NAME _____ CLASS 1T

Catholic Junior College

JC1 Promotional Examinations

Higher 2

PHYSICS 9749/1

Paper 1: Multiple Choice Questions **30 September 2022**

30 minutes

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST
Write your name and tutorial group on this cover page.

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

There are **fifteen** 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 (OMR sheet).

Read the instructions on the Answer Sheet 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.

MARK SCHEME

PHYSICS DATA:

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
			$\approx (1/(36\pi)) \times 10^{-9}$ F 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
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} mol^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

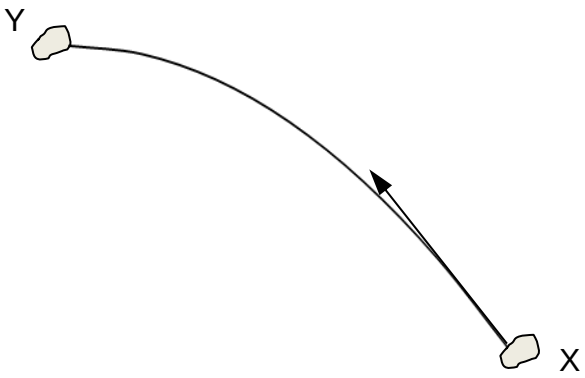
PHYSICS FORMULAE:

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	=	$\rho g h$
gravitational potential	ϕ	=	$-\frac{Gm}{r}$
temperature	T/K	=	$T/^{\circ}C + 273.15$
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	=	$\frac{Q}{4\pi\varepsilon_o r}$
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	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o n I$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1	The resistance of a resistor is measured using an ohmmeter and its reading is 47.12 Ω. The manufacturer of the ohmmeter specifies that the ohmmeter reading has an uncertainty of 10%. How should the resistance of the resistor be recorded, along with its uncertainty?	
	A	(47 ± 5) Ω
	B	(47.1 ± 0.1) Ω
	C	(47.1 ± 4.7) Ω
	D	(47.12 ± 5) Ω
L2	**Answer: A** The uncertainty of the resistance = $47.12 \times 10\% = 4.71 \approx 5$ (1.s.f) Therefore, resistance = (47 ± 5) Ω	

2	Two trains, Train A and Train B, are initially at rest next to each other at a train station. Train A leaves the station with a uniform acceleration of 0.30 m s^{-2}. 2.0 minutes later, Train B leaves the station in the same direction as Train A with a uniform acceleration of 0.50 m s^{-2}. How long does Train B take to catch up with Train A?							
	A	6.9 s	**B**	180 s	**C**	210 s	**D**	410 s
L2	**Answer: D** Let time *t* be the time at which Train B catches up with Train A. Distance traveled by Train A = $s_A = ut + \frac{1}{2}at^2 = \frac{1}{2}(0.30)(t+120)^2$ [t+120 s since Train A travels an additional time of 120 s] Distance traveled by Train B = $s_B = ut + \frac{1}{2}at^2 = \frac{1}{2}(0.50)(t)^2$ Since $s_A = s_B$ when B catches up, $\frac{1}{2}(0.30)(t+120)^2 = \frac{1}{2}(0.50)(t^2)$ Solving for *t*, *t*= 410 s							

3 A stone is thrown from X and moves under gravity to Y, at the top of its path.



Which row correctly describes its motion horizontally and vertically between X and Y? Neglect air resistance.

		horizontally	vertically	
	A	travels at decreasing velocity	velocity decreases uniformly	
	B	travels at increasing velocity	velocity increases uniformly	
	C	travels at constant velocity	velocity increases uniformly	
	D	travels at constant velocity	velocity decreases uniformly	

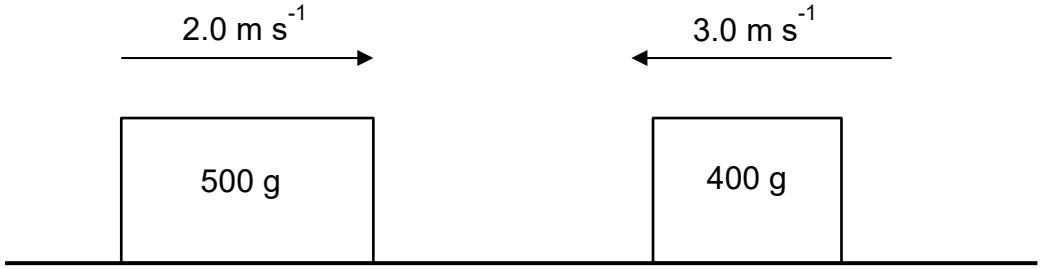
L1 **Answer D**

Since air resistance is neglected,

Horizontal motion – there is no horizontal acceleration, so the stone will travel at constant velocity horizontally.

Vertical motion – the acceleration is constant at 9.81 m s^{-2} (downwards direction), since the stone is moving upwards, its velocity decreases uniformly.

4 Two blocks with masses of 500 g and 400 g are moving towards each other at speeds of 2.0 m s^{-1} and 3.0 m s^{-1} as shown.



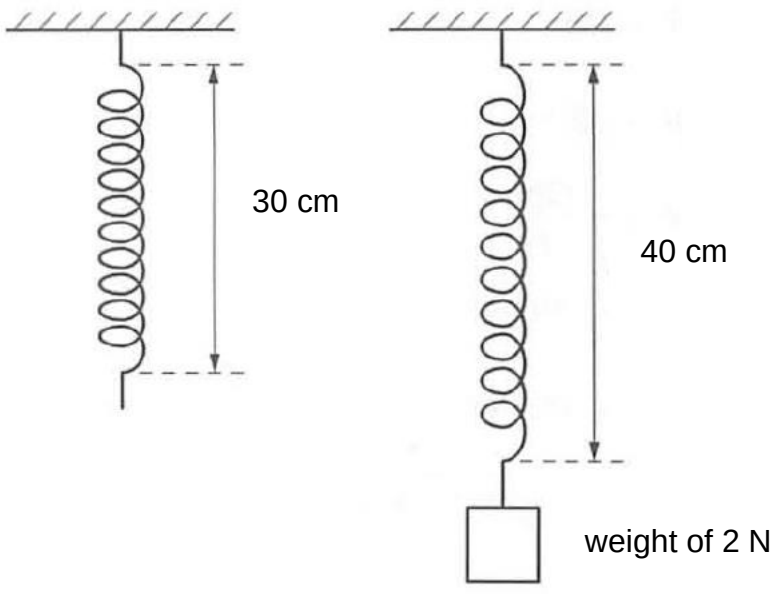
The two blocks stick together after the collision and move off with a common speed.

What is the speed and the direction of motion of the blocks after the collision?

	A	0.22 m s^{-1} to the left
	B	0.22 m s^{-1} to the right
	C	2.4 m s^{-1} to the left
	D	2.4 m s^{-1} to the right
L1	**Answer: A** By the Conservation of Momentum, and taking right as positive *(0.5)(2.0) + (0.4)(-3.0) = (0.5+0.4)v* *v = - 0.22* m s^{-1} (to the left)	

5	A tennis ball of mass 60 g is dropped vertically from a height. It hits the ground with a speed of 21 m s^{-1} downwards and then bounces upwards with an initial speed of 14 m s^{-1}. The time of contact between the ball and the ground is 0.30 s. What is the magnitude of the impulse provided by the ground?						
	A	0.42 N s	**B**	2.1 N s	**C**	7.0 N s	**D**	2100 N s
L1	**Answer: B** Impulse = change of momentum of the ball $=m(v_f - v_i) = 0.060\ (14-(-21))=2.1$ N s							

6 The unstretched length of a spring is 30 cm. It is stretched vertically, with one end fixed on a ceiling, to a length of 40 cm by a weight of 2 N attached to the other end as shown. The weight is at rest.

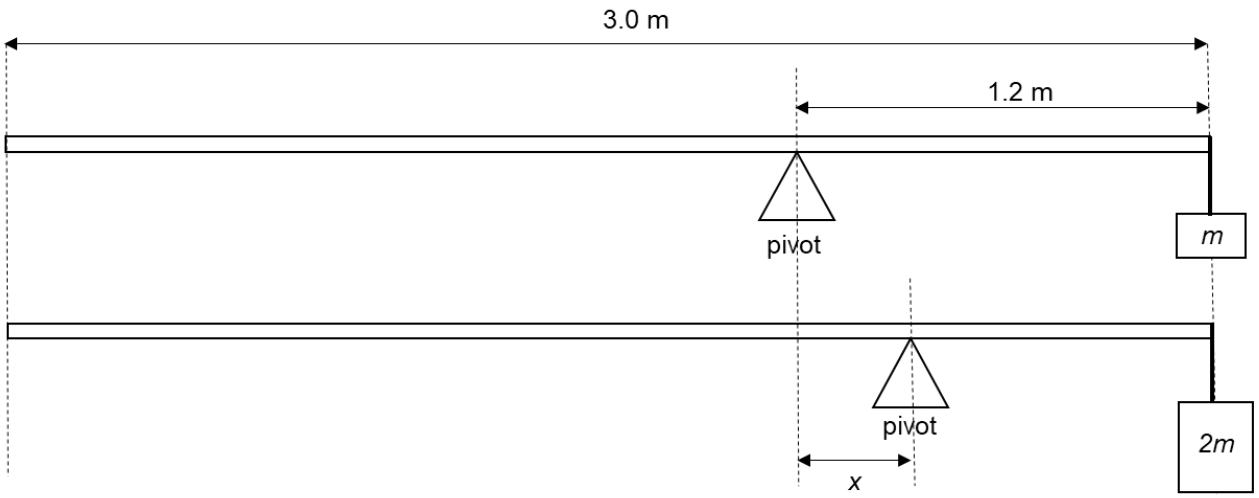


What is the potential energy stored in the spring?

	A	0.1 J	**B**	0.2 J	**C**	0.6 J	**D**	0.8 J
L1	**Answer: A** Hooke's Law: $F = k\,x\,e$ Elastic Potential Energy = $\frac{1}{2}\,x\,k\,x\,e^2 = 0.5\,x\,F\,x\,e = 0.5\,x\,2\,x\,0.1 = 0.1$ J							

7	A wooden block of density 700 kg m^{-3} is completely submerged below the surface of water by a weight placed on top of it. The block floats to the surface when the weight is removed. The density of water is 1000 kg m^{-3}. What is the ratio $\frac{\text{upthrust on the wooden block when it is } \textbf{completely submerged}}{\text{upthrust on the wooden block when it is } \textbf{floating}}$?							
	A	0.143	**B**	0.700	**C**	1.43	**D**	7.00
L2	**Answer: C** Let ρ_b = density of wooden block = 700 kg m^{-3} ρ_w = density of water = 1000 kg m^{-3} V = volume of wooden block g = gravitational acceleration Upthrust on the wooden block when it is **floating** = weight of the wooden block = ρ_b V g [Principle of floatation] Upthrust on the wooden block when it is completely submerged = weight of water displaced by the wooden block = ρ_w V g Ratio of $\frac{\text{upthrust on the wooden block when it is } \textbf{completely submerged}}{\text{upthrust on the wooden block when it is } \textbf{floating}} = \frac{\rho_w V g}{\rho_b V g} = \frac{\rho_w}{\rho_b} = \frac{1000}{700} =$ 1.43							

8	An object of mass *m* is hung at one end of a 3.0 m long uniform rod of mass *M* and placed on a pivot. For the system to be in equilibrium, the pivot has to be placed 1.2 m from the end where the object is hung. When the object's mass is doubled to 2*m*, the pivot has to be moved a distance *x* to the right of its original position for the system to remain in equilibrium as shown.

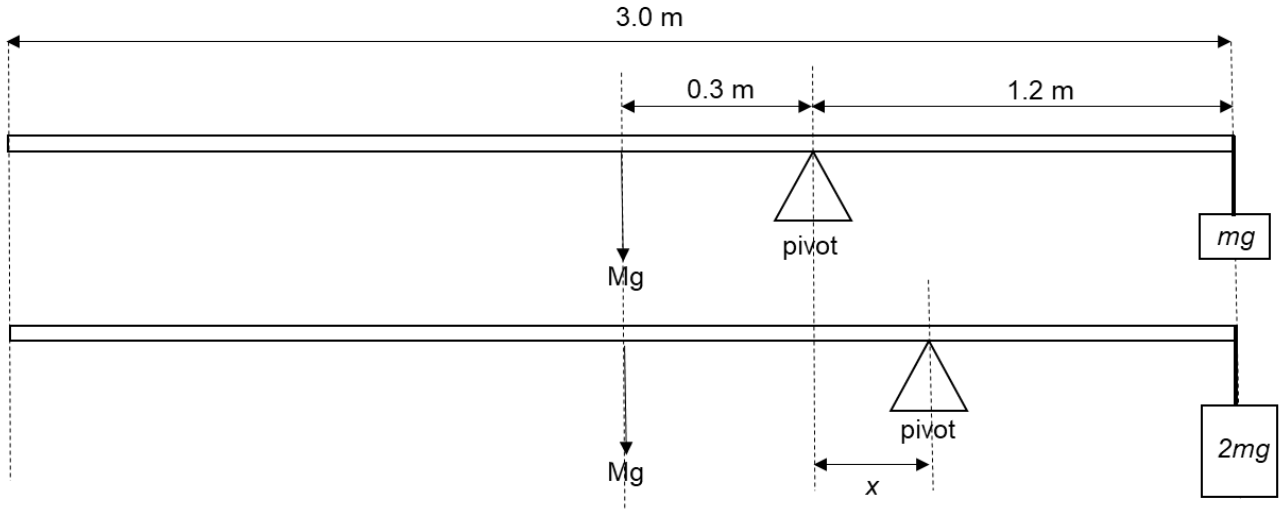


What is the distance *x*?

	A	0.20 m	**B**	0.40 m	**C**	0.50 m	**D**	0.80 m

L3 **Answer: A**

Since the rod is uniform, its weight acts at the centre of the rod, which is 0.3 m to the left of the pivot initially (or 1.5 m from the end of the rod).



Taking moments about the pivot, this means that $(Mg)(0.3) = (mg)(1.2)$ or $\frac{M}{m} = 4$

When the object's mass is doubled, taking moments about the new pivot position,

$(Mg)(0.3+x) = (2mg)(1.2-x)$

and thus $\frac{M}{m} = \frac{2(1.2-x)}{0.3+x} = 4$ and solving for *x* gives $x = 0.20$ m

9 A car with a power output of 100 kW is travelling with a constant speed of 30 m s^{-1} along a straight road. The frictional force on the car is proportional to the square of its speed.

What constant speed will it be travelling at if its power output is 200 kW?

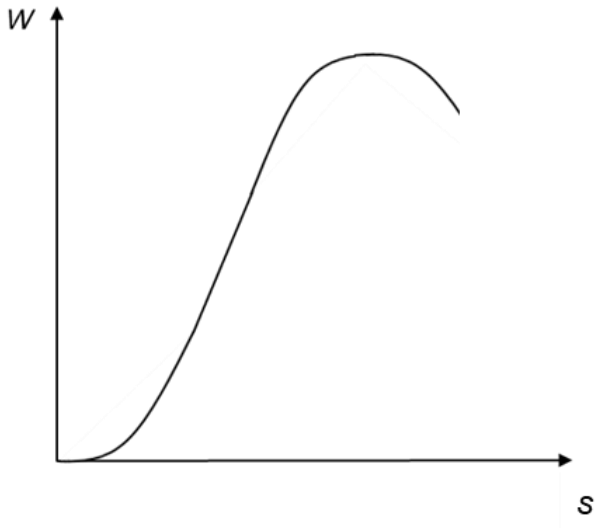
	A	37.8 m s^{-1}	**B**	42.4 m s^{-1}	**C**	51.6 m s^{-1}	**D**	60.0 m s^{-1}

L3

Answer: A

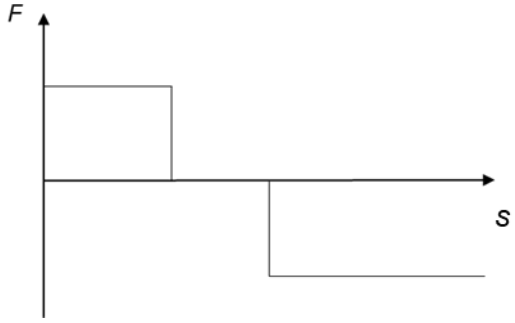
Power P = Force **F** x Velocity **v** when **F** and **v** are constants
When car is moving with constant velocity, net force on the car is zero.
This means force exerted by the car engine **F** = frictional force on the car = k $|\mathbf{v}|^2$
Power output of the car engine P = k $|\mathbf{v}|^2$ x $|\mathbf{v}|$ = k $|\mathbf{v}|^3$
Hence P is proportional to $|\mathbf{v}|^3$.
Therefore $100 / 30^3 = 200 / |\mathbf{v}|^3$
Hence $|\mathbf{v}|^3 = 2 \times 30^3$
$|\mathbf{v}| = 2^{1/3} \times 30 = 37.8$ m s^{-1}

10 The variation with displacement *s* of the total work done on an object *W* is shown below

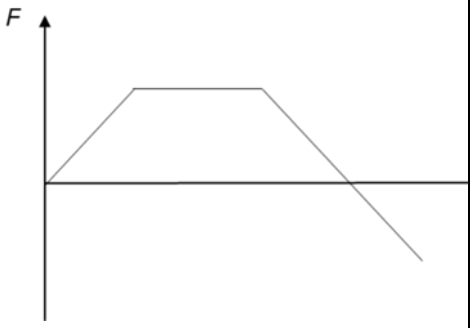


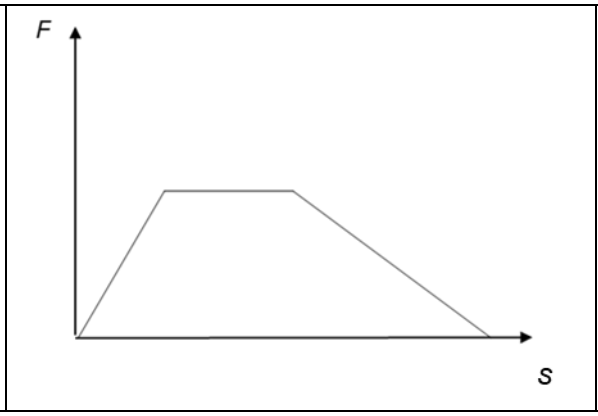
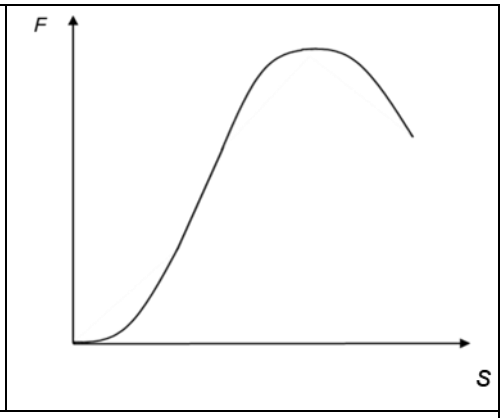
Which of the following graphs best represents the variation with displacement *s* of the resultant force *F* acting on the object?

A



B



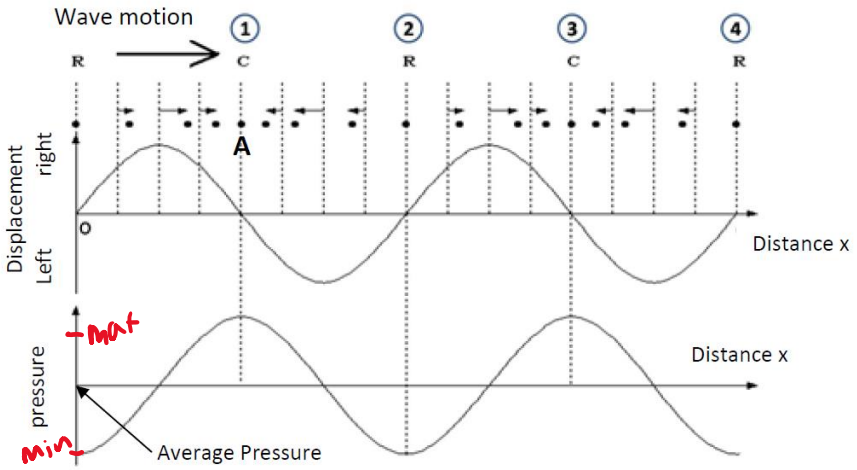
	C		**D**				
L2	**Answer: B** Since $W = \int Fds$, the area under the *F*-*s* graph is the work done on the object. Since the work done initially increases at an increasing rate, then at a constant rate, and then at a decreasing rate until reaches a maximum, the force (which is the gradient of the graph) should initially increase, then become constant, and then decrease to zero. After this, the total work done decreases, which means that the force is doing negative work, and therefore the force has changed direction and hence is negative.						

11	An object of mass *m* is attached to a rigid rod and spun in a uniform vertical circular motion with radius *r* and a linear velocity of *v*. What is the variation of the magnitude of the centripetal acceleration of the object over one revolution?						
	A	zero	**B**	$2g$	**C**	$\frac{v^2}{r}$	**D**	$2\frac{v^2}{r}$
L2	**Answer: A** Since the linear velocity of the object remains constant, the centripetal acceleration does not change in magnitude, because $a_c = \frac{v^2}{r}$.						

12	Which quantity is **not necessarily** the same for satellites in geostationary orbits around the Earth?	
	A	angular velocity
	B	centripetal acceleration
	C	kinetic energy
	D	orbital period
L2	**Answer: C** Geostationary = period of 1 day = same angular velocity Same angular velocity = same orbital period Centripetal acceleration = same Kinetic energy depends on mass so it may not be the same.	

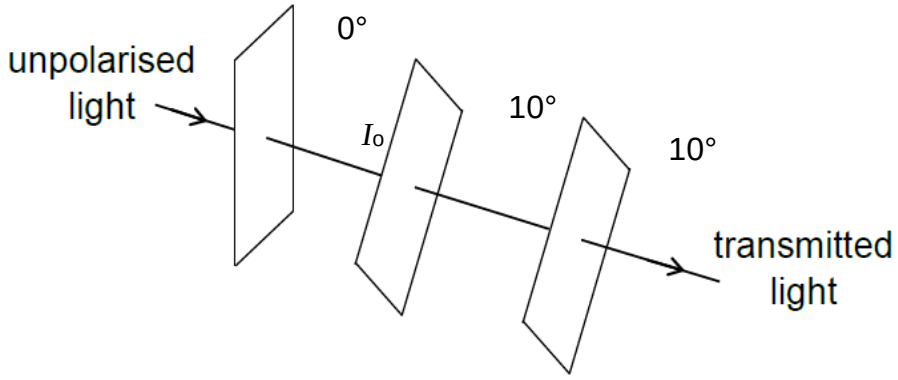
13	A mass on a frictionless table is attached to a fixed horizontal spring and displaced a certain horizontal distance from its equilibrium position. When released, it oscillates in a simple harmonic motion with an angular frequency of 3.14 rad s^{-1}. At what times after its release does the object pass through the equilibrium position?	
	A	0.25 s, 0.75 s, 1.25 s…
	B	0.25 s, 1.25 s, 2.25 s…
	C	0.50 s, 1.00 s, 1.50 s…
	D	0.50 s, 1.50 s, 2.50 s…
L1	**Answer: D** Since the object is released from the amplitude position, the equation for its displacement is $x = x_0 \cos(3.14t)$. For the equilibrium position, solving for x = 0, $3.14t = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}...$ or $t = 0.50, 1.50, 2.50...$ s	

14	A sound wave has a frequency of 2500 Hz and a speed of 1500 m s^{-1}. What is the shortest distance from a point of maximum pressure in the wave to a point of minimum pressure?							
	A	0.15 m	**B**	0.30 m	**C**	0.60 m	**D**	1.20 m
L2	**Answer: B** Distance between a compression (point of max pressure) and rarefaction (point of min pressure) is half a wavelength long. $\lambda = \frac{speed}{freq} = \frac{1500}{2500}$ = 0.6 m $\frac{\lambda}{2} = \frac{0.6}{2} = 0.3\,\text{m}$ Recall:							



15 A narrow, parallel beam of unpolarised light is directed towards three ideal polarising filters.

The beam meets the first filter with a vertical axis of polarisation and emerges with an intensity I_o. The axis of polarisation of the second filter is at an angle of 10° to the first filter. The third filter has its axis of polarization parallel to the second filter as shown.



The third filter is now turned an angle of 34° to the second filter. What is the intensity of the transmitted light after passing through the third filter?

	A	0.25 I_o	**B**	0.33 I_o	**C**	0.5 I_o	**D**	0.67 I_o

L2

Answer: D

Using Malus' law,
Intensity of light after passing through the 2nd filter

$I_2 = I_o \cos^2 10°$

Intensity of light after passing through the 3rd filter

$I_3 = I_2 \cos^2 \theta$

where θ is the angle between the axes of polarisation of the second and third filters

$I_3 = I_2 \cos^2 34^o$

$= \left(I_0 \cos^2 10°\right)\cos^2 34^o = 0.67 I_0$

-- END OF PAPER 1 –