Class	Index Number	Name
23S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2024
Preliminary Examination

PHYSICS, Higher 2 **9749/01**

Paper 1 Multiple Choice **12th 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, index number and Civics Group on 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 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 **20** 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}

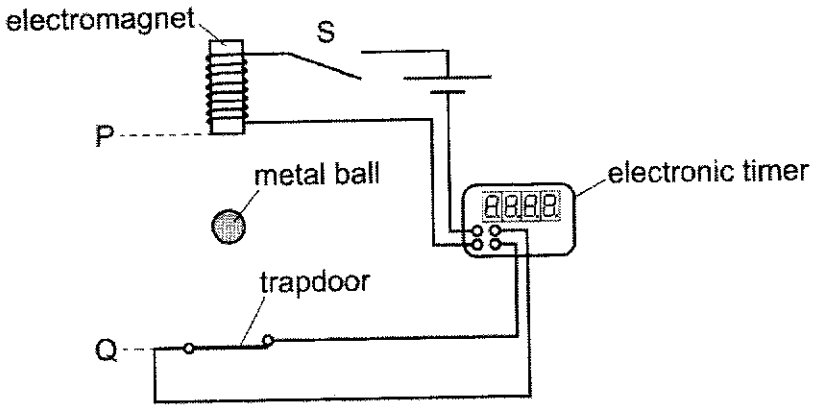
Formulae

uniformly accelerated motion	$s = u t + \frac{1}{2} a t^2$
	$v^2 = u^2 + 2 a s$
work done on/by a gas	$W = p \Delta V$
hydrostatic pressure	$p = \rho g h$
gravitational potential	$\varphi = -\frac{Gm}{r}$
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.	$v = v_o \cos \omega t$
	$v = \pm \omega \sqrt{x_0^2 - x^2}$
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	$x = x_o \sin \omega t$
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 A student determines the acceleration of free fall by using a small metal ball, as shown.



When switch S is opened, the ball is released from an electromagnet and an electronic timer is started. The ball then falls vertically downwards. The timer stops when the ball hits a trapdoor. The student measures the distance PQ between the electromagnet and the trapdoor. This distance and the reading on the timer are then used to calculate the acceleration of free fall.

Which statement about errors in the experiment is correct?

A The random error can be reduced by subtracting the diameter of the ball from the distance PQ.

B The random error can be reduced by adding the diameter of the ball to the distance PQ.

C The systematic error can be reduced by subtracting the diameter of the ball from the distance PQ.

D The systematic error can be reduced by adding the diameter of the ball to the distance PQ.

2 A student takes measurements to determine the constant acceleration of a model car moving from rest in a straight line. The measured values with their absolute uncertainties are as shown.

quantity	measured value	uncertainty
displacement	16.5 m	± 0.1 m
time	15.0 s	± 1.0 s

The student uses the equation $s = 1/2\ at^2$ to calculate the acceleration of the car.

What is the acceleration and its absolute uncertainty?

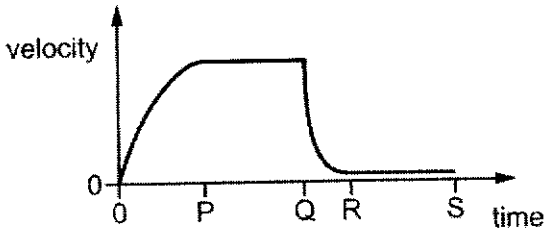
A $(0.11 \pm 0.01)\ \text{m s}^{-2}$

B $(0.11 \pm 0.02)\ \text{m s}^{-2}$

C $(0.15 \pm 0.01)\ \text{m s}^{-2}$

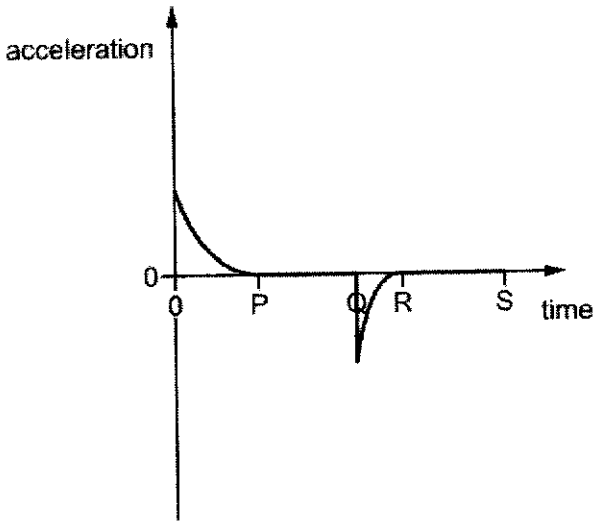
D $(0.15 \pm 0.02)\ \text{m s}^{-2}$

3 A parachutist falls from a stationary balloon at time $t = 0$. The velocity–time graph for the parachutist from time $t = 0$ until the time when he is just above the ground is shown.

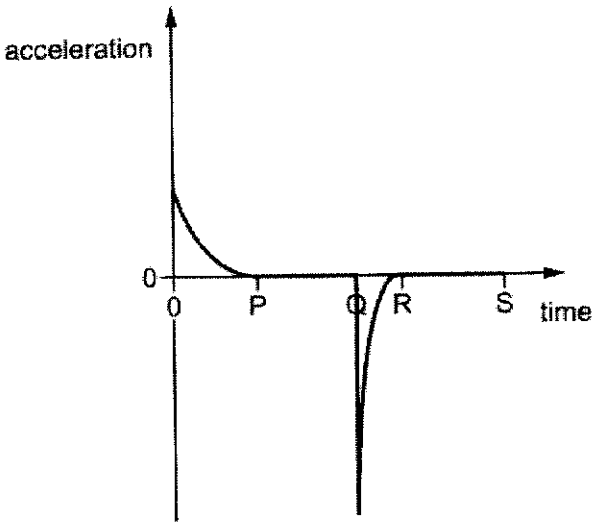


Which graph best shows the variation with time of the acceleration of the parachutist?

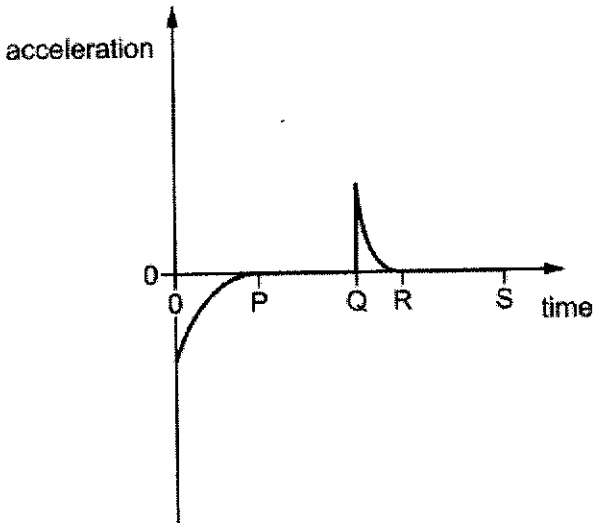
A



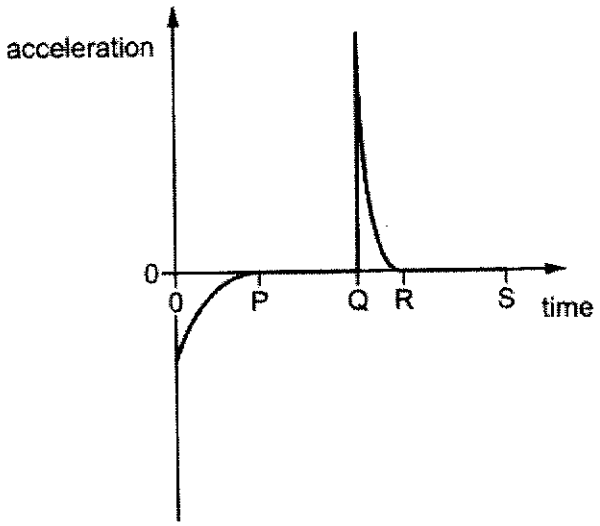
B



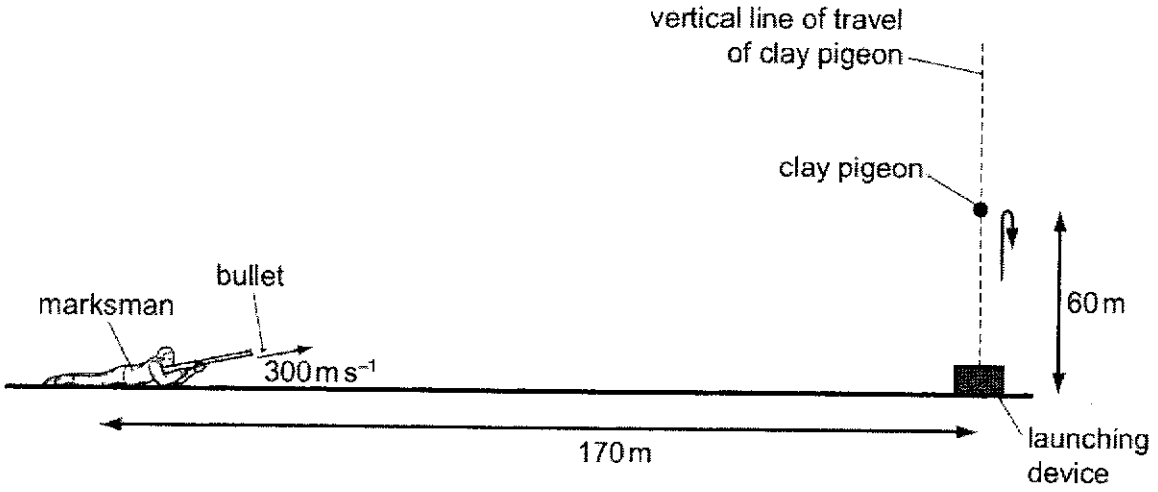
C



D



4 A clay pigeon is launched vertically into the air from the ground.



(diagram not to scale)

A marksman lies 170 m away from the launching device on level ground. Just as the clay pigeon reaches its maximum height of 60 m, the marksman fires a bullet aimed directly at the clay pigeon. The bullet leaves the rifle with a speed of 300 m s^{-1}. Assume air resistance is negligible.

At what time after the bullet is fired is the clay pigeon hit?

A 0.17 s

B 0.57 s

C 0.60 s

D 1.66 s

5 An object of mass m, moving at speed u along a frictionless horizontal surface, collides head-on with a stationary object of mass $4m$.

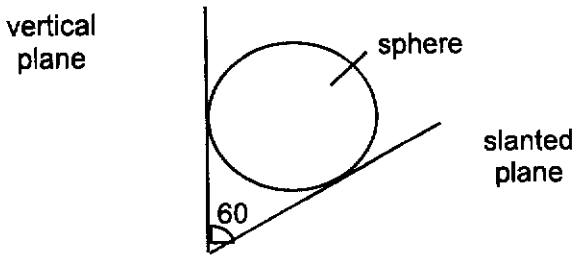
before the collision

After the collision, the object of mass m rebounds along its initial path with $\frac{1}{4}$ of its kinetic energy before the collision.

What is the speed of the object of mass $4m$ after the collision?

A $\frac{u}{8}$ **B** $\frac{3u}{16}$ **C** $\frac{5u}{16}$ **D** $\frac{3u}{8}$

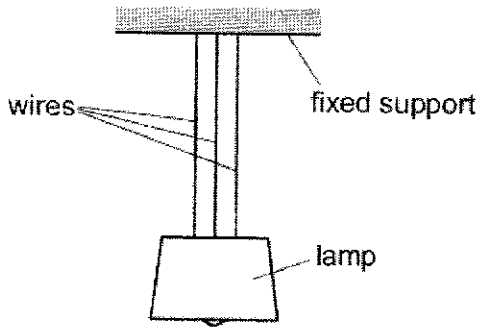
6 A uniform sphere of weight 15 N is placed in between two smooth planes as shown.



What is the magnitude of the force exerted by the vertical plane on the sphere?

A 0 N **B** 7.5 N **C** 8.7 N **D** 26 N

7 A lamp is suspended in equilibrium from a fixed support by three long identical wires.



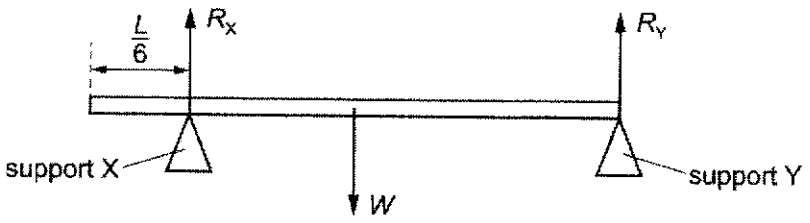
The weight of the lamp causes each wire to have an extension of 0.40 cm. The height h of the lamp above the floor is measured.

The middle wire suddenly breaks and the lamp falls a small distance as the extensions of the remaining two wires increase. The wires obey Hooke's law. When the lamp is in equilibrium, the height h of the lamp above the floor is measured again.

What is the difference between the two values of h?

A 0.20 cm **B** 0.27 cm **C** 0.40 cm **D** 0.60 cm

8 A uniform bar of length L and weight W rests horizontally on two supports X and Y.



Support X exerts a vertical force R_X from one end of the bar while support Y exerts a vertical force R_Y at the other end of the bar as shown.

The bar is in equilibrium.

What is the ratio $\frac{R_x}{R_y}$?

A $\frac{3}{2}$ **B** $\frac{2}{3}$ **C** $\frac{3}{5}$ **D** $\frac{2}{5}$

9 A car is driven from rest along a straight horizontal road. The car engine exerts a constant driving force. Friction and air resistance are negligible. How does the power developed by the engine change with the distance travelled?

A Power does not change

B Power decreases linearly

C Power increases linearly

D Power increases non-linearly

10 Two satellites, A and B, each of mass 14.6 kg, are launched into circular orbits about the Earth's center. Satellite A is to orbit at an altitude of 6370 km while satellite B is to orbit at an altitude of 14100 km.

Which satellite has the greater total energy?

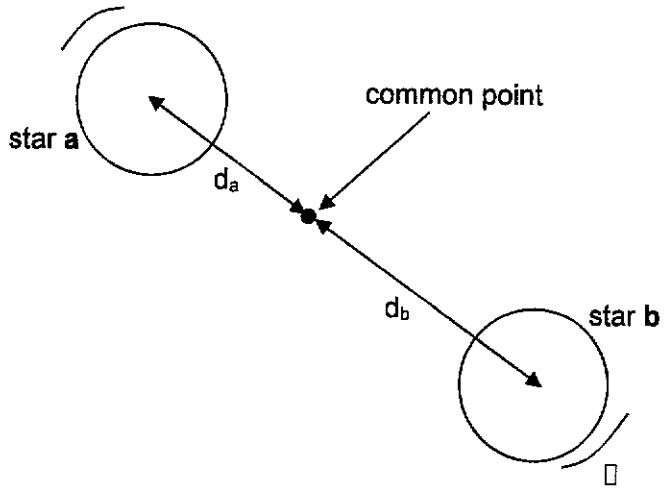
A Satellite A

B Satellite B

C Both satellites have the same total energy.

D There is not enough information to determine the total energy.

11 A binary star is a stellar system consisting of 2 stars of equal mass m orbiting around a common point, as shown below.



The distance between star **a** and the common point is d_a while the distance between star **b** and the common point is d_b.

Which of the following gives an expression for ω the angular velocity of star **b**?

A $\sqrt{\dfrac{Gm}{(d_a+d_b)^3}}$ **B** $\dfrac{1}{d_a+d_b}\sqrt{\dfrac{Gm}{d_a}}$ **C** $\sqrt{\dfrac{Gm}{d_b^3}}$ **D** $\dfrac{1}{d_a+d_b}\sqrt{\dfrac{Gm}{d_b}}$

12 A car tyre, initially at 25 °C, has been inflated to a pressure of 200 kPa as indicated by the pressure gauge. This means that the pressure in the tyre is 200 kPa above atmospheric pressure of 100 kPa.

After driving on hot roads, the temperature of the air in the tyre is 50 °C.

What is the percentage increase in the pressure gauge reading?

A 8.4 % **B** 12.5 % **C** 100 % **D** 150 %

13 The temperature of one mole of oxygen gas is the same as that of one mole of nitrogen gas. Assume both oxygen and nitrogen behave like ideal gases.

Which statement is correct?

A The gas molecules have the same root mean square speed.

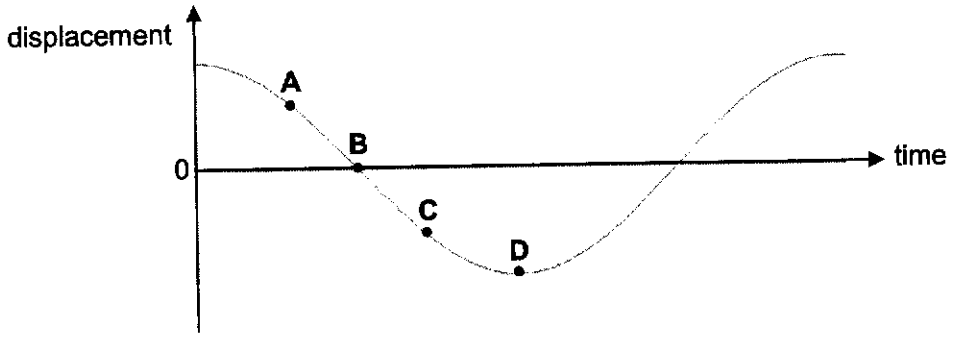
B The gas molecules have different mean translational kinetic energies.

C The total translational kinetic energy of each gas is the same.

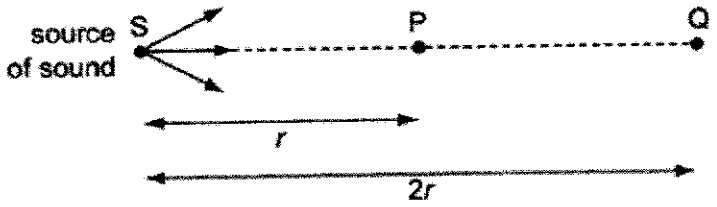
D The values of the product of volume and pressure of both gases are different.

14 The oscillations of a mass suspended on a spring are simple harmonic. The variation with time of the displacement of the mass is shown.

At which point is the mass travelling and accelerating in the same direction?



15 A point source S is emitting sound waves in all directions.



Air molecules at P, a distance r from S, oscillate with amplitude 8.0 μm. Point Q is situated a distance $2r$ from S.

What is the amplitude of oscillation of air molecules at Q?

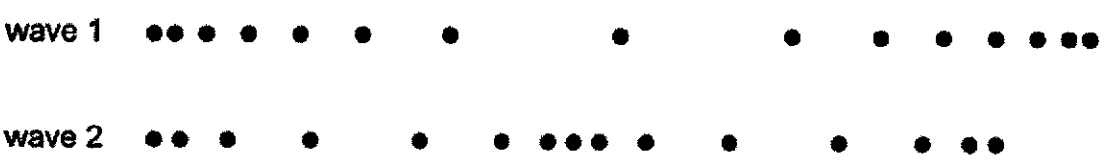
A 1.4 μm

B 2.0 μm

C 2.8 μm

D 4.0 μm

16 The diagram represents the concentration of molecules in two progressive sound waves in air.



Which statement can be deduced from this diagram?

A The amplitude of wave 1 is greater than the amplitude of wave 2.

B The frequency of wave 1 is greater than the frequency of wave 2.

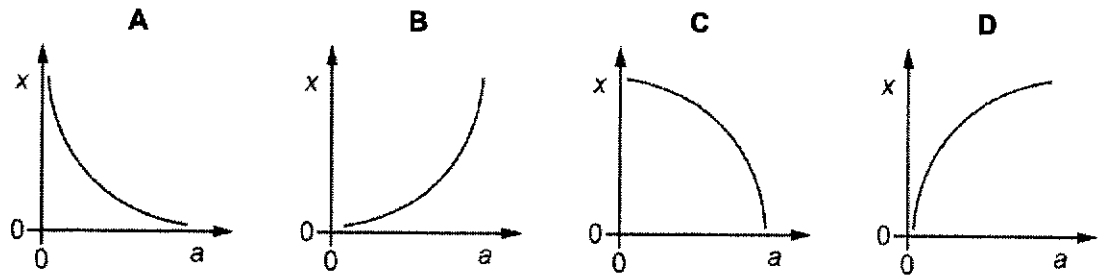
C The speed of wave 1 is greater than the speed of wave 2.

D Wave 1 and wave 2 are both polarized.

17 Light of a single wavelength is incident normally on a double slit. The slit separation can be varied.

A screen is placed a fixed distance away from the double slit. The screen and double slit are parallel. A pattern of bright interference fringes is observed on a screen.

Which graph best shows the variation of the separation x of the bright interference fringes with the slit separation *a*?



18 Which statement describe the electric potential difference across an electrical component?

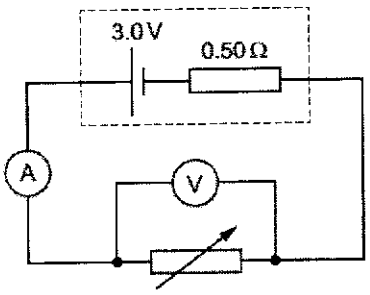
A Charge per unit time passing through the component.

B Energy transferred per unit charge.

C Force per unit charge.

D Resistance per unit current.

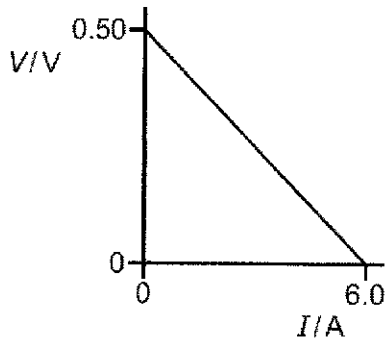
19 A cell of electromotive force (e.m.f.) 3.0 V and internal resistance 0.50 Ω is connected to a variable resistor, a voltmeter and an ammeter, as shown. The resistance of the variable resistor is varied.



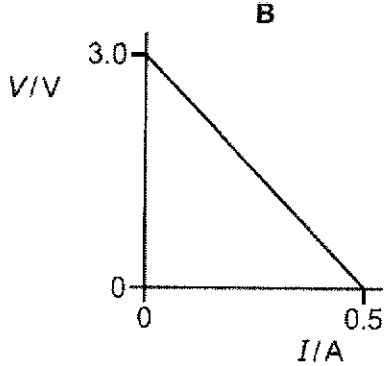
The reading on the ammeter I and the reading on the voltmeter V are recorded.

Which graph shows how V varies with I?

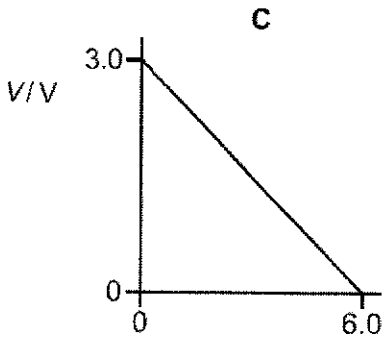
A



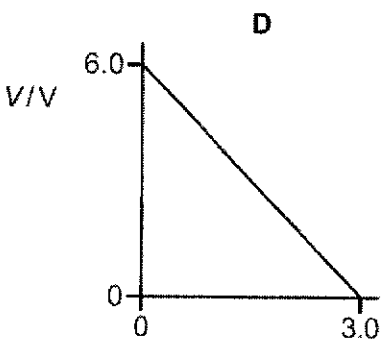
B



C

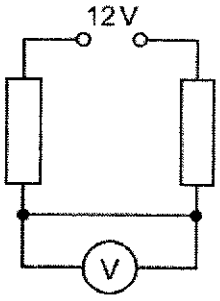


D

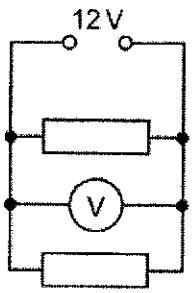


20 In which circuit does the voltmeter not read 12 V?

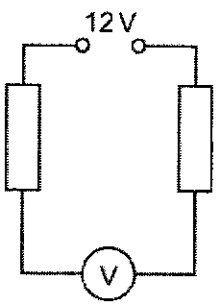
A



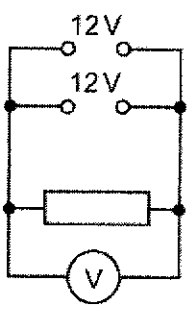
B



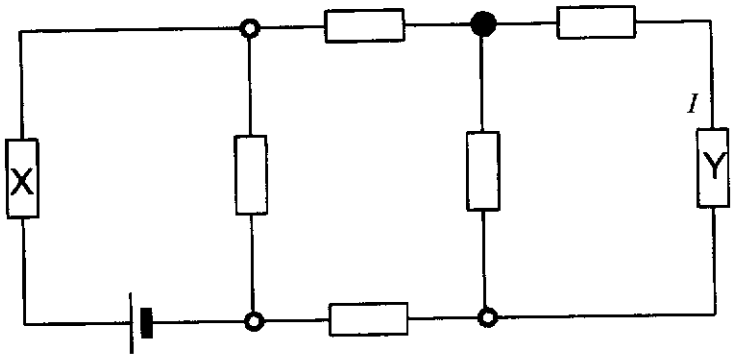
C



D



21 A battery of negligible internal resistance is connected to a network of identical resistors as shown.

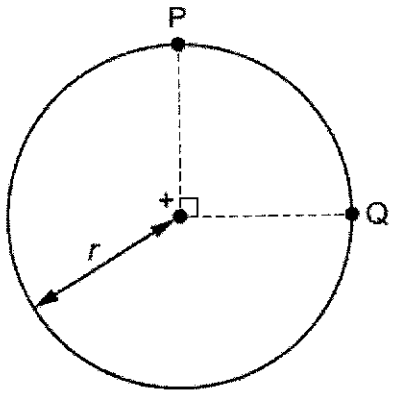


If the current in resistor Y is I, what is the current in resistor X?

A 19 I **B** 11 I **C** 7 I **D** I

22 The diagram shows two points P and Q which lie 90° apart on a circle of radius r.

A positive point charge at the centre of the circle creates an electric field of magnitude E at both P and Q.



Which expression gives the work done in moving a unit positive charge from P to Q?

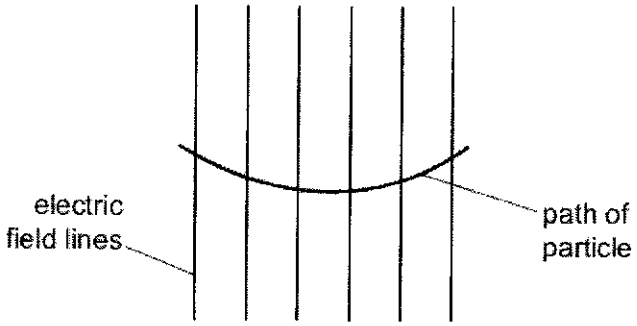
A 0

B $E \times r$

C $E \times (0.5\,\pi r)$

D $E \times (\pi r)$

23 The diagram shows the path of a charged particle through a uniform electric field, having vertical field lines.



What could give a path of this shape?

A a positive charge travelling left to right in a field directed downwards

B a positive charge travelling right to left in a field directed downwards

C a negative charge travelling right to left in a field directed upwards

D a negative charge travelling left to right in a field directed downwards

24 Three long wires W_1, W_2 and W_3 carrying the same current I are arranged in the configuration as shown below.

What is the direction of the resultant force acting on W_1?

A to the right

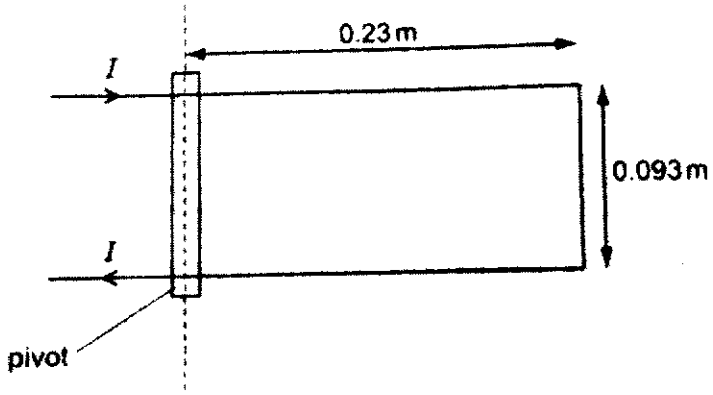
B to the left

C downwards

D upwards

25 In order to determine the value of a current I, it is passed into a current balance. This consists of a U-shaped wire placed in a constant magnetic field of flux density 3.6×10^{-2} T.

The U-shaped wire has length 0.23 m and the arms are 0.093 m apart, as shown in the diagram.



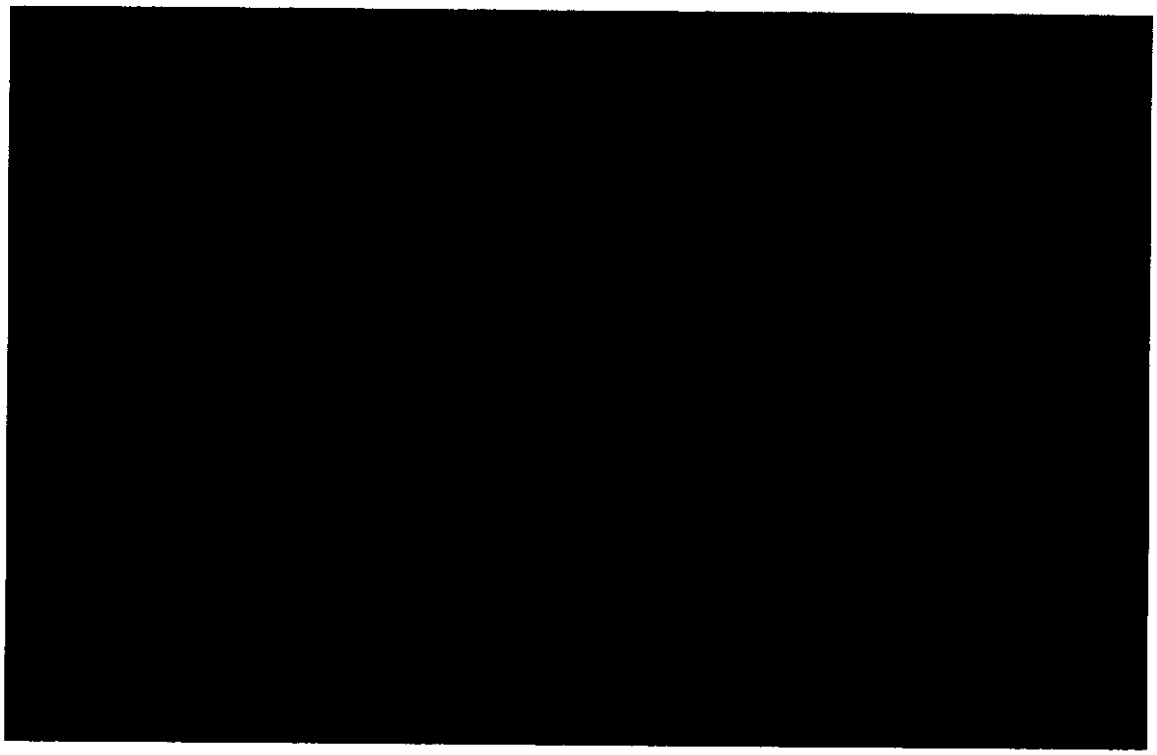
The U-shaped wire experiences a turning moment about the pivot of value 7.4×10^{-3} N m.

What is the value of I ?

A 0.044 A **B** 1.6 A **C** 2.8 A **D** 9.6 A

26 The figure shows a copper disc rotating steadily about its centre O in a uniform magnetic field between two bar magnets. The magnetic field is acting perpendicularly to the disc.

Which of the following graphs correctly shows the variation of the induced emf ε between the centre O and a point R on the rim of the disc with time t?



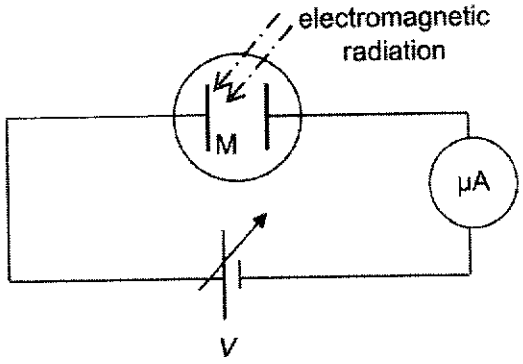
27 A steady current I dissipates a certain power in a variable resistor. When a sinusoidal alternating current is used, the variable resistor has to be reduced to one quarter of its initial value to obtain the same power.

What is the peak value of the alternating current?

A $\sqrt{2}I$ **B** $2I$ **C** $2\sqrt{2}I$ **D** $4\sqrt{2}I$

28 A 0.31 mW beam of electromagnetic radiation is incident on a clean metal plate M. Each photon of the electromagnetic radiation has energy 3.11 eV.

The potential difference V in the circuit is varied until the microammeter gives a maximum reading of 2.0 μA.



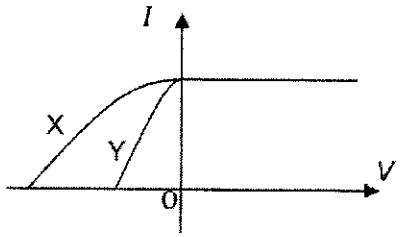
What is the ratio $\frac{number\ of\ electrons\ emitted\ per\ unit\ time}{number\ of\ photons\ incident\ per\ unit\ time}$?

A 3.2×10^{-21} **B** 2.0×10^{-2} **C** 1.0 **D** 1.3×10^{17}

29 In a photoelectric effect experiment, a metallic surface X in an evacuated tube is illuminated with light of wavelength 275 nm causing the emission of photoelectrons which are collected at an adjacent electrode.

The experiment is repeated by replacing metallic surface X by another metallic surface Y.

The variation of photocurrent I with the potential difference V between each of the metallic surfaces and the adjacent electrode is shown in the diagram below.



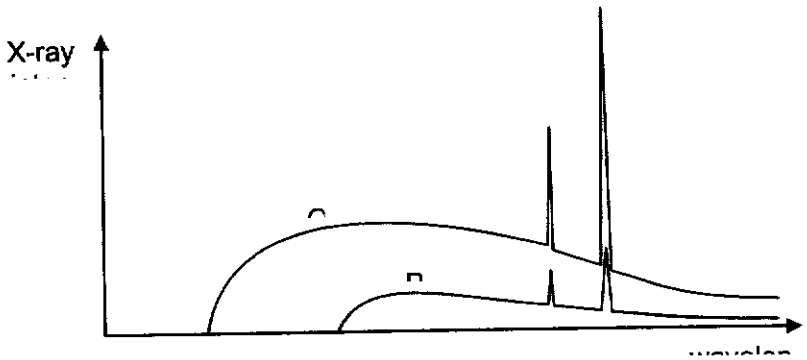
The table below lists the work functions of some elements.

Element	Work Function (eV)
Sodium	2.7
Aluminium	4.3
Copper	4.7

What materials are the metallic surfaces X and Y made of?

	metallic surface X	metallic surface Y
A	copper	copper
B	copper	aluminium
C	sodium	aluminium
D	sodium	copper

30 In the figure below, graph P shows an X-ray spectrum from an X-ray tube.



What are the possible changes that can be made to obtain graph Q?

A Increase the potential difference between the cathode and target.

B Reduce the distance between the cathode and the target.

C Increase the filament current of the cathode.

D Change the target metal.

[End of Paper]

JC2 Prelim (H2 Physics) Paper 1 Solutions

Qn	1	2	3	4	5	6	7	8	9	10
Ans	C	D	B	C	D	C	A	A	D	B
Qn	11	12	13	14	15	16	17	18	19	20
Ans	D	B	C	A	D	A	A	B	C	A
Qn	21	22	23	24	25	26	27	28	29	30
Ans	B	A	D	B	D	D	C	B	C	A

1 Ans: C

A and B are incorrect as the diameter is constant and thus it does not affect the random error.

D does not correct the error.

2 Ans: D

$s = 1/2\ at^2$

a = $2s/t^2$ = 0.14667 ms^{-2}

$$\Delta a/a = \Delta s/s + 2\,\Delta t/t$$
$$\Delta a/0.14667 = 0.1/16.5 + 2(1/15)$$
$$\Delta a/0.14667 = 0.13939$$

$\Delta a = 0.02044 = 0.02$ ms^{-2}
a = (0.14667 ± 0.02) = (0.15 ± 0.02) ms^{-2}

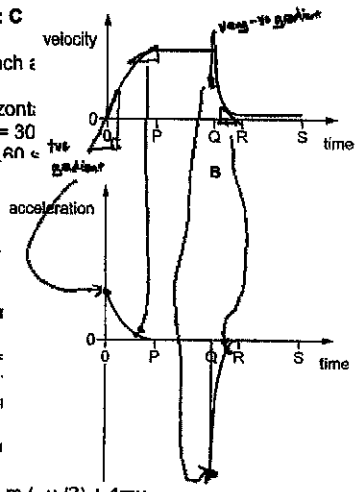
3 Ans: B

The gradient of the velocity-time graph is the acceleration.

4 Ans: C

Launch a

Horizont
170 = 30
t = 0.60 s



5 Ans:

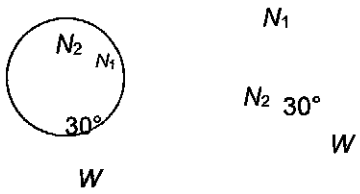
For n

KE_f =
½ m
v_m =

By C

mu = m (- u /2) + 4mv_{4m}
3u / 8 = v_{4m}

6 Ans: C



Resolving the forces,
$N_2 \sin 30 = N_1$ (1)
$N_2 \cos 30 = W$ (2)
$\frac{(1)}{(2)}$: $\tan 30 = \frac{N_1}{W}$
$N_1 = W \tan 30 = 15 \tan 30 = 8.66 = 8.7$ N (2s.f.)

(Alternative: Using vector triangle)
$N_1 = W \tan 30 = 15 \tan 30 = 8.66 = 8.7$ N (2s.f.)

7 Ans: A

Initially,
F = kx for each wire
1/3 W = kx (Weight of lamp W is shared equally by the 3 wires)
W = 3kx

Finally,
½ W = kx' (W is now shared equally by the 2 wires)
½ (3 kx) = kx'
x ' = 3/2 x

difference between h = x' – x = 3/2 x – x = 0.5 x = 0.5 (0.4 cm) = 0.20 cm

8 Ans: A

Ry(5L/6) = W(2L/6) ----- eq. 1
Rx(5L/6) = W(L/2) ----- eq. 2

$R_x / R_y = \frac{1}{2} \times \frac{6}{2} = 3/2$

9 Ans: D

At a velocity v, P = F_Dv

$F_D = F_{net} = ma$

$v^2 = u^2 + 2as$
$v^2 = 2as$

Thus P = ma(2as)$^{1/2}$ □ P increases non-linearly with s

10 Ans: B

The total energy of the satellite is given by $-\frac{GMm}{2r}$. The satellite that has a smaller negative value for its total energy has a greater total energy.

Thus, the satellite B which is further away (ie larger r) has a larger total energy.

11

D $\frac{Gm^2}{(d_a + d_b)^2} = m d_b \omega^2$

$\omega^2 = \frac{Gm}{d_b (d_a + d_b)^2}$

$\omega = \frac{1}{d_a + d_b} \sqrt{\frac{Gm}{d_b}}$

12 Ans: B

=

=

p_2 = 325000 Pa

Hence the gauge reading is 225 kPa.

Percentage increase is (225 – 200) / 200 x 100% = 12.5%

13 Ans: C

Option A and B: Wrong. For one molecule, $T \propto KE \propto \frac{1}{2} m \langle c^2 \rangle$. Since both have the same temperature, they have the same KE. But they have different mass thus different $\langle c^2 \rangle$

Option C: Since they have the same amount of gas molecules and the same temperature, their total KE = KE of 1 molecule x number of molecules are the same.

Option D: PV = nRT. Same T thus same PV.

14 Ans: A

velocity is given by the $v = ds/dt$ thus the gradient of the displacement- time graph
acceleration is given by $a = -\omega^2 x$ thus a is always opposite to x

Option A: negative velocity and negative acceleration (v and a same direction)
Option B: negative velocity and zero acceleration (v and a opp direction)
Option C: negative velocity and positive acceleration (v and a opp direction)
Option D: zero velocity and positive acceleration (v and a opposite direction)

15 Ans: D

$I \propto A^2$ and $I \propto 1/r^2$
Therefore, $A \propto 1/r$
Hence $A_Q/A_P = r/((2r))$
$A_Q = 1/2\ (8.0) = 4.0\ \mu m$

16 Ans: A

The diagrams are a snapshot in time and therefore can only give information about the comparative amplitude or wavelength at that point in time.

17 Ans: A

$x = \lambda D/a$
$x \propto 1/a$

18 Ans: B

V = Work done /Charge

19 Ans: C

$E = Ir + V$
$V = E - Ir$
$V = 3.0 - 0.50I$

Y -intercept = 3.0
Gradient = 0.50 = 3.0 / x- intercept
x -intercept = 3.0 / 0.50 = 6.0

20 Ans: A

Option A: V = 0 as voltmeter measuring the same potential across the two ends
Option B: V = 12 V as voltmeter is in parallel to 12 V battery
Option C: As V is placed in series with significant much higher resistance than the other resistors, it will take all the 12 V by potential divider
Option D: V = 12 V as voltmeter is in parallel to 12 V battery

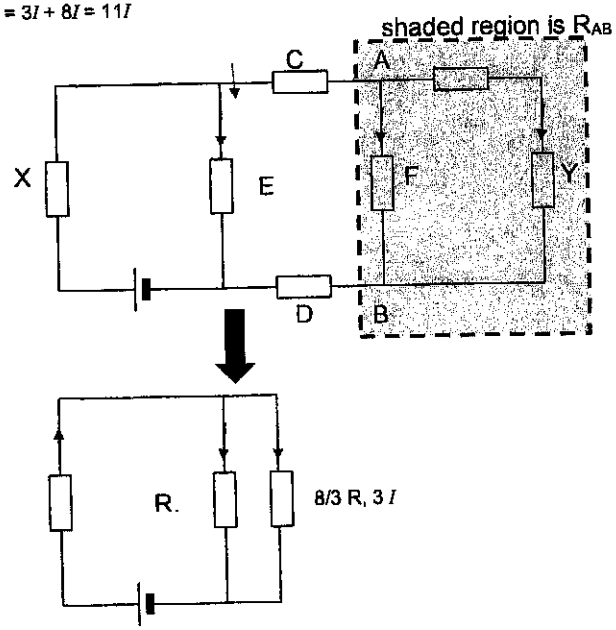
A significant number of candidates did not appear to understand that a voltmeter has a very high resistance and as a consequence selected option C.

21 Ans: B

If current in Y is I, then current in F is $2I$, so current in C is $3I$

Let the resistance of one resistor be R,
$R_{AB} = (1/1+1/2)^{-1}$ R = 2/3 R, so R_{C+AB+D} = 1 + 2/3 + 1 = 8/3 R

Since current in R_{C+AB+D} is $3I$, then current in E is $8I$
so current in X = $3I + 8I = 11I$



22 Ans: A

Potential at both P and Q = E x r

Change in potential moving from P to Q = 0

Thus work done = 0 J

23 Ans: D

D is the only option that gives the charge an upwards electric force that causes the charge to move in the parabolic motion displayed.

24 Ans: B

Current in W_1 is into the page.

Resultant B at W_1 is vertically downwards in plane of page by Rt Hand Grip rule (due to current in W_2 only. Since B field due to current in W_3 is parallel to the current in W_1, W_3 exerts no force on.)

By Fleming's Left hand rule, force on W_1 (due to W_2 only) is directed to the left.

25 Ans: D

Moment about pivot = Fd where d = 0.23 m, F = BILsin90°, L =0.093 m, B = 3.6×10^{-2} T

→ [BILsin90°] x d = 7.4×10^{-3}

→ I = (7.4×10^{-3}) ÷ [BLd]

= 9.6 A

26 Ans: D

Emf of rotating disc = $\pi r^2 fB$

= constant with respect to time

27 Ans: C

$$P = I^2R = I_{rms}^2 \frac{R}{4}$$

$$I_{rms} = 2I$$

$$\Rightarrow I_o = 2\sqrt{2}I$$

28 Ans: B

Electrons: I = dQ/dt = d (eN_e) / d t

□ dN_e/dt = I / e = $2.0 \times 10^{-6} / 1.6 \times 10^{-19}$

Photons: P = dE/ dt = d(N_p x energy of each photon) / dt

□ dN_p/dt = P / E = $0.31 \times 10^{-3} / 3.11 \times 1.6 \times 10^{-19}$

Ratio = 0.020

29 Ans: C

Photon of wavelength 275 nm has 4.52 eV of energy. Copper will not have any emission.

Sodium having the smallest work function will release photoelectrons with greatest kinetic energy.

Sodium will require the largest stopping voltage. The stopping voltage is the value of V such that the photocurrent I = 0 (x-intercept).

30 Ans: A

Increasing the p.d. will result in a smaller minimum wavelength as the electrons will have higher energy when they strike the metal target. The overall intensity will also increase as the chance of emitting X-ray photons will be higher due to the higher energy electrons striking the target.