Cambridge Pre-U

PHYSICS **9792/01**

Paper 1 Multiple Choice **May/June 2022**

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)

* 0 7 8 3 0 7 4 0 8 6 *

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.

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Data

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

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

$$n = \frac{\sin\theta_1}{\sin\theta_2}$$

$$n = \frac{v_1}{v_2}$$

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 A projectile is launched at a speed of $30\,m\,s^{-1}$ at an angle of 20° above the horizontal.

Assume air resistance is negligible.

What is the speed of the projectile at its highest point?

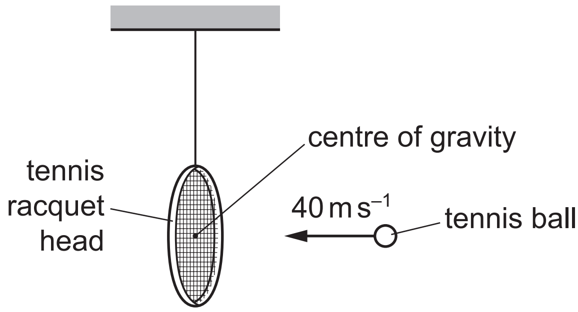
A $0\,m\,s^{-1}$ **B** $10\,m\,s^{-1}$ **C** $28\,m\,s^{-1}$ **D** $30\,m\,s^{-1}$

2 A car pulls a trailer of mass 500 kg. The friction acting on the car is 1200 N and the friction acting on the trailer is 400 N. The acceleration of the car and trailer system is $2.0\,m\,s^{-2}$.

What is the tension in the coupling between the car and trailer for this acceleration?

A 0 N **B** 1400 N **C** 1800 N **D** 2600 N

3 In a test laboratory, the head of a tennis racquet is suspended on a long string.



A tennis ball is fired at the centre of gravity of the racquet head at a speed of $40\,m\,s^{-1}$. The ball bounces from the racquet head in the opposite direction at a speed of $30\,m\,s^{-1}$.

The mass of the tennis ball is 0.060 kg and the mass of the racquet head is 1.2 kg.

What is the change in speed of the racquet head?

A $0.50\,m\,s^{-1}$ **B** $1.5\,m\,s^{-1}$ **C** $1.9\,m\,s^{-1}$ **D** $3.5\,m\,s^{-1}$

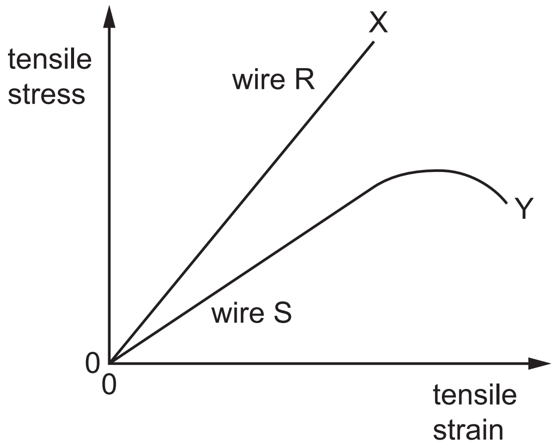
4 A space lander of mass 120 kg is on the surface of a planet.

A buggy of mass 25 kg is ejected from the space lander. The weight of the space lander decreases by 100 N.

What is the surface gravitational field strength of the planet?

A $0.83\,N\,kg^{-1}$ **B** $1.1\,N\,kg^{-1}$ **C** $4.0\,N\,kg^{-1}$ **D** $9.8\,N\,kg^{-1}$

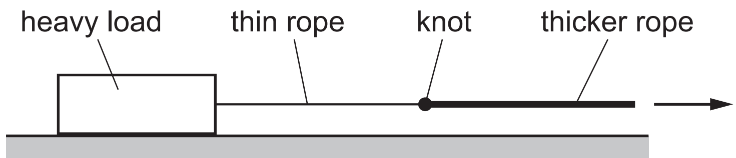
5 The graph shows how the tensile stress and the tensile strain are related for each of two wires R and S. The breaking stress of wire R is at point X and the breaking stress of wire S is at point Y.



Which properties can be deduced from the data plotted?

	comparison of Young modulus	nature of wire R	nature of wire S
A	Young modulus of R > Young modulus of S	brittle	ductile
B	Young modulus of R > Young modulus of S	ductile	brittle
C	Young modulus of S > Young modulus of R	brittle	ductile
D	Young modulus of S > Young modulus of R	ductile	brittle

6 One end of a thin rope is joined by a knot to a thicker rope made of the same material. The combined rope is used to pull a heavy load at constant speed.



Which statement is correct?

A The ratio of stress to strain will be bigger in the thinner rope.

B The strain in each rope is the same.

C The stress in each rope is the same.

D The tension in each rope is the same.

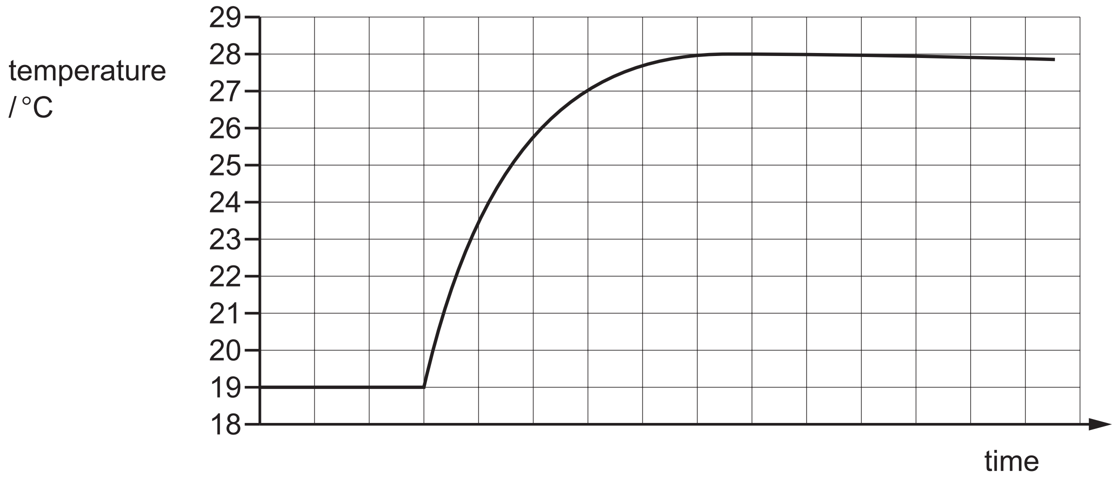
7 The Moon is in a circular orbit around the Earth due to a gravitational force of 2.1×10^{20} N. The radius of the circular orbit is 3.8×10^{5} km.

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

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

8 A glass stopper of mass 100 g at a temperature of 100 °C is dropped into 160 g of water at room temperature.

The water has a temperature sensor fixed within it. The variation of the output from the temperature sensor with time is displayed on a computer monitor.



The specific heat capacity of water is 4200 J kg^{-1} K^{-1}.

What is the specific heat capacity of glass?

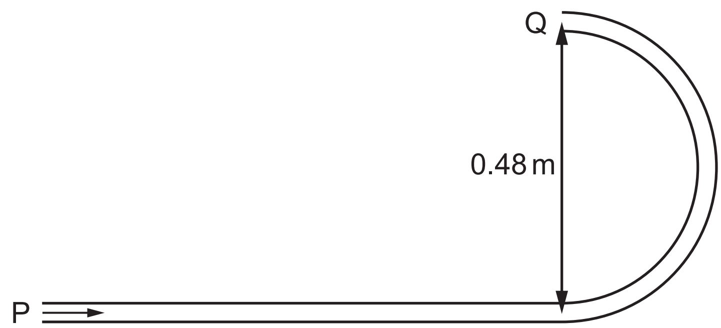
A 840 J kg^{-1} K^{-1}

B 1300 J kg^{-1} K^{-1}

C 1900 J kg^{-1} K^{-1}

D 4600 J kg^{-1} K^{-1}

9 The diagram shows a rigid hollow tube mounted vertically.



A particle is projected along the tube from the lower end P with a speed of 4.0 m s^{-1} so that it just reaches the upper end Q.

The vertical height gained by the particle is 0.48 m.

Which fraction of the initial energy of the particle is used to do work against friction?

A 0.06 **B** 0.41 **C** 0.59 **D** 0.94

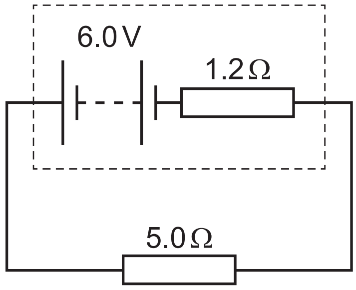
10 A copper wire of length 3.0 m has resistivity $1.7 \times 10^{-8}\,\Omega\,\text{m}$ and resistance $16\,\Omega$.

Assume the wire has a uniform circular cross-section.

What is the diameter of the wire?

A 3.2×10^{-4} m **B** 2.1×10^{-5} m **C** 3.2×10^{-5} m **D** 6.4×10^{-5} m

11 The diagram shows a battery of electromotive force (e.m.f.) 6.0 V and internal resistance $1.2\,\Omega$ connected to a resistor of resistance $5.0\,\Omega$.

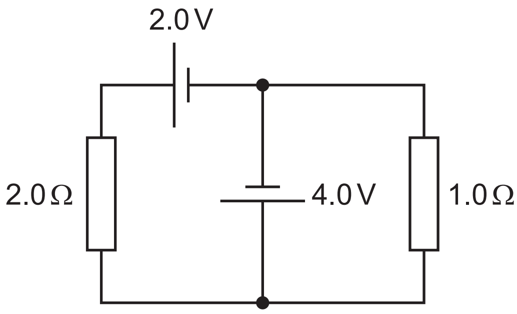


Another $5.0\,\Omega$ resistor is connected in parallel with the original $5.0\,\Omega$ resistor.

What is the ratio $\dfrac{\text{total current with two } 5.0\,\Omega \text{ resistors}}{\text{total current with one } 5.0\,\Omega \text{ resistor}}$?

A 0.50 **B** 0.55 **C** 1.7 **D** 2.0

12 The cells in the circuit shown have negligible internal resistance.



What is the current in the 4.0 V cell?

A 1.0 A **B** 3.0 A **C** 5.0 A **D** 7.0 A

13 What is the relationship between the intensity I of a progressive wave and the amplitude A of the wave?

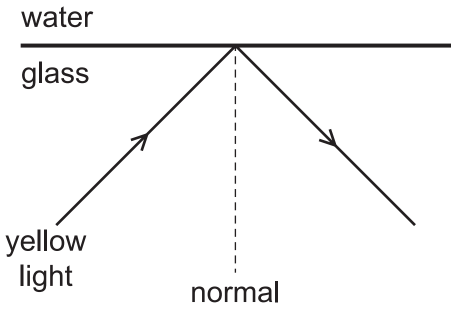
A $A = I \times$ constant

B $A^2 = I \times$ constant

C AI = constant

D A^2I = constant

14 A ray of yellow light **just** undergoes total internal reflection at the interface between glass and water.



The speed of light in glass increases as the wavelength of the light increases.

Which change will result in some light being refracted at the interface?

A increase the angle of incidence in the glass

B replace water by air

C use blue light instead of yellow

D use red light instead of yellow

15 A student is investigating the diffraction of electromagnetic waves at an adjustable single slit.

The wavelength of the electromagnetic waves is λ and the width of the slit is d.

Which combination of λ and d will produce the greatest diffraction at the slit?

	λ/nm	d/nm
A	400	4500
B	450	1100
C	580	2200
D	690	4900

16 Two speakers, X and Y, produce coherent sound waves with a frequency of 170 Hz. The sound waves from speaker X are in anti-phase with those from speaker Y.

A point Z is 0.50 m further from speaker X than it is from speaker Y.

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

What is the path difference and phase difference between the waves arriving at point Z?

	path difference / m	phase difference / rad
A	0.50	0.25
B	0.50	1.6
C	1.5	0.25
D	1.5	1.6

17 Nuclide X decays to stable nuclide Y with a half-life of *T* years.

Geologists know that nuclide Y in a particular rock sample has all come from nuclide X which was present when the rock formed.

The rock is thought to be 3*T* years old.

What is the expected ratio for this rock of $\dfrac{\text{number of atoms of X}}{\text{number of atoms of Y}}$?

A $\dfrac{1}{6}$ **B** $\dfrac{1}{7}$ **C** $\dfrac{1}{8}$ **D** $\dfrac{1}{9}$

18 An isotope P of an element has a mass number A and an atomic number Z.

A nucleus of isotope Q of the same element has one more neutron than isotope P.

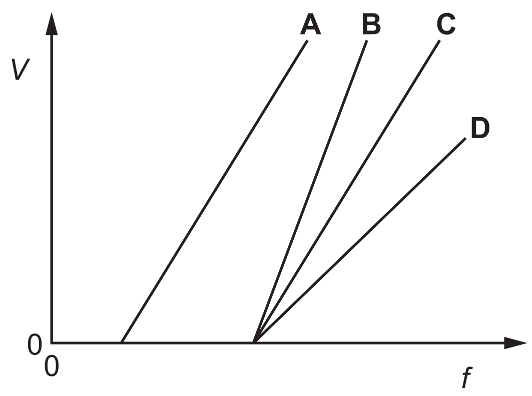
What are the atomic number and mass number of isotope Q in terms of A and Z?

	atomic number	mass number
A	Z	A + 1
B	Z	A
C	Z + 1	A – 1
D	Z + 1	A + 1

19 An experiment is carried out on a photocell to investigate how the stopping potential V varies with the frequency f of the radiation falling on it. The result is line **C** on the graph.

The experiment is repeated using radiation of lower intensity.

Which line will be produced?

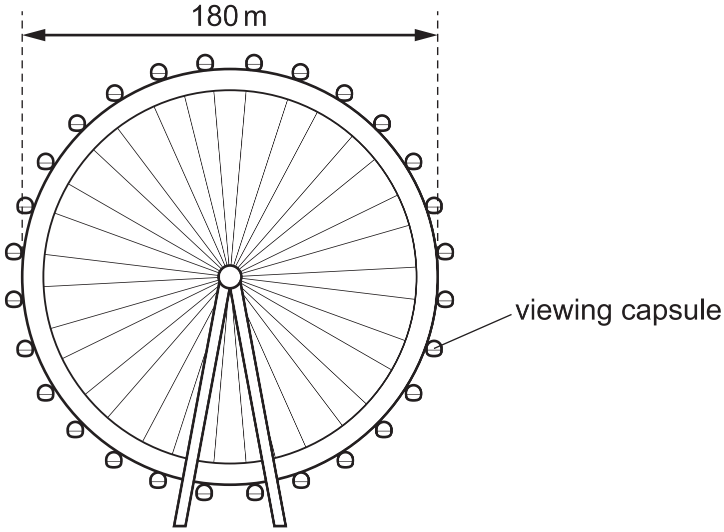


20 Electrons are accelerated from rest through a potential difference V.

How is the de Broglie wavelength λ of the electrons related to V?

A $\lambda \propto V$ **B** $\lambda \propto \frac{1}{V}$ **C** $\lambda \propto \sqrt{V}$ **D** $\lambda \propto \frac{1}{\sqrt{V}}$

21 A Ferris wheel has a diameter of 180 m and rotates at a steady speed, completing one rotation every 30 minutes.



What is the centripetal acceleration that a person in a viewing capsule at the rim of the wheel experiences on the ride?

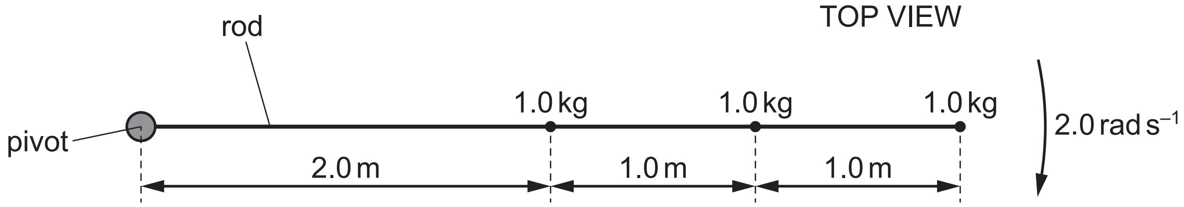
A $2.8 \times 10^{-5}\,\mathrm{m\,s^{-2}}$

B $1.1 \times 10^{-3}\,\mathrm{m\,s^{-2}}$

C $2.2 \times 10^{-3}\,\mathrm{m\,s^{-2}}$

D $3.1 \times 10^{-1}\,\mathrm{m\,s^{-2}}$

22 Three masses, each of magnitude 1.0 kg, are fixed to a rod of negligible mass.

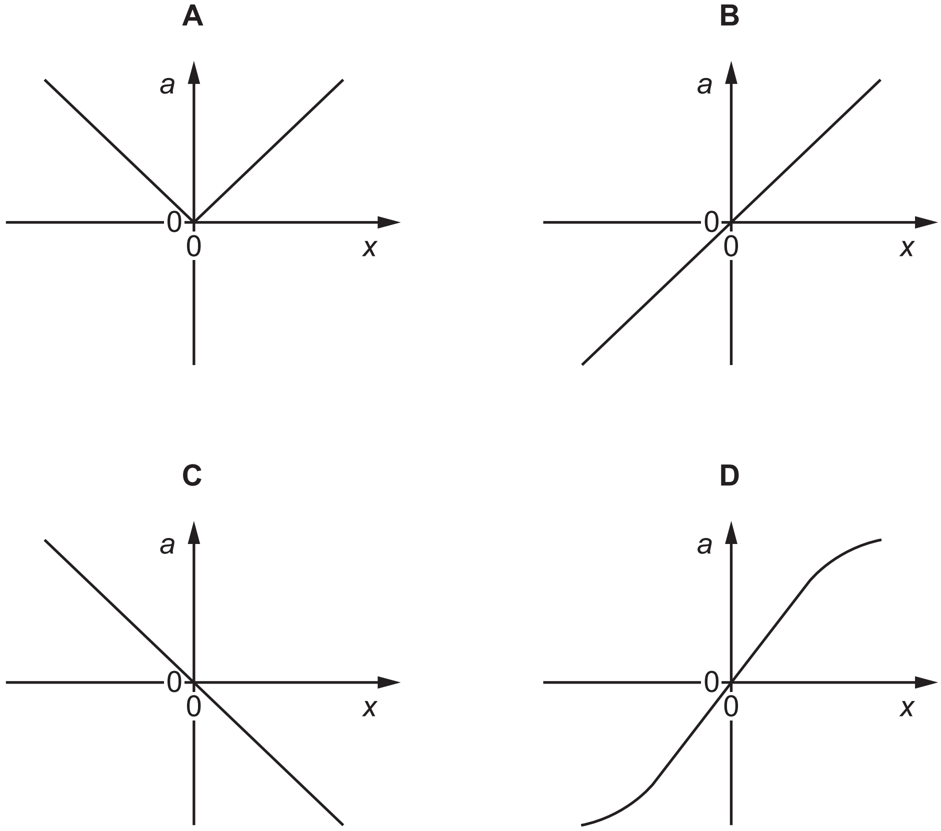


The rod rotates in a horizontal plane about a pivot at a constant angular velocity of $2.0\,\mathrm{rad\,s^{-1}}$.

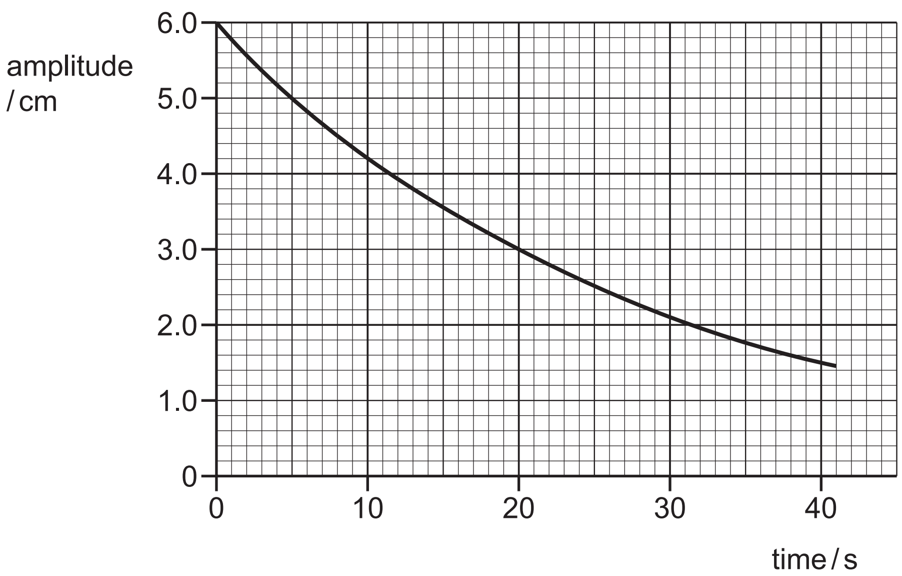
What is the horizontal force exerted on the pivot by the rod?

A 1.8 N **B** 2.4 N **C** 36 N **D** 48 N

23 Which graph shows the correct relationship between the acceleration a and the displacement x of a simple harmonic oscillator?



24 The graph shows how the amplitude of a simple pendulum decays with time from an initial amplitude of 6.0 cm.

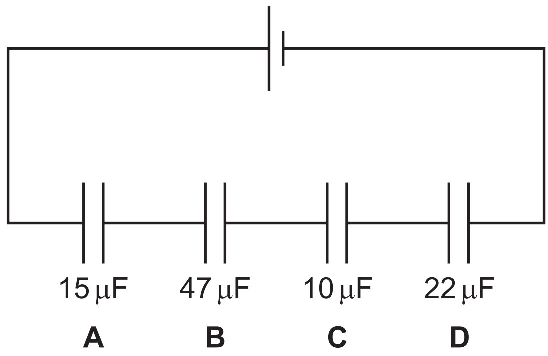


Which fraction of the initial energy is lost in the first 40 s?

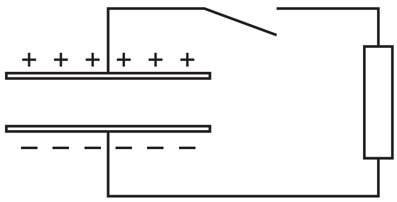
A $\frac{1}{16}$ **B** $\frac{1}{4}$ **C** $\frac{3}{4}$ **D** $\frac{15}{16}$

25 Four capacitors, **A**, **B**, **C** and **D**, are connected in series to a cell.

Which capacitor stores the greatest quantity of energy?



26 A fully charged capacitor is connected in series with an open switch and a resistor.



The time constant of the circuit is 12 s.

The switch is closed at time t = 0. The potential difference (p.d.) across the capacitor at time t = 36 s is 0.20 V.

What was the p.d. across the capacitor at t = 0?

A 0.54 V **B** 0.60 V **C** 1.6 V **D** 4.0 V

27 The electric field strength at a distance r from the centre of an isolated thorium-231 nucleus, ${}^{231}_{90}\mathrm{Th}$, is E_0.

This thorium nucleus emits an electron and changes into a nucleus of protactinium-231, ${}^{231}_{91}\mathrm{Pa}$.

Which expression determines the electric field strength E at a distance 3r from the centre of the protactinium-231 nucleus?

A $E = \left(\dfrac{90 \times 3}{91}\right) \times E_0$

B $E = \left(\dfrac{90 \times 9}{91}\right) \times E_0$

C $E = \left(\dfrac{91}{90 \times 3}\right) \times E_0$

D $E = \left(\dfrac{91}{90 \times 9}\right) \times E_0$

28 An object of mass m is lifted from the Earth's surface to a point one Earth radius above the surface.

M = mass of the Earth
R = radius of the Earth
G = universal gravitational constant

Which expression gives the resulting change in gravitational potential energy?

A an increase of $\frac{GMm}{2R}$

B a decrease of $\frac{GMm}{2R}$

C an increase of $\frac{GMm}{R}$

D a decrease of $\frac{GMm}{R}$

29 The mean distance of the planet Uranus from the Sun is 19 times that of the mean distance of the Earth from the Sun.

How long does it take Uranus to orbit the Sun?

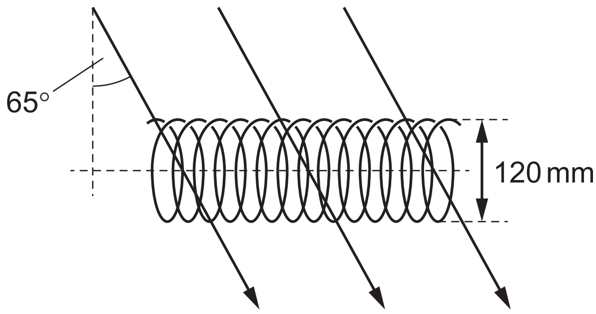
A 7 years

B 83 years

C 360 years

D 6900 years

30 A uniform magnetic field of magnetic flux density 50.0 mT passes through a horizontal coil at an angle of 65° to the vertical.



The coil has 240 turns and a diameter of 120 mm.

What is the magnetic flux linkage in the coil?

A 0.0574 Wb **B** 0.123 Wb **C** 0.492 Wb **D** 0.574 Wb

31 The Hall voltage across a slice of a semiconductor placed at right angles to a uniform magnetic field of magnetic flux density 30 mT is 1.2 mV.

The magnetic flux density is reduced to 25 mT and the mean drift velocity of the charge carriers within the slice is doubled.

What is the new Hall voltage across the slice?

A 0.5 mV **B** 1.0 mV **C** 1.4 mV **D** 2.0 mV

32 A container of volume $2.5 \times 10^3\,cm^3$ contains an ideal gas at pressure $5.0 \times 10^5\,Pa$.

The temperature of the gas is 100 °C.

How many molecules of gas are in the container?

A 2.4×10^{21} **B** 9.0×10^{21} **C** 2.4×10^{23} **D** 9.0×10^{23}

33 During the expansion of an ideal gas at a constant pressure of $5.81 \times 10^5\,Pa$, the volume of the gas increases from $400\,cm^3$ to $1450\,cm^3$.

During the expansion, 1430 J of thermal energy is supplied to the gas.

What is the change in the internal energy of the gas during the expansion?

A –2040 J **B** –820 J **C** +820 J **D** +2040 J

34 The minimum energy required to separate completely all the nucleons of an oxygen-16 nucleus is 128 MeV.

What is the 128 MeV minimum energy?

A the binding energy of the 16 separated nucleons

B the binding energy of the oxygen-16 nucleus

C the work required to overcome the electrostatic forces between nucleons in the nucleus

D the work required to overcome the weak nuclear forces within the nucleus

35 A radioactive source with a half-life of 6.0 hours emits gamma-rays. A gamma-ray detector placed 2.0 m from the source records an average rate of 160 counts per minute (cpm) after correcting for background radiation. The count rate is measured again 24 hours later but the detector is now placed 1.0 m from the source.

What is the expected average count rate for the second measurement after correcting for background radiation?

A 20 cpm **B** 40 cpm **C** 80 cpm **D** 160 cpm

36 Collisions between protons can create many other particles. However, all particle reactions must obey conservation laws.

The reaction shown in the equation is **not** possible:

$$p + p \rightarrow p + n + e + \nu$$

where:

p = proton

n = neutron

e = electron

ν = neutrino

Which conservation laws would be violated by this reaction?

A charge only

B lepton number only

C charge and lepton number only

D charge, baryon number and lepton number

37 Balmer, Lyman and Paschen are names given to different series of spectral lines emitted by hydrogen atoms.

Which statement about these series is correct?

A All of the spectral lines in a particular series involve electron jumps down to the ground state.

B All of the spectral lines in a particular series involve electron jumps that end at the same energy level.

C The number of different spectral lines in each series is the same.

D The number of energy levels that give rise to each series is the same.

38 The hydrogen atom energy levels are given by the equation.

$$E_n = \frac{-13.6}{n^2}\,\text{eV}$$

Which quantum jump results in the emission of a photon with the shortest wavelength?

A $n = 2$ to $n = 1$

B $n = 4$ to $n = 2$

C $n = 6$ to $n = 3$

D $n = 7$ to $n = 6$

39 Which characteristic of a star must be known if it is to be used as a standard candle?

A its distance from the Earth

B its luminosity

C its surface temperature

D its radius

40 Star X has radius R, surface temperature T and luminosity L. Star Y has radius $2R$ and surface temperature $\frac{T}{2}$.

What is the luminosity of star Y?

A $\frac{L}{4}$ **B** L **C** $4L$ **D** $16L$

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