JURONG PIONEER JUNIOR COLLEGE

JC2 Preliminary Examination 2024

PHYSICS **9749/01**
Higher 2 **17 September 2024**

Paper 1 Multiple Choice **1 hour**

Additional Material: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided.

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.

This document consists of **16** printed pages.

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T\ /\ \mathrm{K} = T\ /\ ^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{(x_0^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 What is a reasonable estimate of the cross-sectional area of the wire in a paper clip?

A 1×10^{-3} m^2

B 8×10^{-5} m^2

C 8×10^{-7} m^2

D 1×10^{-9} m^2

2 A photographer wishes to check the time for which the shutter on a camera stays open when a photograph is being taken. It is found that before the shutter opens, the ball falls 2.5 m from rest. During the time that the shutter remains open, the ball falls a further 0.12 m.

What is the time that the shutter remains open?

A 0.017 s

B 0.16 s

C 0.71 s

D 0.73 s

3 A mass initially at rest exploded into two pieces of mass m_1 and m_2 which moves apart from each other with speeds v_1 and v_2 respectively.

What is the ratio of $\frac{v_1}{v_2}$?

A $\frac{m_1}{m_2}$

B $\sqrt{\frac{m_1}{m_2}}$

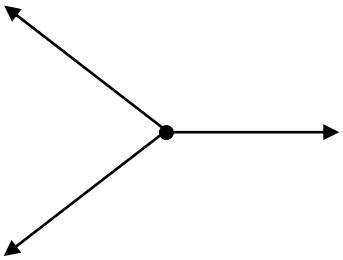
C $\frac{m_2}{m_1}$

D $\sqrt{\frac{m_2}{m_1}}$

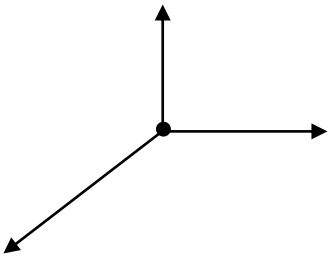
4 A system of three coplanar forces is acting at a point.

Which system of forces is most likely to be in equilibrium?

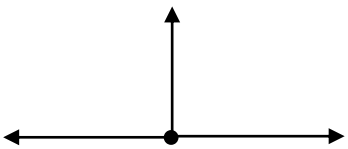
A



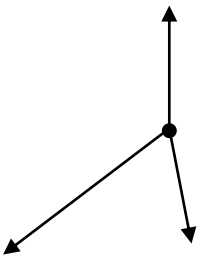
B



C



D



5 A skier of mass 60 kg skies down a slope from rest and reaches the bottom with a speed of 20 m s^{-1}. The vertical height of the slope is 50 m and the effective distance the skier moves along the slope is 200 m.

What is the average frictional force acting on his ski if he skies down the slope under the influence of gravity only?

A 87 N

B 150 N

C 240 N

D 2100 N

6 A block is resting on a weighing scale in a car. When the car is moving with constant velocity, the weighing scale gives a reading of W in newtons. When the car drives over a hump of radius r, the weighing scale reads $\frac{W}{3}$ at the highest point of the hump.

What is the velocity of the car at this point?

A $\sqrt{\frac{gr}{3}}$

B $\sqrt{\frac{2gr}{3}}$

C $\sqrt{gr}$

D $\sqrt{\frac{4gr}{3}}$

7 A planet has a mass M and a radius R. An object at the equator only just remains in contact with the surface of the planet. This is because the speed at which the planet rotates is very large.

What is the period of rotation of the planet?

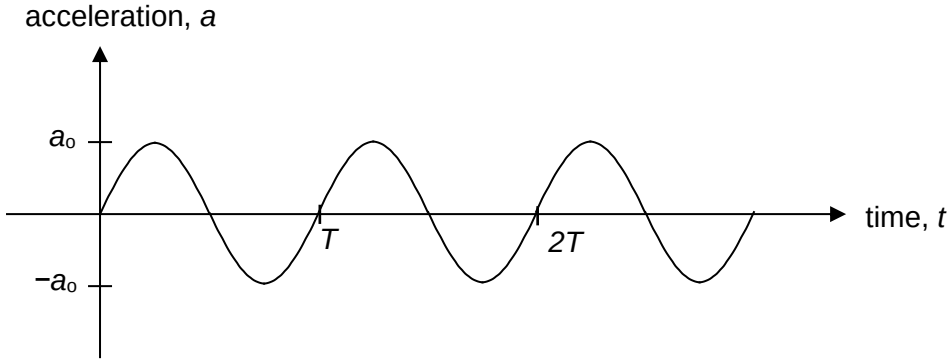
A $2\pi\sqrt{\frac{R^2}{GM}}$

B $2\pi\sqrt{\frac{GM}{R^2}}$

C $2\pi\sqrt{\frac{R^3}{GM}}$

D $2\pi\sqrt{\frac{GM}{R^3}}$

8 A particle undergoes simple harmonic motion with period *T.* The variation with time of its acceleration is shown below.



What is the particle's displacement, in terms of its amplitude x_o, at time $\frac{T}{3}$?

A $-0.87x_o$

B $-0.50x_o$

C $0.50x_o$

D $0.87x_o$

9 In deriving the equation $p = \frac{1}{3}\rho\langle c^2 \rangle$ in kinetic theory of gases, which of the following is not taken as a valid assumption?

A Attractive forces between the molecules are negligible.

B The duration of a collision is negligible compared with the time between collisions.

C Collisions with the walls of the container and with other molecules cause no change in the average kinetic energy of the molecules.

D The molecules suffer negligible change in momentum on collision with the walls of the container.

10 Why does the pressure of a fixed mass of gas at constant volume increase with temperature?

A The molecules collide with the container walls more frequently.

B The number of intermolecular collisions increases.

C The molecules travel greater distances between collisions with one another.

D The energy transferred to the walls during collisions increases.

11 A metal pellet of mass m and specific heat capacity c hits a steel plate at speed v. During the impact, the kinetic energy is reduced to 25% of its original value. The loss in kinetic energy of the pellet is converted to thermal energy in the pellet.

What is the rise in temperature of the pellet?

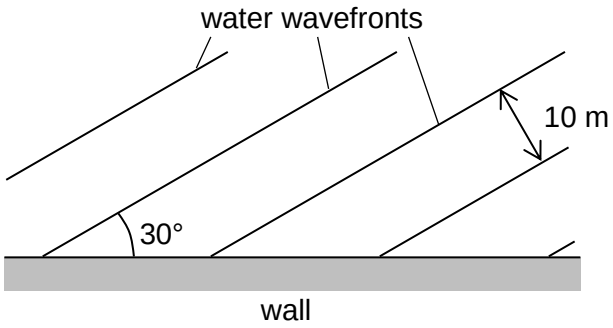
A $\frac{v^2}{8c}$

B $\frac{3v^2}{8c}$

C $\frac{mv^2}{8c}$

D $\frac{3mv^2}{8c}$

12 Water waves of wavelength 10 m approach a wall at an angle of 30° as shown.



What is the phase difference between water waves at two points 5.0 m apart along the wall?

A 0.79 rad

B 0.96 rad

C 1.6 rad

D 3.1 rad

13 Vertical plane-polarised radio-waves of amplitude A is transmitted towards a receiving antenna. The antenna is tilted at an angle θ from the vertical in the plane perpendicular to the direction of propagation of the radio-waves.

Which of the following is the power received by the antenna proportional to?

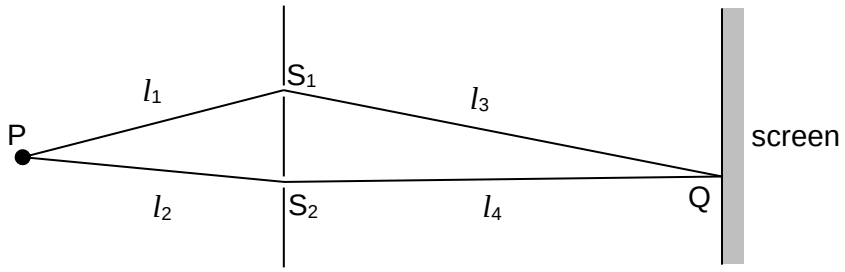
A $A^2 \cos^2 \theta$

B $A \cos \theta$

C $A \sin \theta$

D zero

14 Two identical narrow slits S_1 and S_2 are illuminated by light of wavelength λ from a point source P as shown. The light through the slits is then captured on a screen.



Given that m is a positive integer, what is the condition for destructive interference at Q?

A $l_3 - l_4 = m\lambda$

B $l_3 - l_4 = \left(\frac{2m-1}{2}\right)\lambda$

C $(l_1 + l_3) - (l_2 + l_4) = m\lambda$

D $(l_1 + l_3) - (l_2 + l_4) = \left(\frac{2m-1}{2}\right)\lambda$

15 A man sits in front of a computer monitor screen, such that the distance between his eyes and the monitor screen is 76 cm. The diameter of the pupil in the man's eyes is 2.0 mm.

What is the minimum distance between two pixels of an image on the screen emitting light at a wavelength of 550 nm, such that the man can resolve between the two pixels?

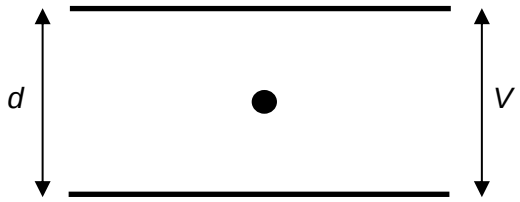
A 0.10 mm

B 0.21 mm

C 0.42 mm

D 0.84 mm

16 A charged oil drop is balanced halfway between two horizontal plates separated by a distance *d* when a potential difference *V* is applied between the plates.

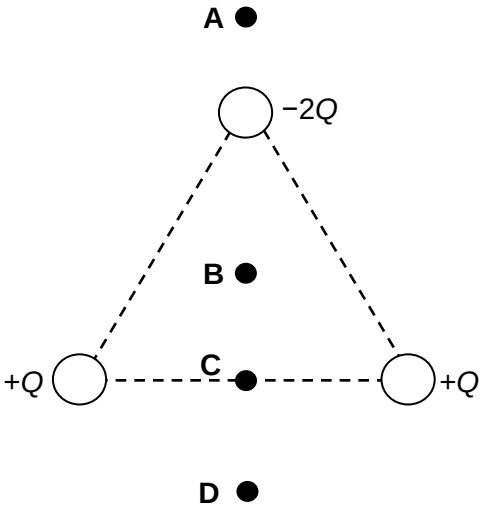


When *d* is doubled and *V* remains unchanged, what is the motion of the oil drop and its acceleration?

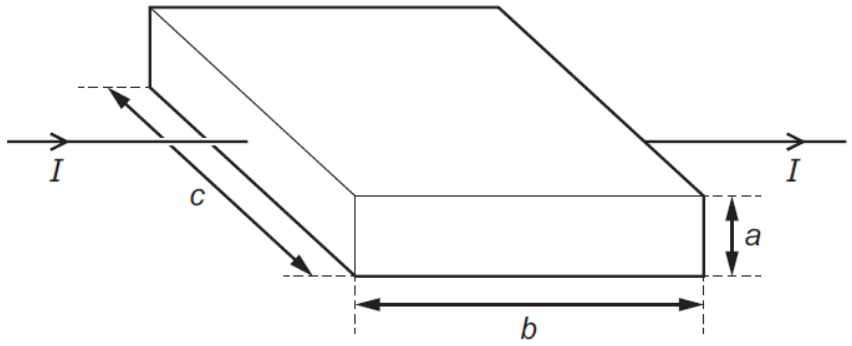
	motion of oil drop	acceleration
A	upwards	0.5*g*
B	upwards	2*g*
C	downwards	0.5*g*
D	downwards	2*g*

17 Three charges of charge +*Q*, +*Q*, and −2*Q* are placed at the corners of an equilateral triangle as shown. A small test charge +*q* is brought near the three charges.

At which position would it be most likely for the small test charge to experience zero net electric force?



18 The diagram shows a metal block.



The block has sides of length *a*, *b* and *c* as shown, and its volume is *V*. Each charge carrier has a charge −*q* and the number density of the charge carriers in the metal is *n*. It takes each charge carrier an average time of *t* to pass through the block.

What is an expression for the current I?

A $I = nqabc$

B $I = \frac{nqV}{t}$

C $I = \frac{nqbc}{t}$

D $I = nqaV$

19 A semiconductor diode with the forward characteristic shown in Fig. 19.1 is connected in series with a variable, low voltage d.c. power supply, a meter of negligible internal resistance and a 50 Ω resistor as shown in Fig. 19.2.

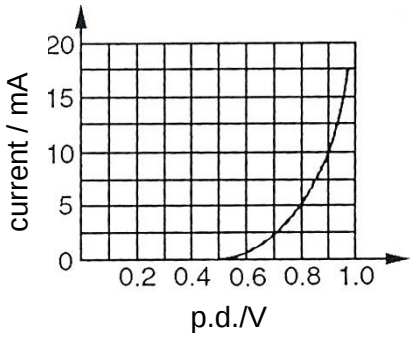


Fig. 19.1

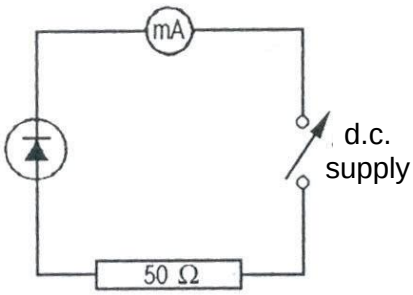


Fig. 19.2

What is the potential difference across the supply when the meter reads 5 mA?

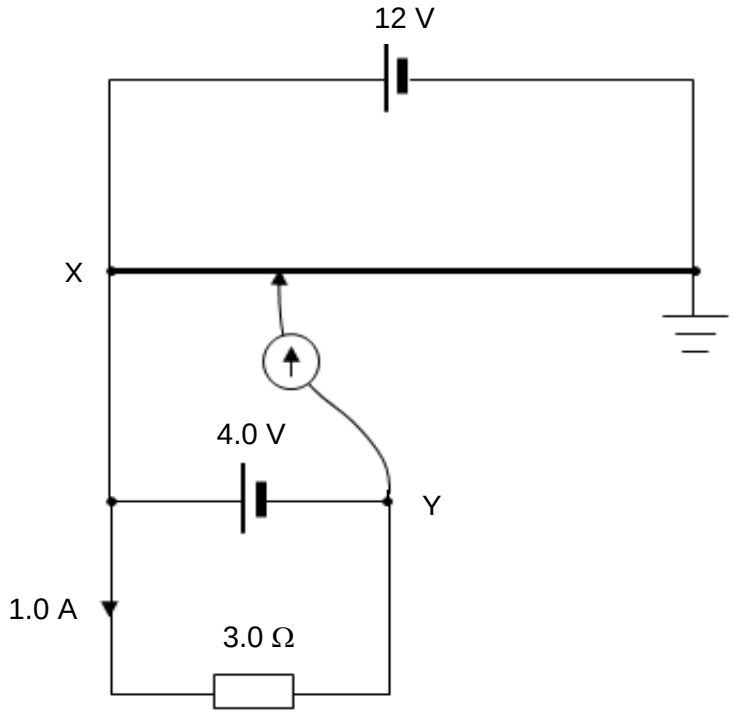
A 0.25 V

B 0.75 V

C 1.05 V

D 1.25 V

20 A 12 V cell with negligible internal resistance is connected to a resistance wire which is earthed at one end. Another cell of e.m.f. 4.0 V drives a current of 1.0 A through a 3.0 Ω resistor. The galvanometer is at zero deflection.

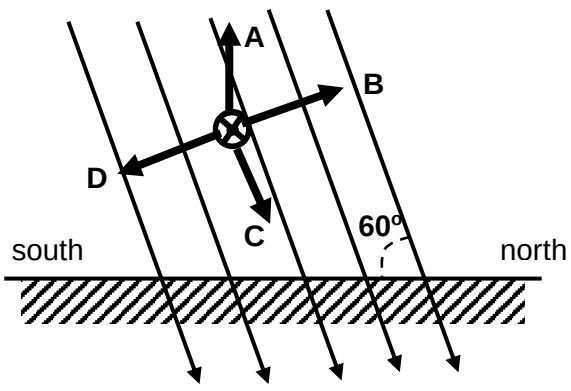


What are the potentials at X and Y?

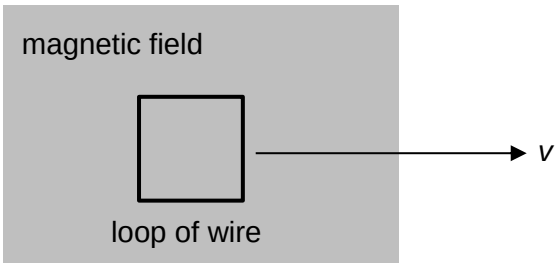
	potential at X / V	potential at Y / V
A	0	–4
B	12	8
C	3	0
D	12	9

21 A horizontal power cable carries a steady current in an east-to-west direction.

Which arrow shows the direction of the force on the cable caused by the Earth's magnetic field, in a region where this field is at 60° to the horizontal?



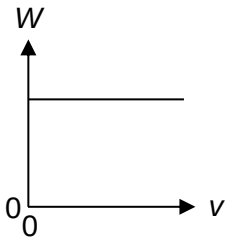
22 A square loop of wire is placed in a region of uniform magnetic field. The direction of the field is perpendicular to the plane of the loop of wire.



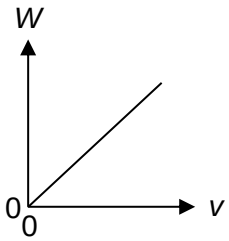
The loop is pulled out of the field at a uniform speed v. During this operation, the loop remains in the same plane.

Which graph shows how the work done W in pulling the loop totally out of the field depends on the speed v?

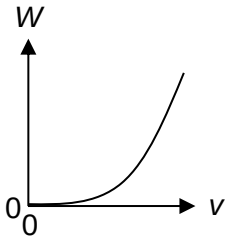
A



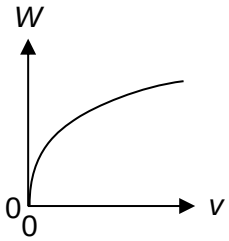
B



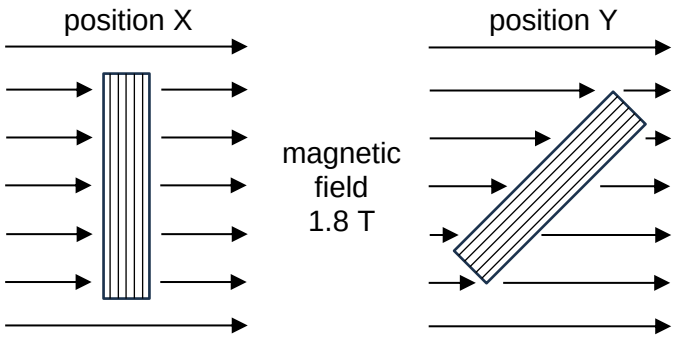
C



D



23 A circular coil of diameter 0.020 m has 3000 turns. It is rotated at an angle of 45° in a magnetic field of 1.8 T from a position X to position Y in 0.060 s.



What is the average e.m.f. induced in the coil during the rotation?

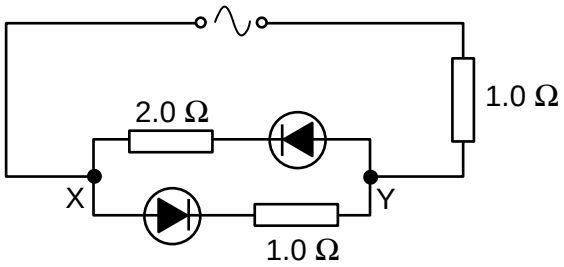
A 8.3 V

B 11 V

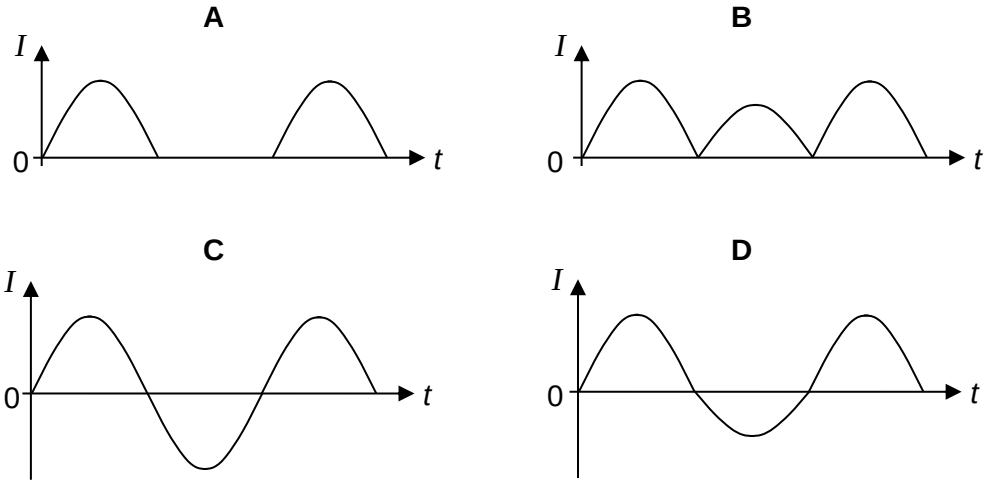
C 33 V

D 530 V

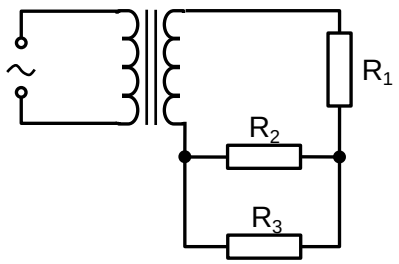
24 An a.c. source is connected to three resistors in the circuit below.



Which graph best represents the variation of the current I through the segment XY in the circuit with time *t*?



25 The secondary coil of a 2:1 step-down transformer is connected to three identical resistors R_1, R_2 and R_3 each of resistance 80 Ω as shown.



The alternating supply to the primary coil delivers a peak voltage of 180 V.

What is the value of the average power dissipated in R_1?

A 11 W

B 23 W

C 45 W

D 90 W

26 The photoelectric effect equation can be written as $hf = hf_0 + \frac{1}{2}mv^2_{max}$.

What is the meaning of each term in this equation?

	hf	hf_0	$\frac{1}{2}mv^2_{max}$
A	the energy of an incoming photon	the least energy required to release a photoelectron	the maximum kinetic energy of the photoelectron
B	the energy of an incoming photon	the threshold frequency which represents least energy required to release a photoelectron	the maximum kinetic energy of the photoelectron
C	the energy of an incoming photoelectron	the least energy required to release a photon	the maximum kinetic energy of a photon
D	the energy of an incoming photon	the work done by the incoming photon	the maximum kinetic energy of the outgoing photon

27 When electrons with velocity *v* travel through a vacuum and are incident on a thin carbon film, they produce a pattern of concentric circles on the fluorescent screen.

What causes the pattern and how would the pattern change when the velocity *v* is decreased?

	cause	change to pattern
A	diffraction	diameters of circles increase
B	diffraction	diameters of circles decrease
C	refraction	diameters of circles increase
D	refraction	diameters of circles decrease

28 Transitions between three energy levels in a particular atom give rise to three spectra lines of wavelengths in decreasing magnitudes, λ_1, λ_2 and λ_3.

Which one of the following equations correctly relates λ_1, λ_2 and λ_3?

A $\frac{1}{\lambda_3} = \frac{1}{\lambda_2} - \frac{1}{\lambda_1}$

B $\frac{1}{\lambda_3} = \frac{1}{\lambda_2} + \frac{1}{\lambda_1}$

C $\frac{1}{\lambda_3} = \frac{1}{\lambda_1} - \frac{1}{\lambda_2}$

D $\lambda_1 = \lambda_2 + \lambda_3$

29 A stationary nucleus X decays into two smaller nuclei Y and Z. Y is of a smaller mass compared to Z.

Which one of the following statements is correct?

A The mass-energy of X is greater than the total mass-energies of Y and Z.

B The binding energy of X is greater than the total binding energies of Y and Z.

C The kinetic energy of Y is greater than that of Z.

D The kinetic energy of Y is less than that of Z.

30 Nuclide X decays with a half-life of 15 days to stable nuclide Y. At a particular time *t*, the ratio of the number of nuclides X to the number of nuclides Y in a sample is 1 : 1.

How long after time *t* will the ratio in the sample be 1 : 3?

A 15 days

B 30 days

C 45 days

D 60 days

End of paper