BP~455

EUNOIA JUNIOR COLLEGE
JC2 PRELIM EXAMINATIONS 2024
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME							
CIVICS GROUP	2	3	-			REGISTRATION NUMBER	

PHYSICS

Multiple Choice

9749/01

September 2024

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
The use of an approved scientific calculator is expected where appropriate.
Answer **all** questions.

There are **thirty** questions in this section.
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.

This document consists of **20** printed pages.

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}

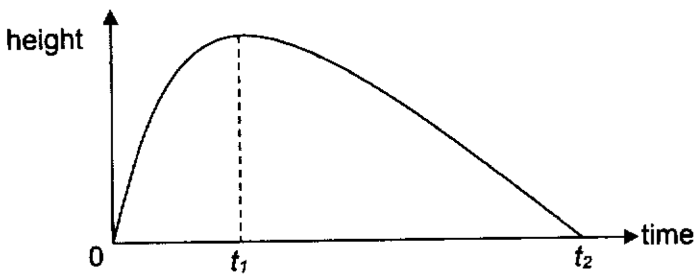
Formulae

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,	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
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.	$x = x_0 \sin \omega t$
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,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
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 A radio aerial of length L, carrying a current I, emits a signal of wavelength λ and power P. These quantities are related by $P = kI^2\left(\frac{L}{\lambda}\right)^2$ where k is a constant. What unit, if any, should be used for the constant k?

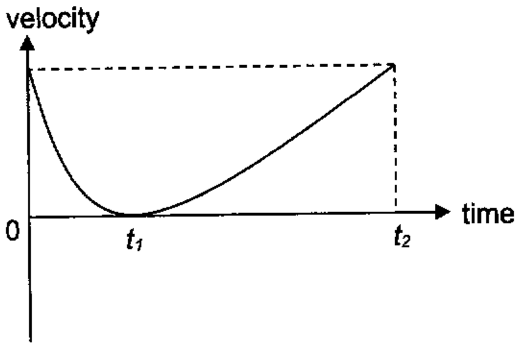
A ohm **B** watt **C** volt **D** no unit

2 A ball is thrown vertically upwards and returns along the same path. The graph shows how its height from the ground varies with time.

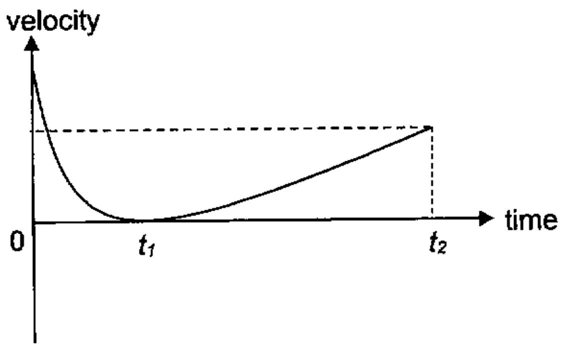


Which velocity-time graph best describes this motion?

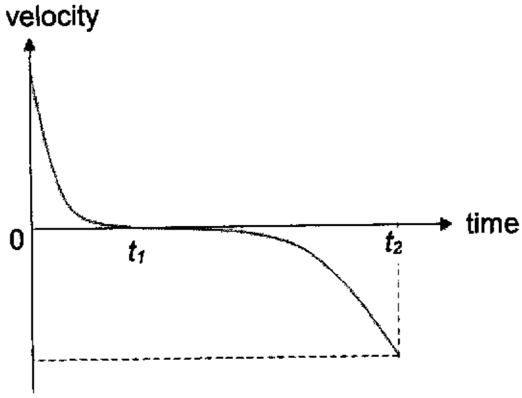
A



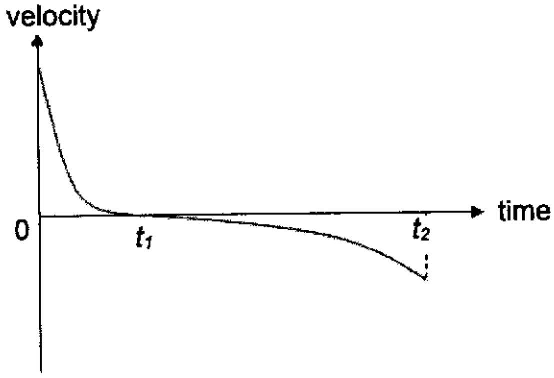
B



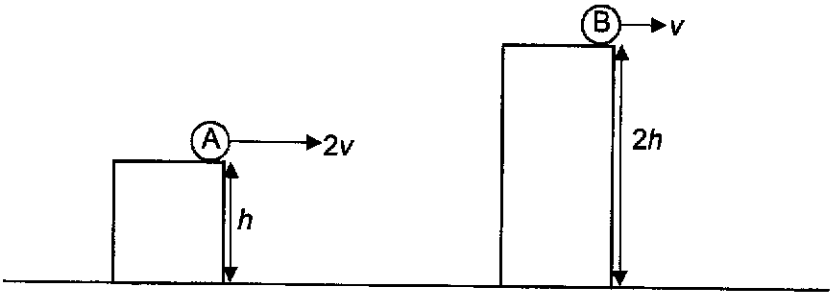
C



D



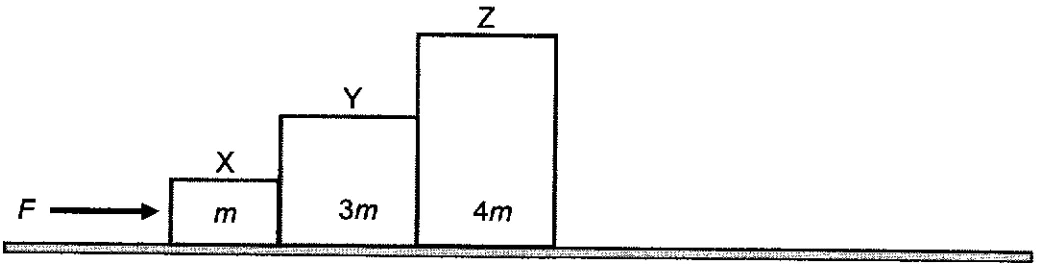
3 Ball A is projected horizontally with an initial velocity 2*v* from a height *h* above ground, while ball B is projected horizontally with an initial velocity *v* from a height 2*h* above ground.



If x_A is the horizontal displacement of ball A from the point of projection to the point of landing and x_B is the corresponding quantity for ball B, what is the ratio $\frac{x_A}{x_B}$?

A 0.35 **B** 1.00 **C** 1.41 **D** 2.83

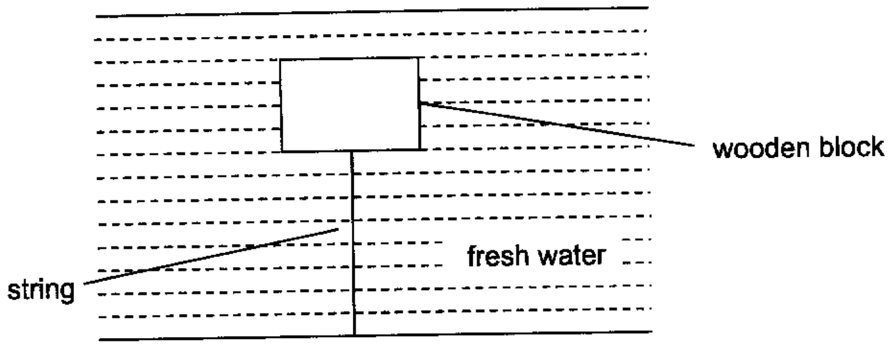
4 Three blocks X, Y and Z, of masses *m*, 3*m* and 4*m* respectively, are accelerated along a smooth horizontal surface by a force *F* applied to block X as shown.



What is the ratio $\frac{\text{force exerted on block X by block Y}}{\text{force on block Y by block Z}}$?

A $\frac{1}{4}$ **B** $\frac{3}{8}$ **C** $\frac{7}{8}$ **D** $\frac{7}{4}$

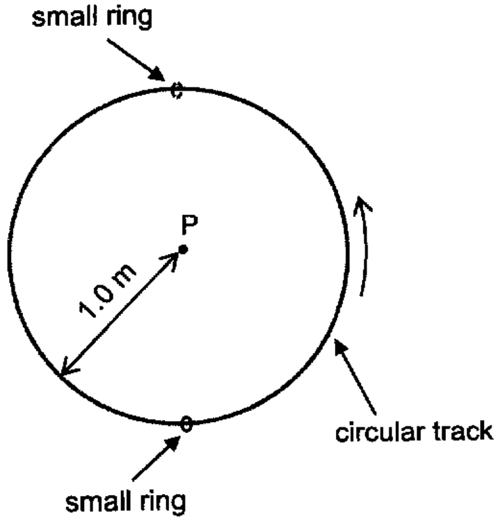
5 A wooden block of density 800 kg m^{-3} and volume 1.0 m^3 is fastened to the bottom of a freshwater pond by a string as shown below. The density of the freshwater is 1000 kg m^{-3}.



If the string suddenly breaks, what is the initial acceleration of the block?

A 0.25 m s^{-2} **B** 1.25 m s^{-2} **C** 2.5 m s^{-2} **D** 12.5 m s^{-2}

6 A small ring, of mass *m*, moves along a smooth circular track in the vertical plane, as shown in the figure below. P is the centre of the circular track.



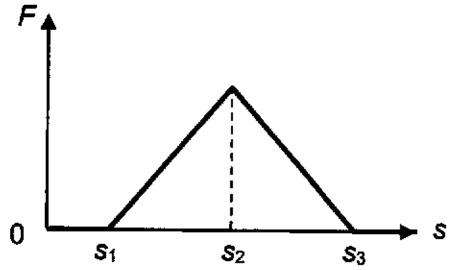
The radius of the track is 1.0 m.

At the bottom of the track, an upward normal force of magnitude 5.5*mg* acts on the small ring.

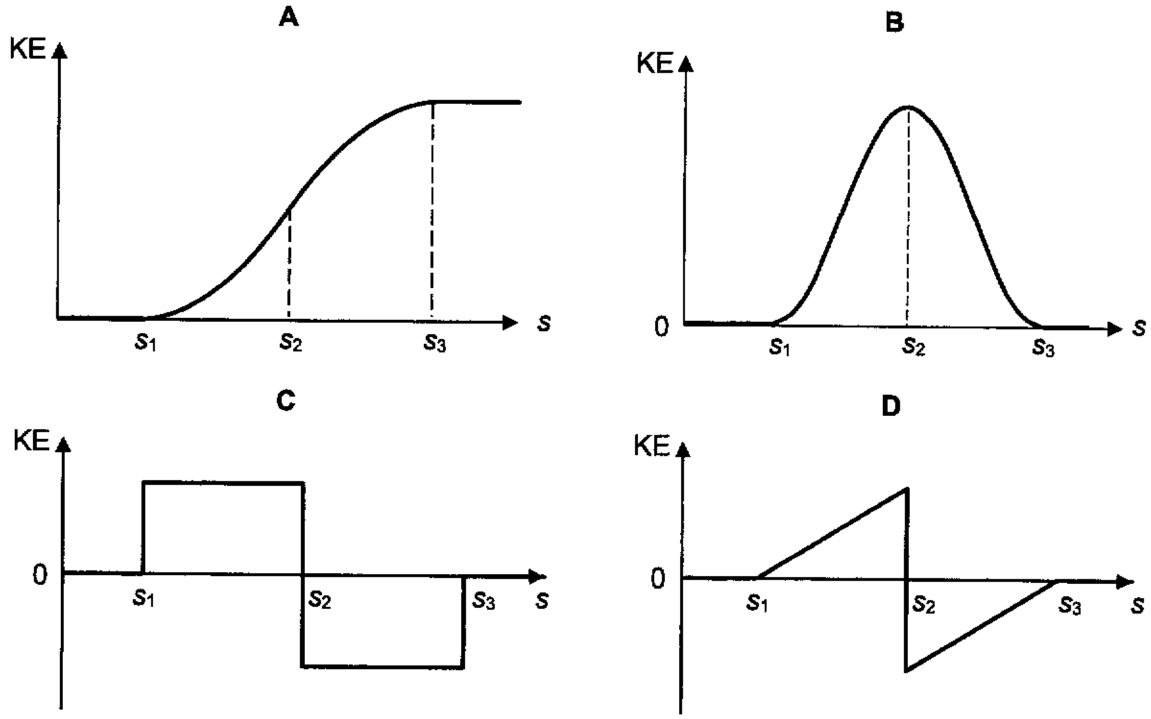
Which row correctly describes the magnitude and direction of the normal force acting on the small ring when it is at the top of the track?

	magnitude	direction
A	0.5*mg*	upwards
B	0.5*mg*	downwards
C	1.5*mg*	upwards
D	1.5*mg*	downwards

7 The diagram shows the variation with displacement s of the net force F acting on an object moving along a straight line. The intial velocity of the object is zero.



Which graph shows the variation with displacement s of the kinetic energy (KE) of the object?



8 The radius of the Earth is 6.371×10^6 m. The gravitational field strength on the surface of the Earth is $9.81\ \text{N kg}^{-1}$.

What is the gravitational potential at a point 80 000 m above the Earth surface?

A $-5.0\ \text{kJ kg}^{-1}$

B $-5.0\ \text{MJ kg}^{-1}$

C $-62\ \text{MJ kg}^{-1}$

D $-62\ \text{GJ kg}^{-1}$

9 Earth has a radius of r. A satellite of mass m is in circular orbit around Earth, at a height r above the Earth and with a period T. The satellite is moved to a new orbit with height $3r$ above the Earth.

What is the new period in terms of T?

A $\sqrt{2}\,T$ **B** $2\sqrt{2}\,T$ **C** $\sqrt{3}\,T$ **D** $3\sqrt{3}\,T$

10 The displacement x of a molecule undergoing simple harmonic motion in a sound wave is given by

$$x = x_0 \sin 2\pi ft$$

where x_0 = 0.32 mm and f = 10 000 Hz.

What is the magnitude of the maximum acceleration experienced by the molecule?

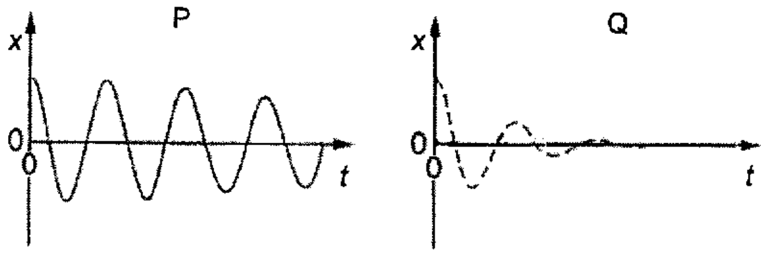
A 20.1 m s^{-2}

B $2.01 \times 10^{4}\text{ m s}^{-2}$

C $1.26 \times 10^{6}\text{ m s}^{-2}$

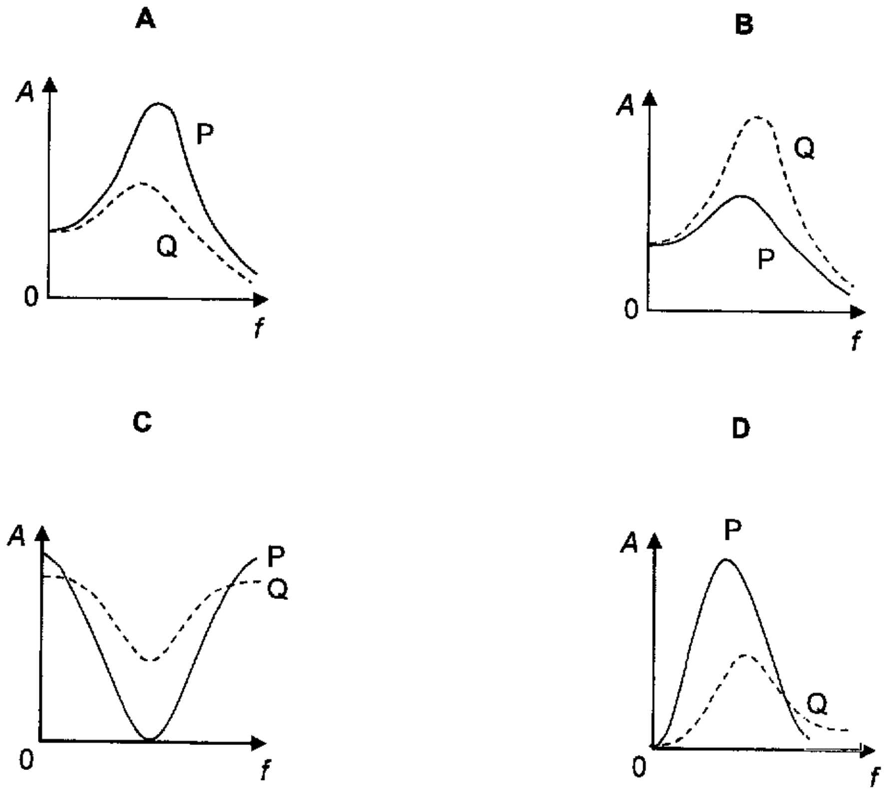
D $1.26 \times 10^{9}\text{ m s}^{-2}$

11 Two oscillating systems P and Q are of the same natural frequency. They are given the same initial displacement before being released. The graphs below show the variation with time t of their displacement x.



P and Q are then subjected to driving forces of the same constant amplitude and of variable frequency f.

Which graph best represents the variation with f of the amplitude A of P and Q?



12 A liquid is maintained at boiling point by means of an electric heater.

The constant rate at which the liquid boils is measured for two different powers of the heater as shown.

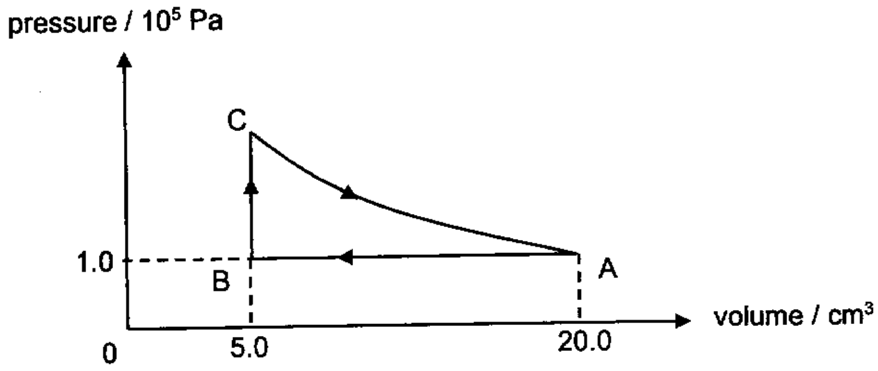
power of heater	rate of loss of mass of liquid
P_1	m_1
P_2	m_2

For each power of the heater, P_1 or P_2, the rate of heat loss to the environment is the same.

Which expression is the correct expression for rate of heat loss to the environment?

A $\dfrac{P_1 - P_2}{m_2 - m_1}$ **B** $P_1 - P_2$ **C** $\dfrac{P_1}{m_1}$ **D** $\dfrac{P_1 m_2 - P_2 m_1}{m_2 - m_1}$

13 An ideal gas undergoes a cycle of changes A → B → C → A, as shown below.

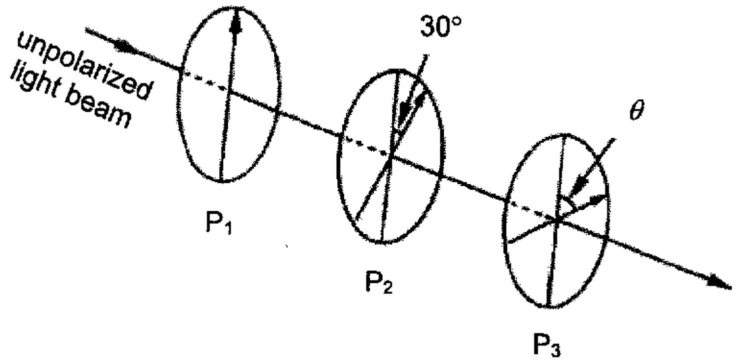


Work done by gas from C to A is 4.2 J.

What is the overall heat gain in process A → B → C → A?

A –5.7 J **B** –2.7 J **C** 2.7 J **D** 5.7 J

14 The figure below shows a beam of initially unpolarised light passing through 3 polarisers P_1, P_2 and P_3. The polarising axis of each polaroid is shown by an arrow. Polaroids P_1 and P_2 are fixed, with their polarising axes at 30° to each other, and P_3 can be set with its polarising axis at a variable angle θ to that of P_1.



The polarised light beam incident on P_2 has an intensity of 30 W m^{-2} while the light beam emerging from P_3 has an intensity of 14 W m^{-2}.

What is a possible value of θ for the light emerging from P_3?

A 38° **B** 52° **C** 57° **D** 68°

15 A camera with a lens diameter of 10 cm captures images using light of wavelength 550 nm.

What is the minimum separation between two objects that can be resolved if they are located 100 meters from the camera?

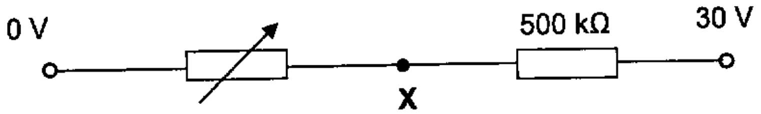
A 0.25 mm **B** 0.37 mm **C** 0.55 mm **D** 0.65 mm

16 Light of wavelengths 480 nm and 640 nm are incident on a diffraction grating with 5000 lines per cm.

What is the angle at which the maxima for one wavelength of light overlaps with a maxima for other wavelength of light?

A 0.22° **B** 16° **C** 37° **D** 74°

17 Two resistors form a potential divider with outer junctions maintained at potentials of 0 V and 30 V. The variable resistor can be adjusted from 100 kΩ to 500 kΩ.



What range of potentials can be obtained at point X?

A 3 V to 15 V

B 5 V to 15 V

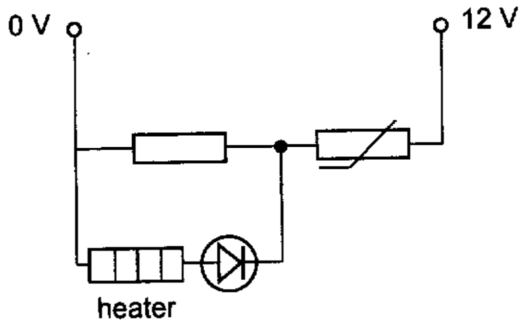
C 5 V to 25 V

D 15 V to 25 V

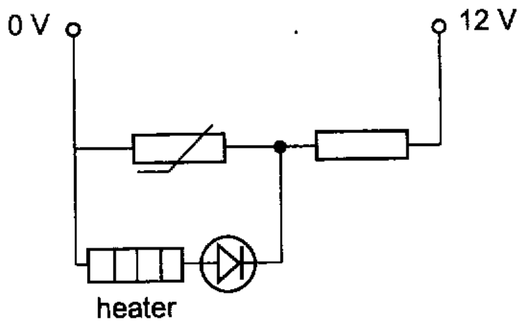
18 A circuit consists of a negative-temperature-coefficient (NTC) thermistor, a fixed resistor and a heater.

Which of the following arrangements allows the heater to be turned on when the temperature is low?

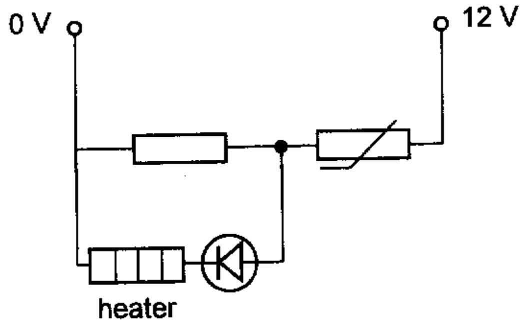
A



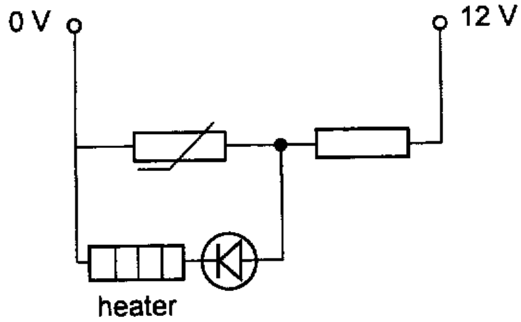
B



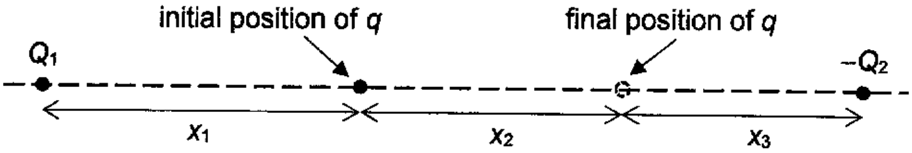
C



D



19 A test charge q is moved from one position to another along the line joining a positive charge Q_1 and a negative charge $-Q_2$. The distances between the positions of the charges are x_1, x_2 and x_3, as shown in the diagram below.



What is the work done by the electric field?

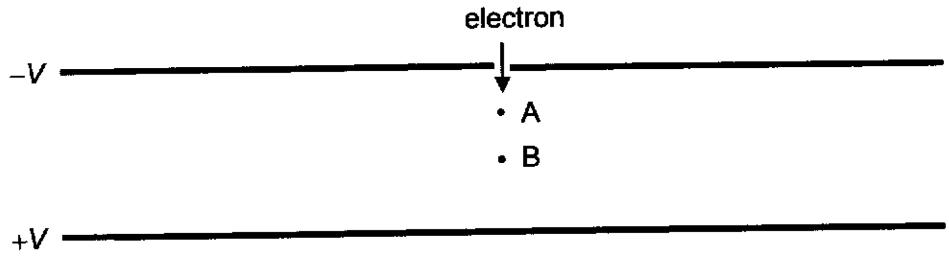
A $\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1}-\frac{1}{x_1+x_2}\right)+\frac{qQ_2}{4\pi\varepsilon_0}\left(\frac{1}{x_3}-\frac{1}{x_2+x_3}\right)$

B $\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1+x_2}-\frac{1}{x_1}\right)+\frac{qQ_2}{4\pi\varepsilon_0}\left(\frac{1}{x_2+x_3}-\frac{1}{x_3}\right)$

C $\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1+x_2}-\frac{1}{x_1}\right)+\frac{qQ_2}{4\pi\varepsilon_0}\left(\frac{1}{x_3}-\frac{1}{x_2+x_3}\right)$

D $\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1}-\frac{1}{x_1+x_2}\right)+\frac{qQ_2}{4\pi\varepsilon_0}\left(\frac{1}{x_2+x_3}-\frac{1}{x_3}\right)$

20 An electron enters the region between two charged parallel plates through a small opening, in the direction as shown in the diagram below. A and B are two points on the path of the electron.



The two plates are at electric potentials $-V$ and $+V$.

Which row correctly describes the relations between the electric forces F, potentials V and potential energies U at A and B?

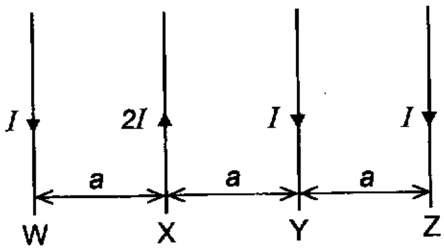
A $F_A > F_B$, $V_A > V_B$, $U_A < U_B$

B $F_A > F_B$, $V_A < V_B$, $U_A > U_B$

C $F_A = F_B$, $V_A > V_B$, $U_A < U_B$

D $F_A = F_B$, $V_A < V_B$, $U_A > U_B$

21 Four parallel wires W, X, Y and Z carry currents of magnitudes and directions shown in the digram below. The spacing between wires are identical.

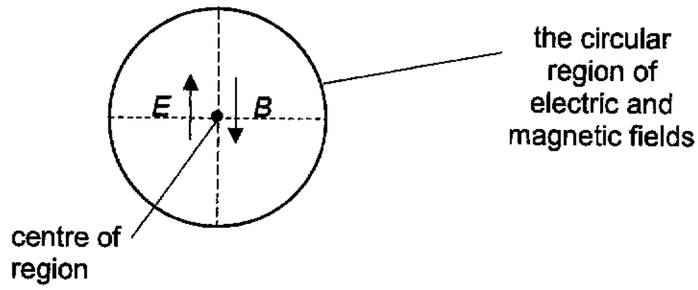


Which wire has the largest resultant force acting on it?

A W **B** X **C** Y **D** Z

22 An electron beam initially passes through the centre of a region in a direction out of the plane of the paper.

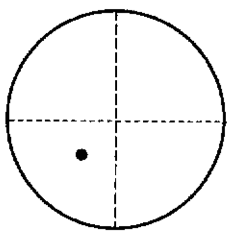
Subsequently, the electric and magnetic fields are directed within a circular region in directions as shown by the arrows in the diagram below.



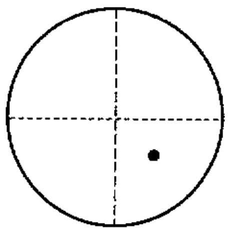
The deflections of the beam from the centre of the region produced by the electric field E and the magnetic field B acting separately are equal in magnitude.

Which diagram shows a possible position of the beam in the circular region when both fields are operating together?

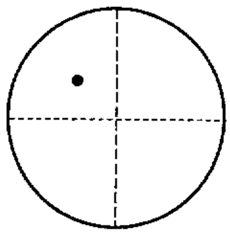
A



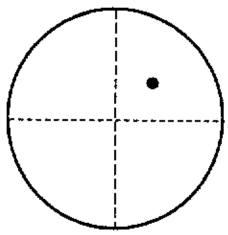
B



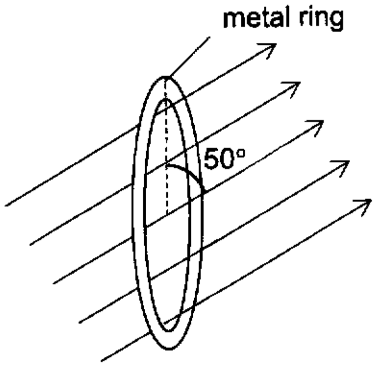
C



D



23 A uniform magnetic field directed at 50° to the plane of a circular metal ring passes through the ring of diameter 0.50 m and resistance 3.0 Ω, as shown in the diagram.



The magnetic flux density through the ring decreases by 4.0×10^{-5} T at a constant rate in 2.0 s. During this change, what is the current induced in the ring?

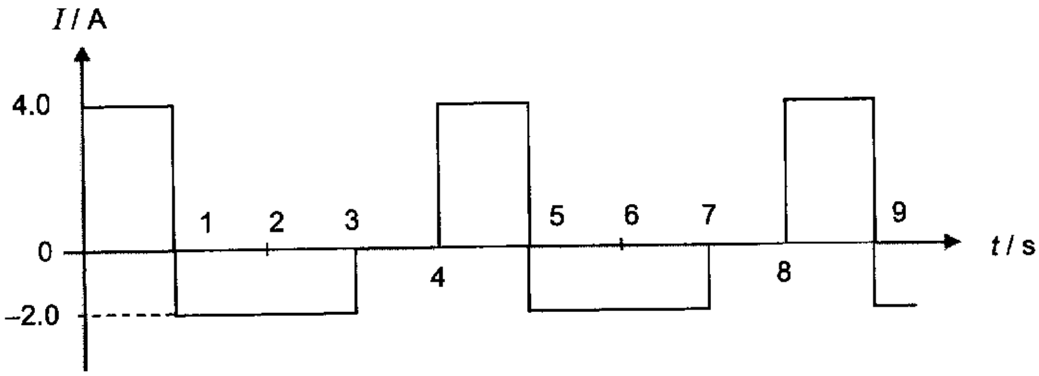
A It remains constant at 1.0 μA.

B It remains constant at 1.3 μA.

C It increases from zero to 1.0 μA at a constant rate.

D It increases from zero to 1.3 μA at a constant rate.

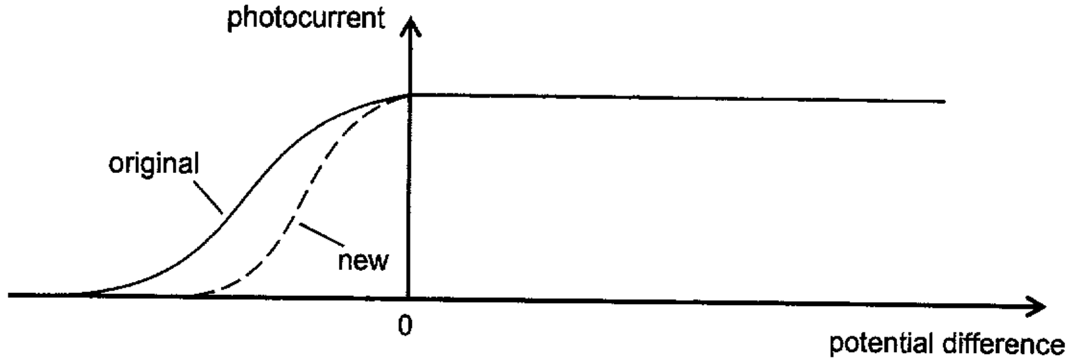
24 An alternating current with a rectangular waveform as shown in the diagram below flows through a 11 Ω resistor.



What is the average power dissipated by the resistor?

A 0 W **B** 44 W **C** 66 W **D** 88 W

25 In a photoelectric effect experiment, the variation of the photocurrent with the potential difference applied is shown in the diagram below, as the solid curve.



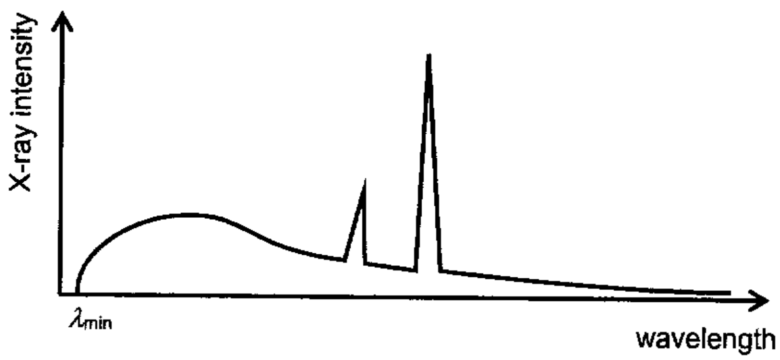
The light source is then replaced with a new one, and the dashed curve is obtained.

Which row correctly describes the new light source relative to the original source?

	intensity	frequency
A	lower	higher
B	lower	lower
C	same	higher
D	same	lower

26 X-rays are produced when a beam of electrons, accelerated to a high speed by a potential difference, collides with a metal target.

The variation with wavelength of the intensity of the X-rays is illustrated in the diagram below.



Which feature of the X-ray graph remains unchanged when the accelerating potential changes?

A the wavelength λ_{min}

B the wavelengths at which the spikes occur

C the intensity of the spikes

D the intensity of the continuous spectrum

27 The Heisenberg uncertainty principle is given by the relationship

$$\Delta p \Delta x \geq h$$

where p = momentum

x = position

h = Planck constant.

Which statement about the interpretation of this relationship is correct?

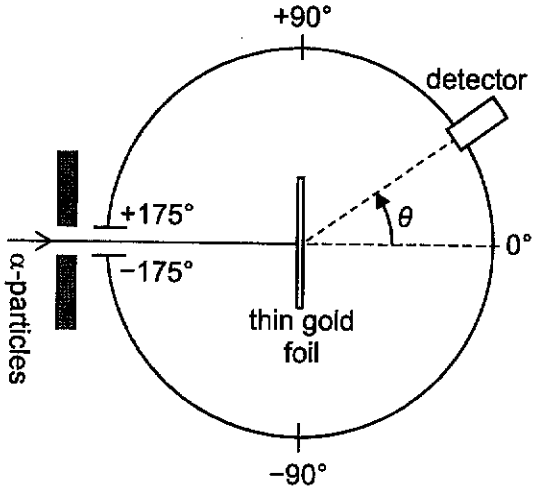
A The uncertainty in position Δx is proportional to the reciprocal of the uncertainty in momentum Δp.

B If the position of a particle is changed by Δx, its momentum must change by at least $\Delta p = h / \Delta x$.

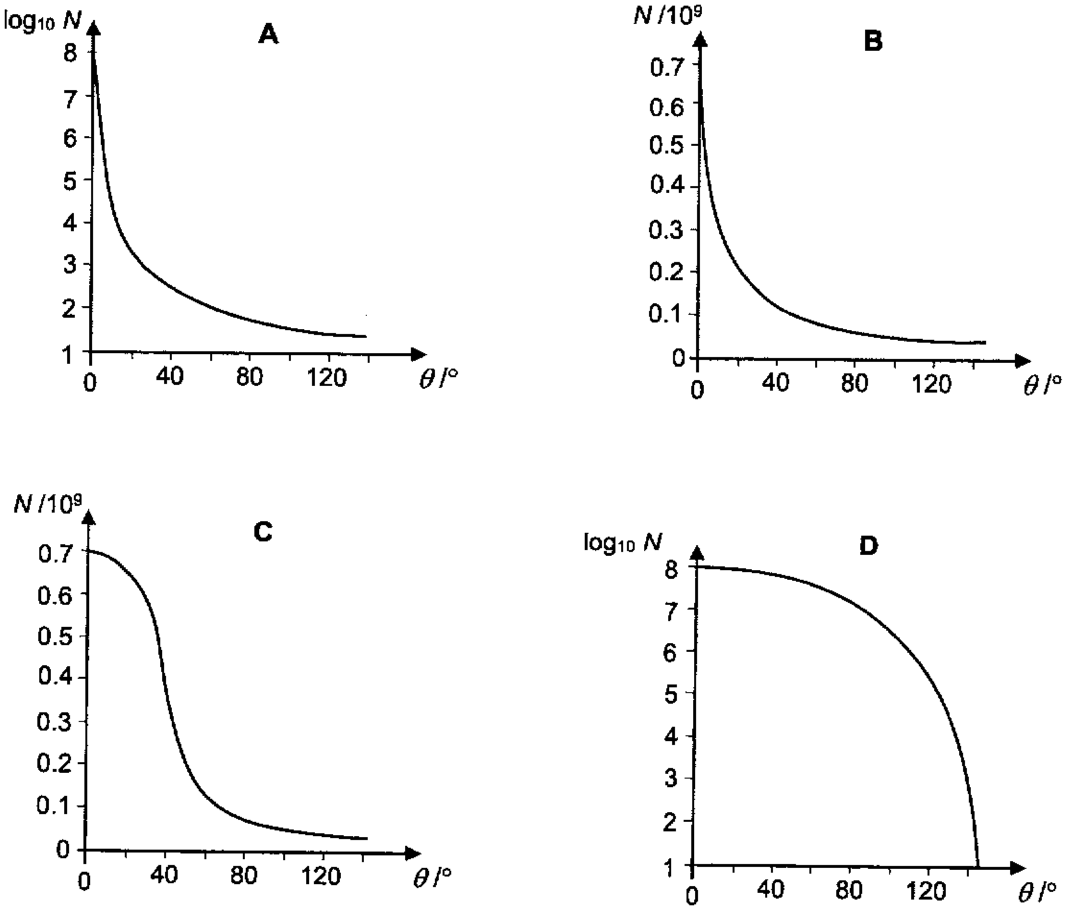
C If the position of a particle is measured with an uncertainty Δx, the minimum uncertainty of its momentum is $\Delta p = h / \Delta x$.

D The greater the uncertainty in the momentum p of a particle, the greater is the uncertainty in its position x.

28 In an α-particle scattering experiment, a student set up the apparatus below to determine the number N of α-particle incident per unit time on a detector held at various angles θ.



Which graph best represents the variation of N with θ?



29 A radioactive source contains two species.

One has a half-life of 4 days and decays by the emission of alpha particles whilst 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 will be the count-rate after 12 days, without the paper present?

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

30 Consider the following nuclear reaction:

$$^{7}_{3}Li + ^{1}_{1}H \rightarrow 2^{4}_{2}He$$

The masses of the nuclei are as follow: $^{7}_{3}Li$: 7.018u, $^{1}_{1}H$: 1.008u, $^{4}_{2}He$: 4.004u.

How much energy is released when 1.0 g of $^{1}_{1}H$ is fused with a sufficient amount of $^{7}_{3}Li$?

A 2.7×10^{-12} J **B** 6.1×10^{-10} J **C** 1.6×10^{12} J **D** 3.6×10^{14} J

EUNOIA JUNIOR COLLEGE
JC2 Preliminary Examination 2024
9749 PHYSICS
MARK SCHEME

Paper 1 – Multiple Choice Questions

Question	Key
1	A
2	D
3	C
4	D
5	C
6	A
7	A
8	C
9	B
10	C

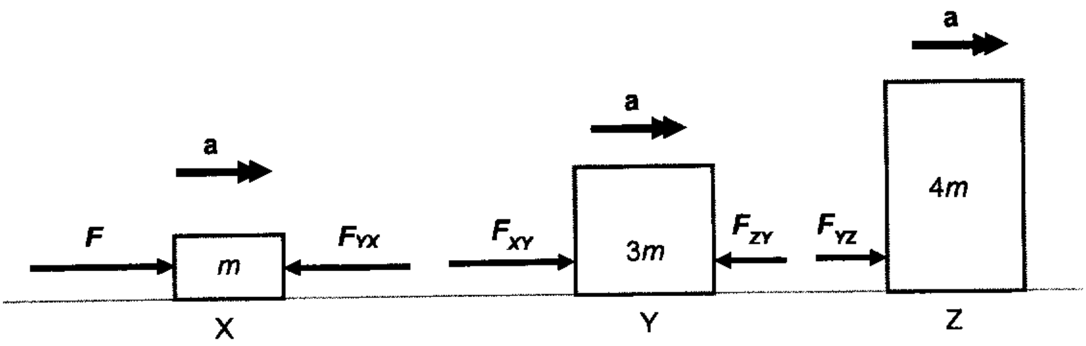
Question	Key
11	A
12	D
13	C
14	D
15	C
16	D
17	B
18	D
19	A
20	D

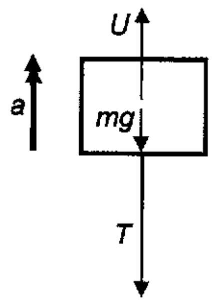
Question	Key
21	C
22	A
23	A
24	C
25	B
26	B
27	C
28	A
29	C
30	C

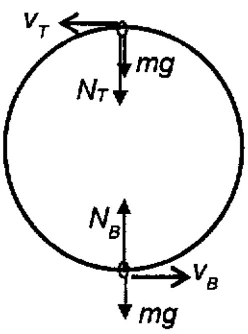
1	**Answer: A**
	Notice that the options are all given in electrical units, hence we express *power* in terms of *potential difference* and *current*. $$\text{unit for } k = \frac{\text{unit for }(IV)}{\text{unit for }(I)^2}\left(\frac{\cancel{\text{unit for }\lambda}}{\cancel{\text{unit for }L}}\right)^2$$ $$= \frac{\text{unit for }(V)}{\text{unit for }(I)} = \text{unit for }(R) = \Omega$$

2	**Answer: D**
	Velocity is a vector, thus the direction sign of the velocity when the ball is going up is the negative of the direction sign of the velocity when the ball is coming back down. Thus, reject option A and option B. Given the asymmetry of the height-time graph where the time taken for upward journey of ball is shorter than downward journey, air resistance must be present. Since work is continually done against air resistance, the final kinetic energy of the ball (just before hitting ground) would be less than the initial kinetic energy of the ball (when it was first thrown up from the ground). Also, the area under graph for the first part of graph should be same as that in the second part since the distance travelled up and down are the same. So, reject option C.

3	**Answer: C**
	$+\downarrow$: $s_y = \cancel{u_y t} + \frac{1}{2}gt^2$ $+\rightarrow$: $s_x = u_x t$ Combining the 2 equations gives $s_y = \frac{1}{2}g\left(\frac{s_x}{u_x}\right)^2$ or $s_x \propto u_x\sqrt{s_y}$ Thus, $\frac{x_A}{x_B} = \frac{u_A}{u_B}\sqrt{\frac{s_A}{s_B}}$ $= \frac{2}{1}\sqrt{\frac{1}{2}} = \sqrt{2} = 1.41$

4	**Answer: D**
	 For Z, $F_{YZ} = 4ma$ ......(1) For Y, $F_{XY} - F_{ZY} = 3ma$ ......(2) From Newton's 3rd Law: $\lvert F_{YZ}\rvert = \lvert F_{ZY}\rvert = 4ma$ ......(3) From (2) & (3), $F_{XY} - 4ma = 3ma$ $F_{XY} = 7ma = F_{YX}$ Thus, $\frac{F_{YX}}{F_{ZY}} = \frac{7ma}{4ma} = \frac{7}{4}$

5	**Answer: C**
	Newton's 2nd Law gives $F_{net} = m_{wood}a$ $U - m_{wood}g - T = m_{wood}a$ When string breaks, tension $T = 0$ $(\rho_{water}V_{wood})g - (\rho_{wood}V_{wood})g - 0 = m_{wood}a$ $1000(1.0)(9.81) - (800)(1.0)9.81 = (800)(1.0)a$ $a = 2.45$ m s^{-1} 

6	**Answer: A**
	Apply Newton's 2nd Law: At bottom, $N_B - mg = \frac{mv_B^2}{r}$ .....(1) At top, assume N_T points downwards $N_T + mg = \frac{mv_T^2}{r}$ .....(2) From bottom to top, conservation of energy gives $mg(2r) = \frac{1}{2}m\left(v_B^2 - v_T^2\right)$ .....(3) (1)-(2), then substituting (3) gives $N_B - N_T = 6mg$ $5.5 - N_T = 6mg$ $N_T = -0.5mg$ Negative sign indicates N_T should point upwards, opposite to assumption. 

7	**Answer: A**
	The work done by the net force provides the change in kinetic energy, which is equal to the kinetic energy if the initial kinetic energy is 0. KE at displacement s = work done by the net force $= \int F ds =$ area under the F-s graph Hence, gradient of KE-s graph = F. (It's easier to work with gradient.) From s_1 to s_2, F increases from 0, so the gradient of KE-s increases from 0. From s_2 to s_3, F decreases from a positive value to 0, so the gradient of KE-s decreases. Only **A** fits the above description. KE is always positive, so reject options C and D. Area under F-s graph = work done by F = Gain in KE. From s_1 to s_3, area always increasing, also F always positive, so KE always increasing, thus reject option B.

8	**Answer: C**
	$\phi = -\frac{GM}{r} = -\frac{GM}{(6.371\times10^6)+80000}$ .... (1) $g = -\frac{GM}{r^2} \Rightarrow 9.81 = -\frac{GM}{(6.371\times10^6)^2} \Rightarrow GM = 3.98\times10^{14}$ .... (2) Sub (2) into (1): $\phi = -\frac{GM}{r} = -\frac{3.98\times10^{14}}{(6.371\times10^6)+80000} = 62\times10^6 = 62$ MJ

9	**Answer: B**
	Using $T^2 \propto r^3$ (Can use in MCQ direct, but must prove starting from F_g provides F_c if in P2 or P3) Note to find "radius of orbit" given the satellite's height above Earth. Height $r \Rightarrow$ radius of orbit = $2r$ Height $3r \Rightarrow$ radius of orbit = $4r$ $\left(\frac{T'}{T}\right)^2 = \left(\frac{4r}{2r}\right)^3$ $T'^2 = 2^3 T^2$ $T' = 2\sqrt{2}T$

10	**Answer: C**
	$a_0 = \omega^2 x_0 = (2\pi f)^2 x_0 = 4\pi^2 (10000)^2 \left(0.32 \times 10^{-3}\right) = 1.26 \times 10^6$ Hz

11	**Answer: A**
	From displacement-time graphs of P and Q in question, the amplitude of oscillation by Q decreases faster than that of P $\Rightarrow$ Q undergoes more damping than P. Hence answer is A. For heavier damping, • Peak has lower amplitude. • Peak shifts to a lower frequency.

12 **Answer: D**

Question asked for "rate of heat loss". [J s^{-1}]

- Eliminate A and C by unit analysis.

  Note that m is defined as rate of loss of mass. [kg s^{-1}]

  $$\left[\frac{P}{m}\right] = \left[\frac{E/t}{m}\right] = \frac{\text{J s}^{-1}}{\text{kg s}^{-1}} = \frac{\text{J}}{\text{kg}}$$

- Option B: $P_1 - P_2$ removes the rate of heat loss term. Eliminate.

- Mathematical proof for D:

  $$P_1 m_2 - P_2 m_{11} = \frac{m_2 m_1 l_v + m_2 h - m_1 m_2 l_v - m_1 h}{m_2 - m_1} = \frac{(m_2 - m_1)h}{m_2 - m_1}$$

13 **Answer: C**

For full cycle processes, the net change in internal energy is zero.

$\Delta U = Q + W$

$0 = Q + [(-4.2) + (1.0 \times 10^5 \times (20.0 - 5.0) \times 10^{-6})]$

$Q = 2.7 \text{ J}$

14 **Answer: D**

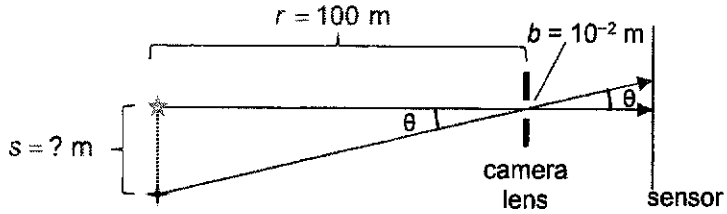
Note that θ is measured with respect from the polarising axis of P_1.

Let the light emerging from P_1, P_2 and P_3 have intensity I_1, I_2, I_3 respectively.

$I_3 = I_2 \cos^2(\theta - 30)° = I_1 \cos^2 30° \cos^2(\theta - 30)°$

$14 = 30 \cos^2 30° \cos^2(\theta - 30)°$

$\theta = 68°$

15	**Answer: C**
	 From circular measure $s \approx r\theta$ Rayleigh's Criterion $\theta \approx \frac{\lambda}{b}$ For small angle, $\frac{s}{r} \approx \theta \approx \frac{\lambda}{b}$ $s \approx \frac{r\lambda}{b}$ $= \frac{(100)(550\times10^{-9})}{10\times10^{-2}}$ $= 5.5\times10^{-4}$ m = 0.55 mm

16	**Answer: D**
	$d\sin\theta = n_1\lambda_1 = n_2\lambda_2 \Rightarrow n_1(480\times10^{-9}) = n_2(640\times10^{-9}) \Rightarrow \frac{n_2}{n_1} = \frac{480}{640} = \frac{3}{4}$ min $n_1 = 4$ and min $n_2 = 3$ Using $d\sin\theta = n_1\lambda_1$, $\frac{0.01}{5000}\sin\theta = 4(480\times10^{-9})$ $\theta = 74°$

17	**Answer: B**
	Applying potential divider principle, the potential difference <u>across</u> the variable resistor, V_R varies between: $V_R = \left(\frac{100}{100+500}\right)30 = 5\text{V}$ to $V_R = \left(\frac{500}{500+500}\right)30 = 15\text{V}$

18	**Answer: D**
	A and B are wrong because the diode is connected in reverse-bias. When temperature of the thermistor is low, resistance is high and hence p.d. across the thermistor is high. The heater should be connected across the thermistor.

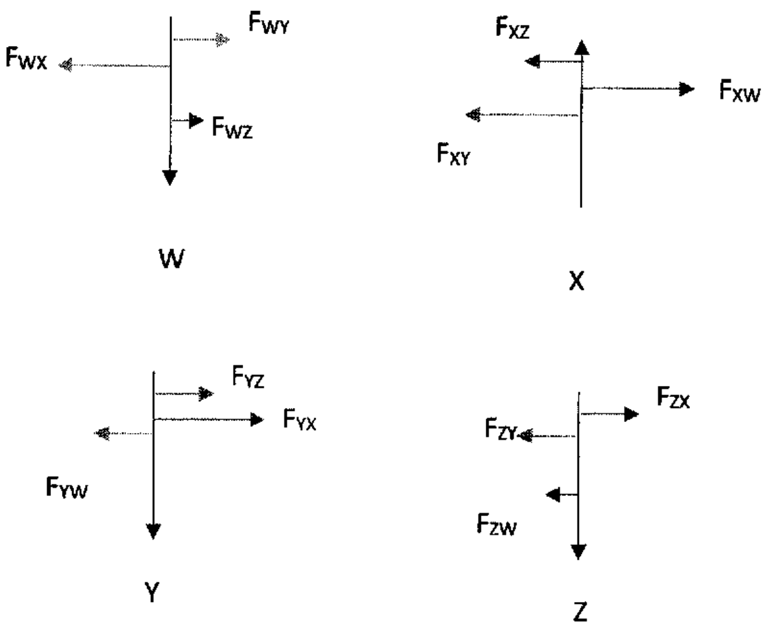
19	**Answer: A**
	change in potential energy = final potential energy – initial potential energy $=\left[\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1+x_2}\right)+\frac{q(-Q_2)}{4\pi\varepsilon_0}\left(\frac{1}{x_3}\right)\right]-\left[\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1}\right)+\frac{q(-Q_2)}{4\pi\varepsilon_0}\left(\frac{1}{x_2+x_3}\right)\right]$ $=\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1+x_2}-\frac{1}{x_1}\right)+\frac{qQ_2}{4\pi\varepsilon_0}\left(\frac{1}{x_2+x_3}-\frac{1}{x_3}\right)$ work done by electric field = –(change in potential energy) $=\frac{qQ_1}{4\pi\varepsilon_0}\left(\frac{1}{x_1}-\frac{1}{x_1+x_2}\right)+\frac{qQ_2}{4\pi\varepsilon_0}\left(\frac{1}{x_3}-\frac{1}{x_2+x_3}\right)$ **Note**: The change in potential energy is the work done by the external force. The electric force is equal and opposite to the external force (in defining the electric potential), hence there is an overall negative sign between the work done by the two forces.

20	**Answer: D**
	The electric field is uniform between the plates, so $F_A = F_B$. Point A is closer to the negative plate, hence is at a lower potential, i.e. $V_A < V_B$. Since $U = qV$, and electron is negatively charged ($q < 0$), $U_A > U_B$.

21	**Answer: C**

Draw the magnetic forces acting on each wire due to the rest of the wires.

Wire Y has a large magnetic force acting to the right due to wire X and its larger current. Wire Y is also attracted to the right by wire Z.



OR

Force on wire X due to wire Y = F_{XY}

$$F_{XY} = B_Y I_X L$$

$$B_Y = \frac{\mu_o I_Y}{2\pi a}$$

$$F_{XY} = \frac{\mu_o I_Y}{2\pi a} I_X L$$

$$F_{XY} = \frac{\mu_o I_Y I_X L}{2\pi a}$$

$$= k\frac{I_Y I_X}{a} \text{ where } k = \frac{\mu_o L}{2\pi}$$

Taking to the right as positive:

$$F_W = -F_{WX} + F_{WY} + F_{WZ}$$

$$= -k\frac{2I^2}{a} + k\frac{I^2}{2a} + k\frac{I^2}{3a}$$

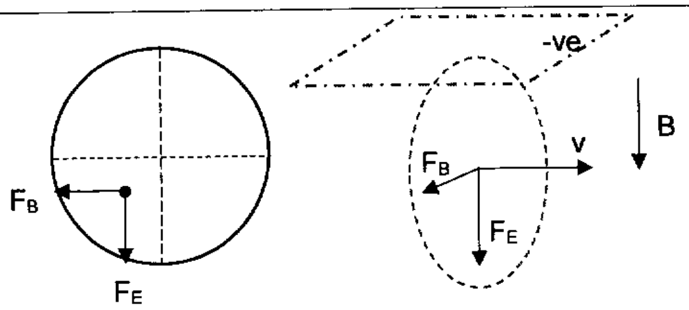
$$= -k\frac{7I^2}{6a}$$

$$F_X = -F_{XY} - F_{XZ} + F_{XW}$$
$$= -k\frac{2l^2}{a} - k\frac{2l^2}{2a} + k\frac{2l^2}{a}$$
$$= -k\frac{l^2}{a}$$

$$F_Y = -F_{YW} + F_{YX} + F_{YZ}$$
$$= -k\frac{l^2}{2a} + k\frac{2l^2}{a} + k\frac{l^2}{a}$$
$$= k\frac{5l^2}{2a}$$

$$F_Z = -F_{ZW} - F_{ZY} + F_{ZX}$$
$$= -k\frac{l^2}{3a} - k\frac{l^2}{a} + k\frac{2l^2}{2a}$$
$$= -k\frac{l^2}{3a}$$

22	**Answer: A**



23	**Answer: A**

$$I = \frac{\varepsilon}{R} = \frac{\Delta BA}{\Delta t}\left(\frac{1}{R}\right) = \frac{(4.0\times10^{-5})\sin 50(\pi(\frac{0.50}{2})^2)}{2.0}\left(\frac{1}{3.0}\right) = 1.0\times10^{-6}\,\text{A}$$

The current remains constant as the rate of change of flux is constant.

24	**Answer: C**
	To find I_{rms}, first square the graph, find total area over 1 period, find the average area over 1 period, then square root. $I_{rms} = \sqrt{\frac{4.0^2 x1 + 2.0^2 x2}{4}}$ $= 2.45$ A $P_{ave} = I_{rms}^2 R$ $= 2.45^2 \times 11$ $= 66$ W

25	**Answer: B**
	$\text{Intensity} = \frac{\text{Power}}{\text{Area}} = \left(\frac{n_{photon}}{t}\right)\frac{hf}{A}$ $E_{photon} = hf = \phi + eV_s$ • From graph, saturated current constant ⇒ number of electrons constant ⇒ no. of photons per unit time constant • stopping potential is smaller ⇒ KE_{max} smaller ⇒ f smaller Hence, intensity must be lower.

26	**Answer: B**
	If the accelerating potential changes, the kinetic energies of the electrons change. The intensities across the spectrum, as well as λ_{min}, will change. The wavelengths of the spikes are determined by the type of metal (the energy differences between the inner shells of the metal atoms). They are <u>not</u> affected by the energy of the electrons (so long as they are fast enough to knock out the inner shell electrons).

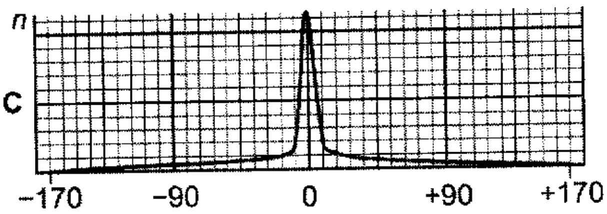
27	**Answer: C**
	According to the uncertainty principle, if a measurement of position is made with uncertainty Δx and a simultaneous measurement of momentum is made with uncertainty Δp, the product of the two uncertainties can never be smaller than the Planck constant. The uncertainty principle is hence about the minimum (lower bound) of the uncertainties.

28	Answer: A

From notes,

- Majority of α-particles went straight through or were deviated by small angles of less than 10°.
- A small proportion (about 1 in 8000) of the α-particles were deflected through large angles of more than 90° or came straight back.

A typical graph of N against θ should look like this, indicating a significant drop from the straight-through position to deviation of 10°:



It is hence useful to make sense of the numbers at key points of the given graphs

	N		
	0° (Straight-through)	**10°**	**Remarks**
Option A	10^8	10^5	Decrease to 1/1000 of straight through
Option B	0.7×10^9	0.35×10^9	Decrease by 50%
Option C	0.7×10^9	0.68×10^9	Decrease by less than 10 times
Option D	10^8	$10^{7.8}$	Decrease by less than 10 times

Option A shows the drastic drop in N from the straight through to 10° deviation position. This also implies that beyond 10° deviation, there is only a small fraction of particles with those angular deflection.

29	**Answer: C**
	Paper stops alpha particles, so $\alpha + \beta + background = 352$min^{-1} $\beta + background = 256$min^{-1} Initial count of beta particle source = 256-16=240min^{-1} Initial count of alpha particle source = 352-256=96min^{-1} After 12 days, alpha particle source undergoes 3 half-lives and beta particle source undergoes 4 half-lives Final count of alpha particle source=$\frac{96}{2^3} = 12min^{-1}$ Final count of beta particle source=$\frac{240}{2^4} = 15min^{-1}$ Total count = 12+15+16=43min^{-1}

30	**Answer: C**
	Number of reactions = 0.0010 / 1.008u = 5.976×10^{23} Energy released in one reaction = [7.018u + 1.008u – 2(4.004u)]c^2 = 2.689×10^{-12} J Total energy released = $2.689 \times 10^{-12} \times 5.976 \times 10^{23}$ = 1.61×10^{12} J

Paper 2 – Structured Questions