H

NANYANG JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME	SOLUTION		
CLASS		TUTOR'S NAME	
CENTRE NUMBER	S	INDEX NUMBER	

PHYSICS 9749/01

Paper 1 Multiple Choice **17 September 2024**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, class, Centre number and index number in the spaces at the top of this page.

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 **15** printed pages.

Data

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

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	$p = \rho g h$
gravitational potential	$\phi = -Gm / r$
temperature	$T / \mathrm{K} = T / {}^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal 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	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 n I$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer all questions.

1 The base units of the SI system include those of The base units of the SI system include those of

mass, kg; length, m; time, s; electric current, A.

Which base units would be needed to express the SI unit of potential difference (the volt)?

A m and A only.

B s and A only.

C m, s and A only.

D kg, m, s and A.

Ans: **D**

$$\left[V = \frac{W}{Q} = \frac{Fs}{It} = \frac{mas}{It}\right]$$

$$= \frac{\text{kg ms}^{-2}\text{ m}}{\text{A s}}$$

2 A car travelling at a speed of 15.0 m s^{-1} can be brought to rest in 1.20 s when a uniform braking force is applied. The reaction time of the driver is 0.100 s.

What is the minimum distance at which the driver must notice a stationary object in order to avoid hitting it?

A 1.50 m **B** 7.50 m **C** 9.00 m **D** 10.5 m

Ans: **D**

$$v = u + at \Rightarrow 0 = 15.0 + a(1.20) \Rightarrow a = -\frac{15.0}{1.20}\text{ m s}^{-2}$$

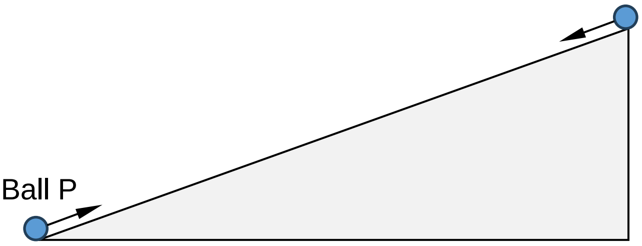
$$v^2 = u^2 + 2as \Rightarrow 0 = 15.0^2 + 2\left(-\frac{15.0}{1.20}\right)s \Rightarrow s = 9.00\text{ m}$$

Thinking distance = 15.0 m $s^{-1} \times$ 0.100 s = 1.50 m

Minimum distance = 1.50 + 9.00 = 10.5 m

3 Ball P is projected upwards from the bottom of a smooth inclined plane with an initial speed that is just sufficient for it to reach the top of the plane.

At the same time that Ball P is projected, Ball Q is projected downwards from the top of the plane with the same initial speed as Ball P.



What is the ratio of the distance travelled by Ball 2 to the distance travelled by Ball 1 when they collide?

A 0.78 **B** 1.0 **C** 1.3 **D** 3.0

Ans: **C**

From $s_1 = ut - \frac{1}{2}at^2$ and $s_2 = ut + \frac{1}{2}at^2$, where $a = g \sin \theta$

$\Rightarrow s_1 + s_2 = 2ut$ (1)

From $v^2 = u^2 - 2as$,

$\Rightarrow s_1 + s_2 = \frac{u^2}{2a}$ (2)

From (1) & (2),

$\Rightarrow 2ut = \frac{u^2}{2a}$

$\Rightarrow t = \frac{u}{4a}$

$$\frac{s_2}{s_1} = \frac{ut + \frac{1}{2}at^2}{ut - \frac{1}{2}at^2} = \frac{u + \frac{1}{2}a\left(\frac{u}{4a}\right)}{u - \frac{1}{2}a\left(\frac{u}{4a}\right)} = \frac{\frac{9}{8}}{\frac{7}{8}} = 1.3$$

4 The rate of change of momentum experienced by a free-falling ball when it hits the ground is equal to

A its weight.

B the net force acting on it.

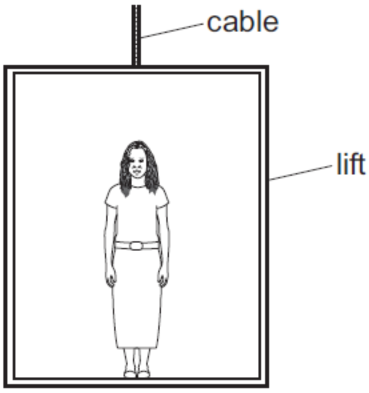
C the force exerted on it by the ground.

D the impuse on the ball due to the ground.

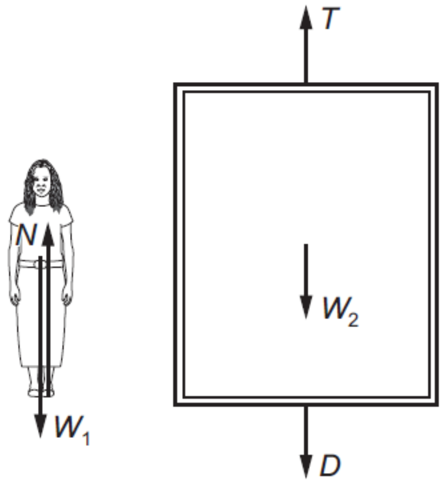
Ans: **B**

By Newton's second law.

5 The diagram shows a woman standing in a 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.

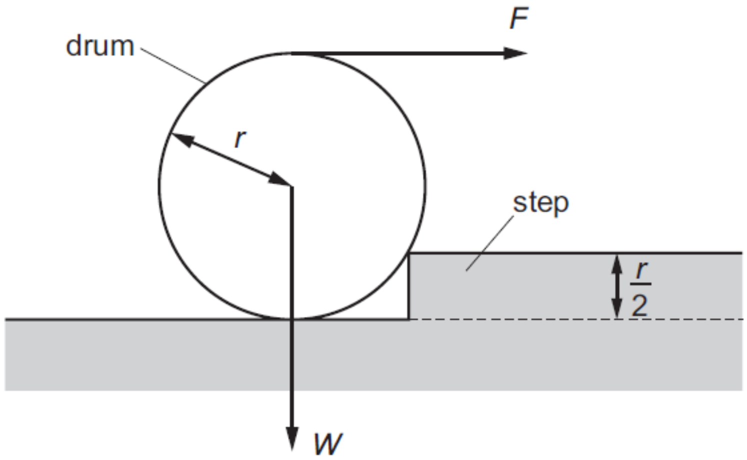
B $(W_1 + W_2)$ is always equal to T.

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

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

Ans: **D**

6 A cylindrical drum has radius r and weight W. The drum is to be rolled over onto a step of height $\frac{r}{2}$ by a horizontal force F applied to the top of the drum.



What is the minimum force F required for the drum to start rolling on the step?

A $\frac{W}{2}$ **B** $\frac{W}{\sqrt{3}}$ **C** W **D** $\frac{\sqrt{3}}{2}W$

Ans: **B**

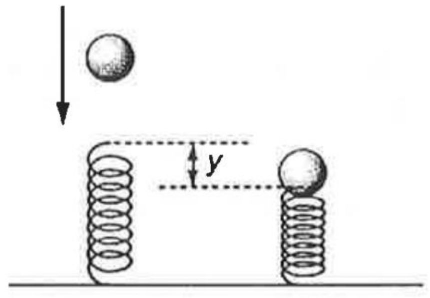
Taking moments about the step,

$$W\left(\frac{\sqrt{3}}{2}r\right)=F\left(2r-\frac{r}{2}\right)$$

$$F=\frac{W\left(\frac{\sqrt{3}}{2}r\right)}{\frac{3r}{2}}$$

$$=\frac{W}{\sqrt{3}}$$

7 A ball of mass m falls freely from rest as shown below. When it has reached a speed v, it just strikes a vertical spring.
The spring is then compressed by a distance y before the ball moves upwards again.



Assumes that all the energy the ball loses becomes elastic potential energy in the spring.

What is the average force exerted by the spring during its compression.

A $\dfrac{mv^2}{2y}$ **B** $\dfrac{m}{2y}(v^2 - 2gy)$ **C** $\dfrac{mv^2}{y}$ **D** $\dfrac{m}{2y}(v^2 + 2gy)$

Ans: **D**

$$\frac{1}{2}Fy = \frac{1}{2}mv^2 + mgy$$

$$F_{ave} = \frac{1}{2}F = \frac{\frac{1}{2}mv^2 + mgy}{y}$$

8 The driver of a 1000 kg car tries to turn through a circle of radius 100 m on an unbanked curve at a speed of 10 m s^{-1}. The maximum frictional force between the tyres and the slippery road is 900 N. The car will

A Slide into the inside of the curve.

B Make the turn.

C Slow down due to the centrifugal force.

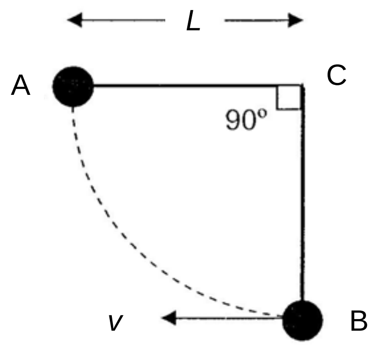
D Slide off to the outside of the curve.

Ans: **D**

Centripetal force required, $F_c = mv^2/r = 1000\times(10^2)/100 = 1000$ N

The maximum frictional force between the tyres and the slippery road is 900 N, which is insufficient to allow the car to turn around. Hence, the car will slide off to the outside of the curve.

9 A simple pendulum consists of a bob of mass m at the end of a light and inextensible thread of length L. The other end of the thread is fixed at C. The bob swings through point B with velocity v and just reaches A, where the string is just taut.



What is the tension in the thread as the bob passes point B?

A mg **B** $2mg$ **C** $3\ mg$ **D** $4\ mg$

Ans: **C**

$$gain\ in\ GPE = loss\ in\ KE$$

$$mgL = \frac{1}{2}m\left(v^2 - v_A{}^2\right) \quad [v_A = 0]$$

$$mgL = \frac{1}{2}mv^2$$

$$mv^2 = 2mgL$$

$$T - mg = \frac{mv^2}{L} = \frac{2mgL}{L}$$

$$T = 3\text{mg}$$

10 An object X has weight W on the surface of the Earth. How much energy is needed to raise X to height of $2R$ above the surface of the Earth, where R is the radius of the Earth?

A $\frac{1}{3}WR$ **B** $\frac{2}{3}WR$ **C** $\frac{3}{2}WR$ **D** $2WR$

Ans: B

$$W = \frac{GMm}{R^2}$$

$$\text{Increase in GPE} = -\frac{GMm}{3R} - \left(-\frac{GMm}{R}\right) = \frac{2GMm}{3R} = \frac{2}{3}WR$$

11 The density of air is 1.20 kg m^{-3} at a temperature of 20 °C and standard atmospheric pressure.

Assuming that the air behaves as an ideal gas, what is the density of air at a temperature of 27 °C and standard atmospheric pressure?

A 0.89 kg m^{-3} **B** 1.17 kg m^{-3} **C** 1.23 kg m^{-3} **D** 1.62 kg m^{-3}

Ans: **B**

$$\frac{V_1}{V_2}=\frac{T_1}{T_2} \text{ and } \frac{\rho_2}{\rho_1}=\frac{V_1}{V_2}$$

$$\therefore \frac{\rho_2}{\rho_1}=\frac{T_1}{T_2}$$

$$\frac{\rho_2}{1.20}=\frac{20+273.15}{27+273.15}$$

$$\rho_2=1.172 \text{ kg m}^{-3}$$

12 A metal block X of mass m, specific heat capacity c and temperature 80 °C is placed in good thermal contact with a second metal block Y of mass $2m$, specific heat capacity $2c$ and temperature 30 °C.

Assume no energy losses to the surroundings.

What will be the final temperature of both blocks?

A 30 °C **B** 40 °C **C** 55 °C **D** 70 °C

Ans: **B**

Heat lost by X = Heat gain by Y

$$mc(80-T)=2m(2c)(T-30)$$

$$80-T=4T-120$$

$$T=40\ ^{\circ}C$$

13 A particle of a mass of 90.0 g undergoes simple harmonic motion. The graph in Fig. 13 shows the variation of its kinetic energy, E_K with time, t.

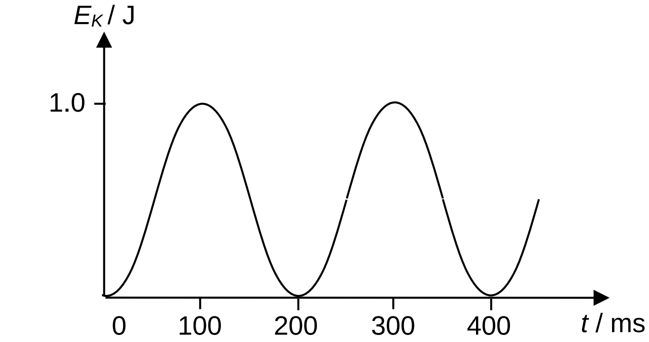


Fig. 13

What is the maximum acceleration of the particle?

A 0.074 m s^{-2} **B** 0.148 m s^{-2} **C** 37 m s^{-2} **D** 74 m s^{-2}

Ans: **D**

$T = 400ms$

max $ke = \frac{1}{2}m\omega^2 x_o^2 = 1$

$x_o = 0.3m$

$a_{max} = 74ms^{-2}$

14 A conical pendulum undergoes uniform circular motion in a horizontal plane. The radius of the circular path is 0.500 m and the time taken to complete one revolution is 2.16 s. A lamp shines on the pendulum bob as shown in Fig. 14.

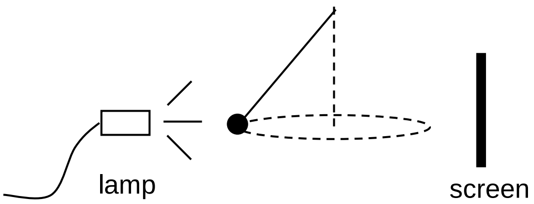


Fig. 14

The shadow of the bob on the screen was observed to move back and forth along a horizontal line with

A constant speed of 1.45 m s^{-1}.

B constant speed of 4.23 m s^{-1}.

C speed varying between 0 and 1.45 m s^{-1}.

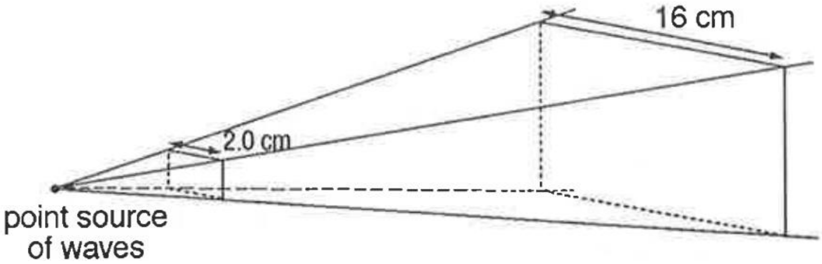
D speed varying between 0 and 4.23 m s^{-1}.

Ans: **C**

$$\text{max } speed = \omega x_0 = \frac{2\pi}{2.16} \times 0.5 = 1.45 ms^{-1}$$

Shadow is moving in SHM.

15 Waves from a point source pass through an area that is 2.0 cm wide as shown below.



Within this area, the intensity of the waves is I and their amplitude is A. The waves reach a second area of width 16 cm.

What will be the intensity and amplitude of the waves when they reach the second area?

	Intensity	amplitude
A	$\frac{I}{8}$	$\frac{A}{4}$
B	$\frac{I}{64}$	$\frac{A}{4}$
C	$\frac{I}{64}$	$\frac{A}{8}$
D	$\frac{I}{256}$	$\frac{A}{16}$

Ans: **C**

$$I \; \alpha \; \frac{A^2}{area}$$

$$I(2x2) = I_{new}(16x16)$$

$$I_{new} = \frac{I}{64}$$

$$\frac{I}{A^2} = \frac{I_{new}}{{A_{new}}^2}$$

$$A_{new} = \frac{A}{8}$$

16 Which of the following is a necessary condition for clear and stable interference patterns to be formed by waves from two sources?

A The sources of the waves are in phase.

B The sources produce waves that are of similar amplitudes.

C The sources produce waves that are propagating in the same direction.

D The sources produce waves that are polarised in the same plane.

Ans: B

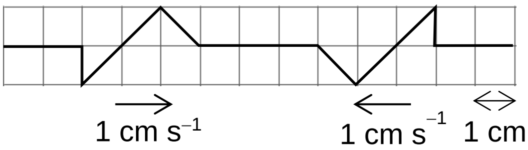
The sources need not be in phase, but their phase difference must be constant (coherence).

If the waves are of very different amplitudes, the contrast between the maxima and the minima will not be significant, which does not produce a clear interference pattern.

The paths of the waves must intersect, and not run parallel in the same direction.

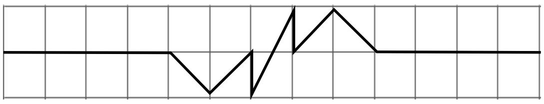
The waves must not be polarised in perpendicular planes, but they can be unpolarised.

17 Two waves approach each other with speed 1 cm s^{-1}, as shown in the figure below.

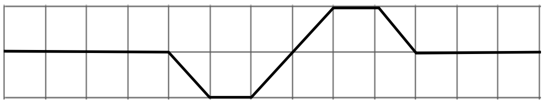


Which of the following gives the result of the superposition of the waves 4 s later?

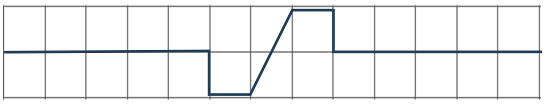
A



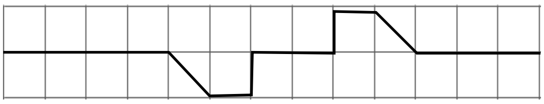
B



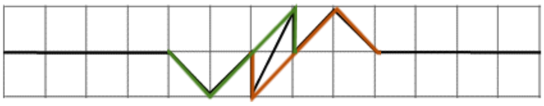
C



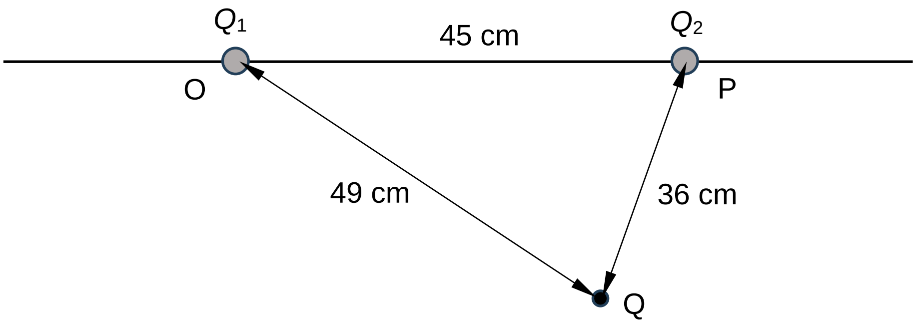
D



Ans: A



18 Two fixed point charges, each of magnitude Q_1 = – 7.4 nC and Q_2 = + 3.6 nC, are located at O and P respectively as shown. The distance OP is 45 cm.



The distances between O, P and Q are shown in the figrure.

What is the value of the potential at point Q?

A – 120 V **B** – 56 V **C** – 46 V **D** 220 V

Ans: **C**

$$V = V_1 + V_2 = \frac{Q_1}{4\pi\varepsilon_o r_1} + \frac{Q_2}{4\pi\varepsilon_o r_2} = \frac{1}{4\pi\varepsilon_o}\left(\frac{Q_1}{r_1} + \frac{Q_1}{r_1}\right) = -46 \text{ V}$$

19 Which one of the following statements about the electric potential and electric field at a point is correct?

A The potential at the point is always zero when the electric field at that point is zero.

B The potential at a point is zero when the electric field around the point is constant.

C The electric field at a point is zero when the potential around the point is constant.

D The electric potential is given by the rate of change of electric field strength with distance.

Ans: **C**

Electric field points from a region of higher potential to a region of lower potential. There is no electric field if there is no potential difference i.e. potential is constant.

$$E = -\frac{dV}{dr}$$

If E = 0, $\frac{dV}{dr} = 0$ i.e. potential does not change with distance and is hence constant.

20 A high electric potential is applied between two electrodes of a hydrogen discharge tube so that the gas is ionized. Electrons then move towards the positive electrode and protons towards the negative electrode. In each second, 5.0×10^{18} electrons and 2.0×10^{18} protons pass a cross-section of the tube. What is the current, in amperes, flowing in the discharge tube?

A 0.16 **B** 0.48 **C** 0.80 **D** 1.1

Ans: D

$I = I_e + I_p$

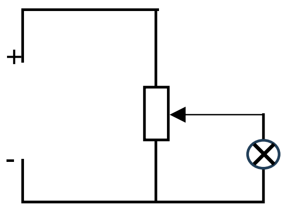
$= n_e(e) + n_p(p)$ charge on proton,p = charge on electron, e = 1.6×10^{-19} C

$= (5.0 \times 10^{18})(1.6 \times 10^{-19}) + (2.0 \times 10^{18})(1.6 \times 10^{-19})$

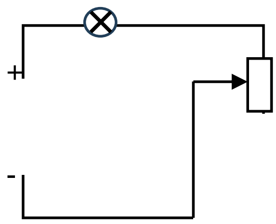
$= 1.1$ A

21 A lamp is connected to a power supply of negligible internal resistance. Which circuit could not be used as a practical means to vary the voltage across the lamp?

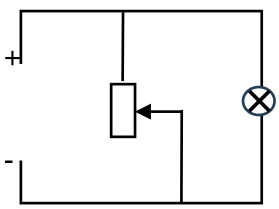
A



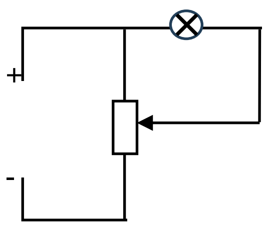
B



C



D

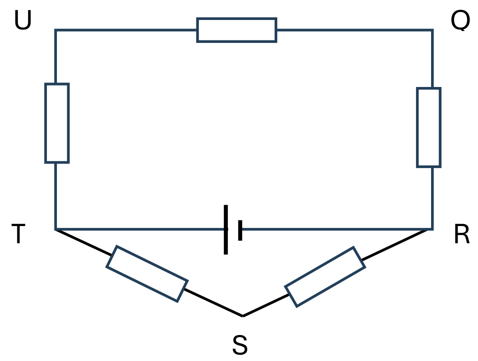


Ans: C

Options A, B & D allow adjusting the slider to vary the voltage across.

Option C connect directly between the terminals of the cell.

22 Five resistors, each of 50 Ω, are connected in a loop as shown below. A 10.0 V battery of zero internal resistance is connected across TR. What is the p.d. between U and R, V_{UR} ?



A 10.0 V **B** 8.7 V **C** 6.7 V **D** 3.7 V

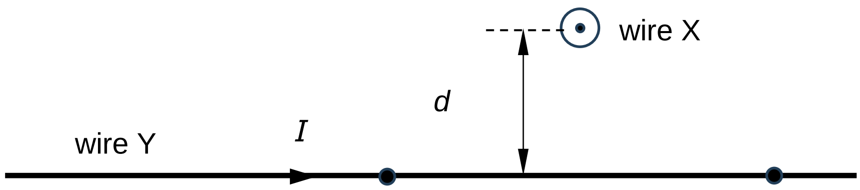
Ans: C

TSR is irrelevant to the calculation.

$$V_{QR} = \frac{R_{QR}}{R_{TU} + R_{QR}} \times 10 = \frac{50 + 50}{50 + 50 + 50} \times 10 = 6.67 \text{ V}$$

23 Two long straight wire X and Y are place perpendicular to each other at a distance *d* apart. A current flows out of the page in wire X. The same current flows from left to right in wire Y.

What are the directions of the forces acting on wire Y at the point P and Q due to the magnetic field produced by wire X?

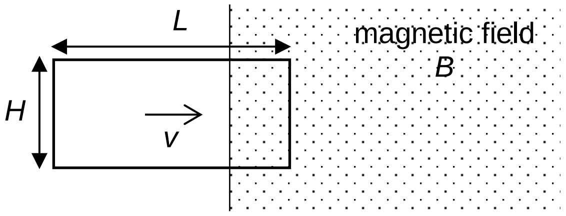


	force at P	force at Q
A	out of page	into page
B	into page	out of page
C	towards X	away from X
D	towards X	towards X

Ans: B

Using right-hand grip rule for the wire X, the B-field due to wire X is anti-clockwise on the plane of paper cutting through point P and Q, giving a vertical component downwards at point P, and vertical component pointing upwards at point Q.
Using Fleming's Left Hand rule at point P and Q, the direction of magnetic force can be obtained at points P and Q.

24 As a rectangular coil of dimensions L by H enters a magnetic field of flux density B at right angle with a constant speed v as shown in the figure below, an e.m.f. E is induced in the coil.



Which of the following will not increase the magnitude of E?

A Increase L

B Increase H

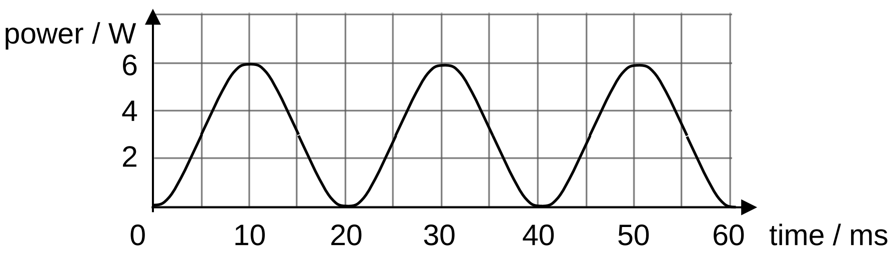
C Increase v

D Increase B

Ans: A

e.m.f. induced = rate of increase in flux linkage = $B\ H\ v$

25 The figure below shows the power supplied by a sinusoidal a.c. source to a load of resistance 1.5 Ω over 60 ms.



Which of the following is correct?

A The mean value of the power supplied is 4.2 W.

B The peak value of the current supplied is 2.0 A.

C The root mean square value of the voltage supplied is 4.5 V

D The frequency of the source is 50 Hz.

Ans: B

$\langle P \rangle = \frac{1}{2} \times P_0 = 3.0$ W

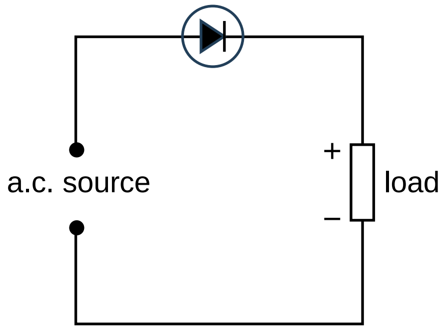
$P_0 = I_0^2 R \rightarrow I_0 = 2.0$ A

$\langle P \rangle = V_{rms}^2 / R \rightarrow V_{rms} = 3.0$ V

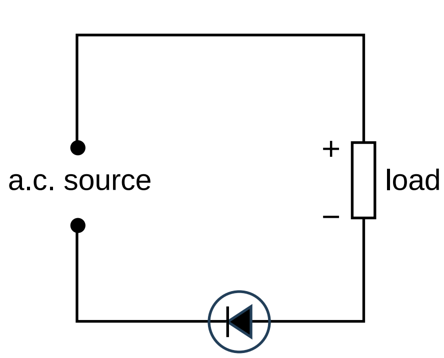
Period of power = ½ × Period of current → $f = 1/0.040 = 25$ Hz

26 An a.c. source can be rectified to supply a d.c. to a load using a semiconductor diode, which is assumed to ideal. Which of the following circuits will not correctly supply the required d.c. to the load?

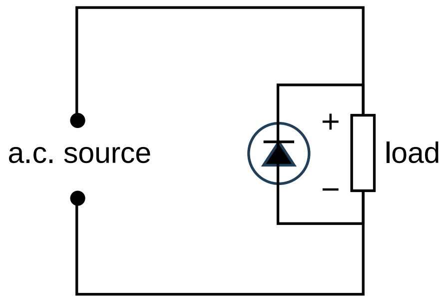
A



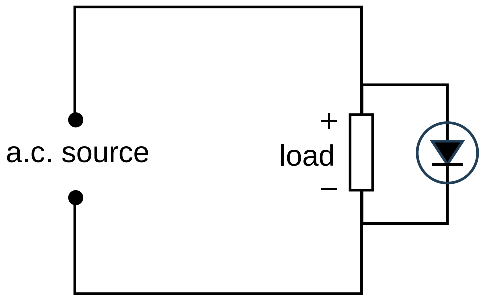
B



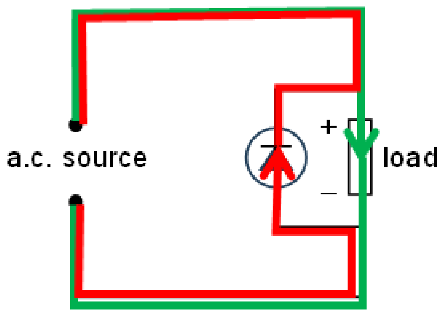
C

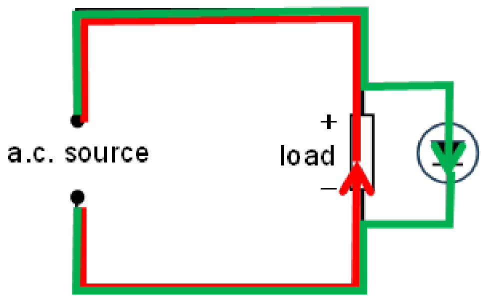


D



Ans: D

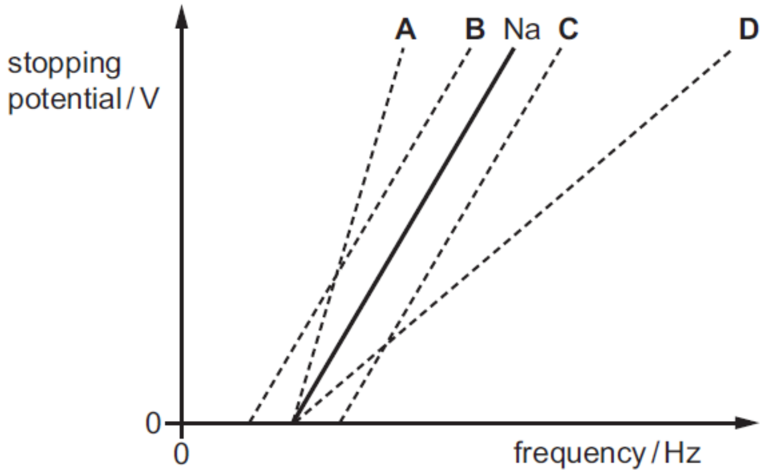




27 In a photoelectric cell experiment, sodium (Na) metal is exposed to electromagnetic radiation of different frequencies and the potential required to stop the photoelectrons is measured.

The graph uses a solid line, marked Na, to show the results of the experiment.

Which line represents the results for the photoelectric cell using a metal that has a larger work function than sodium?



Ans: C

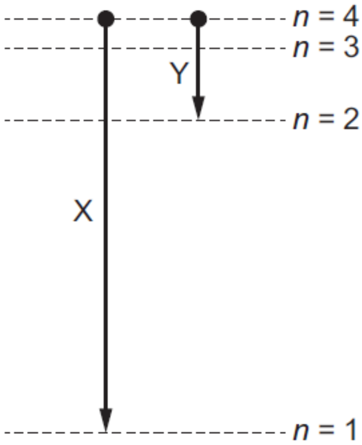
$hf = \Phi + eV$

$V = \left(\frac{h}{e}\right)f - \frac{\Phi}{e}$

$\Phi \uparrow$, $-\frac{\Phi}{e} \uparrow$, negative y-intercept $\uparrow$

28 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.



Which 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

Ans: A

$$\Delta E \propto \frac{1}{\lambda} \quad \text{and} \quad \Delta E \propto \left|\frac{1}{{n_f}^2} - \frac{1}{{n_i}^2}\right|$$

$$\frac{\lambda_X}{\lambda_Y} = \frac{\Delta E_Y}{\Delta E_X} = \frac{\left(\frac{1}{2^2} - \frac{1}{4^2}\right)}{\left(\frac{1}{1^2} - \frac{1}{4^2}\right)} = \frac{\left(\frac{3}{16}\right)}{\left(\frac{15}{16}\right)} = \frac{1}{5}$$

29 In a therapy unit, patients are given treatment from a certain radioactive source. This source has a half-life of 4 years. A particular treatment requires 10 minutes of irradiation when the souce is first used.

How much time is required for this treatment, using the same source, 2 years later?

A 7 minutes **B** 12 minutes **C** 14 minutes **D** 20 minutes

Ans: C

$A_{2years} = \frac{1}{2}^{0.5} A_0$

$A \ \alpha \ \frac{1}{t}$

$and \ thus \ t_{2years} = 14 \, mins$

30 The rest masses of three particles, tritium ${}^3_1H$, proton ${}^1_1p$, and neutron ${}^1_0n$, are 3.0160 u, 1.0086 u and 1.0097 u respectively. A tritium may disintegrate to its constituent protons and neutrons if it

A captures a photon of energy 10 MeV.

B captures a photon of energy 12 MeV.

C emits a photon of energy of 10 MeV.

D emits a photon of energy of 12 MeV.

Ans: B

Energy required = (3.016 -1.0086 - (2 $\times$ 1.0097))u

= 11.2 MeV

End of Paper