Name:		Centre/Index Number:		Class:	

DUNMAN HIGH SCHOOL
Preliminary Examination
Year 6

H2 PHYSICS

9749/01

Paper 1 Multiple Choice

23 September 2024
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D.**
Choose the one you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **18** printed pages and **2** blank pages.

[Turn over

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_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}

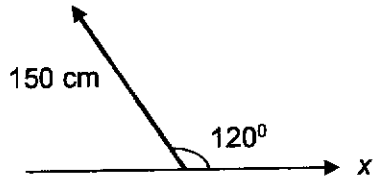
Formulae

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	=	ρgh
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	T/°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	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 Which expression could be correct for the velocity v of the ocean waves in terms of the density of sea water ρ, the acceleration of free fall g, the depth of the ocean h, and the wavelength λ?

A $\sqrt{g\lambda}$ **B** $\sqrt{\frac{g}{h}}$ **C** $\sqrt{\rho g h}$ **D** $\sqrt{\frac{g}{\rho}}$

2 A man pushing a mop across a floor causes it to undergo two displacements. The first has a magnitude of 150 cm and makes an angle of 120° with the positive x-axis as shown below. The resultant displacement has a magnitude of 140 cm and is directed at an angle of 30.0° to the positive x-axis. Both angles are measured anti-clockwise with respect to the positive x-axis.



What are the magnitude and direction of the second displacement?

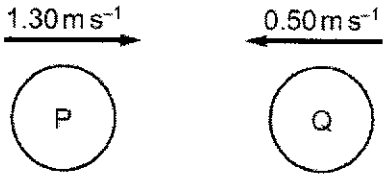
	magnitude / cm	angle to the positive x-axis / ^{0}
A	205	−17
B	205	17
C	290	−90
D	290	90

3 A car is travelling at a speed of 15 m s^{-1} and can be brought to rest with a uniform deceleration in 1.2 s if the brakes are applied. The reaction time of the driver is 0.10 s.

What is the closest distance that the moving car can be to a stationary object if a collision is to be avoided?

A 9.0 m **B** 10.5 m **C** 12.0 m **D** 19.5 m

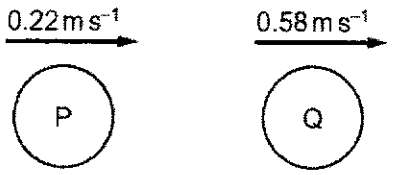
4 Two balls P and Q, of equal mass, move along a straight line directly towards each other as shown.



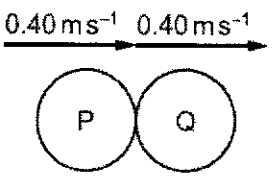
Ball P has velocity 1.30 m s^{-1} to the right. Ball Q has velocity 0.50 m s^{-1} to the left.
P and Q collide with one another. The collision is perfectly elastic and the total momentum is conserved.

Which diagram correctly shows the motion of P and Q after the collision?

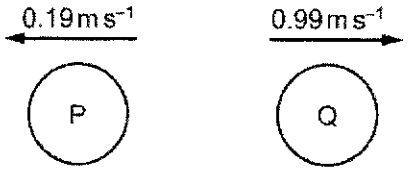
A



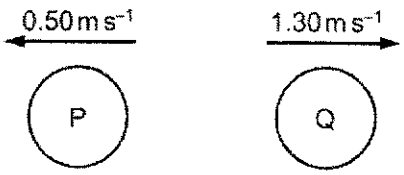
B



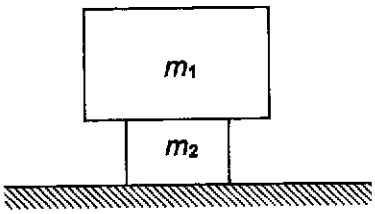
C



D



5 The figure shows a block of mass m_1 resting on a block of mass m_2 which is resting on a table. m_1 is larger than m_2.



Which of the following statements is correct?

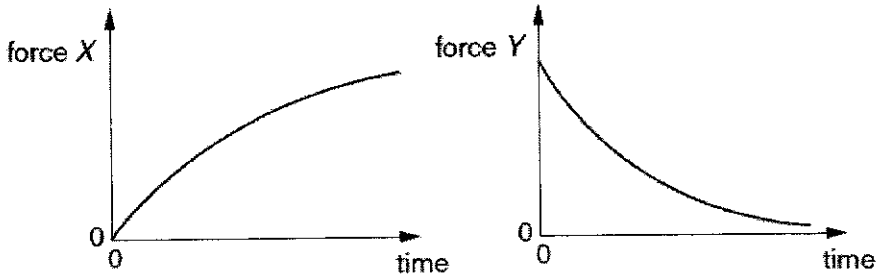
A The weight of m_1 and the force exerted on m_1 by m_2 form an action-reaction pair.

B The magnitude of the force exerted on m_1 by m_2 is equal to the magnitude of the force exerted on m_2 by m_1.

C The total force from the table on the bottom block depends on which block is placed below.

D The force exerted by m_1 on m_2 is larger if m_2 is now placed above m_1.

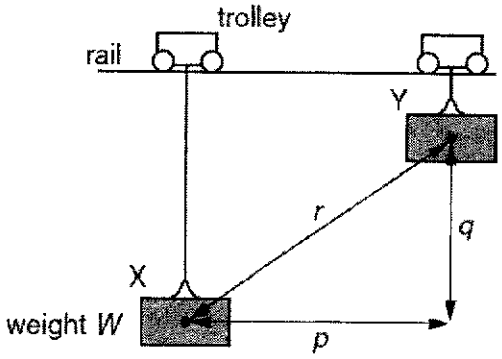
6 A ball falls from rest through air and eventually reaches a constant velocity. For this fall, forces X and Y vary with time as shown.



What are forces X and Y?

	force X	force Y
A	air resistance	resultant force
B	air resistance	weight
C	upthrust	resultant force
D	upthrust	weight

7 A weight W hangs from a trolley that runs along a rail. The trolley moves horizontally through a distance p and simultaneously raises the weight through a height q.



As a result, the weight moves through a distance r from X to Y. It starts and finishes at rest.

How much work is done on the weight during this process?

A Wp **B** $W(p + q)$ **C** Wq **D** Wr

8 An airplane has two jet engines. If each of the jet engines has an efficiency of 80%, what is the power input of each jet engine required to allow the airplane to fly with a thrust of 200 kN at a speed of 250 m s^{-1}?

A 25.0 MW **B** 31.3 MW **C** 62.5 MW **D** 140 MW

9 The minute hand of a large clock is 45 cm long.

What is its average angular velocity?

A 6.00 rad s^{-1}

B 1.05×10^{-1} rad s^{-1}

C 1.75×10^{-3} rad s^{-1}

D 5.24×10^{-3} rad s^{-1}

10 When a satellite is at its launch site on the Earth's surface, it is found to have a weight W.

When the satellite is placed in a circular orbit at a height $h = 6R$ above the Earth's surface, where R is the radius of the Earth, what is the gravitational force acting on the satellite?

A $\frac{W}{6}$ **B** $\frac{W}{7}$ **C** $\frac{W}{36}$ **D** $\frac{W}{49}$

11 Several satellites are in geostationary orbits around the Earth.

Which of the following quantities is not necessarily the same for all the satellites?

A angular velocity
B centripetal acceleration
C kinetic energy
D orbital period

12 In a mixture of 2 monatomic gases X and Y, the molecules of Y have twice the mass of those of X. The mixture is in thermal equilibrium and the molecules of Y have a mean translational kinetic energy of 6.0×10^{-21} J.

What is the mean translational kinetic energy of the molecules of X?

A 3.0×10^{-21} J **B** 4.2×10^{-21} J **C** 6.0×10^{-21} J **D** 8.5×10^{-21} J

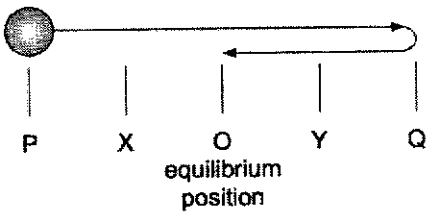
13 Heat is supplied at a constant rate to a liquid in a beaker. Just before it begins to boil, the temperature of the liquid was rising at 4.0 K per minute. All the liquid are boiled away after 40 minutes. The heat capacity of the beaker may be taken to be negligible.

What is the value of the ratio $\frac{\text{specific heat capacity}}{\text{specific latent heat of vaporisation}}$?

A $\frac{1}{10}\ \text{K}^{-1}$ **B** $\frac{1}{40}\ \text{K}^{-1}$ **C** $\frac{1}{160}\ \text{K}^{-1}$ **D** $\frac{1}{640}\ \text{K}^{-1}$

14. An object performs linear simple harmonic motion between P and Q.

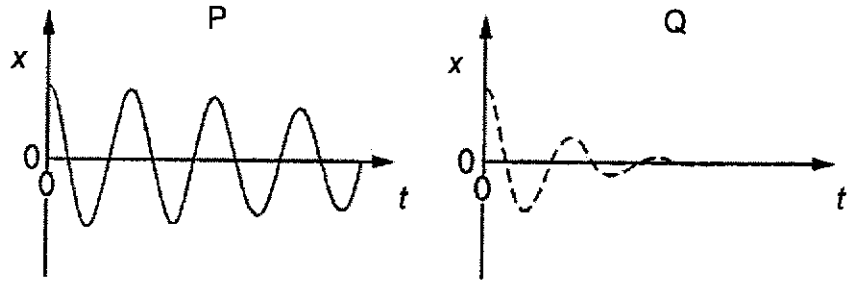
X and Y are the midpoints between the equilibrium position O with P and Q respectively as shown.



If the period of the oscillation is T, what is the minimum time required for the object to move from X to Q?

A $\frac{3T}{4}$ **B** $\frac{2T}{3}$ **C** $\frac{3T}{8}$ **D** $\frac{T}{3}$

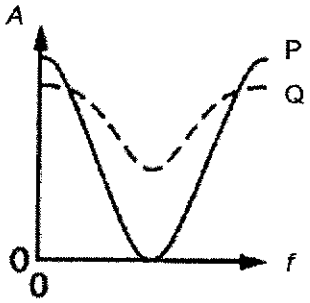
15. Two objects P and Q are given the same initial displacement and are then released. The graphs show the variation with time t of their displacement x.



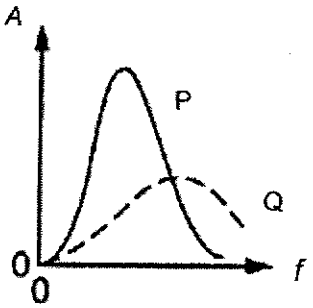
P and Q are then subjected to driving forces of the same constant amplitude and of variable frequency f.

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

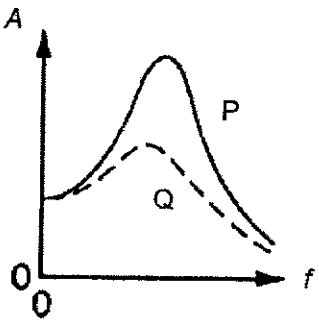
A



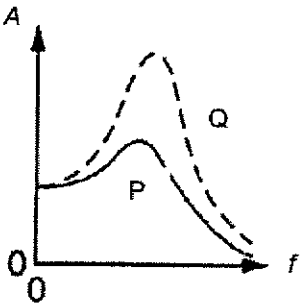
B



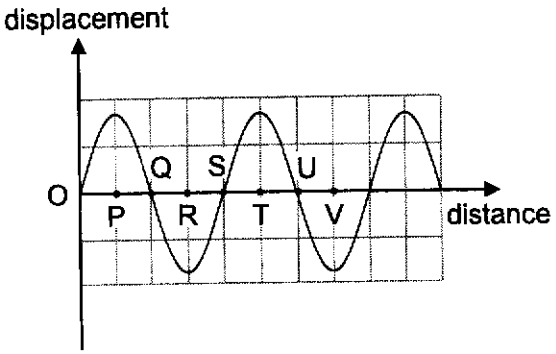
C



D



16 The figure below shows the variation of displacement with distance, of air molecules from source O in a longitudinal progressive wave at a particular instant. The displacement to the right is taken to be positive.



Which statement is correct?

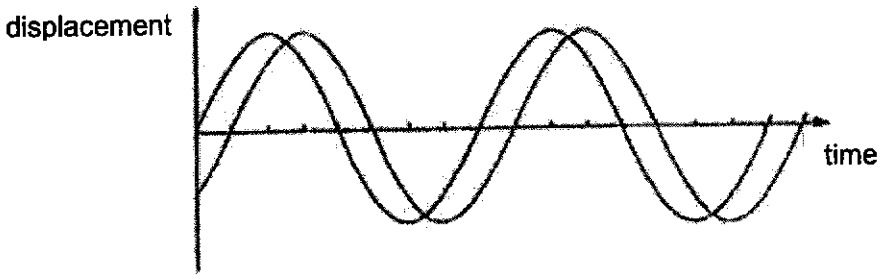
A Points P, Q, R, S, T, U and V are compressions.

B Points P, Q, R, S, T, U and V are rarefactions.

C Points Q and U are rarefactions and point S is a compression.

D Points Q and U are compressions and point S is a rarefaction.

17 The diagram shows two particles on the same wave.



What is the phase difference between the oscillations of the particles?

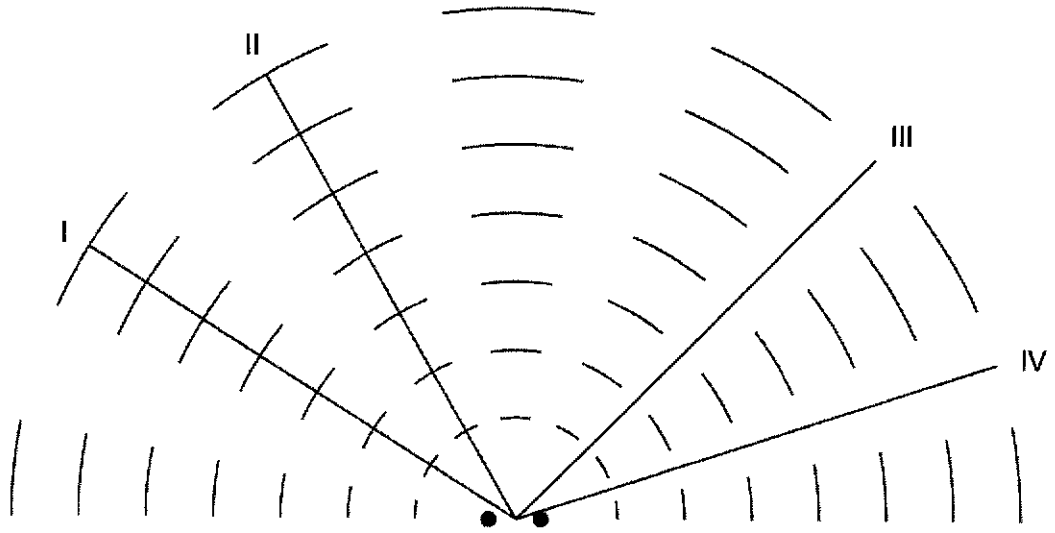
A $\frac{\pi}{4}$

B $\frac{\pi}{2}$

C $\frac{3\pi}{4}$

D $\frac{3\pi}{2}$

18 Two identical sources in a ripple tank generate waves of wavelength λ. The interfering waves produce the wave pattern shown below.



Along which of the labelled lines is the path difference between the waves from the sources equal to 1.5λ?

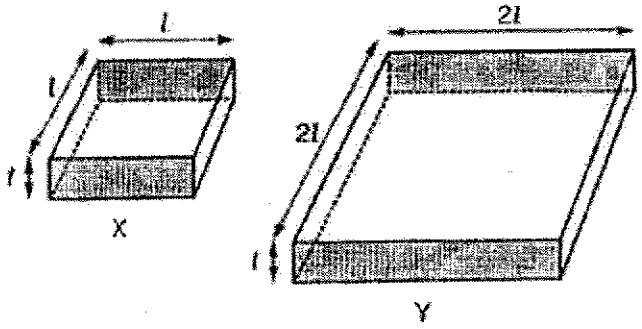
A I **B** II **C** III **D** IV

19 A pair of large horizontal conducting plates are separated by 4.0 mm. The lower plate is at a potential of −6.0 V. An electric field strength of 4000 V m^{-1} upwards exists in the space between the plates.

What is the potential applied to the upper plate?

A −22 V **B** −10 V **C** 10 V **D** 22 V

20 Two squares, X and Y, are cut from the same sheet of metal of thickness t. The lengths of the sides of X and Y are l and $2l$ respectively.



What is the ratio $\frac{R_X}{R_Y}$ of the resistances between the opposite shaded faces of X and of Y?

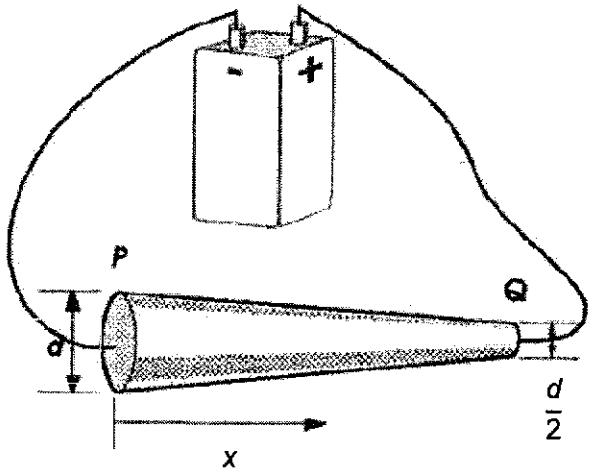
A $\frac{1}{4}$

B $\frac{1}{2}$

C $\frac{1}{1}$

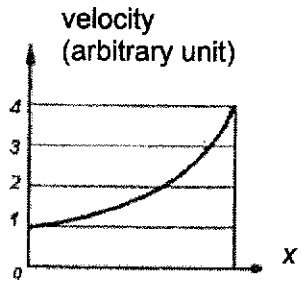
D $\frac{2}{1}$

21 A wire PQ tapers uniformly from P to Q with the diameter at P twice as large as that at Q. A potential difference is applied across the ends of the wire.

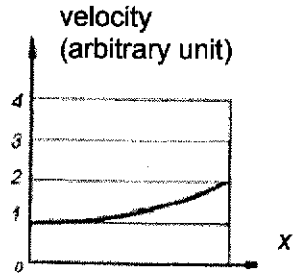


Which of the following graphs best represents the variation of the drift velocity of the conduction electrons with distance *x* from P?

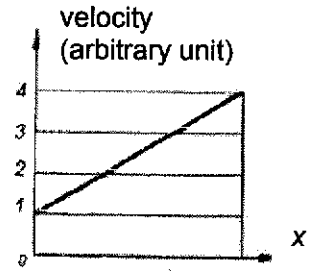
A



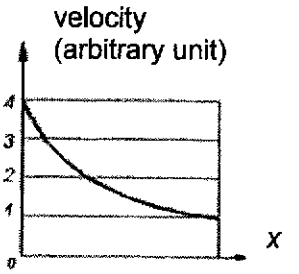
B



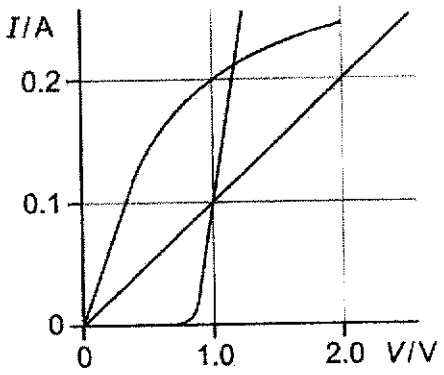
C



D



22 The graph shows the I-V characteristics of a diode, a filament lamp and a resistor, plotted on the same axes.



Which statement is correct?

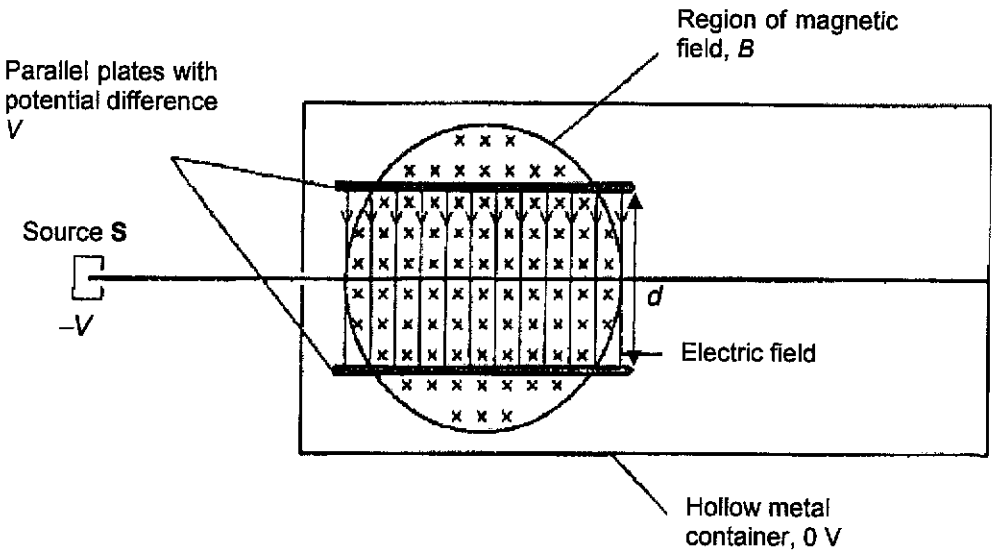
A The resistance of the filament lamp is twice that of the resistor at 1.0 V.

B The resistance of the diode is constant above 0.8 V.

C The resistance of the resistor equals that of the filament lamp when V = 0.8 V.

D The resistance of the diode equals that of the filament lamp at about 1.2 V.

23 A part of a mass spectrometer is shown in the figure below. Negative ions are generated at the source S, which is at a potential of $-V$ with respect to the hollow metal container. Inside the container, there are parallel plates separated by distance d and a uniform magnetic field B is applied to the region between the parallel plates.

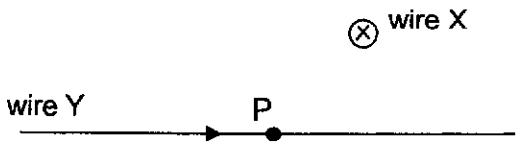


If the potential difference between the parallel plates is V, what is the charge to mass ratio of the ions that can pass through the fields undeflected?

A $\frac{V}{2B^2d^2}$ **B** $\frac{2V}{B^2d^2}$

C $\frac{2B^2d^2}{V}$ **D** $\frac{B^2d^2}{2V}$

24 Two long straight current carrying wires, X and Y are placed perpendicular to each other as shown in the diagram.



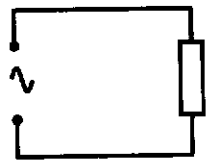
Current flows into the page in wire X and from left to right in wire Y.

What is the direction of the force acting on wire Y at point P due to the magnetic field produced by wire X?

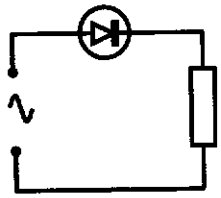
A into the page **B** out of the page

C towards wire X **D** away from wire X

25 The rate of heat dissipation of a resistor connected to an a.c. supply is P.



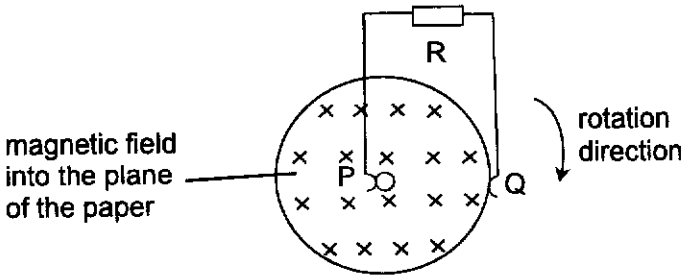
An ideal diode is then connected in series with the resistor.



What is the new rate of heat dissipation of the resistor?

A $\frac{P}{8}$ **B** $\frac{P}{4}$ **C** $\frac{P}{2}$ **D** P

26 In the following figure, a copper disc rotates uniformly between the pole-pieces of a magnet (not shown in figure) in a clockwise direction. P and Q are metallic brushes making contact with the axle and the edge of the disc respectively. R is a resistor connected between P and Q.



Which statement is correct?

A No current flows through R because P and Q are at the same horizontal level.

B No current flows through R because the disc is rotating uniformly.

C A steady current flow from P, through R, to Q.

D Q is at a higher potential compared to P.

27 When a beam of light of wavelength λ is incident normally on a plane mirror, it is reflected totally. The intensity of the light corresponds to a rate of n photons per second.

Which of the following expressions gives the force exerted on the mirror by the beam of light?

A $nh\lambda$ **B** $\frac{nh}{\lambda}$ **C** $2nh\lambda$ **D** $\frac{2nh}{\lambda}$

28 The metal cathode of a photocell is illuminated by light quanta of energy 3.5×10^{-19} J each. By applying a stopping potential of 0.25 V, the current through the cell is just reduced to zero.

What is the work function of the metal cathode?

A 2.9×10^{-19} J **B** 3.1×10^{-19} J **C** 3.5×10^{-19} J **D** 3.9×10^{-19} J

29 The photoelectric effect refers to the phenomenon that electrons may be ejected from a metal surface when light falls on the surface.

Which of the following statements about the photoelectric effect is correct?

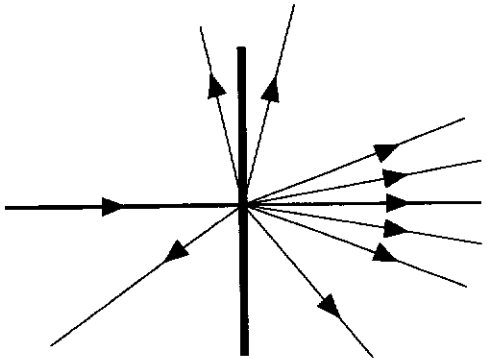
A The maximum energy of the electrons is independent of the type of metal.

B The maximum energy of the electrons is independent of the intensity of the incident light.

C The waves associated with the electrons have the same wavelength as the incident light.

D Electrons are ejected only if the wavelength of the incident light is greater than some minimum value.

30 The given diagram illustrates a thin gold foil being bombarded with α-particles.



What is the information provided by the results of this experiment?

A Size of a gold nucleus

B Structure of a gold nucleus

C Binding energy of a gold nucleus

D Energy levels of electrons in gold atoms

BLANK PAGE

BLANK PAGE

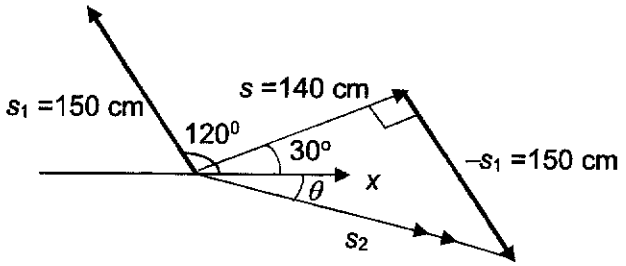
2024 DHS H2 Physics Prelim Paper 1 Suggested Solutions

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
A	**A**	**B**	**D**	**B**	**A**	**C**	**B**	**C**	**D**
Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20
C	**C**	**C**	**D**	**C**	**D**	**A**	**C**	**A**	**C**
Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30
A	**D**	**A**	**B**	**C**	**D**	**D**	**B**	**B**	**A**

1 **A** By dimensional analysis,

Units of $\sqrt{g\lambda} = \sqrt{\text{m}^2\,\text{s}^{-2}}$ = $\text{m}\,\text{s}^{-1}$

2 **A**



$s_2 = s - s_1$

By Pythagoras theorem, s_2 = $\sqrt{140^2 + 150^2}$ = 205 cm

$\tan\theta = \dfrac{150}{140}$ or $\theta = 47°$

Hence $\theta = -17°$ anti-clockwise with respect to positive x-axis

3 **B** $a = (v - u)/t = (0 - 15)/1.2 = -12.5\ \text{m s}^{-2}$

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

$0^2 = 15^2 + 2(-12.5)s$

$s = 9.0$ m

Closest distance = 9.0 + 15(0.10) = 10.5 m

4 **D** For a (perfectly) elastic collision between two bodies, the relative speed of approach is equal to the relative speed of separation.

relative speed of P approaching Q	Option	relative speed of Q separating from P	equal ?
$(1.30)-(-0.50)$ $=1.80\ \text{m s}^{-1}$	**A**	$(0.58)-(0.22)=0.36\ \text{m s}^{-1}$	×
	B	$(0.40)-(0.40)=0.00\ \text{m s}^{-1}$	×
	C	$(0.99)-(-0.19)=1.18\ \text{m s}^{-1}$	×
	D	$(1.30)-(-0.50)=1.80\ \text{m s}^{-1}$	✓

5 **B** By Newton's Third Law of Motion,
the magnitude of the force exerted on m_1 by m_2 is equal to the magnitude of the force exerted on m_2 by m_1.

6 **A** Air resistance increases proportionately with speed.
Resultant force = Weight – Air resistance

7 **C** Work done by a constant force on an object is defined as the product of the force and its displacement in the direction of the force.

8 **B** (0.5 x power output/power input) = 0.80

(0.5 x 200 000 x 250/power input) = 0.80

Power input = 31.3 MW

9 **C** Period, $T = 60\ x\ 60\ \text{s}$

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{60 \times 60} = 1.75 \times 10^{-3}\ \text{rad s}^{-1}$$

10 **D** At the Earth's surface: $W = \dfrac{GMm}{R^2}$

At orbit: $F = \dfrac{GMm}{(R+6R)^2} = \dfrac{1}{49}\left(\dfrac{GMm}{R^2}\right) = \dfrac{W}{49}$

11 **C** For geostationary satellites, all satellites orbit the Earth at a fixed distance from the Earth, r, and the orbital period T is the same as Earth's rotation of 24 hours. Hence, all geostationary satellites also have the same angular velocity by $\omega = \frac{2\pi}{T}$ **(options A and D are eliminated)**

For a satellite, the gravitational force F_G provides the centripetal force. Therefore,

$$\frac{GMm}{r^2} = mr\omega^2$$

$$\frac{GM}{r^2} = r\omega^2 = g$$

Therefore, the centripetal acceleration which is dependent on the radius and orbital period is the same for geostationary satellites. **(Option B is eliminated)**

Even though the speed of the satellites are the same, as given by the equation $v = r\omega$, the mass of the satellites may be different. So by $KE = \frac{1}{2}mv^2$, the kinetic energy of the satellites may be different. **(Option C is the answer)**

12 **C** Since the mixture is in thermal equilibrium, gases X and Y have the same temperature. Since $T \propto KE_{avg}$, the average kinetic energy of gases X and Y are the same.
Therefore, the average kinetic energy of molecules of X is 6.0×10^{-21} J.

13 **C** Let Q be the heat supplied to the liquid per minute,

Considering the heat capacity of the liquid: $Q = mc\Delta T = mc(4)$

Considering the latent heat of the liquid: $Q(40) = mL$

Therefore, $$\frac{c}{L} = \frac{\left(\frac{Q}{4m}\right)}{\left(\frac{40Q}{m}\right)} = \frac{1}{160}\ \mathrm{K}^{-1}$$

14 **D** The time required for the object to move from P to Q, half a complete oscillation, is half a period, $\frac{T}{2}$. Thus, **A** and **B** are eliminated since the options are more than $\frac{T}{2}$.

Consider the time taken t required for the object in Simple Harmonic Motion (SHM) with amplitude A to move from P to X, thus

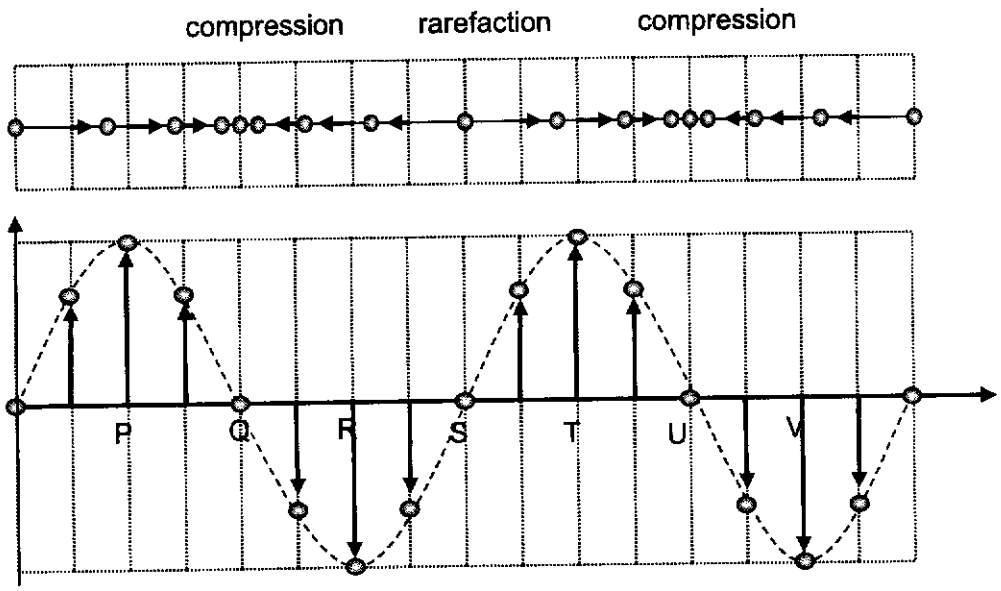
$$\frac{A}{2} = A\cos\left(\frac{2\pi}{T}t\right) \rightarrow t = \frac{T}{6}$$

and the required answer is given by

$$\frac{T}{2} - \frac{T}{6} = \frac{T}{3}$$

15 **C** Object Q experiences more damping. Hence amplitude of Q is smaller. The graphs do not pass through the origin, so B is wrong, leaving C as correct answer.

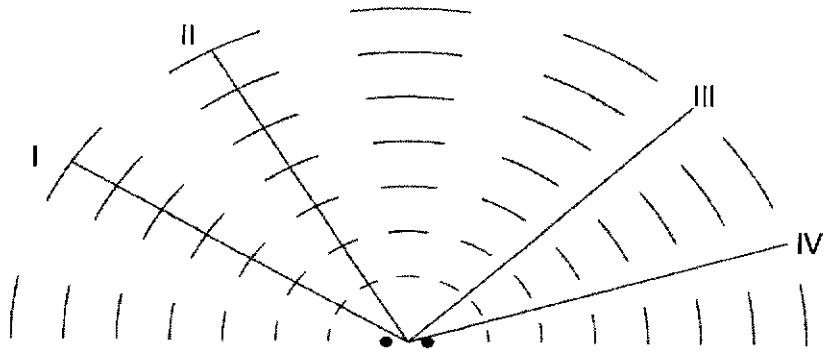
16 **D**



17 **A** Using $\frac{x}{\lambda} = \frac{\theta}{2\pi}$,

$$\frac{1}{8} = \frac{\theta}{2\pi} \rightarrow \theta = \frac{\pi}{4}$$

18 **C**



Constructive interference occurs at I, II while destructive interference occurs at III, IV.
Since sources are in phase,
path difference = λ and 2λ at II and I respectively,
path difference = 1.5λ and 2.5λ at III and IV respectively.

19 **A** An electric field strength upwards means that the lower plate is at a higher potential than the upper plate **(Options C and D are eliminated)**

$$E = \frac{|\Delta V|}{d}$$

$$(V_{lower} - V_{upper}) = Ed$$

$$-6 - V_{upper} = 4000(4 \times 10^{-3}) = 16$$

$$V_{upper} = -22 \text{ V}$$

20 **C**

For X, $R_X = \frac{\rho L}{A} = \frac{\rho l}{l^2}$

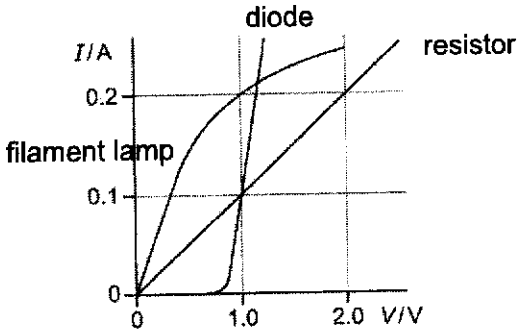
For Y, $R_Y = \frac{\rho L}{A} = \frac{2\rho l}{2l^2} = R_X$

21 **A** $I = nAve$

$$v = \frac{I}{nAe} = \frac{I}{ne\pi\frac{d^2}{4}} = \frac{4I}{ne\pi d^2}$$

Since I, n and e are constants, as x increases, d decreases and v increases.
The graph is non-linear as v is not linearly related to d.

22 **D**



$R = \frac{V}{I}$

for resistor, resistance = 10 Ω (constant)
for filament lamp, resistance = 5.0 Ω at 1.0 V
At about 1.2 V, the graphs for diode and filament lamp intersects and they both have the same I, V values and hence same resistance.

23 **A** Before the negative ions of mass m and charge q enter the metal container, its velocity v is found from the following:

$$qV = \frac{1}{2}mv^2 \qquad \text{or} \qquad v = \sqrt{\frac{2qV}{m}}$$

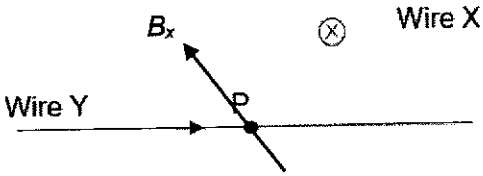
For the ions to travel undeflected,
electric force qE = magnetic force Bqv

$$q\left(\frac{V}{d}\right) = Bq\left(\sqrt{\frac{2qV}{m}}\right.$$

$$\frac{V}{Bd} = \sqrt{\frac{2qV}{m}}$$

$$\frac{q}{m} = \frac{V}{2B^2d^2}$$

24 **B**



Direction of magnetic field produced by wire X at point P is as shown.
Using Fleming left hand rule to determine force on wire Y, where the vertical component of B_x is upwards in the plane of the paper.

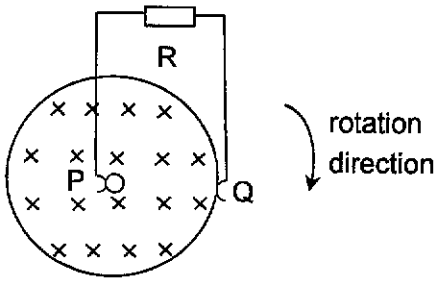
25 **C**

rate of heat dissipation $P = I_{rms}^2 R = \frac{I_o^2}{2} R$

for half-rectified wave, $I_{rms} = \frac{I_o}{2}$

so rate of heat dissipation $P_{new} = I_{rms}^2 R = \frac{I_o^2}{4} R = \frac{P}{2}$

26 **D**



From Fleming left hand rule, electrons at Q will experience a force towards O. Hence Q is at higher potential than P or an induced current will flow from Q to P.

27 **D** Using the de Broglie's relation, the magnitude of the momentum of a photon of wavelength λ is $p = \frac{h}{\lambda}$.

From Newton's 2nd law, the force exerted by 1 photon upon reflection off the mirror is

$$F = \frac{dp}{dt} = \frac{\Delta p}{t} = \frac{2h}{\lambda}$$

For n photons: $F = \frac{2nh}{\lambda}$

28 **B**

$$E_{photon} = \phi + eV_s$$
$$3.5 \times 10^{-19} = \phi + 1.6 \times 10^{-19}(0.25)$$
$$\phi = 3.1 \times 10^{-19} \text{ J}$$

29 **B** From $\frac{hc}{\lambda} = \phi + KE_{max}$:

As the intensity of light affects the number of photons incident on the metal rather than the energy carried by each photon, $\frac{hc}{\lambda}$, the maximum KE of an electron is independent of the intensity.

30 **A** The diagram shows that most of the alpha particles passed through the gold foil undeflected or deflected by small angles.

This indicates that the size of the nucleus relative to the size of the atom is small, as most alpha particles interacting with the gold atoms were not close enough to the nucleus to experience significant electrical repulson and hence, were only deflected by small angles or remain undeflected.

~ THE END ~