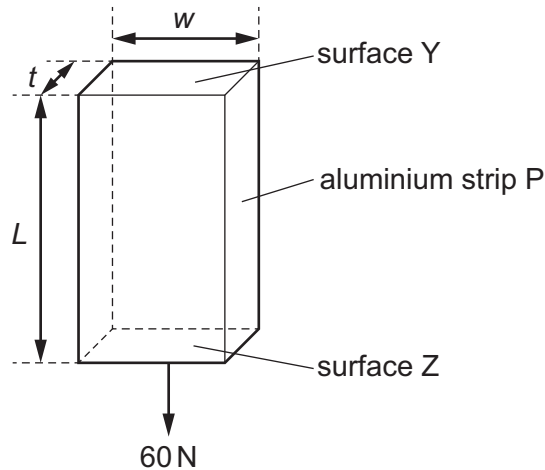
Surface Y is fixed to the ceiling. A vertical downward force of 60 N is applied to surface Z.

The table shows data on two different aluminium strips P and Q.

	P	Q
width of strip	w	$3w$
thickness of strip	t	$2t$
length of strip	L	$1.5L$
breaking force / N	60	F

The breaking stress for aluminium is constant.

What is the breaking force F for strip Q?

A 120 N **B** 180 N **C** 360 N **D** 540 N

9 A block of ice of mass 7.0 kg at a temperature of 263 K is placed in water of mass 12.0 kg. When all the ice has melted, the temperature of the water is 273 K.

Assume that there is no heat gained from or lost to the surroundings.

Data

specific heat capacity of water = 4200 J kg^{-1} K^{-1}

specific heat capacity of ice = 2100 J kg^{-1} K^{-1}
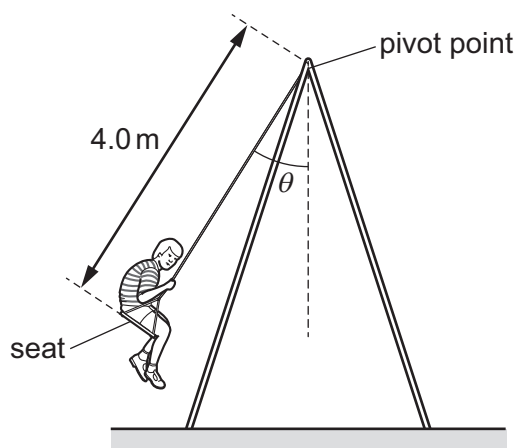
specific latent heat of fusion of ice = 320 000 J kg^{-1}

What was the initial temperature of the water?

A 276 K **B** 280 K **C** 317 K **D** 320 K

10 A child is on a swing which is suspended by ropes from a pivot point on a rigid support.

The distance from the pivot point to the seat is 4.0 m.

The horizontal speed of the child as he passes through the lowest point is $3.0\,\text{m s}^{-1}$.

What is the angle θ that the ropes make with the vertical when the child is at his highest point?

A 28°   **B** 40°   **C** 42°   **D** 62°

11 The heater of an electric fire has resistance $20.0\,\Omega$ when connected to the mains power supply of 230 V. The heater is left on for five minutes.

How many electrons pass a given point in the heater in five minutes?

A 5.52×10^{-16} **B** 1.63×10^{20} **C** 3.60×10^{20} **D** 2.16×10^{22}

12 A metal strip of length 3.5 m has a width of 40 mm and a thickness t. The resistance of the metal strip is $6.2 \times 10^{-3}\,\Omega$. The resistivity of the metal is $5.2 \times 10^{-8}\,\Omega\,\text{m}$.

What is the thickness t of the metal strip?

A 0.54 mm   **B** 0.73 mm   **C** 1.3 mm   **D** 7.5 mm

13 Green light from a laser-pen travels from a vacuum into a diamond of refractive index 2.40.

The wavelength of the light in a vacuum is 530 nm.

Which row is correct?

	speed of light in diamond/m s^{-1}	wavelength of light in diamond/nm
A	1.25×10^8	221
B	1.25×10^8	1270
C	3.00×10^8	221
D	3.00×10^8	1270

14 Plane polarised light of amplitude A is incident on a polarising filter aligned so that no light is transmitted.

The filter is now rotated through an angle of 30°.

What is the amplitude of the transmitted light?

A 0.25A **B** 0.50A **C** 0.75A **D** 0.87A

15 A beam of red laser light of wavelength 680 nm is incident perpendicularly on a narrow vertical slit. The diffraction pattern shown is produced on a screen that is 2.0 m away.
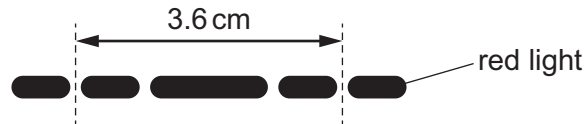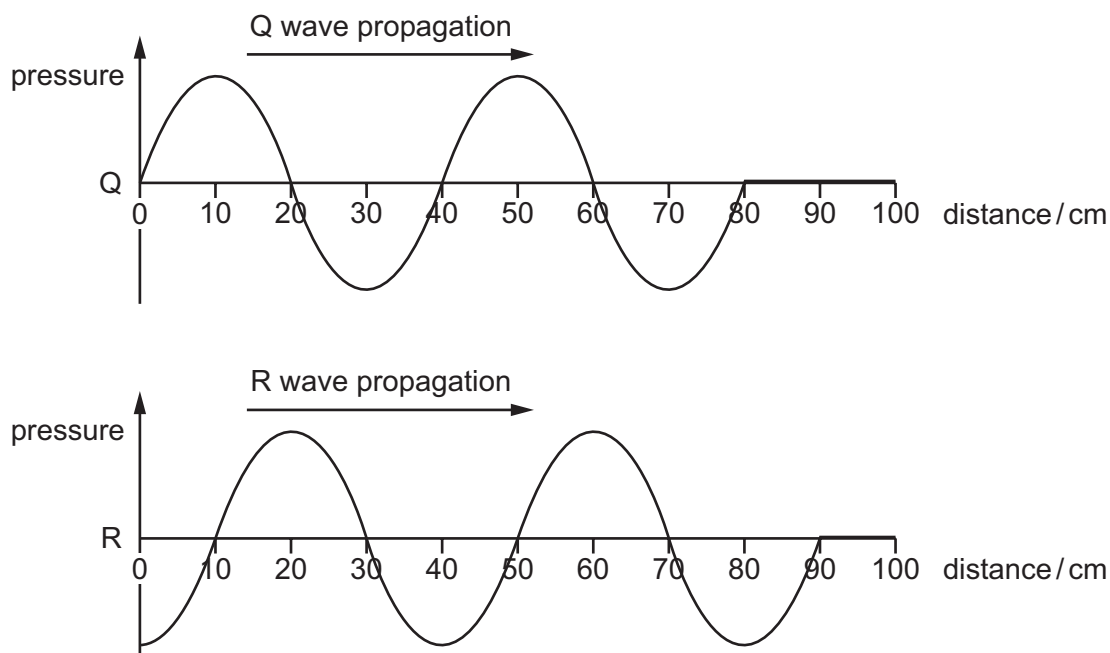

What is the width of the slit?

A 1.0 μm **B** 38 μm **C** 75 μm **D** 150 μm

16 Two sources of sound are set up side by side. The sources begin emitting waves at slightly different times. One source emits sound wave Q. The other source emits sound wave R.

At a particular instant, the pressures in the two sound waves are monitored and the results are plotted as shown.

What is the phase relationship between the waves from Q and R?

A   Wave from Q leads wave from R by $\dfrac{\pi}{2}$.

B   Wave from Q leads wave from R by $\dfrac{3\pi}{2}$.

C   Wave from R leads wave from Q by $\dfrac{\pi}{2}$.

D   Wave from R leads wave from Q by $\dfrac{3\pi}{2}$.

17 A nucleus X emits a β^- particle and transforms into a daughter nucleus of 5 protons and 5 neutrons.

What is the correct representation of the original nucleus?

A $^{11}_{4}X$ **B** $^{10}_{4}X$ **C** $^{10}_{5}X$ **D** $^{10}_{6}X$

18 The background count for an experiment is 14 counts per second.

An experiment is conducted with a sample of a radioactive isotope.

sample   ionising radiation detector

rate meter
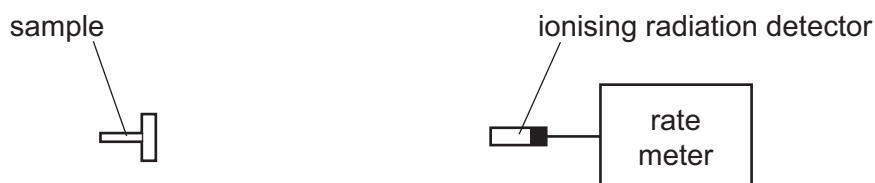
The initial count rate is recorded as 110 counts per second. After 10 minutes, the count rate decreases to 20 counts per second.

What is the most likely count rate that would have been recorded after only 5 minutes?

A   24 counts per second

B   38 counts per second

C   45 counts per second

D   57 counts per second

19 An electron with kinetic energy E has a de Broglie wavelength of 0.28 nm.

What is the de Broglie wavelength of an electron with kinetic energy $0.5E$?

A   0.14 nm   **B**   0.20 nm   **C**   0.40 nm   **D**   0.56 nm

20 The table shows the work function for four metals.

metal	work function / J
aluminium	6.9×10^{-19}
calcium	4.6×10^{-19}
gold	8.2×10^{-19}
sodium	3.7×10^{-19}

Which statement is correct?

A   The threshold frequency for aluminium is 2.1×10^{15} Hz.

B   The threshold frequency for calcium is 6.9×10^{14} Hz.

C   Ultraviolet light of wavelength 3.0×10^{-7} m could eject electrons from the surface of gold.

**D**   Visible light of wavelength 6.0×10^{-7} m could eject electrons from the surface of sodium.

21 The drum of a washing machine has a diameter of 60.0 cm. The manufacturer states that the machine has a maximum spin rate of 1500 revolutions per minute.

Assume that, during the spin, the clothes are pressed against the edge of the drum.

What is the maximum centripetal acceleration experienced by the clothes in the machine?

A $7.40 \times 10^3\,\mathrm{m\,s^{-2}}$

B $1.48 \times 10^4\,\mathrm{m\,s^{-2}}$

C $6.75 \times 10^5\,\mathrm{m\,s^{-2}}$

D $1.35 \times 10^6\,\mathrm{m\,s^{-2}}$

22 A pendulum consists of a small bob of mass m on the end of a string of length l.
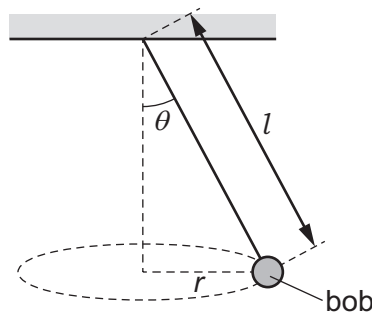
The bob moves in a horizontal circle with radius r so that the string is at an angle θ with the vertical.

One end of the string is fixed and the mass moves in a horizontal circle with a constant speed v.

What is the kinetic energy of the bob?

A $mgl(1 - \cos\theta)$

B $\dfrac{\frac{1}{2}mrg}{\tan\theta}$

C $\frac{1}{2}mrg \tan\theta$

D $mgl \cos\theta$

23 A mass of 0.25 kg is suspended from a light spring. When the mass is displaced through a vertical distance of 0.050 m and released, it undergoes undamped simple harmonic oscillations with a time period of 0.64 s.

What is the maximum kinetic energy of the mass?

A 0.76 mJ **B** 3.1 mJ **C** 5.1 mJ **D** 30 mJ

24 What is **not** an example of forced oscillations?

    A   a footbridge oscillating as people walk on it

    B   a loudspeaker connected to a signal generator producing a continuous note

    C   a pendulum bob oscillating in air after having been initially displaced

    D   a washing machine oscillating as its drum rotates at high speed

25 The diagram shows a circuit.
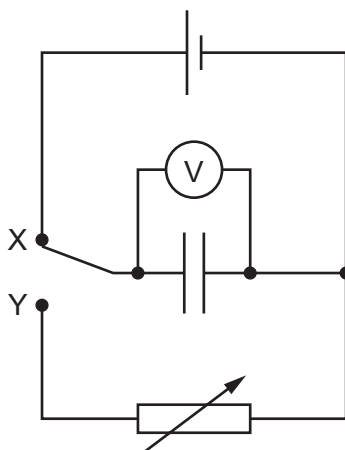
Initially, the capacitor of capacitance C is fully charged with the switch in position X.

The switch is moved to position Y and a timer is started to record time $t_{\frac{1}{2}}$ for the voltmeter reading to halve.
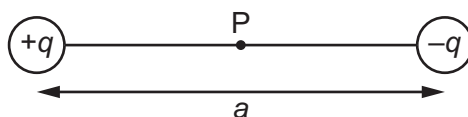
This procedure is repeated for different values of the resistance R for the variable resistor.

A graph of $t_{\frac{1}{2}}$ against R is plotted.

What is the expected gradient of this graph?

    A $C\ln2$ **B** $\dfrac{1}{C}\ln2$ **C** $-C\ln2$ **D** $-\dfrac{1}{C}\ln2$

26 A dipole molecule can be represented as two point charges, $+q$ and $-q$, separated by distance a.

What is the magnitude of the electric field strength at point P in the centre of the molecule?

    A   0   **B** $\dfrac{q}{2\pi\varepsilon_0 a^2}$ **C** $\dfrac{q}{\pi\varepsilon_0 a^2}$ **D** $\dfrac{2q}{\pi\varepsilon_0 a^2}$

27 The diagram shows the electric field lines and equipotential surfaces around a small positive charge. Four points, R, S, T and U, have been marked at different positions in the field.
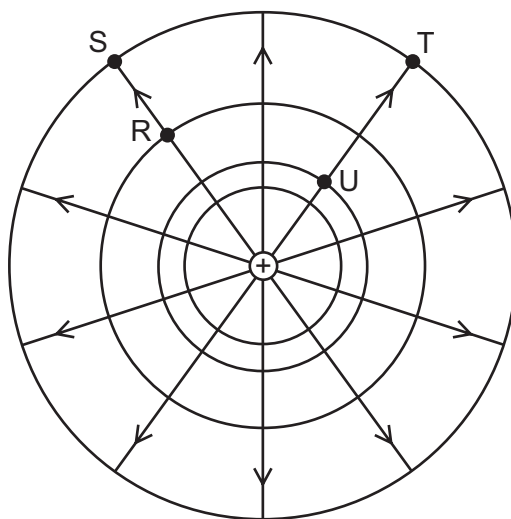
Which statement is correct?

A   The electric field strength at T is greater than the electric field strength at U.

B   When a negative charge moves from U to R, there will be an increase in electric potential energy.

C   When a positive charge is moved from S to T, no force acts on it.

D   Work must be done by an external agent to move a positive charge from U to T.

28 There is evidence that there is a black hole at the centre of the Milky Way galaxy that behaves as a massive object. Kepler's third law can be used to estimate the mass of this black hole by using data from stars that orbit the central mass.

A star at a distance of 1.0×10^{14} m from the centre of the black hole moves in a circular orbit with a period of 5.0×10^{9} s.

What is the mass of the black hole?

A 4.7×10^{10} kg

B 4.0×10^{22} kg

C 1.5×10^{31} kg

D 2.4×10^{34} kg

29 The escape velocity from the Earth is $11 \, \text{km} \, \text{s}^{-1}$.

The density of Mercury is similar to the density of the Earth.

Mercury's diameter is 0.40 times that of the Earth.

What is the escape velocity from Mercury?

A $2.2 \, \text{km} \, \text{s}^{-1}$ B $4.4 \, \text{km} \, \text{s}^{-1}$ C $17 \, \text{km} \, \text{s}^{-1}$ D $25 \, \text{km} \, \text{s}^{-1}$
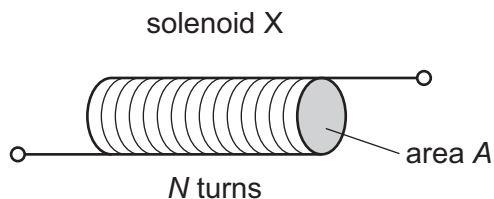
30 The magnetic field of a cyclotron causes protons to travel in a circle of radius 0.75 m at a speed of $5.5 \times 10^7 \, \text{m s}^{-1}$.

What is the magnitude of the magnetic flux density?

Assume the mass of the protons remains constant.

A 0.38 T **B** 0.77 T **C** 1.3 T **D** 2.6 T

31 A solenoid (long coil of wire) X has N turns and a cross-sectional area A.

solenoid X

area A

N turns

A second solenoid Y has $4N$ turns and a cross-sectional area $2A$.

The two solenoids are connected in series to a power supply. The magnetic flux density in X is B. Both solenoids have equal flux linkage.

What is the magnetic flux density in Y?

A $\dfrac{B}{8}$ **B** $\dfrac{B}{2}$ **C** $2B$ **D** $8B$

32 A metal aircraft has a wingspan of 40 m. It is flying horizontally at a constant velocity of $250 \, \text{m s}^{-1}$ over a region where the Earth's magnetic field has a flux density of $50 \, \mu\text{T}$. The direction of the magnetic field is $25°$ to the vertical.

What is the electromotive force (e.m.f.) between the aircraft's wing tips?

A 0 V **B** 0.21 V **C** 0.45 V **D** 0.50 V

33 A car tyre is repaired. Before being put back on the car, the tyre is inflated from atmospheric pressure to 300 kPa.

Assume that the volume of the tyre is constant at $0.020 \, \text{m}^3$ during the process and that the temperature is constant at $27 \, °\text{C}$. Atmospheric pressure is 100 kPa.

Which amount of air is pumped into the tyre?

A 0.0016 mol **B** 0.018 mol **C** 1.6 mol **D** 2.4 mol

34 An ideal gas is in a container.

Which quantity alone can be used to determine the mean kinetic energy of the gas molecules?

A   temperature of the gas

B   mass of a gas molecule

C   volume of the container

D   root-mean-square speed of the gas molecules

35 Which statement about protons and neutrons is correct?

A   Protons and neutrons are both classified as leptons.

B   Protons and neutrons both contain the same number of up quarks.

C   Protons and neutrons both have the same baryon number.

D   Protons and neutrons both have the same charge.

36 An unstable nuclide X decays to another nuclide Y with decay constant λ_X. Y is also unstable and decays to a stable nuclide Z with decay constant λ_Y.

At a given time, a sample contains N_X nuclei of X, N_Y nuclei of Y and N_Z nuclei of Z.

Which expression is equal to the rate at which the number of nuclei of Y in this sample is changing?

A $\lambda_X N_X$ **B** $\lambda_Y N_Y$ **C** $\lambda_X N_X - \lambda_Y N_Y$ **D** $\lambda_Y N_Y + \lambda_X N_X$

37 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 a pair consisting of an up quark and an anti-up quark ($u\bar{u}$)?

A 1.3×10^{-21} J

B 2.5×10^{-21} J

C 3.8×10^{-13} J

D 7.5×10^{-13} J

38 A photon is emitted when an electron transfers from energy level $n = 5$ to energy level $n = 2$ in a hydrogen atom.

What is the energy of the photon?

A   0.544 eV   **B**   2.86 eV   **C**   3.40 eV   **D**   4.08 eV

39 A star has a radius of 7.00×10^8 m and an average surface temperature of 6000 °C.

How much electromagnetic energy is emitted by the star in an hour?

A 4.52×10^{26} J

B 5.41×10^{26} J

C 1.63×10^{30} J

D 1.95×10^{30} J

40 A galaxy is at a distance of 4.6×10^{23} m from the Earth.

The wavelength of every spectral line from this galaxy is redshifted by +0.30%.

What is the age of the Universe based on this information?

A 1.5×10^{15} s

B 5.1×10^{15} s

C 5.1×10^{17} s

D 1.5×10^{26} s

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