NAME: ______SOLUTIONS__________ CLASS: ___________ INDEX: __________

CATHOLIC JUNIOR COLLEGE
JC2 Preliminary EXAMINATIONS
Higher 1

PHYSICS

Paper 1

8866/01
1 September 2015
60 min

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, tutorial group and index number on this cover page.

Write and/or shade your name, NRIC / FIN number and HT group on the Answer Sheet (OMR sheet), unless this has been done for you.
Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.

There are a total of **30 Multiple Choice Questions (MCQs)** 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 Answer Sheet (OMR sheet) provided.

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.
Calculators may be used.

[Turn Over]

PHYSICS DATA:

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
acceleration of free fall,	g	=	9.81 m s^{-2}

PHYSICS 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	=	$\rho\,g\,h$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots$

1	Estimate the time taken for a laser beam to travel from a laser gun at the grandstand to the goalkeeper.						
	A	3 ns	**B**	300 ns	**C**	3 ps	**D**	300 ps

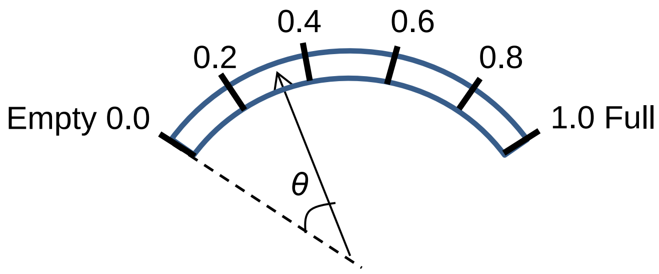
Answer: B

Estimate distance = 100 m

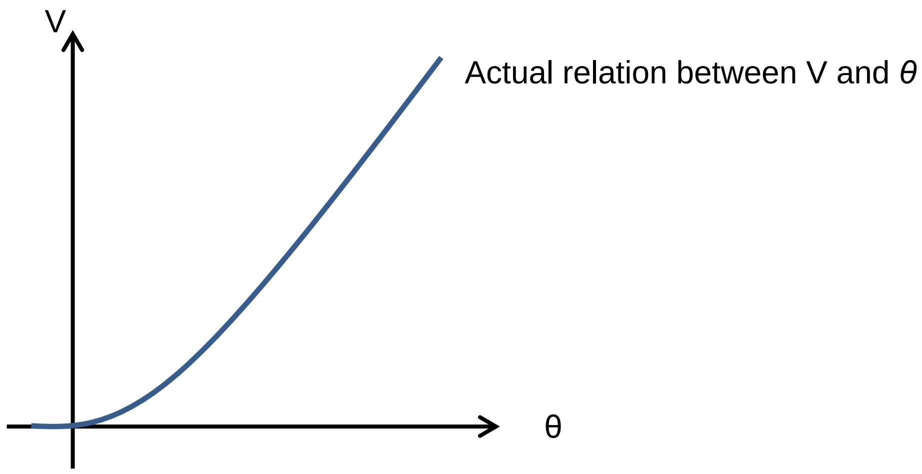
Speed = 3×10^8 m s^{-1}

time = distance / speed = $100 / 3 \times 10^8 = 3 \times 10^{-7}$ = 300×10^{-9} = 300 ns

2 A petrol gauge in a car indicates the volume *V* of fuel in the tank. *V* is given by the angular deflection *θ* of the pointer on a dial such hat the scale is linear.



The graph below shows the actual variation of the volume *V* of fuel with the angular deflection *θ.*



Which of the following statements are **not** correct?

P: The petrol gauge is most sensitive when the tank has low fuel level.
Q: The petrol gauge is most sensitive when the tank has high fuel level.
R: The readings of V from the scale results in a random error.
S: The readings of V from the scale results in a systematic error

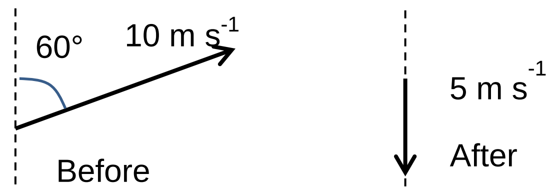
	A	P & R	**B**	P & S	**C**	Q & R	**D**	Q & S

Answer: C

Low fuel level the gauge is sensitive because the change in angle is larger per unit change in volume

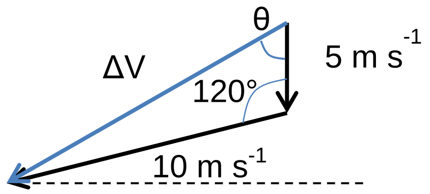
The volume recorded is always larger than the actual volume, hence there is a systematic error in the reading.

3 Figure below shows the movement of a vehicle. It is initially moving at 10 m s^{-1} with a bearing of 60° and after 2 seconds it moves in the bearing of 180^o at 5 m s^{-1}.



What is the direction and magnitude of the change in velocity?

	Direction	Magnitude/ m s^{-1}
A	180°	5.0
B	90°	8.7
C	123°	11
D	221°	13



By scale drawing and measurement
ΔV = 13 m s^{-1}
Direction = 220^o

By calculation:
By cosine rule,
$(\Delta V)^2 = 10^2 + 5^2 - 2\,(10)(5)\cos(120°)$
$\Delta V = \sqrt{175} = 13.2$ m s^{-1}

By sine rule,

$$\frac{13.2}{\sin 120°} = \frac{10}{\sin\theta}$$

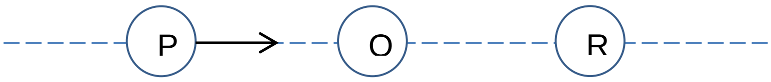
θ = 41°
Hence the bearing is 180 + 41 = 221°

4	A ball, dropped from a building, is timed to take (4.5 ± 0.1) s to fall to the ground. If the acceleration of free fall is taken to be 10 m s^{-2}, the calculated height of the building should be quoted as	
	A	(101 ± 2) m
	B	(101 ± 5) m
	C	(101.3 ± 2.3) m
	D	(101.3 ± 4.5) m
		Ans B $H = ut + ½ at^2 = 0 + ½ (10)(4.5)^2 = 101.3$ m $\Delta H/H = \Delta a/a + 2\Delta t/t$ $\Delta H/101.3 = 0 + 2 \times (0.1 /4.5)$ ➔ $\Delta H = 4.5 = 5$ m s^{-1} (1 sf) H = (101 ± 5) m

5	A body is thrown vertically upwards in a medium in which the viscous drag cannot be neglected. If the times of flight for the upward motion t_u and the downward motion t_d (to return to the same level) are compared, then	
	A	$t_d < t_u$, because the average speed is smaller its downward motion as compared to its upwards motion.
	B	$t_d < t_u$, because the net accelerating force when the body is moving downwards is greater than the net decelerating force when it is moving upwards
	C	$t_d > t_u$, because the viscous force is greater in the downward motion as compared to its upwards motion.
	D	$t_d > t_u$, because the net accelerating force when the body is moving downwards is smaller than the net decelerating force when it is moving upwards.
	Answer: D **For the upward motion, viscous drag and gravitational force are both acting downwards,** **net force = gravitational force + viscous drag** **net deceleration = (gravitational force + viscous drag)/mass** **For the downward motion, viscous drag and gravitational force are in opposite direction and the net acceleration force = gravitational force - viscous drag.** **net acceleration = (gravitational force - viscous drag)/mass** **Comparing the acceleration in downwards motion is less than the deceleration during the upwards motion,** **hence $t_d > t_u$,**	

6	When a man is standing in an ascending lift that has a constant upward acceleration, the magnitude of the force exerted on the man's feet by the floor is always	
	A	equal to the magnitude of his weight.
	B	less than the magnitude of his weight.
	C	greater than the magnitude of his weight.
	D	greater than his weight only when the acceleration is greater than g.
		Ans C Let N : normal upwards force; W = weight of man ; M: mass of man Net upwards force = N – W Using N2LM "F=ma" N-W = Ma N = W + Ma ➔ N > W

7 Three identical stationary discs, P, Q and R are placed in a line on a horizontal, flat and frictionless surface. Disc P is projected straight towards disc Q.



If all consequent collisions are perfectly elastic, what will be the final motion of the three spheres?

		P		**Q**		**R**		
	A	stationary		stationary		moving right		
	B	moving left		moving left		moving right		
	C	moving left		stationary		moving right		
	D	moving right		moving right		stationary		

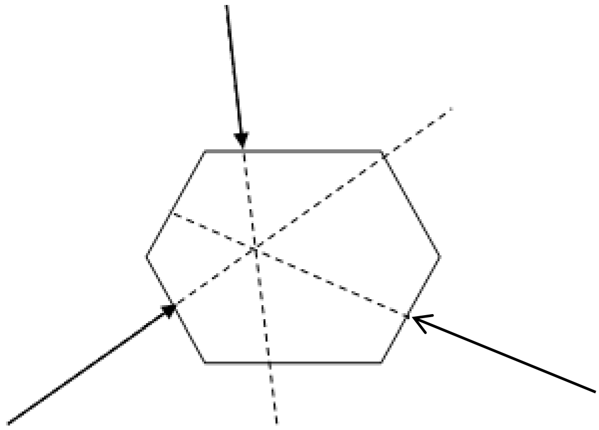
Answer: A

Consider the collision between P and Q,
After collision, P stops and Q move with speed of P
Reason:

By conservation of momentum,
$m_1u_1 = m_1v_1 + m_2v_2$ ➔ $u_1 = v_1 + v_2$
Since the collision is elastic, ➔ $u_1 – u_2 = v_2 – v_1$
Solving simultaneously, $v_1 = 0$ **and** $v_2 = u_1$

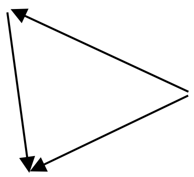
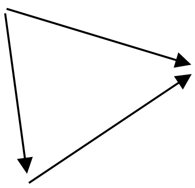
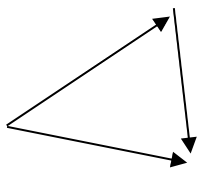
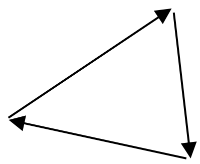
Similarly, when Q collide with R, Q stops and R move with speed of Q

8 Three forces act on different parts of a rigid body as shown in the diagram below. Which of the following vector diagram represents the body in equilibrium?



Answer: D

In equilibrium, the vectors form a closed vector triangle with their directions in the same sense.

A		**B**		**C**		**D**	

9 A smooth uniform rod of mass 30 g rests on the rim of a smooth, hemispherical bowl as shown in the diagram below (drawn to scale). What is the magnitude of the normal contact force by the rim of the bowl on the rod?

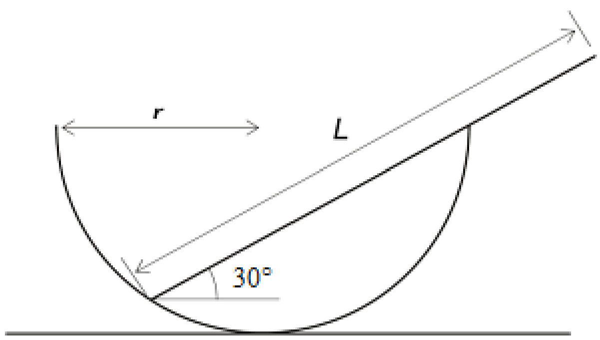
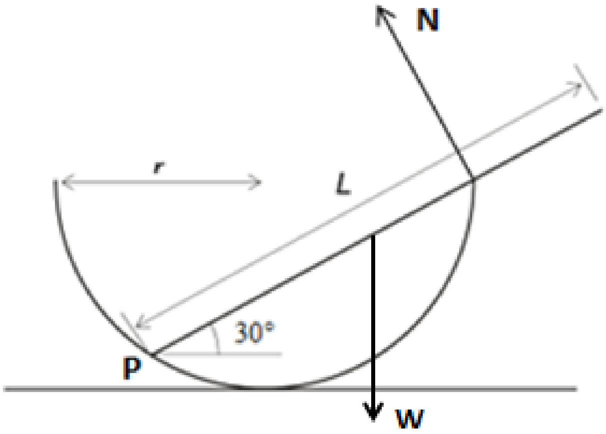


Diagram is drawn to scale

	A	0.4 W	**B**	0.6 W	**C**	0.9 W	**D**	W

Answer B

By the principle of moments,



Taking P as the pivot,

The total sum of clockwise moments = the total sum of the anticlockwise moments.

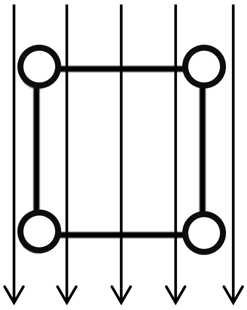
W x perpendicular distance of W from P = N x perpendicular distance of N from P

By measurement,
perpendicular distance of W from P = 2.9 cm
perpendicular distance of N from P = 4.8 cm

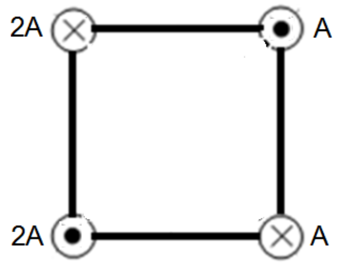
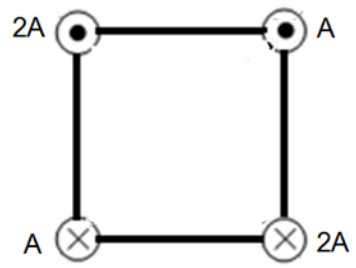
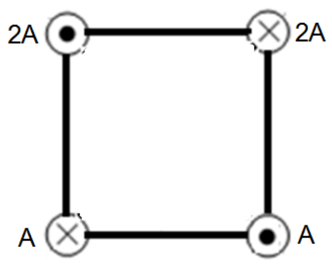
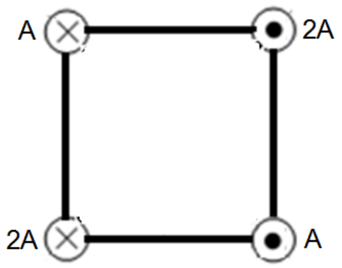
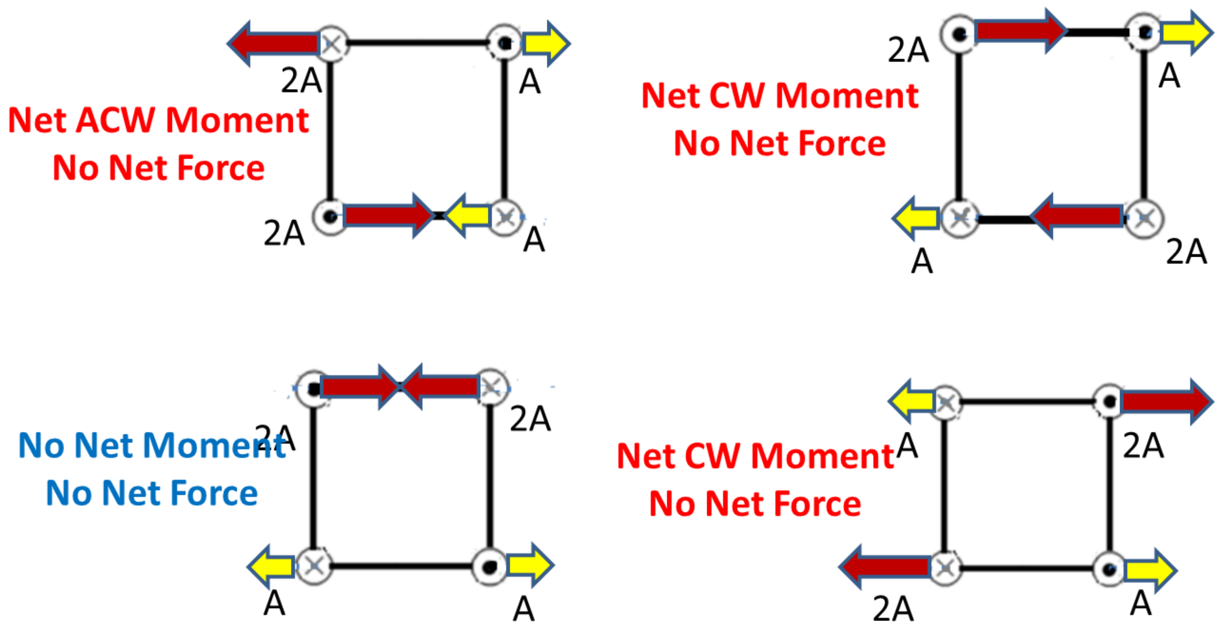
W x 2.9 = N x 4.8
N = 0.6 W

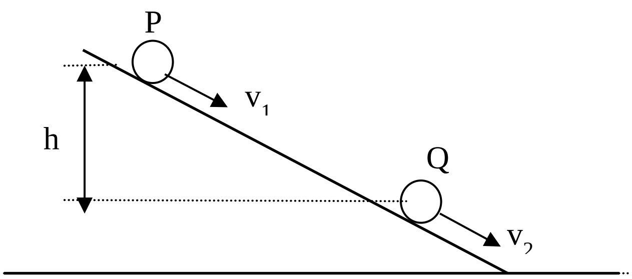
10	Four long straight vertical wires carry currents are attached to the corners of a rigid square. A uniform magnetic field is applied in the direction as shown. Which of the following configurations is in equilibrium?

Top view



uniform magnetic field

	A		**B**	
	C		**D**	
	Answer: C 			

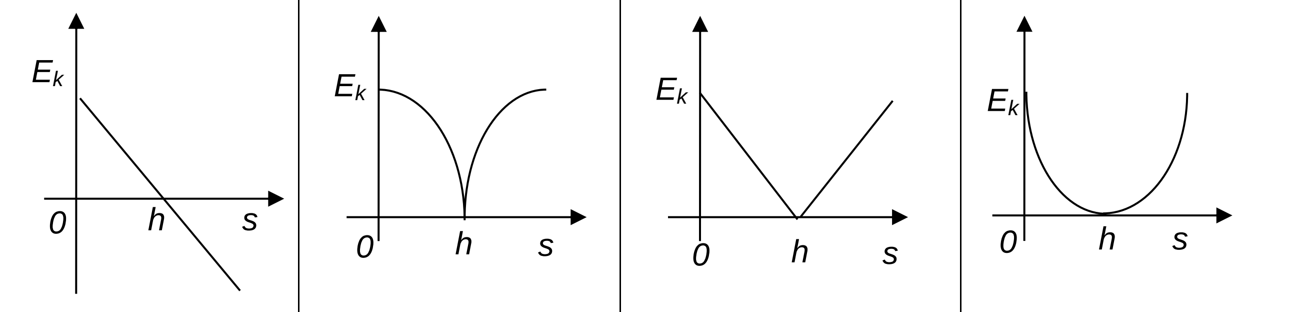
11	A particle of mass m is moving down a rough incline. At position P, its velocity is v_1 while at position Q, a vertical distance h down the incline, its velocity is v_2. What is the work done against friction in going from P to Q? (Take g to be acceleration due to gravity.)	
		
	A	$\frac{1}{2} m v_2^2 - \frac{1}{2} m v_1^2$

[Turn Over]

	B	mgh
	C	mgh – (½ mv_2^2 – ½ m v_1^2)
	D	mgh - ½ mv_1^2
		Ans : C Loss in GPE = gain in KE + work done against friction mgh = (½ mv_2^2 – ½ m v_1^2) + work done against friction work done against friction = mgh - (½ mv_2^2 – ½ m v_1^2)

12 A ball, thrown vertically upwards, rises to a height *h* and then falls to its starting point. Air resistance may be taken as negligible. Which graph best shows the variation of kinetic energy E_k of the ball with the distance *s* traveled?

A	B	C	D



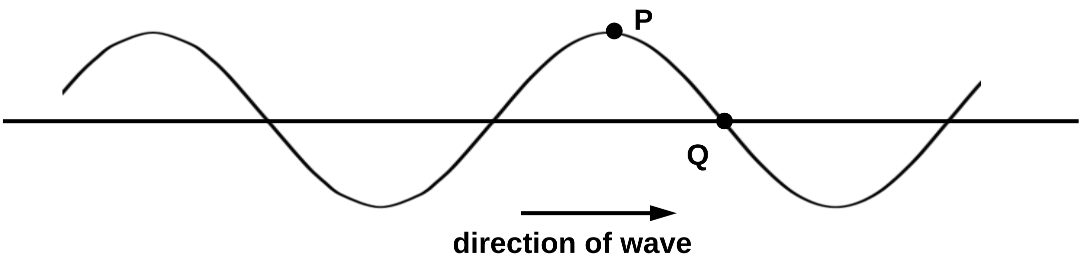
Ans : C

Total energy TE = KE + GPE = constant
KE = TE - GPE = TE – mgh TE = constant
KE varies linearly with distance fall or rise

A is wrong because KE cannot be negative

13		An electric motor is used to haul a cage of mass 100 kg up a mine shaft through a vertical height of 1000 m in 90 s. What will be the electrical power required if the overall efficient is 70 %?
	A	1.6 kW
	B	7.8 kW
	C	15.6 kW
	D	952 kW
		Ans C Output power = mgh / t = 100 x 9.81 x 1000 / 90 = 10900 W Efficiency = output power / input power 70 / 100 = 10900 / input power Input power = 15600 W

14 The diagram below shows a transverse wave on a rope. The wave is travelling from left to right. At the instant shown, the points **P** and **Q** have maximum and zero displacement respectively.



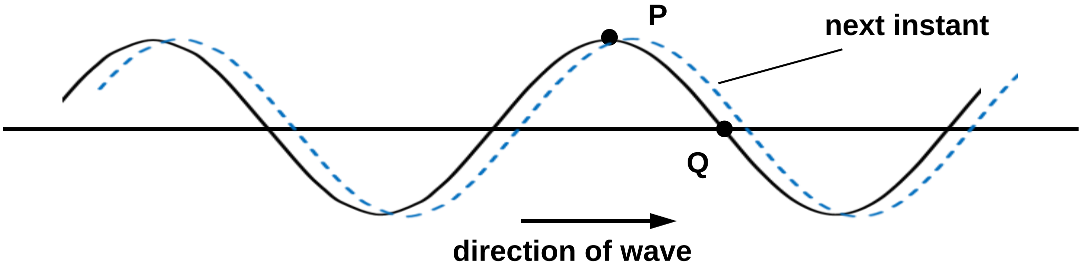
Which of the following describes the direction of motion of the points **P** and **Q** at *this instant*?

	point ***P***	*point* **Q**
A	downwards	stationary
B	upwards	stationary
C	stationary	downwards
D	stationary	upwards

Ans: D

At this instant,

- **point P is at the maximum displacement and it is stationary**
- **point Q is moving upwards (deduced by drawing the waveform for the next instant)**



15 A plane wave of amplitude *A* is incident on a surface of area *S* placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time intercepted by the surface is *E*.

The amplitude of the wave is doubled and the area of the surface is reduced by half.

How much energy per unit time is intercepted by this smaller surface?

A	$4E$	B	$2E$	C	E	D	$E/2$

Ans: B

Intensity = Power / Area
Power = Intensity x Area …….1
Intensity ∝ Amplitude^2 ………..2
1 =2
Power ∝ Amplitude^2 x Area ➔ E ∝ A^2 S ……………3

If A is double E will be increased by 4 times
If S is halved, E will be decreased by 2 times
Combined ==> E increased by 2 times

Alternatively
Let
New amplitude A' = 2A
New area S' = S/2
New power E' ∝ A'^2 S'
E' ∝ $(2A)^2$ (S/2)
E' ∝ $2A^2$ S ………….4

4 / 3
E' /E = 2
E' = 2E

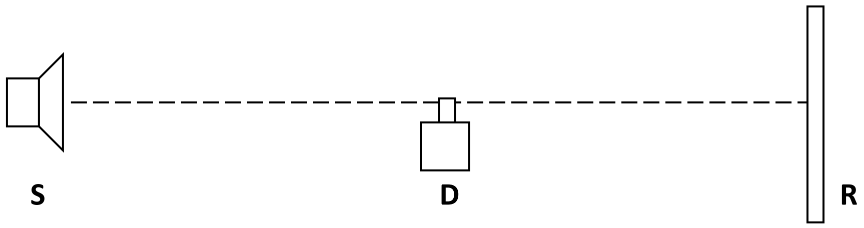
16 Plane waves of wavelength λ in a ripple tank approach a straight barrier parallel to the wave crests. There is a gap of width *w* in the middle of the barrier. Which of the following λ and *w* will produce the largest diffraction?

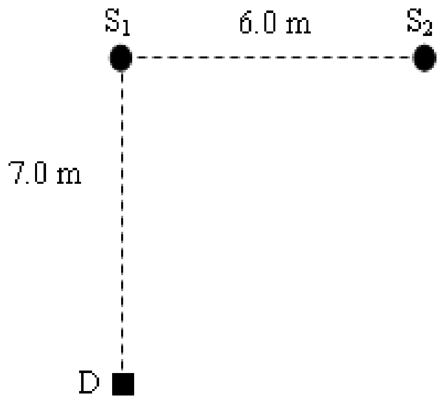
	λ / cm	*w* / cm
A	0.5	2.0
B	0.5	4.0
C	1.5	2.0
D	1.5	4.0

Ans: C

Diffraction is large when w is small and λ is large

By comparing A & B, C & D, A & C, B & D,
Option C will produce the largest diffraction

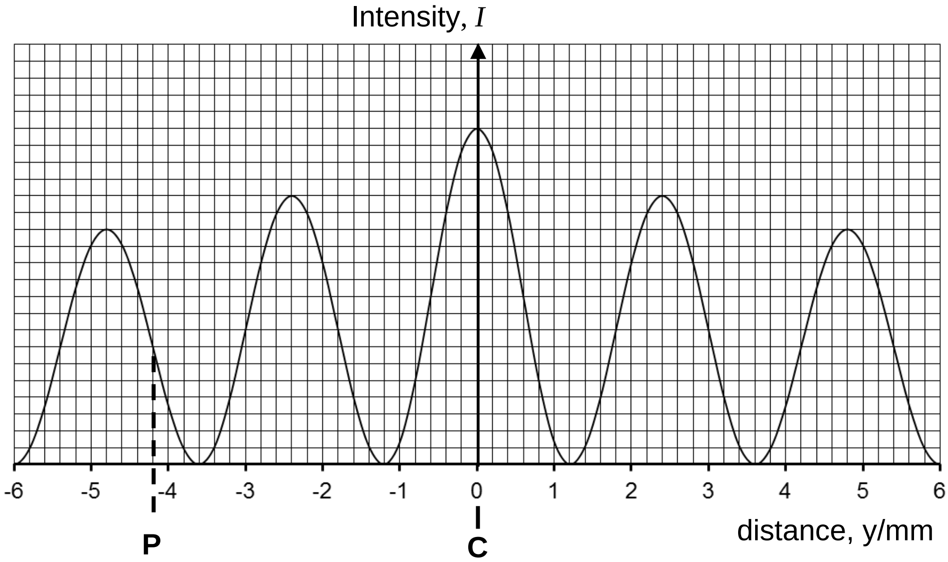
17	A microwave source **S** is placed in front of a detector **D**, and a metal reflecting screen **R** is placed beyond **D** such that its plane is perpendicular to the line joining **S** to **D**. As the detector is moved slowly away from the source, it registers a series of maxima and minima.  It is observed that the detector moved through a distance of 5.6 cm between the first and fifth minimum. What is the frequency of the microwaves in GHz?						
	A	5.4	**B**	10.7	**C**	13.4	**D** 27.5
	Ans: B Distance between the first and fifth minimum = 4 (½ λ) = **2λ** **2λ = 0.056 ➔ λ = 0.056/2= 0.028 m** **v = fλ** **(3.0×10^8) = f(0.00028)** **➔ f = 10.7 GHz**						

18	Two wave generators S_1 and S_2 produce water waves of wavelength 2.0 m. They are placed 6.0 m apart as shown and are operated in phase. A sensor D which measures the amplitude of water waves is 7.0 m away from S_1 as shown in the diagram below.  The shortest distance D could be moved along the straight line S_1D in order to detect large amplitude of the resultant wave motion is	
	A	1.0 m away from S_1
	B	3.0 m away from S_1
	C	1.0 m towards S_1
	D	3.0 m towards S_1
	Ans: A	

[Turn Over]

	For option A Path difference = $\left(\sqrt{8^2+6^2}\right)-8$ = 2.0 m = one wavelength Constructive interference occurs ➔ Large amplitude For other options, path difference is not whole no of wavelength

19 In a Young double slit experiment, coherent monochromatic light is incident normally on a double slit. The figure bellows shows the variation with distance from **C** of the intensity I of the light on the screen, where **C** is the central bright fringe on the screen.



If **P** is a point on the screen and its position is indicated in the figure above, what is the phase angle between the waves from the double slit when the waves meet at **P**?

A	$\frac{\pi}{2}$	**B**	$\frac{3}{4}\pi$	**C**	$\frac{5}{4}\pi$	**D**	$\frac{3}{2}\pi$

Ans: D

At the point where 1st order bright fringe is formed,
Phase difference of the two waves arriving = 2π**.**
Refer diagram linear distance from C = $2.4\ mm$

Let phase difference of the two waves arriving at P = $\Delta\phi$
Linear distance from P to C, CP = 4.2 mm

Assuming phase difference varies with linear distance from C

$\Delta\phi / 2\pi$ **= 4.2 / 2.4 ➔** $\Delta\phi = \frac{4.2}{2.4}\times 2\pi = \frac{7}{2}\pi \equiv \left(\frac{7}{2}\pi - 2\pi\right) = \frac{3}{2}\pi$

20	A heater of resistance 5.0 Ω dissipates 125 W when current flows through it. The amount of energy converted to heat when 0.4 C of charge passes through it is						
	A	2 J	**B**	10 J	**C**	50 J	**D** 625 J

Ans: B

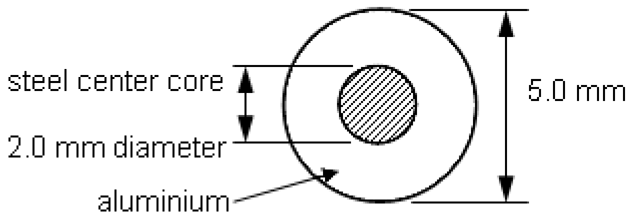
$P = \frac{V^2}{R} \implies V^2 = 125 \times 5$

$\implies p.d\ across\ heater, V = \sqrt{625} = 25\ V$

$V = \frac{W}{Q}$

$Amount\ of\ energy\ conveted\ to\ heat,$
$W = VQ = 25 \times 0.4 = 10\ J$

21	A 5.0 mm thick wire comprises a steel core of diameter 2.0 mm surrounded by a coating of aluminium as shown in the figure below.						



The resistivity of steel and aluminium are 1.0 x 10^{-7} Ω m and 2.8 x 10^{-8} Ω respectively. What is the resistance of a length of 1.0 m of such a wire?

	A	0.88 mΩ	**B**	1.6 mΩ	**C**	3.5 mΩ	**D** 34 mΩ

Ans: B

Using

$$R = \frac{\rho l}{A} = \frac{\rho l}{\pi(\frac{D}{2})^2} = \frac{4\rho l}{\pi D^2}$$

For steel wire of a 1.0 m, resistance

$$R_S = \frac{4 \times 1.0 \times 10^{-7} \times 1.0}{\pi \times (2 \times 10^{-3})^2} = 0.0318\ \Omega$$

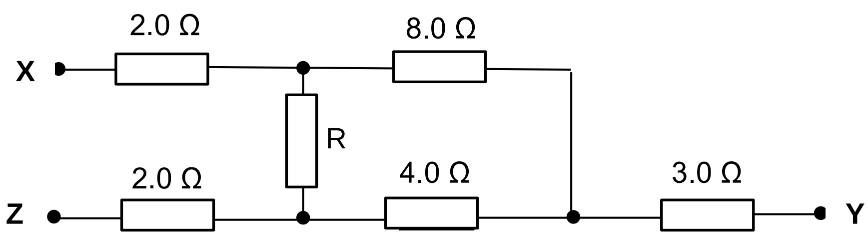
For aluminium wire of a 1.0 m, resistance

$$R_A = \frac{4 \times 2.8 \times 10^{-8} \times 1.0}{\pi \times (5 \times 10^{-3})^2 - \pi \times (2 \times 10^{-3})^2} = 0.00170\ \Omega$$

The two wires may be considered to be in parallel
Effective resistance of 1.0 m of the composite wire

$$= \left(\frac{1}{0.0318} + \frac{1}{0.00170}\right)^{-1} = 1.6 \times 10^{-3}\Omega$$

22	The diagram shows a network of six resistors. A multi-meter measures the resistance between X and Z as 8.0 Ω. What is the value of resistance R?



A	2.0 Ω	**B**	4.0 Ω	**C**	6.0 Ω	**D**	8.0 Ω

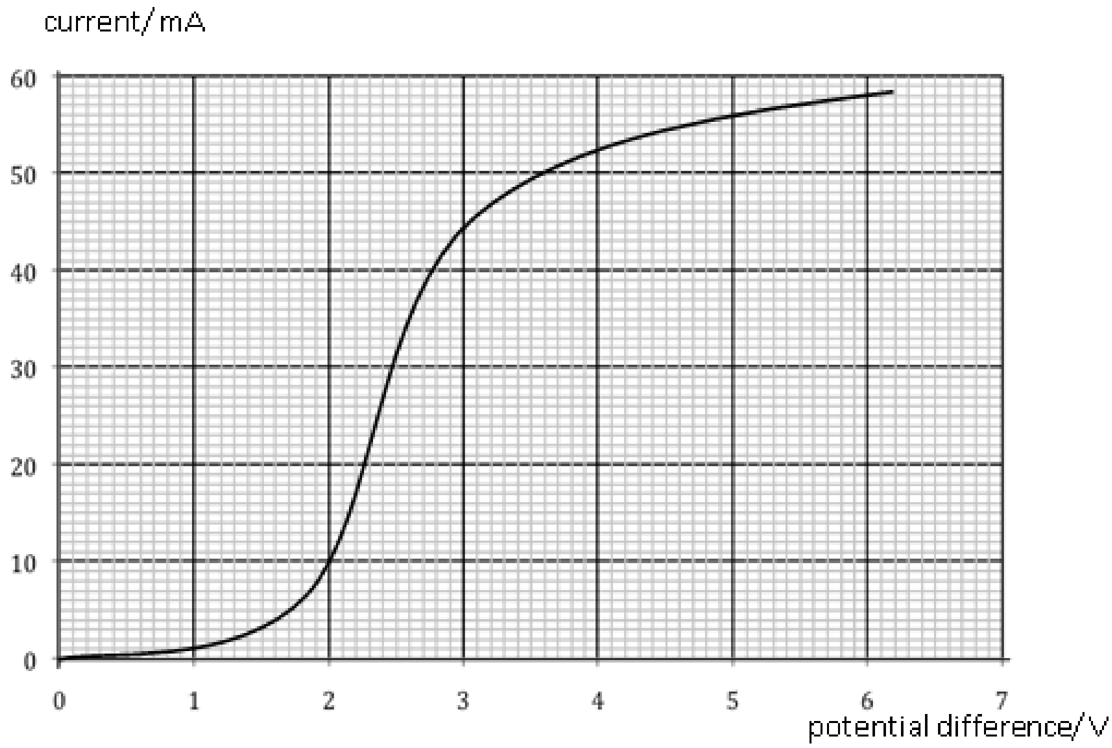
Ans: C

The 3 ohm resistor does not contribute to the combined resistance, it may be excluded when calculating the combined resistance between X and Z,

$$R_{eff} = \left(\frac{1}{R} + \frac{1}{12}\right)^{-1} + 2 + 2 \qquad = 8$$

$$R = 6\ \Omega$$

23	A graph of current against potential difference for a component is given below.



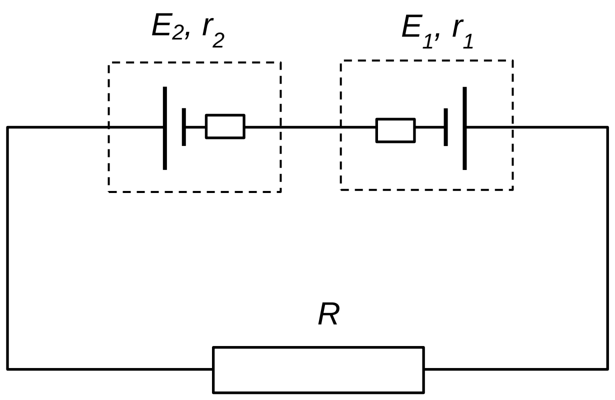
What is the potential difference across the component when its resistance is at its lowest?

A	0.90 V	**B**	2.50 V	**C**	3.00 V	**D**	5.00 V

Ans: C

Considering each option
Option A : when V = 0.90 V, I = 1 mA ➔ R = 0.9 / 0.001 = 900 Ω
Option B : when V = 2.50 V, I = 30 mA ➔ R = 2.50 / 0.030 = 83 Ω
Option C : when V = 3.00 V, I = 44 mA ➔ R = 3.00 / 0.044 = 68 Ω
Option D : when V = 5.00 V, I = 56 mA ➔ R = 5.0 / 0.056 = 89 Ω

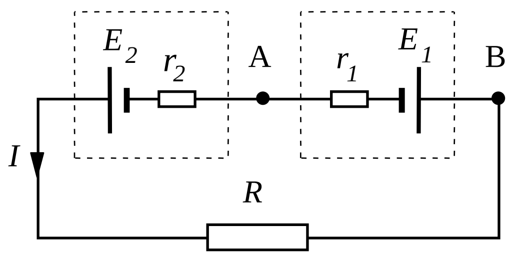
24 Two cells of emfs E_1 and E_2 , and internal resistances r_1 and r_2 , are connected to a load resistance R in the circuit shown.



If the current flowing in the circuit is I and $E_1 < E_2$, what is the magnitude of the terminal p.d. across the cell $\boldsymbol{E_1}$?

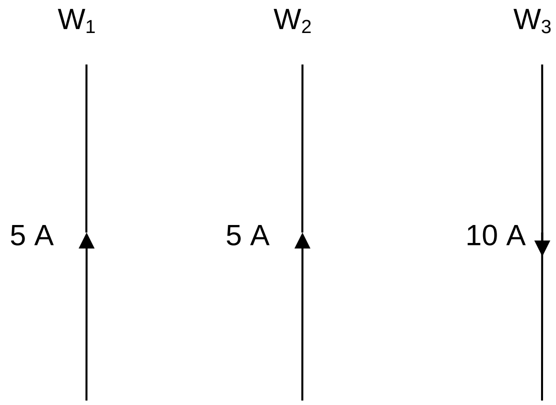
A	$E_1 - Ir_1$
B	$E_1 + Ir_1$
C	$E_2 - I(r_1 + r_2 + R)$
D	$E_2 + Ir_2 - IR$

Ans: B



Current from along E2 and opposite to E1 because E2 > E1
Because current flow in opposite to E1
Terminal p.d of E_1
= p.d. across BA = $E_1 + Ir_1$

25	W_1, W_2 and W_3 are three long parallel wires carrying currents in a vertical plane as shown.



The resultant force on wire W_2 is

A	zero
B	perpendicular to the plane of the paper
C	towards W_1
D	towards W_3

Ans C

Wires carrying currents in the same direction will attract each other while wires carrying currents in opposite directions will repel one another.

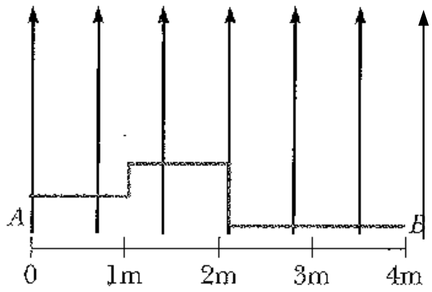
Hence W_2 will be repelled by W_3 and attracted by W_1.

Both forces on W2 act to the left

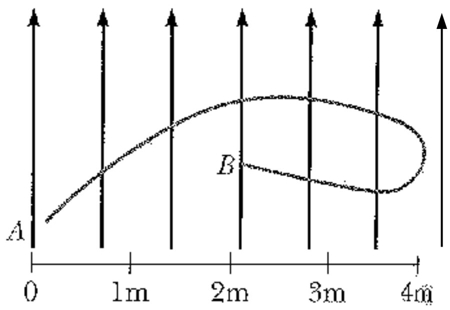
Therefore the resultant force on W_2 is towards W_1.

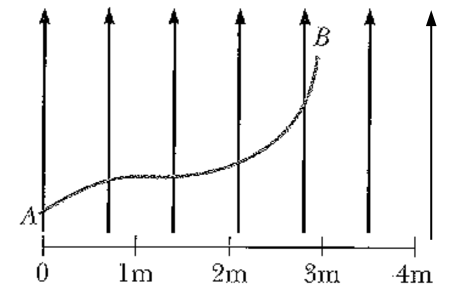
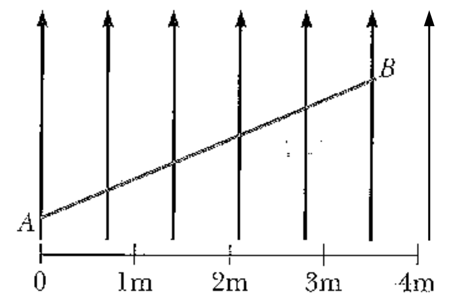
26	The four wires shown in the diagrams below all carry the same current from point **A** to point **B** through the same magnetic field as indicated by the arrows. Which wire experiences the greatest magnetic force?

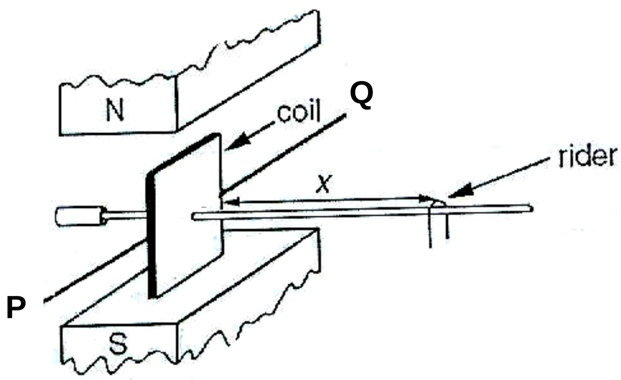
A



B



	C		**D**	
	Ans A Magnetic force F = BILsin $\theta \propto$ Lsin θ B & I are the same for all cases and L sin θ is the length perpendicular to the magnetic field For A: length perpendicular to the magnetic field = 4 m is the greatest (The short vertical pieces experience no magnetic force because their currents are parallel to the field.), the force is the greatest For D: length perpendicular to the magnetic field = 3.5 m For C: length perpendicular to the magnetic field = 3.0 m For B: the first part of wire length perpendicular to the magnetic field = less than 4.0 m) The second part of wire length perpendicular to the magnetic field = 2.0 m experience a force that is opposite to the first part because the current is reversed. So effectively the resultant force is due to 2.0 m length			

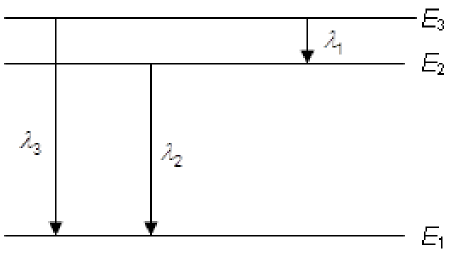
27	A small square coil of *N* turns has sides of length *L* and is mounted so that it can pivot freely about a horizontal axis **PQ**, parallel to one pair of sides of the coil, through its centre as shown in the diagram above. The coil is situated between the poles of a magnet which produces a uniform magnetic field of flux density *B*.						
							
	The coil is maintained in a vertical plane by moving a rider of mass *M* along a horizontal beam attached to the coil. When a current *I* flows through the coil, equilibrium is restored by placing the rider a distance *x* along the beam from the coil. What is the expression for *B*?						
	A	$\frac{Mg}{ILN}$	**B**	$\frac{Mgx}{2IL^2N}$	**C**	$\frac{Mgx}{IL^2N}$	**D** $\frac{2Mgx}{IL^2N}$

	Ans C At equilibrium, by Principle of Moments: Torque of coil = Moment of rider $F_B \times L = Mg \times x$ $BIL(N) \times L = Mg \times x$ $B = \frac{Mgx}{IL^2N}$

28	The wave nature of electrons is suggested by experiments on	
	A	line spectra of atoms
	B	measuring maximum kinetic energy of emitted electrons
	C	the photoelectric effect
	D	electron diffraction by a crystalline material
	Ans: D **Diffraction is a phenomenon related to waves.** **The fact that electrons diffract when passing through a crystalline materials proves that electrons exhibit wave properties.**	

29	Transitions between three energy levels in a particular atom give rise to three spectra lines of wavelengths in decreasing magnitudes, λ_1, λ_2 and λ_3. Which one of the following equations correctly relates λ_1, λ_2 and λ_3?							
	A	$\frac{1}{\lambda_3} = \frac{1}{\lambda_2} - \frac{1}{\lambda_1}$	**B**	$\frac{1}{\lambda_3} = \frac{1}{\lambda_2} + \frac{1}{\lambda_1}$	**C**	$\frac{1}{\lambda_3} = \frac{1}{\lambda_1} - \frac{1}{\lambda_2}$	**D**	$\lambda_1 = \lambda_2 + \lambda_3$

Ans: B



$$\Delta E3 = E_3 - E_1 = \frac{hc}{\lambda_3} \quad ---(1)$$

$$\Delta E2 = E_2 - E_1 = \frac{hc}{\lambda_2} \quad ---(2)$$

	$\Delta E1 = E_3 - E_2 = \frac{hc}{\lambda_1} \quad - - - (3)$ $\Delta E3 = \Delta E2 + \Delta E1$ $\frac{hc}{\lambda_3} = \frac{hc}{\lambda_2} + \frac{hc}{\lambda_1}$ $\frac{1}{\lambda_3} = \frac{1}{\lambda_2} + \frac{1}{\lambda_1}$

30	What is the de Broglie wavelength of a particle of mass m and kinetic energy E? [h is the Planck constant]						
	A	$h\sqrt{2mE}$	**B**	$\frac{\sqrt{2mE}}{h}$	**C**	$\frac{h}{\sqrt{2mE}}$	**D**	$\frac{h}{\sqrt{mE}}$
	Ans: C **K.E. of mass,** $E = \frac{1}{2}mv^2 = \frac{1}{2}\frac{(mv)^2}{m} = \frac{p^2}{2m}$ **where p is the momentum of the mass** $\Longrightarrow \quad p^2 = 2mE \quad \Longrightarrow \quad p = \sqrt{2mE}$ **From de Broglie equation** $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}$						

End of Paper -