2021-2022
F6 PHY
PAPER 1A

Bishop Hall Jubilee School
2021-2022 Mock Examination

F.6 PHYSICS PAPER 1A

Date: 23-02-2022
Time: 8:20 – 10:50
Duration: 150 mins
Total page no.: 18 (including cover page)
This paper must be answered in English

GENERAL INSTRUCTIONS

1. There are TWO sections, A and B, in this Paper. You are advised to finish Section A in about 60 minutes.
2. Section A consists of multiple-choice questions in this question paper, while Section B contains conventional questions printed separately in Question-Answer Book **B**.
3. Answers to Section A should be marked on the MC Answer Sheet while answers to Section B should be written in the spaces provided in the Question-Answer Book.
4. The diagrams in this paper are **NOT** necessarily drawn to scale.
5. The last two pages of this question paper contain a list of data, formulae and relationships which you may find useful.

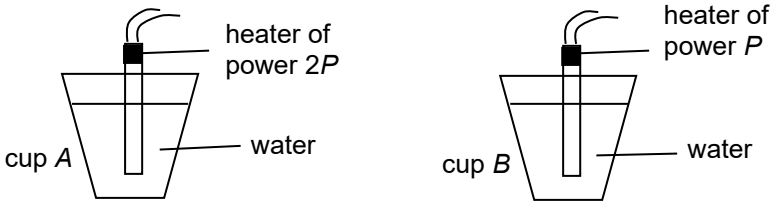
INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

1 After the announcement of the start of the examination, you should first write your name, class and class number in the spaces provided on the MC Answer Sheet.

1. When told to open this book you should check that all the questions are there. Look for the words '**END OF SECTION A**' after the last question.
2. All questions carry equal marks.
3. **Answer ALL questions in this paper**. You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a clean rubber. You must mark the answers clearly; otherwise you will lose marks if the answer cannot be captured.
4. You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.
5. No marks will be deducted for wrong answers.

Section A (40%): There are 33 multiple-choice questions.

1 Two identical foam cups, *A* and *B*, carry the same amount of water at 20 °C initially. Then, water in cups *A* and *B* is heated by electrical heaters of power 2*P* and *P* respectively for the same period of time. Assume no energy is lost to the surroundings.



If the final temperature of the water in cup *A* is 80 °C, find the final temperature of the water in cup *B*.

A 30 °C

B 40 °C

C 50 °C

D 60 °C

2 Ice cubes of mass 25 g at 0 °C are dropped into a beaker containing 250 g of water at 40 °C. What is the final temperature of the mixture? Assume that no energy is lost to the surroundings.

Specific latent heat of fusion of ice = 3.34×10^5 J kg^{-1}

Specific heat capacity of water = 4200 J kg^{-1} °C^{-1}

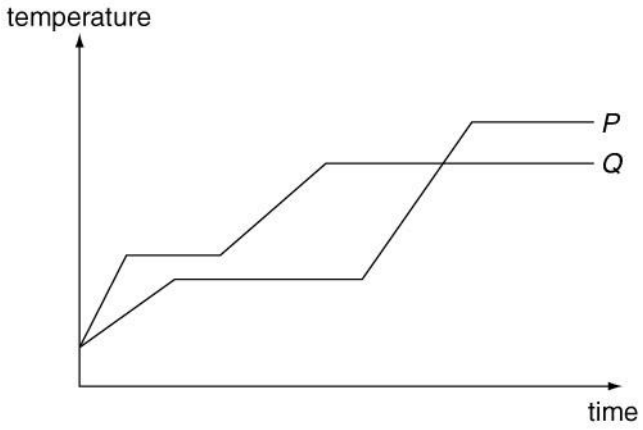
A 20.0 °C

B 25.0 °C

C 29.1 °C

D 32.2 °C

3 Two solid substances *P* and *Q* of equal mass are heated by two identical heaters of constant power until they boil. The temperatures of each substance at different times are recorded, as shown in the graph below.



Which of the following statements is **not** correct?

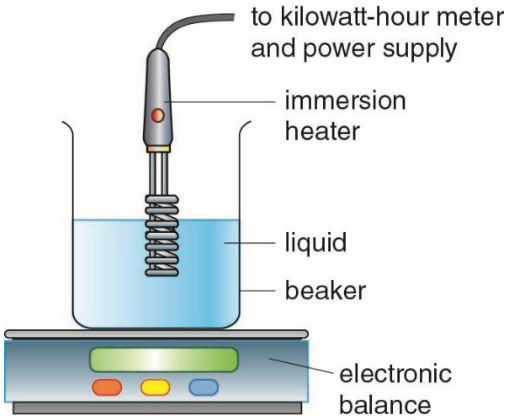
A The specific heat capacity of solid *P* is larger than that of solid *Q*.

B The specific heat capacity of liquid *P* is larger than that of liquid *Q*.

C The specific latent heat of fusion of *P* is larger than that of *Q*.

D The boiling point of *P* is higher than that of *Q*.

4 A student carries out an experiment to measure the specific latent heat of vaporization of a liquid using the set-up below.



Which of the following modifications should be made to obtain a more accurate result?

(1) Add more liquid into the beaker.

(2) Add a lid to cover the beaker.

(3) Replace the beaker with a polystyrene cup.

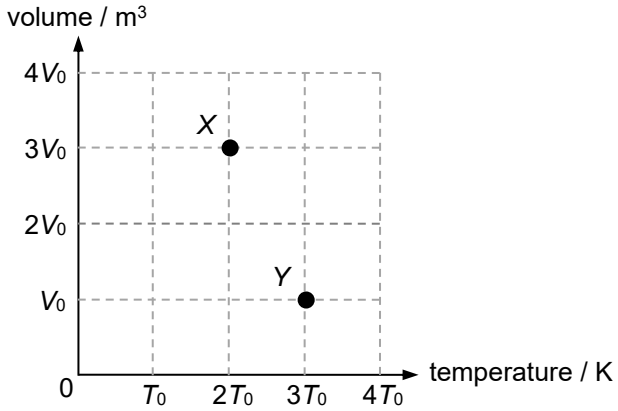
A (1) only

B (3) only

C (1) and (3) only

D (2) and (3) only

5 A certain amount of ideal gas is sealed in a container. The following graph shows the volumes and the temperatures of the gas at two states *X* and *Y*.



Find the ratio of the pressures of the gas at state *X* and state *Y*.

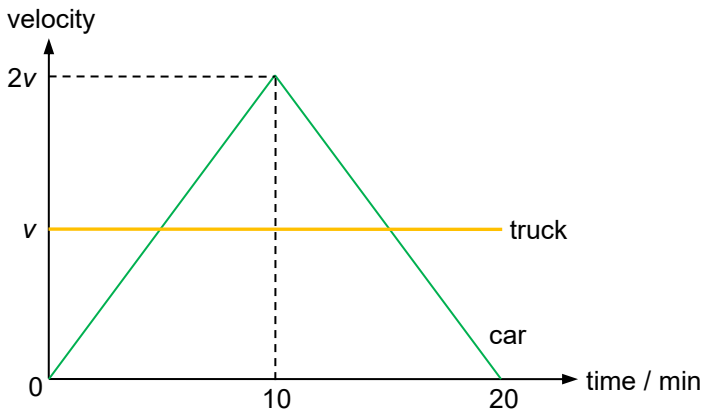
A 1 : 2

B 2 : 1

C 2 : 9

D 9 : 2

6 A car and a truck are at the same location on a straight road at time $t = 0$. Their velocity–time graph is shown below.



Which of the following statements is/are correct?

(1) The car is ahead of the truck at $t = 8$ min.

(2) The truck is closer to the car at $t = 13$ min than at $t = 12$ min.

(3) The two vehicles meet each other again at $t = 10$ min.

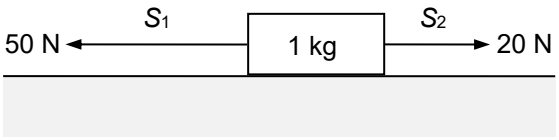
A (1) only

B (3) only

C (1) and (2) only

D (2) and (3) only

7 A block of mass 1 kg is moving to the left with an acceleration of 18 m s^{-2} when strings S_1 and S_2 are pulling it as shown. The tensions in S_1 and S_2 are 50 N and 20 N respectively.



S_1 is then suddenly broken. What will be the motion of the block immediately after this incident?

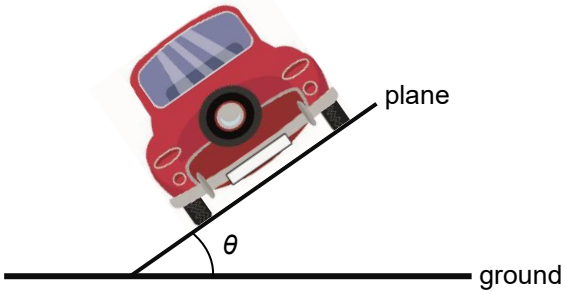
A Stop immediately

B Slow down with 8 m s^{-2}

C Slow down with 32 m s^{-2}

D Speed up with 8 m s^{-2}

8 A car is undergoing a tilt test. It rests on a plane tilted at an angle θ to the horizontal ground as shown.



When θ is increased to 35°, the car remains at rest on the tilted plane. The friction acting on the car by the plane is 6490 N. What is the normal force acting on the car by the plane?

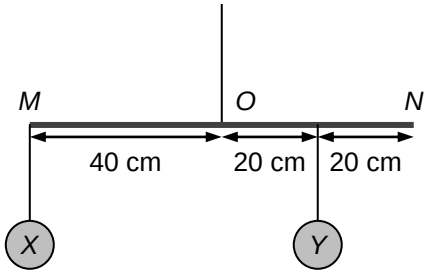
A 4540 N

B 9270 N

C 11 300 N

D Cannot be determined

9 In the following figure, two balls *X* and *Y* are hung from a uniform rod *MN* with inextensible light strings. The rod is hung by another inextensible light string at its mid-point *O*. It is given that the mass of *X* is three times that of the mass of *Y*.



Which of the following statement is/are correct at the instant just after the system is released from rest?

(1) The rod starts rotating in the anticlockwise direction.

(2) The tension in the string hanging *X* is smaller than the weight of *X*.

(3) The tension in the string hanging *Y* is larger than the weight of *Y*.

A (1) only

B (1) and (2) only

C (2) and (3) only

D (1), (2) and (3)

10 Arthur of mass 65 kg is jumping on a trampoline (Fig a). *X* is the highest position that he reaches and is 1.5 m above the flat fabric of the trampoline (Fig b). After falling back onto the fabric, the fabric deforms and he falls another 0.3 m to the lowest position *Y*. What is the magnitude of the average force acting on him by the fabric?

Fig a

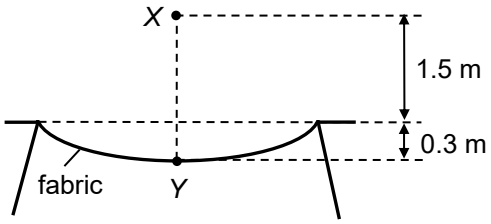


Fig b

A 638 N

B 2130 N

C 3190 N

D 3830 N

11 A satellite is initially at rest. Suddenly, it explodes and breaks into two parts, namely *X* and *Y*. The ratio of the mass of *X* to *Y* is 1 : 2. Which of the following statements is/are correct?

(1) The ratio of the speed of *X* to *Y* is 2 : 1.

(2) The ratio of the kinetic energy of *X* to *Y* is 2 : 1.

(3) The ratio of the magnitude of momentum of *X* to *Y* is 1 : 2.

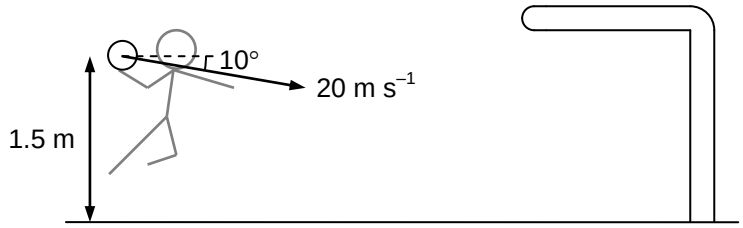
A (1) only

B (3) only

C (1) and (2) only

D (2) and (3) only

12 Vincent attempts for a goal in a handball match. He shoots the ball with a velocity of 20 m s^{-1} at an angle 10° below the horizontal. When the ball leaves his hand, it is 1.5 m above the ground.



Find the horizontal distance travelled by the ball before it hits the ground.

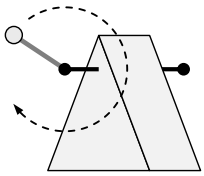
A 5.96 m

B 6.06 m

C 7.18 m

D 8.51 m

13 The following figure shows a toy which consists of a stand and a ball attached to the stand via a light rod. The mass of the ball is 200 g. It rotates in a circular path with radius 10 cm on a vertical plane at a constant angular speed of 5 rad s^{-1}.



Find the magnitude of force applied on the ball by the rod when the rod is horizontal.

A 0.5 N

B 0.99 N

C 1.46 N

D 2.02 N

14 The weight of an artificial satellite on the Earth's surface is 2500 N. What is its weight when it is orbiting around the Earth in a circular path of radius 2×10^8 m?

Given: Earth's radius = 6370 km

Acceleration due to gravity on Earth's surface = 9.81 m s^{-2}

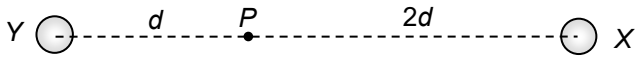
A 0

B 2.54 N

C 24.9 N

D 2500 N

15 Point *P* is at a distance of 2*d* from star *X* and at a distance of *d* from star *Y* as shown. *X*, *P* and *Y* lie on a straight line. The net force acting on an object at *P* is zero. If the mass of *X* is *M*, what is the mass of *Y*?



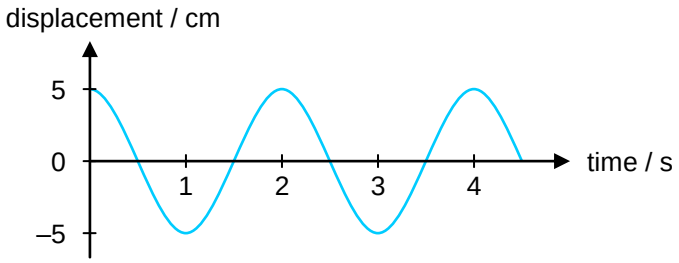
A $\frac{M}{4}$

B $\frac{M}{2}$

C $2M$

D $4M$

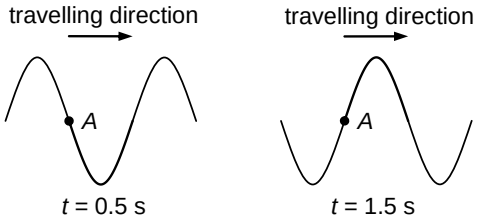
16 A transverse wave travels from *P* to *Q* at a speed 2 m s^{-1}. The following figure shows the displacement–time graph of the particle at *Q*.



If the distance between *P* and *Q* is 3 m, which of the following correct describes the motion of the particle at *P* at *t* = 2 s?

	Displacement	**Movement**
A	0	moving upwards
B	0	moving downwards
C	5 cm	at rest
D	–5 cm	at rest

17 A wave is travelling to the right. The waveforms at t = 0.5 s and t = 1.5 s are shown in the following figure.



What is the minimum possible frequency of the wave?

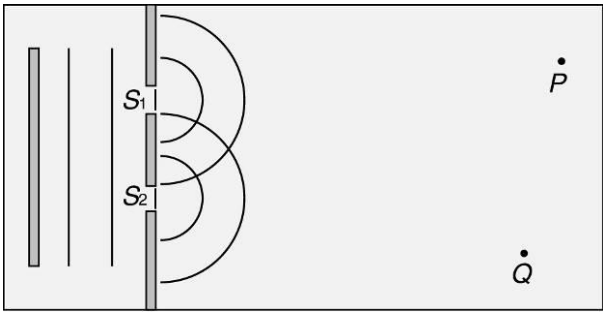
A 0.25 Hz

B 0.5 Hz

C 0.75 Hz

D 1 Hz

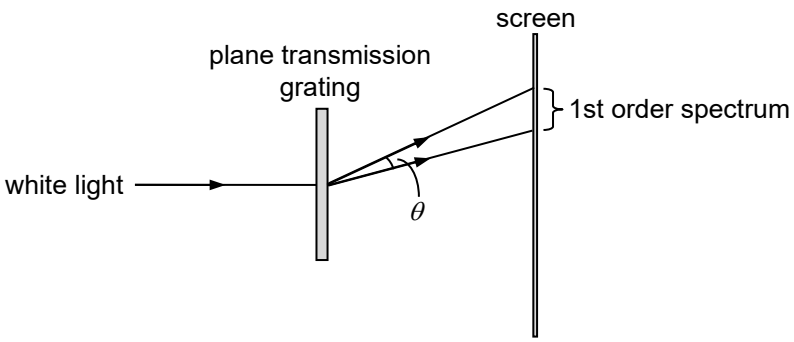
18 In the following figure, a plane wave travels towards two narrow gaps and two circular waves emerge from the gaps. Point P is at a distance 15 cm from S_1 and 20 cm from S_2, while point Q is at a distance 14 cm from S_1 and 12 cm from S_2.



If the wavelength of the plane wave is 2 cm, what kind of interference will occur at P and Q?

	P	***Q***
A	constructive	constructive
B	constructive	destructive
C	destructive	constructive
D	destructive	destructive

19 A beam of white light is incident normally on a plane transmission grating and a pattern with some continuous spectra is formed on the screen behind the grating. The figure below shows how the boundary of the 1st order spectrum is formed. The grating has 500 lines per mm. The white light covers visible light with wavelength 4×10^{-7} m to 7×10^{-7} m.



What is the angle θ subtended by the 1st order spectrum?

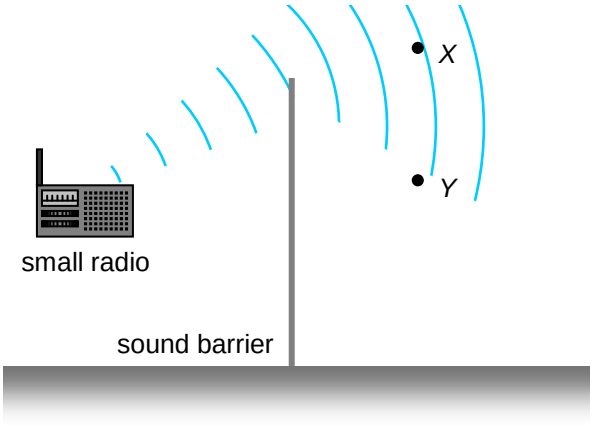
A 8.95°

B 11.5°

C 20.5°

D 20.8°

20 A small radio is playing a song in front of a sound barrier as shown below. The song is audible at positions *X* and *Y*.



Which of the following statements is/are correct?

(1) The high-pitch part of the song is heard more clearly at *X* than at *Y*.

(2) The low-pitch part of the song is heard more clearly at *X* than at *Y*.

(3) The speed of sound waves is higher at *X* than that at *Y*.

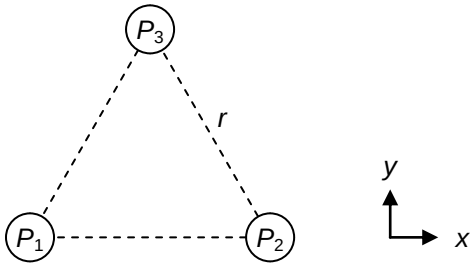
A (1) only

B (2) only

C (1) and (2) only

D (1) and (3) only

21 Three particles P_1, P_2 and P_3 are situated on the vertices of an equilateral triangle with side length r, as shown in the following figure. Each particle carries a charge of Q.



What is the electrostatic force acting on P_3?

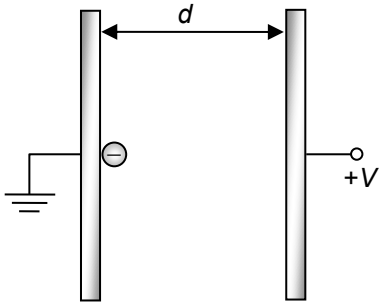
A $\dfrac{Q^2}{4\pi\varepsilon_0 r^2}$ in the positive x direction

B $\dfrac{Q^2}{2\pi\varepsilon_0 r^2}$ in the positive x direction

C $\dfrac{Q^2}{2\pi\varepsilon_0 r^2}$ in the positive y direction

D $\dfrac{\sqrt{3}Q^2}{4\pi\varepsilon_0 r^2}$ in the positive y direction

22 The voltage across two parallel metal plates is V and the distance between the plates is d as shown. A negatively charged particle is released from rest from the earthed plate. The speed of the particle is v when it reaches the positive plate. Neglect the effect of gravity.



Which of the following statements is/are correct?

(1) v will increase if d increase.

(2) The particle accelerates uniformly when it moves from the earthed plate to the positive plate.

(3) v is independent of the mass of the particle.

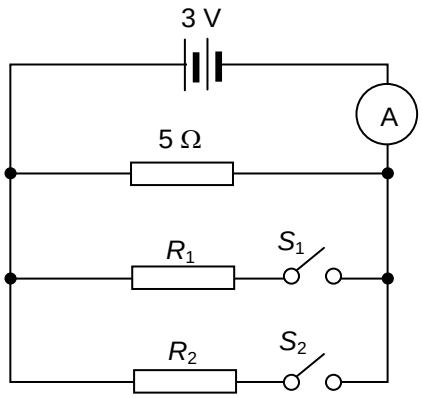
A (2) only

B (1) and (2) only

C (1) and (3) only

D (1), (2) and (3)

23 In the following circuit, the resistance of R_2 is half that of R_1. When S_1 is closed, the ammeter reads 1.6 A. Assume that the battery and the ammeter are ideal.



What is the reading of the ammeter when both S_1 and S_2 are closed?

A 0.6 A

B 2.8 A

C 3.6 A

D 4.2 A

24 Which of the following statements about Ohm's law is/are correct?

(1) All conductors obey Ohm's law.

(2) Ohmic devices refer to the devices that obey Ohm's law.

(3) If two ohmic devices are connected in parallel, the resulting combination is also ohmic.

A (1) only

B (2) only

C (1) and (2) only

D (2) and (3) only

25 The electric kettle below is rated at '220 V, 3000 W'.

When it works at its rated value, it takes time T to boil a certain amount of water. How long does it take to boil the same amount of water when the kettle works at 110 V?

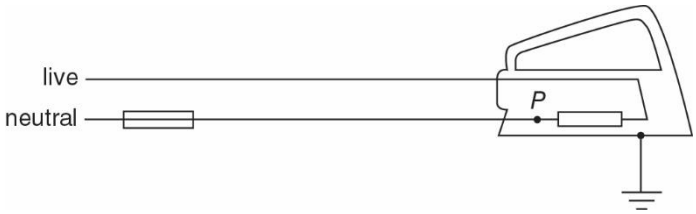
A $\frac{1}{4}T$

B $\frac{1}{2}T$

C $2T$

D $4T$

26 The figure shows the circuit for an electrical appliance. The fuse is placed in the neutral wire instead of the live wire.



If point *P* of the wire touches the metal body of the appliance, which of the following will happen?

(1) The appliance does not work.

(2) The fuse does not melt.

(3) If someone touches the metal body, he will not get an electric shock.

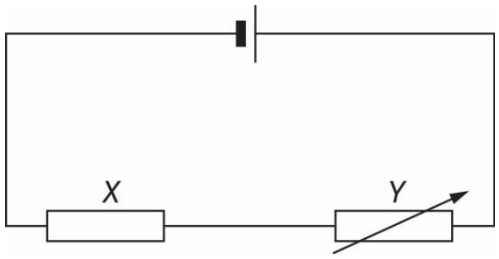
A (1) and (2) only

B (1) and (3) only

C (2) and (3) only

D (1), (2) and (3)

27 A fixed resistor *X* and a variable resistor *Y* are connected to a battery as shown.



At the beginning, the resistance of *Y* is set equal to that of *X* and the power of *Y* is *P*. Find the power of *Y* when its resistance is halved.

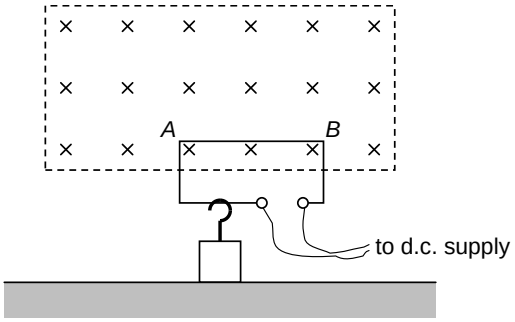
A $\frac{2}{9}P$

B $\frac{1}{2}P$

C $\frac{8}{9}P$

D $2P$

28 A rectangular wire frame with side length AB = 20 cm is held vertically and connected to a d.c. power supply. A weight is hanged on the frame and part of the frame is inside a uniform magnetic field as shown in the figure below. The magnitude of the magnetic field is 0.5 T and the total mass of the weight and the wire frame is 200 g. Take g = 9.81 m s^{-2}.



To lift up the weight, what should be the minimum current passing through the wire frame?

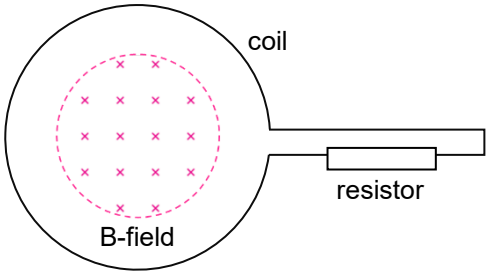
A 0.196 A (from A to B)

B 0.196 A (from B to A)

C 19.6 A (from A to B)

D 19.6 A (from B to A)

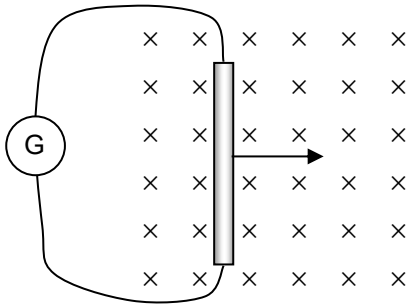
29 There is a uniform magnetic field within the circular region of radius 5 m enclosed by the dotted lines as shown. The field points into the page and the flux density increases at a constant rate of 0.01 T s^{-1}. A circular coil of radius 10 m is placed normally to the field and is connected to a resistor of resistance 3 Ω.



What is the magnitude and direction of the induced current in the coil?

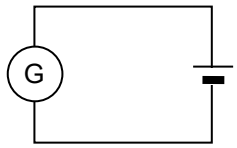
	Magnitude	**Direction**
A	0.26 A	clockwise
B	0.26 A	anti-clockwise
C	1.05 A	clockwise
D	1.05 A	anti-clockwise

30 A metal rod moves at a constant velocity towards the right in a uniform magnetic field pointing into the page as shown. The galvanometer connected to the rod shows a constant deflection.

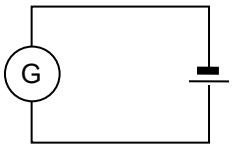


Which of the following is best to replace the rod and the magnetic field to produce the same deflection in the galvanometer?

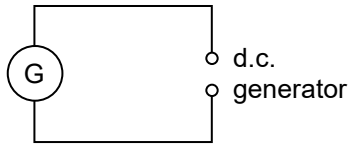
A



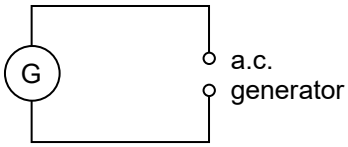
B



C



D



31 The primary coil of the transformer draws a current from a 220 V a.c. power supply. The turns ratio of the transformer is 3:1 and the ratio of the primary current to the secondary current is 2:1. What is the efficiency of the transformer?

A 16.7%

B 50%

C 66.7%

D 100%

32 In a factory, a bottle of fruit juice is found to be contaminated by radioactive substance. If 0.25 mg of radioactive substance is contained in the bottle of juice, what is the amount of radioactive substance remaining in the bottle of juice after 2 days? The half-life of the radioactive substance is 5.5 days.

A 0.019 mg

B 0.037 mg

C 0.056 mg

D 0.194 mg

33 In some older stars, the following reactions may take place to produce C-12.

$$^{4}_{2}\text{He} + ^{4}_{2}\text{He} \rightarrow ^{8}_{4}\text{Be}$$

$$^{8}_{4}\text{Be} + ^{4}_{2}\text{He} \rightarrow ^{12}_{6}\text{C}$$

Given: mass of He-4 nucleus = 4.001 506 u

mass of C-12 nucleus = 11.996 709 u

Estimate the total energy release in the above nuclear reactions.

Given: 1 u = 1.661×10^{-27} kg = 931 MeV

A 1.14 MeV

B 4.21 MeV

C 7.27 MeV

D 10.33 MeV

End of Section A

List of data, formulae and relationships

Data

molar gas constant	$R = 8.31\ \text{J mol}^{-1}\ \text{K}^{-1}$
Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
acceleration due to gravity	$g = 9.81\ \text{m s}^{-2}$ (close to the Earth)
universal gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$
speed of light in vacuum	$c = 3.00 \times 10^8\ \text{m s}^{-1}$
charge of electron	$e = 1.60 \times 10^{-19}\ \text{C}$
electron rest mass	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2\ \text{N}^{-1}\ \text{m}^{-2}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
atomic mass unit	$\text{u} = 1.661 \times 10^{-27}\ \text{kg}$ (1 u is equivalent to 931 MeV)
astronomical unit	$\text{AU} = 1.50 \times 10^{11}\ \text{m}$
light year	$\text{ly} = 9.46 \times 10^{15}\ \text{m}$
parsec	$\text{pc} = 3.09 \times 10^{16}\ \text{m} = 3.26\ \text{ly} = 206265\ \text{AU}$
Stefan constant	$\sigma = 5.67 \times 10^{-8}\ \text{W m}^{-2}\ \text{K}^{-4}$
Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$

Rectilinear motion

For uniformly accelerated motion :

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Mathematics

Equation of a straight line	$y = mx + c$
Arc length	$= r\theta$
Surface area of cylinder	$= 2\pi rh + 2\pi r^2$
Volume of cylinder	$= \pi r^2 h$
Surface area of sphere	$= 4\pi r^2$
Volume of sphere	$= \frac{4}{3}\pi r^3$

For small angles, $\sin\theta \approx \tan\theta \approx \theta$ (in radians)

Astronomy and Space Science

$U = -\frac{GMm}{r}$	gravitational potential energy
$P = \sigma A T^4$	Stefan's law
$\left\|\frac{\Delta f}{f_0}\right\| \approx \frac{v}{c} \approx \left\|\frac{\Delta\lambda}{\lambda_0}\right\|$	Doppler effect

Energy and Use of Energy

$\frac{Q}{t} = k\frac{A(T_H - T_C)}{d}$	rate of energy transfer by conduction
$U = \frac{k}{d}$	thermal transmittance U-value
$P = \frac{1}{2}\rho A v^3$	maximum power by wind turbine

Atomic World

$\frac{1}{2}m_e v_{max}{}^2 = hf - \phi$	Einstein's photoelectric equation
$E_n = -\frac{1}{n^2}\left\{\frac{m_e e^4}{8h^2\varepsilon_0^2}\right\} = -\frac{13.6}{n^2}\ \text{eV}$	energy level equation for hydrogen atom
$\lambda = \frac{h}{p} = \frac{h}{mv}$	de Broglie formula
$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)

Medical Physics

$\theta \approx \frac{1.22\lambda}{d}$	Rayleigh criterion (resolving power)
$\text{power} = \frac{1}{f}$	power of a lens
$L = 10\log\frac{I}{I_0}$	intensity level (dB)
$Z = \rho c$	acoustic impedance
$\alpha = \frac{I_r}{I_0} = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}$	intensity reflection coefficient
$I = I_0 e^{-\mu x}$	transmitted intensity through a medium

A1.	$E = mc\,\Delta T$	energy transfer during heating and cooling
A2.	$E = l\,\Delta m$	energy transfer during change of state
A3.	$pV = nRT$	equation of state for an ideal gas
A4.	$pV = \frac{1}{3}Nm\overline{c^2}$	kinetic theory equation
A5.	$E_K = \frac{3RT}{2N_A}$	molecular kinetic energy

B1.	$F = m\frac{\Delta v}{\Delta t} = \frac{\Delta p}{\Delta t}$	Force
B2.	moment $= F \times d$	moment of a force
B3.	$E_P = mgh$	gravitational potential energy
B4.	$E_K = \frac{1}{2}mv^2$	kinetic energy
B5.	$P = Fv = \frac{W}{t}$	mechanical power
B6.	$a = \frac{v^2}{r} = \omega^2 r$	centripetal acceleration
B7.	$F = \frac{Gm_1m_2}{r^2}$	Newton's law of gravitation

C1.	$\Delta y = \frac{\lambda D}{a}$	fringe width in double-slit interference
C2.	$d\sin\theta = n\lambda$	diffraction grating equation
C3.	$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$	equation for a single lens

D1.	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$	Coulomb's law
D2.	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	electric field strength due to a point charge
D3.	$V = \frac{Q}{4\pi\varepsilon_0 r}$	electric potential due to a point charge
D4.	$E = \frac{V}{d}$	electric field between parallel plates (numerically)
D5.	$I = nAvQ$	general current flow equation
D6.	$R = \frac{\rho l}{A}$	resistance and resistivity
D7.	$R = R_1 + R_2$	resistors in series
D8.	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$	resistors in parallel
D9.	$P = IV = I^2R$	power in a circuit
D10.	$F = BQv\sin\theta$	force on a moving charge in a magnetic field
D11.	$F = BIl\sin\theta$	force on a current-carrying conductor in a magnetic field
D12.	$V = \frac{BI}{nQt}$	Hall voltage
D13.	$B = \frac{\mu_0 I}{2\pi r}$	magnetic field due to a long straight wire
D14.	$B = \frac{\mu_0 NI}{l}$	magnetic field inside a long solenoid
D15.	$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$	induced e.m.f.
D16.	$\frac{V_s}{V_p} \approx \frac{N_s}{N_p}$	ratio of secondary voltage to primary voltage in a transformer

E1.	$N = N_0e^{-kt}$	law of radioactive decay
E2.	$t_{\frac{1}{2}} = \frac{\ln 2}{k}$	half-life and decay constant
E3.	$A = kN$	activity and the number of undecayed nuclei
E4.	$E = mc^2$	mass-energy relationship