| Class | Index Number | Name |
|---|---|---|
| 22S | | |

**ST. ANDREW'S JUNIOR COLLEGE**
**JC 2 2023**
**Preliminary Examination**

**PHYSICS, Higher 2** **9749/01**

Paper 1 Multiple Choice **18th September 2023**
**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, index number and Civics Group the Answer Sheet in the spaces provided.

There are **thirty** questions in 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.

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.

| For Examiner's Use | |
|---|---|
| Total | / 30 |

This document consists of **15** printed pages including this page.

## Data

| | |
|---|---|
| speed of light in free space | $c = 3.00 \times 10^{8}$ m s$^{-1}$ |
| permeability of free space | $\mu_o = 4\pi \times 10^{-7}$ H m$^{-1}$ |
| permittivity of free space | $\varepsilon_o = 8.85 \times 10^{-12}$ 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 | $p = \rho g h$ |
| gravitational potential | $\phi = -\frac{Gm}{r}$ |
| temperature | $T/\text{K} = T/{}^{\circ}\text{C} + 273.15$ |
| 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. | $x = x_o \sin \omega t$ |
| velocity of particle in s.h.m. | $v = v_0 \cos \omega t$ |
| | $v = \pm\omega\sqrt{x_0^2 - x^2}$ |
| 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 | $x = x_o \sin \omega t$ |
| 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 | $x = x_o \exp(-\lambda t)$ |
| decay constant | $\lambda = \frac{\ln 2}{t_{1/2}}$ |

## Answer all questions.

**1** Planck's Law of black body radiation is given by

$$R = \frac{2h(D)^3}{c^2} \times \frac{1}{e^{\left(\frac{hf}{kT}\right)} - 1}$$

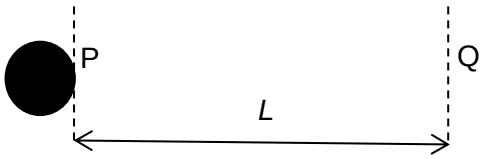
where $R$ is power per unit area per unit frequency,
$h$ is Planck's constant,
$c$ is the speed of light in a vacuum,
$f$ is frequency of electromagnetic radiation,
$k$ is Boltzmann's constant,
$T$ is the thermodynamic temperature,
and $D$ is an unknown physical quantity.

Which of the following shows the correct units for $D$?

**A** kg m $s^{-2}$ **B** $s^{-1}$ **C** kg $m^2$ $s^{-2}$ **D** $s^{-3}$

**2** The momentum $p$ of a rubber ball of mass $m$, as it rolls across a table surface at constant speed is given by the equation $p = \frac{mL}{t_2 - t_1}$, where

$t_1$ is the time at which the front end of the ball passes point P,
$t_2$ is the time at which the front end of the ball passes point Q.




Data from an experiment to determine $p$ is recorded as follows:
$m$ = (52.000 ± 0.001) g
$L$ = (10.0 ± 0.1) cm
$t_1$ = (0.00 ± 0.01) s
$t_2$ = (0.63 ± 0.01) s

The momentum of the rubber ball should be recorded as

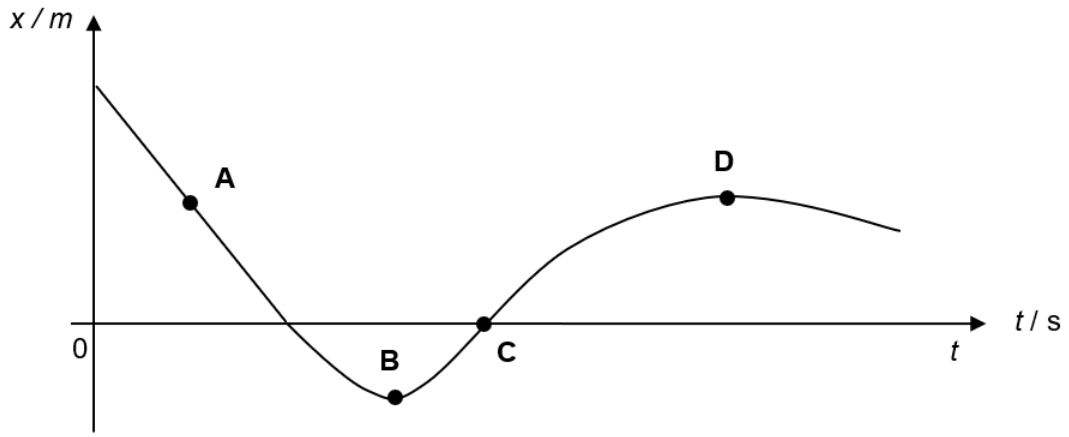
**A** (830 ± 20) g cm $s^{-1}$

**B** (830 ± 30) g cm $s^{-1}$

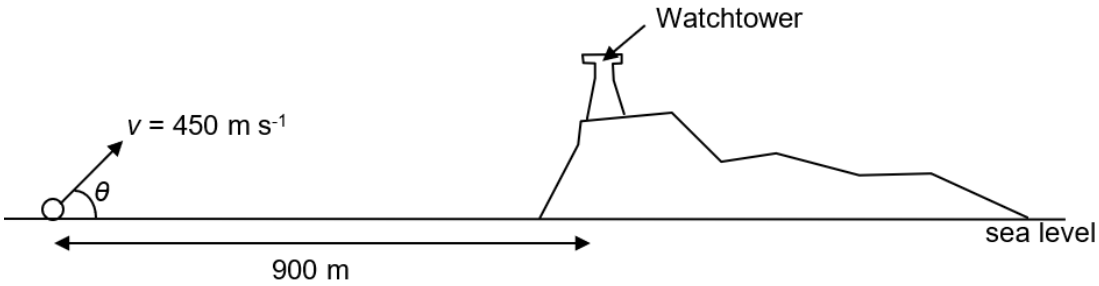
**C** (825 ± 28) g cm $s^{-1}$

**D** (825 ± 35) g cm $s^{-1}$

**3** A ball moves along a straight line. The variation of its displacement $x$ with time $t$ is given by the graph. At which point is the acceleration of the ball the greatest?



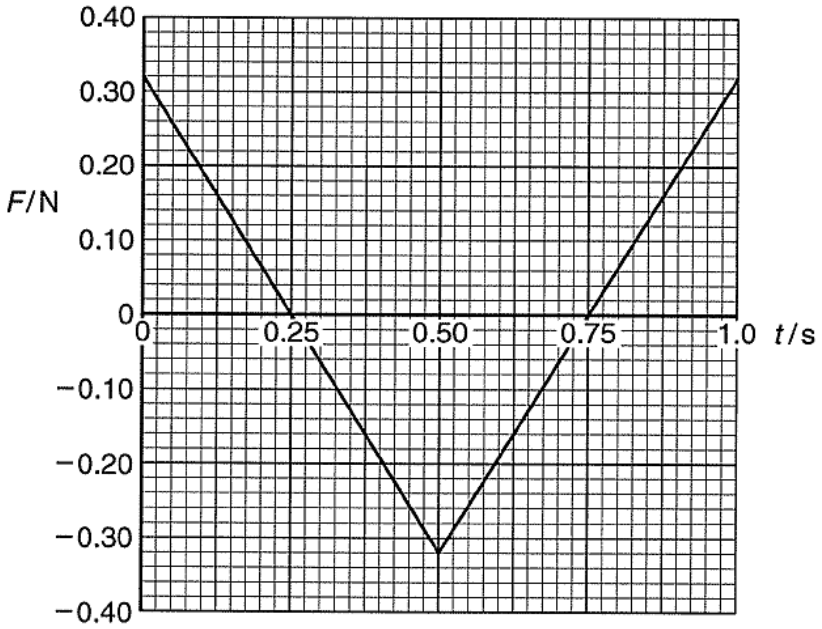

**4** A cannon ball is fired at a speed of 450 m $s^{-1}$ at sea level at an angle of $\theta = 31.6^{o}$ with respect to horizontal. The cannon ball hits the top of a watchtower located 900 m away.




How high is the top of the watchtower above sea level? Neglect air resistance.

**A** 526 m **B** 542 m **C** 580 m **D** 1390 m

**5** A resultant force $F$ acts on a mass $m$. The variation with time $t$ of $F$ is as shown.




Mass $m$ is 150 g. At time $t$ = 0, the mass is at rest.

Which of the following statements is ***incorrect***?

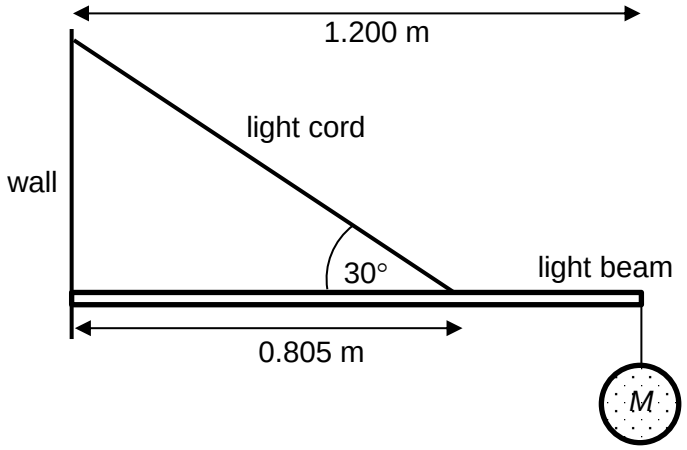
**A** The mass slowed down at a decreasing rate from $t$ = 0.25 s to $t$ = 0.50 s.

**B** The mass is momentarily at rest at $t$ = 0.50 s.

**C** The mass reversed direction at $t$ = 0.50 s and sped up at a decreasing acceleration from $t$ = 0.50 s to $t$ = 0.75 s.

**D** The magnitude of the change in velocity of the mass from $t$ = 0.25 s to $t$ = 0.75 s is 0.53 m $s^{-1}$.

**6** A 1.200 m light beam carries a mass *M* at one end. A light cord affixed to the wall is supporting the beam at 0.805 m from the wall as shown.




What is the maximum mass *M* that can be supported if the maximum allowed tension in the cord is 300 N?

**A** 10.3 kg **B** 17.8 kg **C** 20.5 kg **D** 101 kg

**7** A helium balloon of volume *V* carrying a light weather instrument rises into the atmosphere. The total mass of the balloon skin and the weather instrument is *M* kg. Given the gravitational field strength is *g*, the density of air is $\rho_{air}$, and the density of helium is $\rho_{He}$, the net force acting on the balloon is

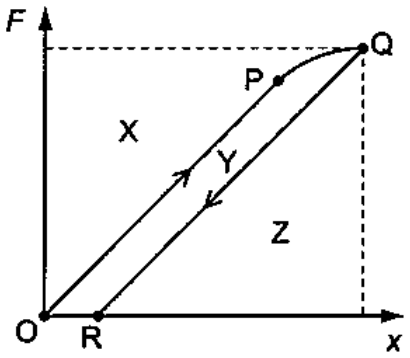
**A** $(\rho_{air} - \rho_{He})Vg$

**B** $(\rho_{air})Vg - Mg$

**C** $(\rho_{air} - \rho_{He})Vg - Mg$

**D** $(\rho_{He} - \rho_{air})Vg - Mg$

**8** A metal wire is stretched by a varying force *F*, causing its extension *x* to increase as shown by the line OPQ on the graph. The force is then gradually reduced to zero and the relation between force and extension is indicated by line QR.



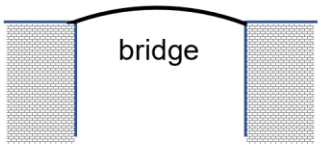

Which of the following correctly represents the work done by the force *F* in stretching the wire to Q and the corresponding elastic potential energy stored in the wire

| | **Work done by the force *F* in stretching the wire to Q** | **Elastic potential energy stored in the wire** |
|---|---|---|
| **A** | Y+X | X |
| **B** | Y | Z |
| **C** | Y+Z | Z |
| **D** | Y+Z | Y+Z |

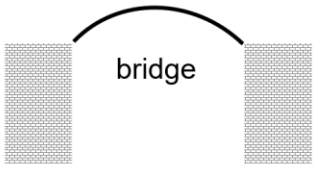
**9** A car moves with the same speed over each of the 4 bridges shown below.

In which option is the force which the car exerts on the midpoint of the bridge the smallest?

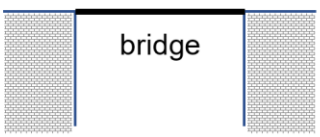
**A**



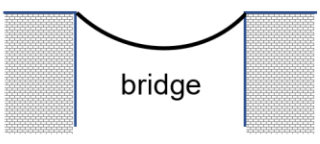

**B**




**C**




**D**



**10** An isolated spherical planet has mass $M$ and radius $R$. The acceleration of free fall on the surface of the planet is $g$.

What is the work done to move a small mass $m$ from the surface to a height $2R$ above the surface?

**A** 0.50 $mgR$ **B** 0.67 $mgR$ **C** $mgR$ **D** 2.0 $mgR$

**11** The temperature of 1 kg of Hydrogen gas is the same as that of 1 kg of Helium gas if

**A** the gases have the same internal energy
**B** the gas occupy equal volumes
**C** the gas molecules have the same root mean square speed
**D** the gas molecules have the same mean translational kinetic energy

**12** A 40 W filament lamp has been operating normally for some time so that its temperature is stable.

Which of the following shows the correct quantities with respect to the filament?

| | rate of heating the filament / W | rate of doing work on filament / W |
|---|---|---|
| **A** | - 40 | +40 |
| **B** | 0 | +40 |
| **C** | +40 | 0 |
| **D** | +40 | -40 |

**13** A small mass executes s.h.m. about a point O with amplitude $a$ and period $T$. Its displacement from O at time $T/8$ after passing through O is

**A** $\frac{a}{8}$ **B** $\frac{a}{2\sqrt{2}}$ **C** $\frac{a}{2}$ **D** $\frac{a}{\sqrt{2}}$

**14** Fig. 14.1 shows the variation with displacement $x$ of velocity $v$ of a simple harmonic oscillator. Fig. 14.2 shows the variation with time $t$ of the acceleration $a$ of the oscillator.

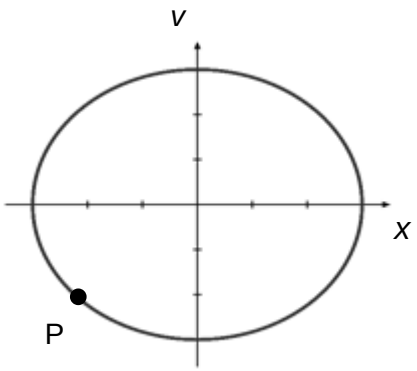



**Fig. 14.1**

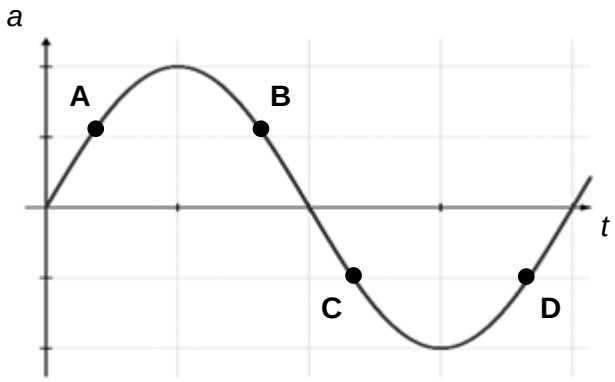
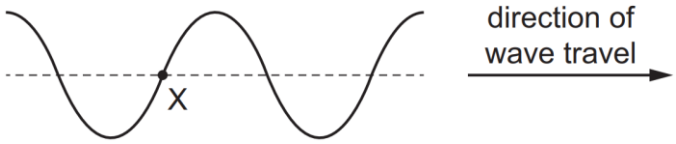



**Fig. 14.2**

Which of the points on Fig. 14.2 correspond to the state of motion represented by point P on Fig. 14.1?

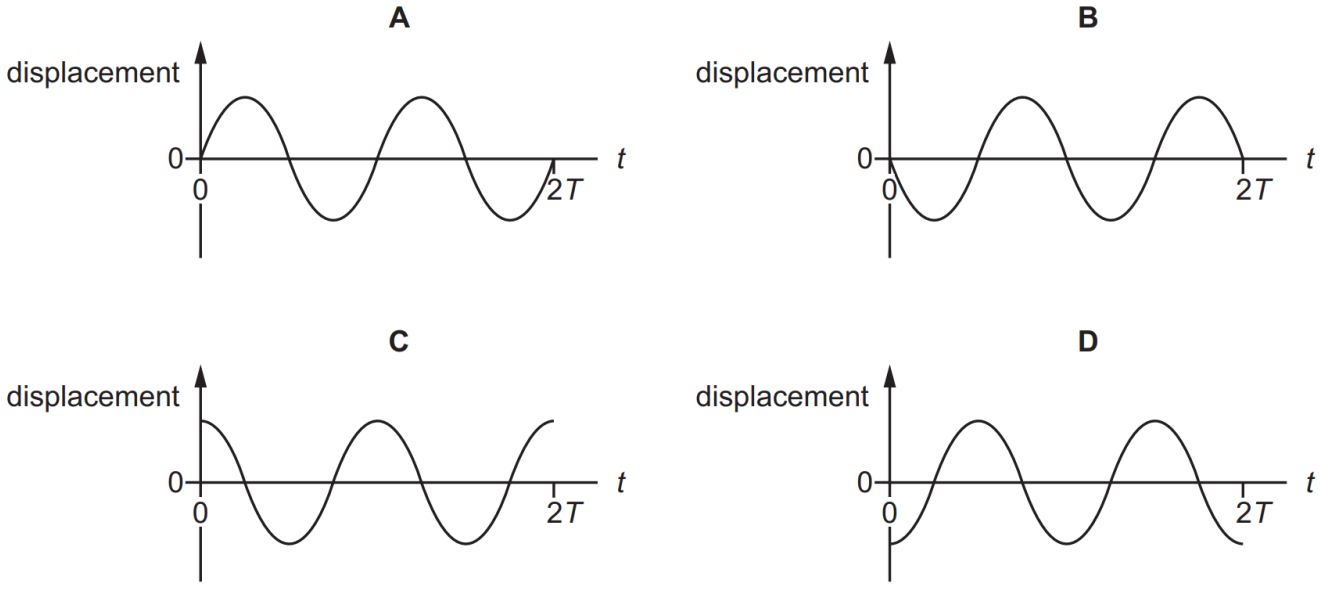
**15** A transverse wave travels along a rope. The diagram shows the rope at time $t = 0$.

The wave is travelling from left to right. The period of the wave is $T$.



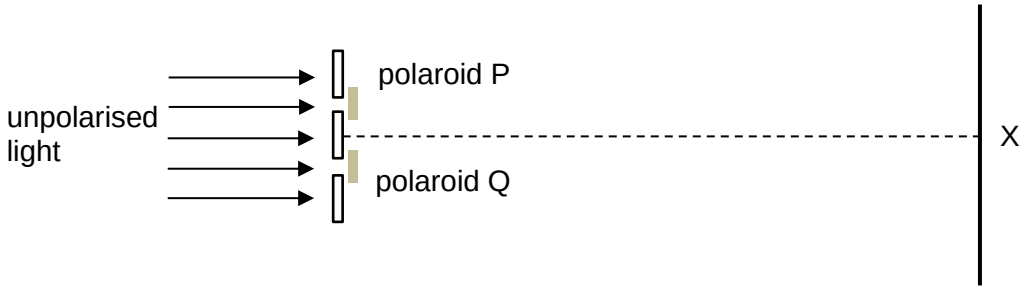

One particle of the rope is labelled X.

Which graph shows the variation with time of the displacement of particle X between $t = 0$ and $t = 2T$?



**16** Two sheets of polaroid P and Q are placed in front of a double slit such that their directions of polarization are parallel to each other.

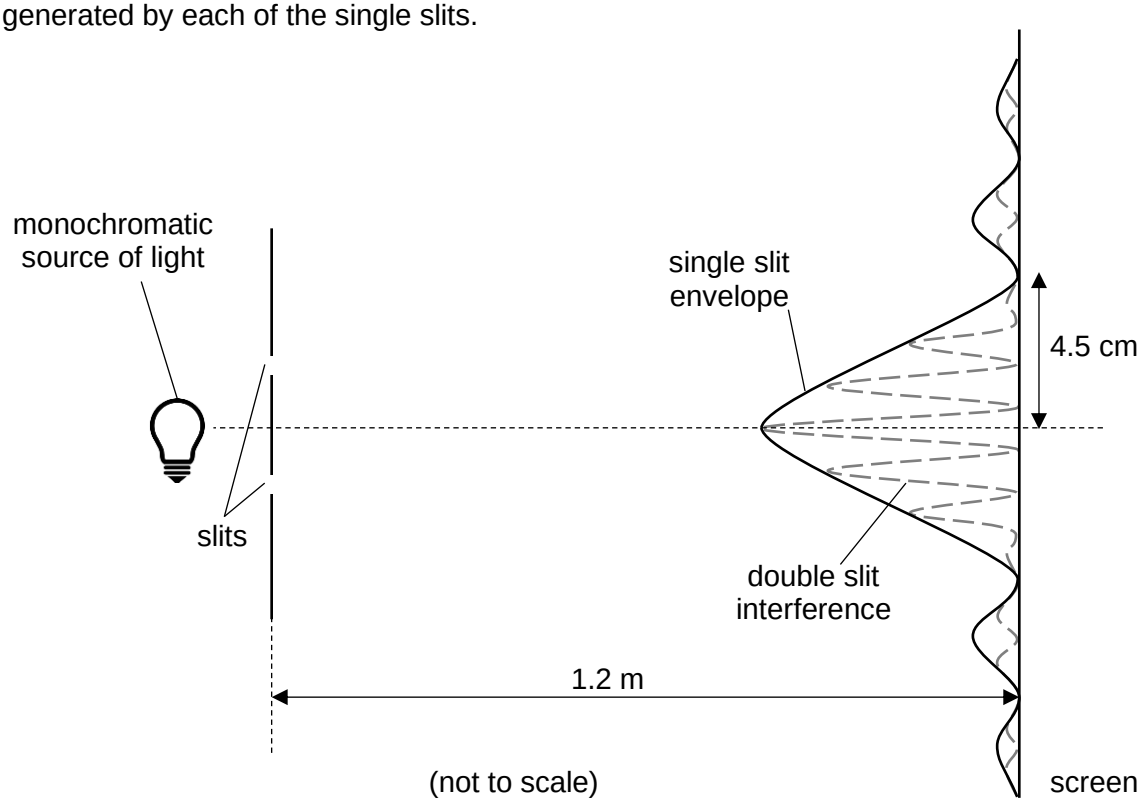
When unpolarised light is incident normally on the double slit, the central bright fringe at X has an amplitude 2*A*.




What is the amplitude at X when polaroid P is turned through an angle of 60°?

**A** 0.5*A* **B** 1.5*A* **C** 1.7*A* **D** 2*A*

**17** In reality, the resulting fringe pattern from a double slit experiment is enveloped by a pattern generated by each of the single slits.




What is the ratio of the slit width to the slit separation?

**A** 3.9 **B** 3.5 **C** 1.0 **D** 0.29

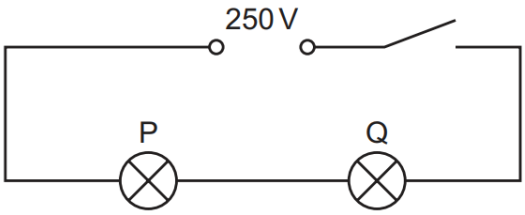
**18** Two wires, X and Y, are made of different materials, but have the same resistance.

X is twice as long as Y but has half the diameter of Y.

What is the ratio $\frac{\text{resistivity of material from which wire X is made}}{\text{resistivity of material from which wire Y is made}}$ ?

**A** $\frac{1}{8}$ **B** $\frac{1}{4}$ **C** 4 **D** 8

**19** In the circuit shown, lamp P is rated 250 V, 50 W and lamp Q is rated 250 V, 200 W. The two lamps are connected in series to a 250 V power supply.




Assume that the resistance of each lamp remains constant.

Which statement most accurately describes what happens when the switch is closed?

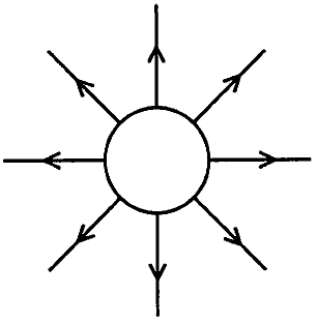
**A** Lamp P emits four times as much power as lamp Q.

**B** Lamp P emits twice as much power as lamp Q.

**C** Lamp Q emits four times as much power as lamp P.

**D** Lamp Q emits twice as much power as lamp P.

**20** A charged sphere has both a gravitational field and an electric field around it. The diagram represents the field around such a sphere.



Which field could this diagram represent?

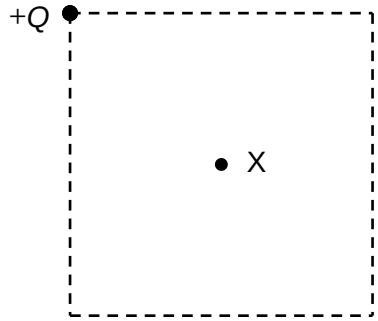
**A** both electric and gravitational

**B** electric but not gravitational

**C** gravitational but not electric

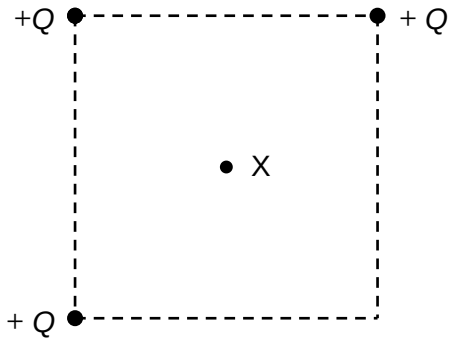
**D** neither electric nor gravitational

**21** A point charge +*Q* is placed at the top-left hand corner of a square as shown.




At the centre X of the square, the electric field strength is *E* and the electric potential is *V.*

Two additional point charges of the same magnitude +*Q* are placed at the top-right and bottom-left corners of the square as shown.

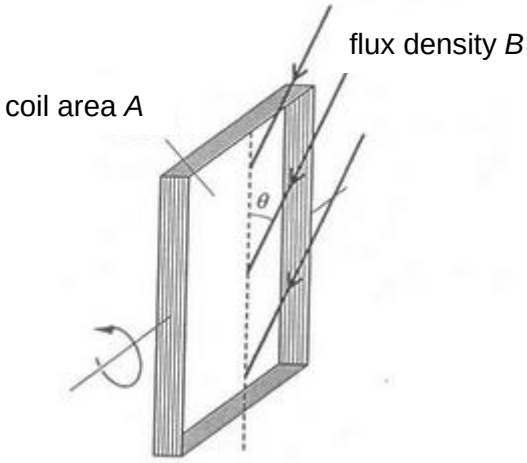



What are the electric field strength and the electric potential at the centre X of this second square?

| | electric field strength | electric potential |
|---|---|---|
| **A** | *E* | 1.5*V* |
| **B** | *E* | 3*V* |
| **C** | 2*E* | 3*V* |
| **D** | 3*E* | 3*V* |

**22** A coil has area $A$ and $N$ turns.

A uniform magnetic field of flux density $B$ acts at an angle $\theta$ to the plane of the coil, as shown in the figure below.




What is the change in magnetic flux linkage when the coil rotates to a horizontal position?

**A** $BAN\cos\theta$

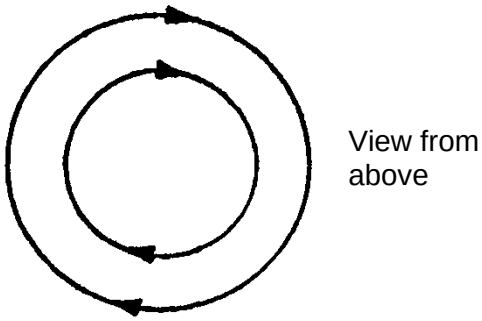
**B** $2BAN\cos\theta$

**C** $BAN(\cos\theta - \sin\theta)$

**D** $2BAN\sin\theta$

**23** A small flat circular coil lies inside a similar larger coil. Each coil carries a current as shown in the figure below.

What is experienced by the small coil due to these currents?



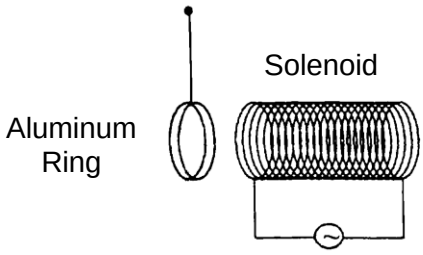

**A** a torque about a horizontal axis

**B** a torque about a vertical axis

**C** a vertical force along the axis

**D** no resultant force

**24** Which of the following statements best describes the motion of the suspended ring as shown below when a large alternating current is passed through the solenoid?




**A** The ring remains stationary

**B** The ring will be attracted towards the solenoid

**C** The ring is repelled from the solenoid

**D** The ring moves back and forth from the solenoid

**25** A transformer with turns ratio of primary to secondary coil of 20:1 is 95% efficient due to joule heating effects. A 240 V alternating voltage is connected to the primary coil and a 5.0 Ω resistor is connected to the secondary coil.

What is the current flowing in the primary coil?

**A** 0.120 A
**B** 0.126 A
**C** 2.40 A
**D** 48.0 A

**26** A sinusoidally-alternating voltage supply at 50 Hz connected across a load resistor of 200 Ω delivers a peak current of 2.0 A. The frequency of the supply is doubled to 100 Hz.

What is the mean power dissipated in the load resistor at the higher frequency?

**A** 200 W **B** 400 W **C** 800 W **D** 1600 W

**27** Which of the following statements explains the existence of energy levels within atoms?

**A** Atoms in a solid can diffract electrons in the same way as crystals diffract X-rays.

**B** Photoelectrons are only emitted from a metal surface for incident photos of wavelengths shorter than a critical wavelength.

**C** When viewed through a diffraction grating, line spectra can be observed from a sodium vapour lamp.

**D** There is a minimum cut-off wavelength in the production of X-ray.

**28** A microwave pulse lasts for $3.0 \times 10^{-9}$ s. A photon of the microwave may be considered to be anywhere within this pulse, although the exact location is not known.

What is the uncertainty in the momentum of the photon?

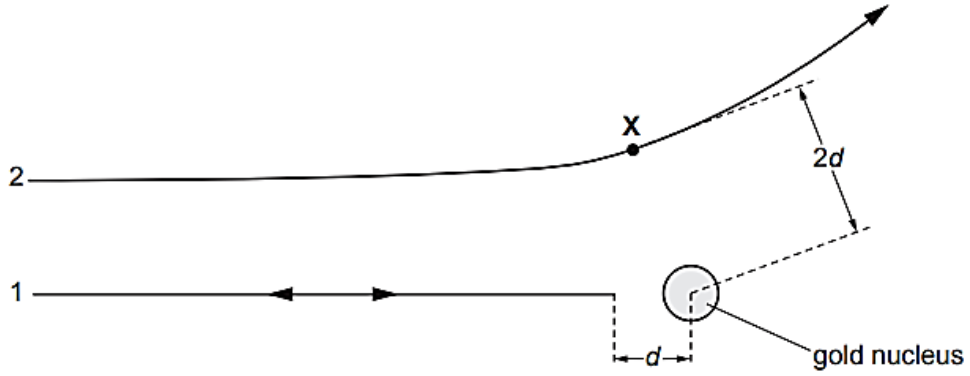
**A** $5.9 \times 10^{-35}$ kg m s$^{-1}$

**B** $1.2 \times 10^{-34}$ kg m s$^{-1}$

**C** $3.7 \times 10^{-34}$ kg m s$^{-1}$

**D** $7.4 \times 10^{-34}$ kg m s$^{-1}$

**29** The diagram shows the path of two alpha particles, each of initial kinetic energy 4.0 MeV, as they are scattered by a gold nucleus.




Alpha particle 1 approaches head-on towards the gold nucleus and is repelled back along its own path, with a closest distance of separation from the nucleus being *d*. Alpha particle 2 follows the path shown, with a closest distance of separation from the nucleus being 2*d* at the point X.

What is the kinetic energy of alpha particle 2 at the point X?

**A** 0.0 MeV **B** 1.0 MeV **C** 2.0 MeV **D** 4.0 MeV

**30** A radioactive source contains two species. One has a half-life of 4 days and decays by the emission of alpha particles while the other has a half-life of 3 days and emits beta particles. The initial count-rate is 352 min$^{-1}$, but when a sheet of paper is placed between the source and the detector this becomes 256 min$^{-1}$. The background count-rate is 16 min$^{-1}$.

What would be the count-rate without the paper present after 12 days?

**A** 27 min$^{-1}$ **B** 28 min$^{-1}$ **C** 43 min$^{-1}$ **D** 44 min$^{-1}$

**End of Paper**

# JC2 H2 Physics 2023 Preliminary Exam

## Paper 1 Solutions

| Qn | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ans | B | B | B | A | A | A | C | C | B | B |

| Qn | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ans | D | A | D | A | B | C | D | A | A | B |

| Qn | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ans | B | C | D | D | B | B | C | D | C | C |

**1 Ans: B**

The term $\frac{1}{e^{\left(\frac{hf}{kT}\right)}-1}$ is unitless.

Hence comparing units: $\left[\left(D^3\right)\right]=\frac{[R]\times[c^2]}{[h]}$ where [ ] represents "units of".

Since units of $R$ are J $s^{-1}$ $m^{-2}/s^{-1}$, units of $c^2$ are $m^2\,s^{-2}$ and units of $h$ are J s, units of $D^3$ are $s^{-3}$. Hence $D$ has unit $s^{-1}$.

**2 Ans: B**

$p = mL / (t_2 - t_1) = (52.000)(10.0) / (0.63 - 0.00) = 825.397$ g cm $s^{-1}$

$$\frac{\Delta p}{p}=\frac{\Delta m}{m}+\frac{\Delta L}{L}+\frac{\Delta(t_2-t_1)}{(t_2-t_1)}$$

$$=\frac{0.001}{52}+\frac{0.1}{10}+\frac{0.02}{0.63}$$

= 0.041765

$\Delta p$ = 34.5 g cm $s^{-1}$ = 30 g cm $s^{-1}$ (1 s.f.), {so since $\Delta p$ is now expressed in 'tens', $p$ must be expressed to nearest 'tens', or 830 }

$p$ = 830 ± 30 g cm $s^{-1}$

**3 Ans: B**

The acceleration is rate of change of velocity which is equal to the rate of change of the gradient.
The gradient changes more quickly at the turning point B than D.
Gradient around A is constant, implying constant velocity (zero acceleration) and the gradient change around C is much less than at the turning points.

**4 Ans: A**

$s_x = v_x t$

$900 = 450\cos(31.6^\circ)\ t$

t = 2.348 s

$s_y = u_y t + \frac{1}{2} a_y t^2$

$s_y = 450\sin(31.6^\circ)\ (2.348) + \frac{1}{2}(-9.81)(2.348)^2$

$s_y = 526$ m

**5 Ans: A**

The mass slowed down at an increasing rate from $t$ = 0.25 s to $t$ = 0.50 s

**6 Ans: A**

Clockwise moment by weight of M = anticlockwise moment by tension in string

Mg(1.200) = 300 sin30° (0.805)

M = 10.3 kg

**7 Ans: C**

Net force

= Upthrust by air – Weight of helium – Weight of balloon skin & instrument

= Weight of air displaced – $\rho_{He}Vg$ – $Mg$

= $\rho_{air}Vg$ – $\rho_{He}Vg$ – $Mg$

= $(\rho_{air} - \rho_{He})Vg$ – $Mg$

**8 Ans: C**

Option A: Student thought that force and extension were reversed.

Option B: Student confused the net work done with work done by the force $F$.

**Option C: Correct.**

Option D: Student thought that there is no deformation in the wire.

**9 Ans: B**

By drawing the free body diagram of the car for each bridge, realise that for convex bridges

Weight of car – Normal contact force on car by road = $mv^2/r$

Normal contact force on car by road = Weight of car – $mv^2/r$ (smaller than weight)

The convex bridge which has the shorter radius will exert the least normal contact force on the car.

By Newton's 3rd Law, force exerted by car has same magnitude as the normal contact force

**10 Ans: B**

$g = \frac{GM}{R^2}$

Work done = increase in GPE $= -\frac{GMm}{3R} - \frac{GMm}{R}$

$= \frac{2}{3}\frac{GMm}{R}$

$= \frac{2}{3}\frac{GMm}{R^2}R$

$= \frac{2}{3}mgR$

**11 Ans: D**

By definition, temperature is proportional to mean translational kinetic energy, which is also indicated in the list of formulae in page 3.

**12 Ans: A**

As the temperature is stable, the rate of increase in internal energy over the period is zero.

The filament, which would be hotter than the surroundings, would have lost heat, hence, the rate of heating of the filament would be negative.

By First Law of Thermodynamics, the rate of work done on the filament would be positive as work is done to drive unit charge through the filament.

Hence, A is the only possible answer.

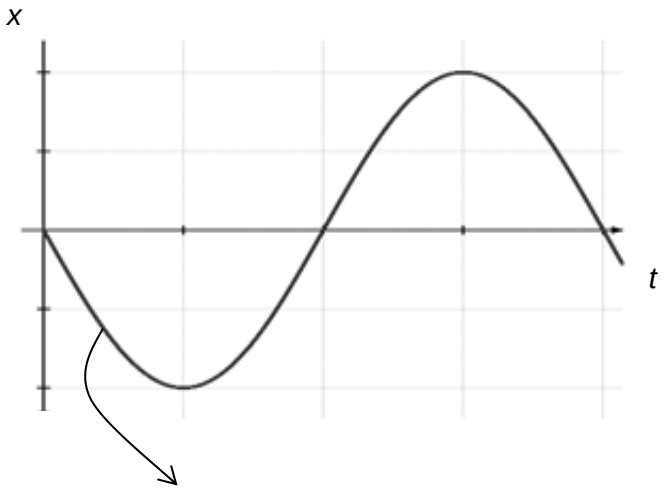
**13 Ans: D**

Using $x = x_0 \sin \omega t$, $x = a \sin (2\pi/T \times T/8)$

$$x = a \sin (\pi/4) = \frac{a}{\sqrt{2}}$$

**14 Ans: A**

Displacement-time is anti-phase with acceleration-time.

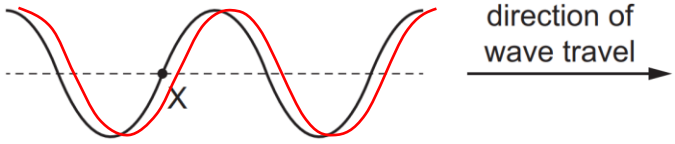



Point A has negative gradient → negative velocity

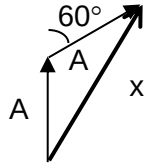
From Fig. 14.1, both v and x are negative.
Hence, point P from Fig 14.1 corresponds to A from Fig. 14.2

**15 Ans: B**

As wave travels to the right, in the next moment in time, particle X will move towards the negative displacement.

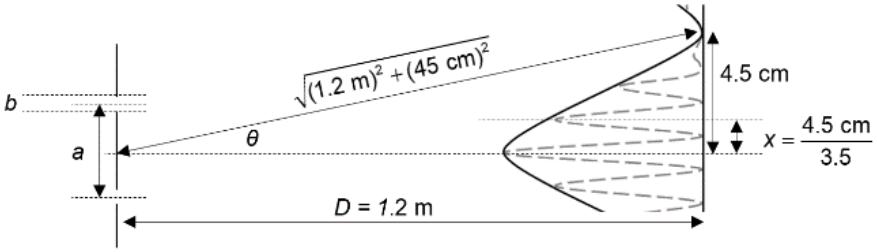


**16 Ans: C**




Resultant amplitude x = $\sqrt{(2A^2 - 2A^2\cos 120°)} = \sqrt{3}\,A$

**17 Ans: D**




$\sin\theta = \dfrac{\lambda}{b}$ and $\lambda = \dfrac{ax}{D}$

$\sin\theta = \dfrac{ax}{bD}$

$$\frac{b}{a} = \frac{x}{D\sin\theta} = \frac{4.5\times10^{-2} \div 3.5}{(1.2)\dfrac{4.5\times10^{-2}}{\sqrt{\left(4.5\times10^{-2}\right)^2 + 1.2^2}}} = 0.29$$

**18 Ans: A**

$L_x = 2L_Y$

$A_x = \pi r_x^2 = \pi(0.5r_y)^2 = 0.25\pi r_y^2 = 0.25\,A_y$

Since resistance are equal,

$$\frac{\dfrac{\rho_X L_X}{A_X}}{\dfrac{\rho_Y L_Y}{A_Y}} = 1$$

$$\frac{\dfrac{\rho_X (2L_Y)}{0.25\,A_Y}}{\dfrac{\rho_Y L_Y}{A_Y}} = 1$$

$$\frac{8\rho_X}{\rho_Y} = 1$$

$$\frac{\rho_X}{\rho_Y} = \frac{1}{8}$$

**19 Ans: A**

At same operating voltage, $P_Q = 4P_P$

$V^2 / R_Q = (4)(V^2 / R_P)$

$R_P = 4R_Q$

When placed in series, current through P and Q is the same.

Hence, $P_Q' = I^2R_Q$

$P_P' = I^2R_P = I^2(4R_Q)$

$P_P' = 4P_Q'$

**20 Ans: B**

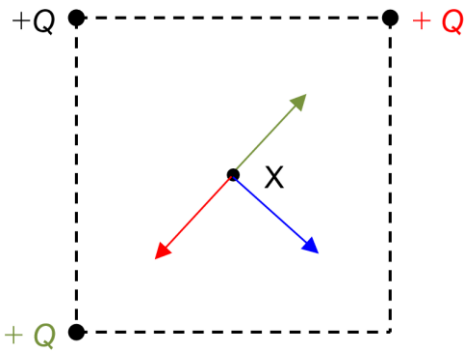
Electric force can be both attractive and repulsive while gravitational force can only be attractive. The diagram above shows a field that can provide a repulsive force on a positive test charge hence it can be an electric field.

For gravitational field, the field lines always point towards the source as that is the direction which the field causes a force on the mass, hence, it cannot be gravitational field.

**21 Ans: B**

Resultant potential is determined through the scalar sum and with point X acted upon by three similar charges of similar distance away, the potential is three times that of the potential due to one charge.

For electric field strength at point X, the field due to the charges on the top-right (red) and bottom-left (green) would cancel out, leaving the field due to the charge on the top-left (blue) unscathed, and hence, net magnitude is *E*.



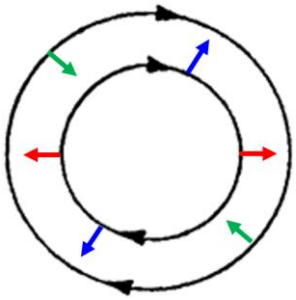

**22 Ans: C**

Flux linkage in the current position = NBAsinθ
(i.e. horizontal component of field lines so they are perpendicular to the area in its current position)

Flux linkage when the coil is horizontal = NBAcosθ
(i.e. vertical component of field lines vertical so they are perpendicular to the area when horizontal)

Hence, the change in magnetic flux linkages would be (NBAcosθ – NBAsinθ)

**23 Ans: D**



The forces set up on the ring would be equal and opposite at each and opposite point within each ring, thus, cancelling out (as shown by arrows of same colour in the diagram above). There would be no resultant force on either ring.

**24 Ans: D**

When current runs through the solenoid, magnetic poles are set up on the solenoid and by Lenz's Law, magnetic poles will also be set up on the Aluminum ring to oppose the poles due to solenoid.

When current in solenoid starts to decrease, by Lenz's Law, current in aluminium ring will change direction and results in attraction between ring and solenoid.

Hence, the forces acting on the ring will alternate periodically.

**25 Ans: B**

The output voltage is 240/20 = 12 V, and output current is 12/5. Output power is 12x12/5, which is 0.95 of the input power.

$\frac{12x12}{5}$ = 0.95x 240 $I$

$I$ = 0.126 A

**26 Ans: B**

Frequency plays no part in affecting the mean power.

$P_{ave} = I_{rms}^2 R = (\frac{2}{\sqrt{2}})^2(200) = 400$ W

**27 Ans: C**

When electrons in the sodium vapour atoms transit from higher energy level to lower energy level, photon are emitted. As the photons pass through the diffraction grating, line spectra can be observed. Hence line spectra is evidence for existence of energy levels with atoms

**28 Ans: D**

Uncertainty in the position of the photon:

$\Delta x = c \times t = (3.00 \times 10^8)(3.0 \times 10^9) = 0.90$ m

$\Delta x \Delta p \geq h$

$\Delta p = \frac{h}{0.90} = 7.4 \times 10^{-34}$ kg m s$^{-1}$

**29 Ans: C**

This is actually an E-field question. PE is assumed to be zero initially.

| | | |
|---|---|---|
| For Particle 1, | Initial $KE_1$ + Initial PE | = Final KE + Final PE |
| | 4.0 MeV + 0 | = 0 + $Qq$ / $4\pi\varepsilon_0 d$ |
| For Particle 2, | Initial $KE_2$ + Initial PE | = Final KE + Final PE |
| | Initial $KE_2$ + 0 | = 0 + $Qq$ / $4\pi\varepsilon_0(2d)$ |
| | Initial $KE_2$ | = 4.0 / 2 = 2.0 MeV |

**30 Ans: C**

Excluding the background count-rate of 16 $min^{-1}$, the initial total count-rate of the $\alpha$-particles and β-particles is 336 $min^{-1}$ (= 352 – 16).

The sheet of paper prevents the $\alpha$-particles from reaching the detector. Hence the initial count rate due to the $\alpha$-particles is 96 $min^{-1}$ (= 352 – 256). The initial count rate due to the β-particles is 240 $min^{-1}$ (= 336 – 96).

At $t$ = 12 days,

count-rate of $\alpha$-particles = $\left(\frac{1}{2}\right)^{\frac{12}{4}}(96)$

count-rate of β-particles = $\left(\frac{1}{2}\right)^{\frac{12}{3}}(240)$

total count-rate (including background) = $\left(\frac{1}{2}\right)^{\frac{12}{4}}(96) + \left(\frac{1}{2}\right)^{\frac{12}{3}}(240) + 16 = 43$ $min^{-1}$