Catholic Junior College
JC1 Promotional Examinations
Higher 2

CANDIDATE NAME	
CLASS	**1T**

PHYSICS **9749/2**

Paper 2: Structured Questions

30 September 2022

2 hours

Candidates answer on the Question Paper
No Additional Materials are required

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
Answer **all** questions.

The number of marks is given in brackets [ ] at the end of each question or part question.

FOR EXAMINER'S USE		DIFFICULTY		
		L1	L2	L3
Q1	/ 11			
Q2	/ 10			
Q3	/ 10			
Q4	/ 12			
Q5	/ 9			
Q6	/ 15			
Q7	/ 13			
PAPER 2	/ 80			

MARK SCHEME

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}
			$(1/(36\pi)) \times 10^{-9}$ 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}

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	=	$T / {}^\circ C + 273.15$
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	=	$\frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 **(a)** A ball of mass 0.50 kg leaves the edge of a table with a horizontal velocity *v*, as shown in Fig. 1.1.

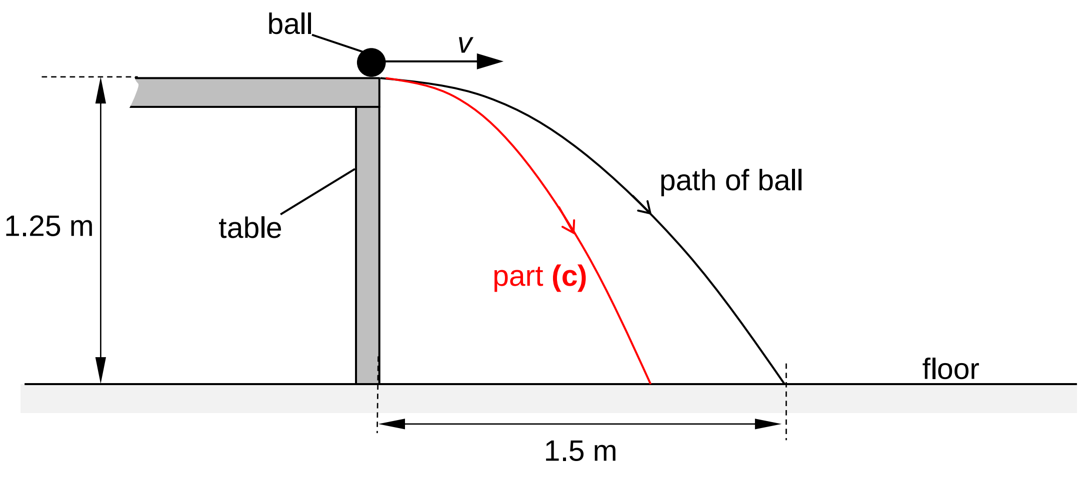


Fig. 1.1

The height of the table is 1.25 m. The ball travels a distance of 1.50 m horizontally before hitting the floor.

Air resistance is negligible.

For the ball,

(i) Show that the horizontal velocity *v* is 3.0 m s^{-1},

[2]

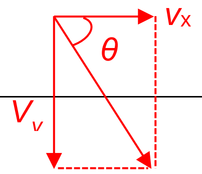
L2 **Solution:**

Assume downwards and rightwards directions as positive.

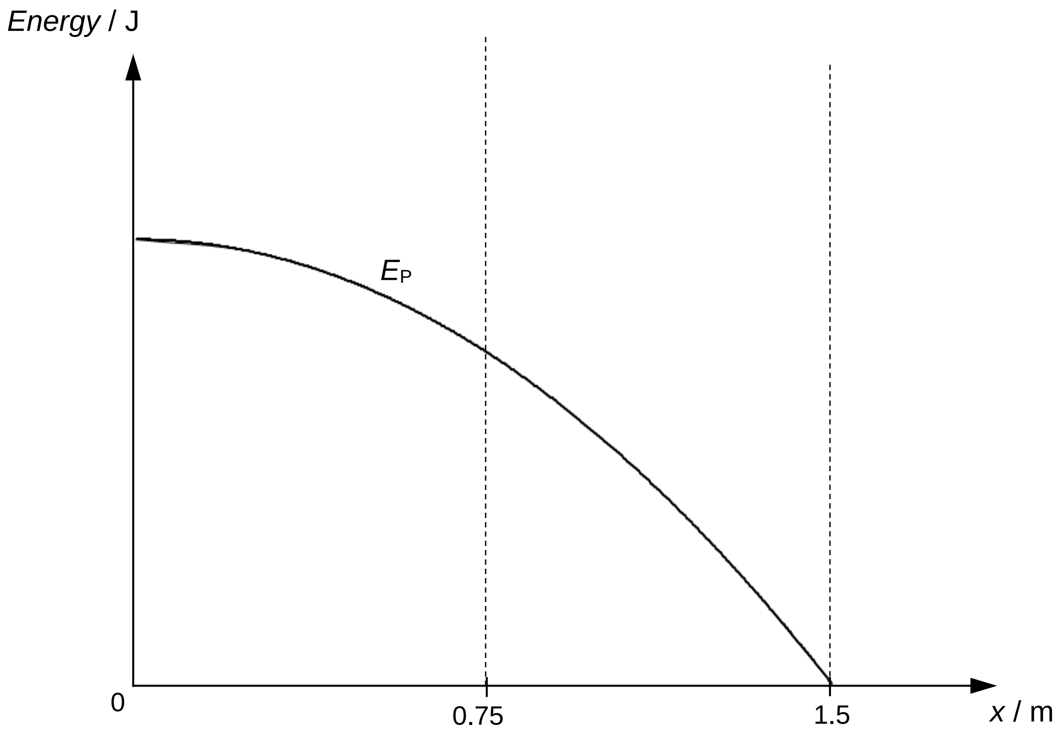
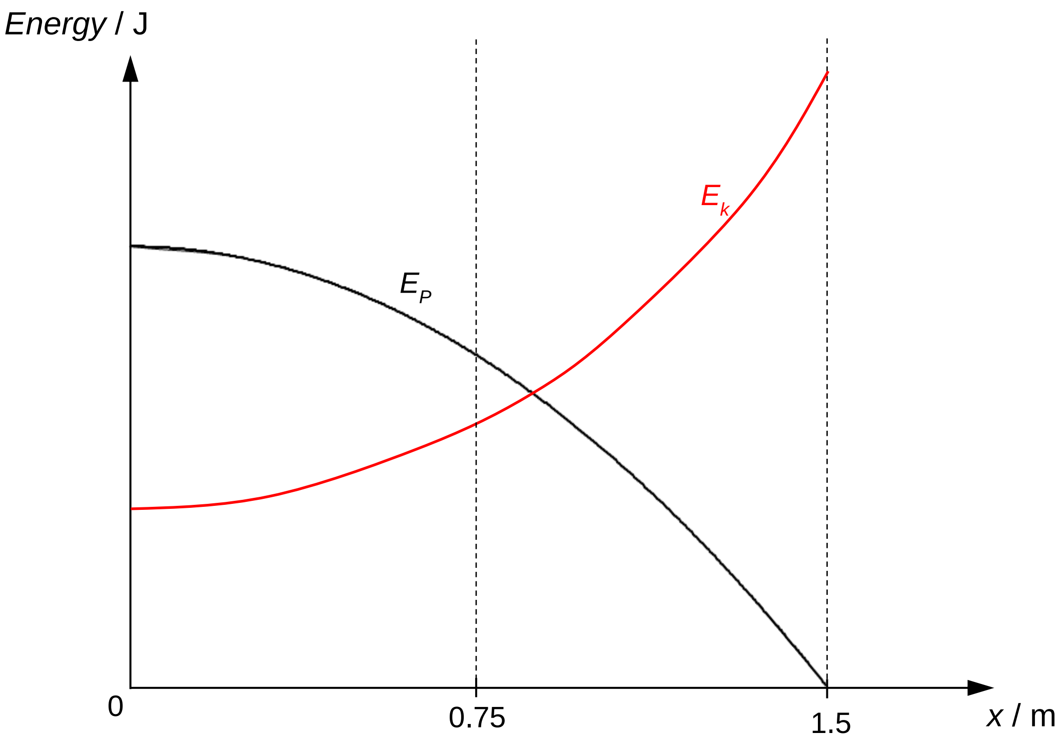
Consider horizontal motion,

$s_x = u_x t$

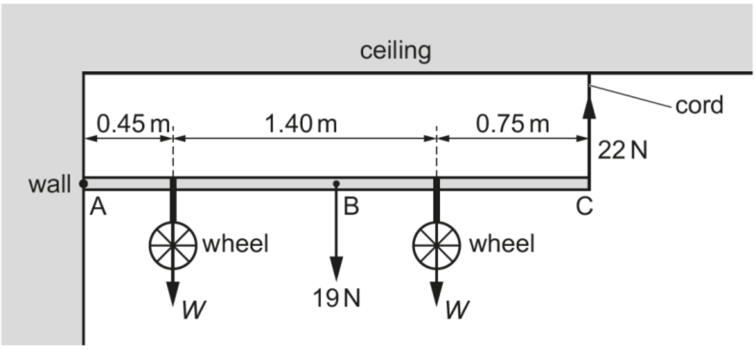
$1.5 = vt \quad \Rightarrow \quad t = \dfrac{1.5}{v} \quad ----(1)$ **M1**

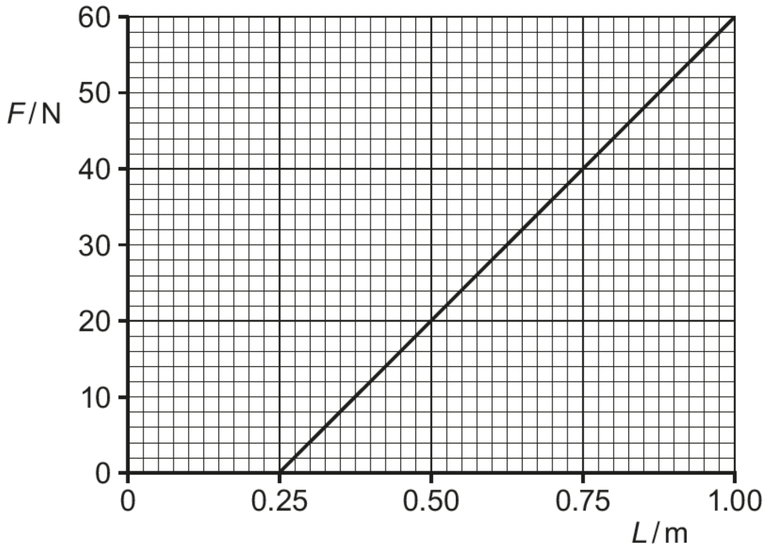
			Consider vertical motion, $s_y = u_y t + \frac{1}{2} a_y t^2$ $1.25 = 0 + \frac{1}{2}(9.81)t^2 \quad -----(2)$ Sub (1) into (2), $1.25 = \frac{1}{2}(9.81)\left(\frac{1.5}{v}\right)^2$ $v = 2.97$ or 3.0 m s^{-1}	**M1** **A0**
			Examiner's Comments Mostly well done.	
		(ii)	Calculate the velocity just as it hits the floor,	
			magnitude of velocity = ……………………………… m s^{-1} direction of velocity = ………………………………………	[3]
		L2	**Solution:** Assume downwards and rightwards directions as positive. Let v_1 be the magnitude of velocity just as it hits the floor. Consider vertical motion, $v_y^{\ 2} = u_y^{\ 2} + 2a_y s_y$ $v_y^{\ 2} = 0 + 2(9.81)(1.25)$ $v_y = 4.95$ m s^{-1} $\therefore\ v_1 = \sqrt{3.0^2 + 4.95^2}$ $= 5.788 = 5.79$ or 5.8 m s^{-1} Let θ be the angle below the horizontal,  	 **M1** **A1**

			$$\tan\theta = \frac{v_y}{v_x} = \frac{4.95}{3}$$ $\theta = 58.8^o$ below the horizontal	A1
			Examiner's Comments Generally well done. Many students did not obtain credit for the answer on direction of velocity. Most students did **not** give the answer on the direction of velocity accurately and clearly. For example answers such as "from the horizontal" or "to horizontal" are not accepted. The accepted answers are "below the horizontal" or "clockwise below the horizontal". The context of the question is not related to bearing or compass, answers stating "south of east" or "east of south" are not accepted.	
		(iii)	Using the floor as reference where the potential energy of the ball is zero, calculate the kinetic energy and potential energy of the ball at the top of the table.	
			kinetic energy = ……..…….…..……………… …J potential energy = ……..…….…..……………… …J	[2]
		L1	**Solution:** Kinetic energy $= \frac{1}{2}mv^2 = \frac{1}{2}(0.50)(3)^2 = 2.25\,\text{J}$ Potential energy $= mgh = (0.50)(9.81)(1.25) = 6.13\,\text{J}$	A1 A1
			Examiner's Comments Mostly well done. However, a handful of students thought that K.E. at top of table is zero even though the ball has velocity when projected horizontally at the top of the table.	
	(b)		The horizontal distance, along the floor, from the bottom of the table is *x*. Fig. 1.2 shows the variation with *x* of the potential energy E_p of the ball.	

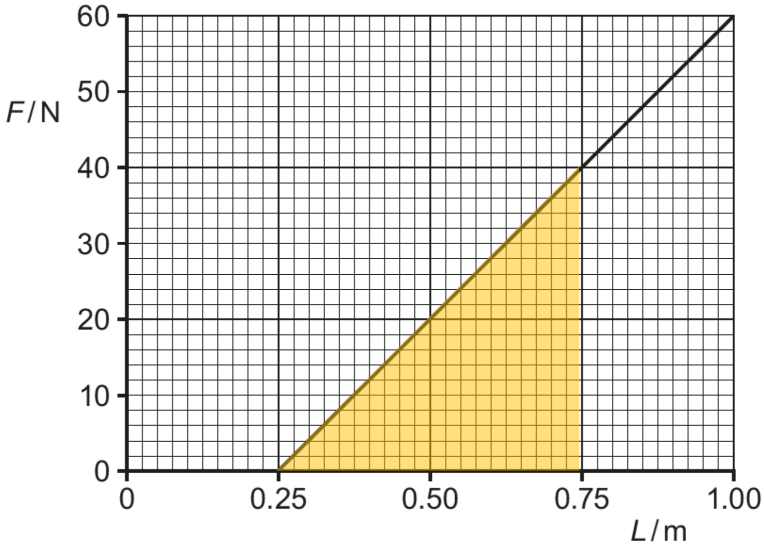
		On Fig 1.2, sketch the variation with *x* of the kinetic energy E_k of the ball.  **Fig. 1.2**	[2]
	L3	 1 mark – award mark for correct **shape** of graph 1 mark – award only if the sketched graph has all the following 2 features:	B1

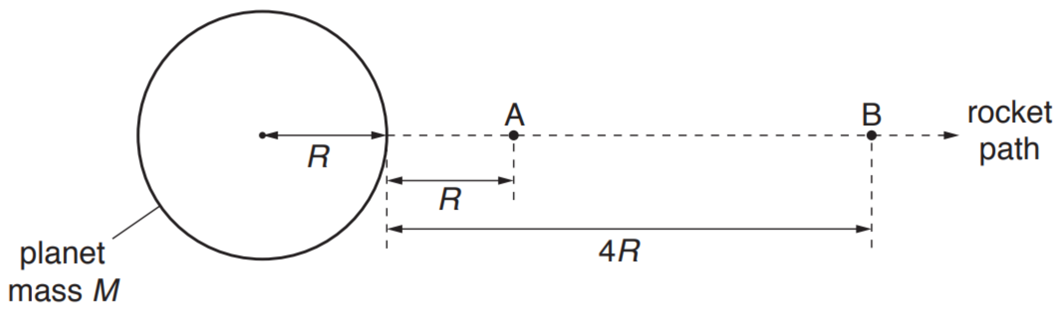
		• E_k graph start below E_p but not 0. • E_k graph ends at x = 1.5 m with a value higher than the initial E_p value at x = 0. **Additional Notes to determine the expressions for E_P and E_K (for student learning):** $E_P = mg\Delta h = mg(1.25 - s_y)$ ------(1) Taking downwards as positive, $s_y = u_y t + \frac{1}{2}a_y t^2 = 0 + \frac{1}{2}gt^2$ $s_y = \frac{1}{2}gt^2$ ------- (2) Since $s_x = u_x t \Rightarrow x = 2.97t$ or $t = \frac{x}{2.97}$ ---- (3) Subs (2) & (3) into Eqn (1) $E_P = mg\left(1.25 - \frac{1}{2}g\left(\frac{x}{2.97}\right)^2\right) = (0.5)(9.81)\left(1.25 - \frac{1}{2}(9.81)\frac{x^2}{8.82}\right)$ $E_P = 6.13 - 2.73x^2$ $E_K = \text{Total Energy} - E_P = (\text{Initial } E_P + \text{Initial } E_K) - E_P$ $E_K = (2.25 + 6.13) - (6.13 - 2.73x^2)$ $E_K = 2.25 + 2.73x^2$	B1
		Examiner's Comments Averagely well done. The common mistake is that many students sketch the K.E. graph starting at 0 J and ending at the same value as the Initial EP. This in incorrect. Assuming no loss of energy to air resistance, the loss in G.P.E will be entirely converted to gain in K.E. Since the ball has an initial K.E., the final K.E. will be higher than the value of the Initial EP.	
	(c)	On Fig 1.1, draw the path of the ball if air resistance was not negligible.	[2]
	L2	Solution: Shorter range Strike ground at a steeper angle	 B1 B1
		Examiner's Comments Mostly well done.	

2	**(a)**	State the principle of moments. …………………………………………………………………………………… ……………………………………………………………………………………	**[1]**
	L1	**Solution:** For a <u>body in equilibrium</u>, <u>sum/total of clockwise moments about a point must be equal to the sum/total of anticlockwise moments</u> about the (same) point	**B1**
		Examiner's Comments Mostly well done.	
	(b)	In a bicycle shop, two wheels hang from a horizontal uniform rod AC, as shown in Fig. 2.1.  **Fig. 2.1** (not to scale) The rod has weight 19 N and is freely hinged to a wall at end A. The other end C of the rod is attached by a vertical elastic cord to the ceiling. The centre of gravity of the rod is at point B. The weight of each wheel is *W* and the tension in the cord is 22 N.	
		(i) By taking moments about end A, show that the weight *W* of each wheel is 14 N.	[2]
		L2 **Solution:** (*W* × 0.45) **or** (19 × 1.3) **or** (*W* × 1.85) **or** (22 × 2.6)	C1

			$(W \times 0.45) + (19 \times 1.3) + (W \times 1.85) = (22 \times 2.6)$ $W = 14$ N	M1 A0
			Examiner's Comments Mostly well done.	
		(ii)	Determine the magnitude and the direction of the force acting on the rod at end A. magnitude = …………………………. N direction = ………………………………	[2]
		L1	**Solution:** magnitude = 19 + 14 + 14 – 22 = 25 N direction = vertically upwards	**A1** **A1**
			Examiner's Comments Mostly well done.	
	(c)	The unstretched length of the cord in **(b)** is 0.25 m. The variation with length *L* of the tension *F* in the cord is shown in Fig. 2.2.  **Fig. 2.2**		

		(i)	State and explain whether Fig. 2.2 suggests that the cord obeys Hooke's law.	[2]
		L2	**Solution:** The extension is zero when the force is zero graph is a straight line and (so) Hooke's law obeyed	 **B1** **B1**
			Examiner's Comments The question required how the figure suggests whether the cord obeys hooke's law. Most of the students did not make clear reference to the features of the graph (straight line) in the responses, or passing through the point where when the force is 0 N, there is no extension.	
		(ii)	Calculate the spring constant *k* of the cord. k = ... N m^{-1}	[2]
		L2	**Solution:** k = gradient = 60 / (1.00 – 0.25) k = 80 N m^{-1}	 M1 A1
			Examiner's Comments Mostly well done.	
		(iii)	On Fig. 2.2, shade the area that represents the work done to extend the cord when the tension is increased from F = 0 to F = 40 N.	[1]
		L2	**Solution:**	


F / N
60
50
40
30
20
10
0
0
0.25
0.50
0.75
1.00
L / m

3	**(a)**	**(i)**	Define gravitational potential at a point.	
			....	[2]
		L1	**Solution:** It is the <u>work done per unit mass</u> by external agent in bringing (small test) mass from infinity (to the point).	**B1** **B1**
		(ii)	Use your answer in **(i)** to explain why the gravitational potential near an isolated mass is always negative.	
			....	[2]
		L1	**Solution:** <u>Gravitational potential at infinity is 0</u>. There is negative work done by the external agent as the <u>force by the external agent and displacement</u> by mass are in <u>opposite directions</u>.	**B1** **B1**
	(b)		A rocket is launched from the surface of a planet and moves along a radial path, as shown in Fig. 3.1.  **Fig.3.1** The planet may be considered to be an isolated sphere of radius *R* with all of its mass *M* concentrated at its centre. Point A is a distance *R* from the surface of the planet. Point B is a distance 4*R* from the surface.	
		(i)	Show that the difference in gravitational potential $\Delta\phi$ between points A and B is given by the expression $$\Delta\phi = \frac{3GM}{10R}$$ where *G* is the gravitational constant.	
				[1]

		L2	**Solution**: $\phi_B = \frac{-GM}{(R+4R)} = \frac{-GM}{5R}$ $\phi_A = \frac{-GM}{(R+R)} = \frac{-GM}{2R}$ $\Delta\phi = \phi_B - \phi_A$ $= \frac{-GM}{5R} - \frac{-GM}{2R}$ $= \frac{-2GM-(-5GM)}{10R}$ $= \frac{3GM}{10R}$	B1 A0
		(ii)	The rocket motor is switched off at point A. During the journey from A to B, the rocket has a constant mass of 4.7×10^4 kg and its kinetic energy changes from 1.70 TJ to 0.88 TJ. For the planet, the product GM is 4.0×10^{14} N m^2 kg^{-1}. It may be assumed that resistive forces to the motion of the rocket are negligible. Use the expression in **(b)(i)** to determine the distance from A to B.	
			distance = ... m	[3]
		L3	**Solution:** By Conservation of energy Gain in GPE = loss in KE Gain in GPE $m\Delta\phi = m\frac{3GM}{10R}$ $m\frac{3GM}{10R} = (1.7-0.88)x10^{12}$ $(4.7x10^4)\frac{3(4x10^{14})}{10R} = 8.2x10^{11}$ $R = \frac{3x(4.7x10^4)(4x10^{14})}{8.2x10^{11}x10}$ = 6.88×10^6 m (radius of earth)	C1 C1 A1

		Distance from A to B = 4R – R = 3R = 3 x 6.88 x 10^6 = 2.1 x 10^7 m	
	(c)	A spherical planet has mass 6.00 × 10^{24} kg and radius 6.40 × 10^6 m. The planet may be assumed to be isolated in space with its mass concentrated at its centre. A satellite of mass 340 kg is in a circular orbit about the planet at a height 9.00 × 10^5 m above its surface. Determine the satellite's orbital speed.	
		orbital speed = ………………………………… m s^{-1}	[2]
	L2	**Solution:** The gravitational force provides the centripetal force $F_{grav} = F_c$ $\frac{GMm}{R^2} = \frac{mv^2}{R}$ $v = \sqrt{\frac{GM}{R}}$ $= \sqrt{\frac{6.67x10^{-11}x6x10^{24}}{(6.4x10^6 + 9x10^5)}}$ = 7.4 x 10^3 m s^{-1}	**M1** **A1**

4	**(a)**	Define *simple harmonic motion* ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………	[2]
	L1	**Solution:** the motion of an object such **that its acceleration is proportional to its displacement from a fixed equilibrium point** and is always **directed towards that point**	**B1** **B1**

Examiner's Comments

While a fair number of students remembered the general gist of the definition, many students did not receive full credit for omitting the detail that the displacement is measured from **the equilibrium point**. A few students simply stated the equation (or a textual form of the equation).

(b) A mass is hung from a vertical spring attached to the ceiling. *d* is the distance between the ceiling and the centre of the mass as shown in Fig. 4.1.

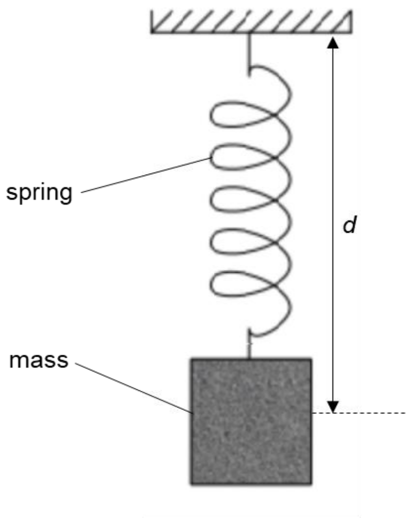


Fig. 4.1

At time $t = 0$, the mass is displaced a small distance downwards and released. It moves with simple harmonic motion, and the variation with time *t* of the distance *d* is shown in Fig. 4.2

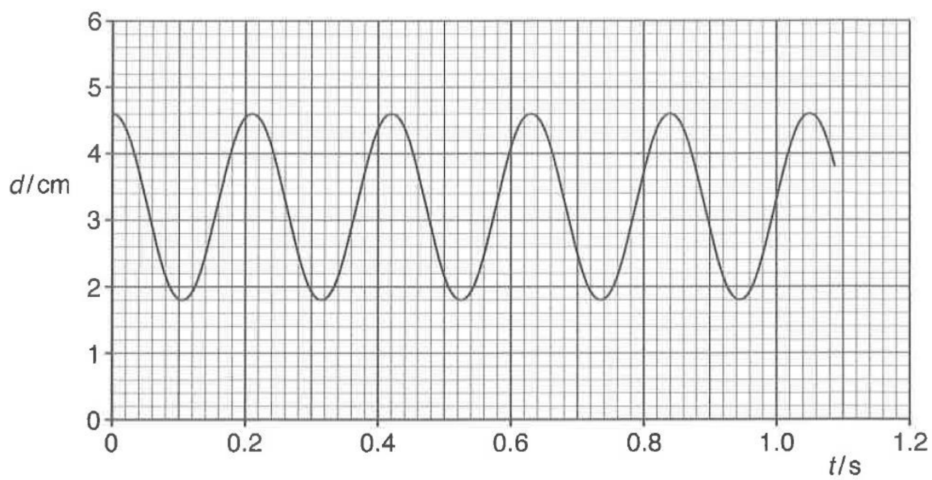


Fig. 4.2

(i) Use Fig. 4.2 to state two times at which the mass is:

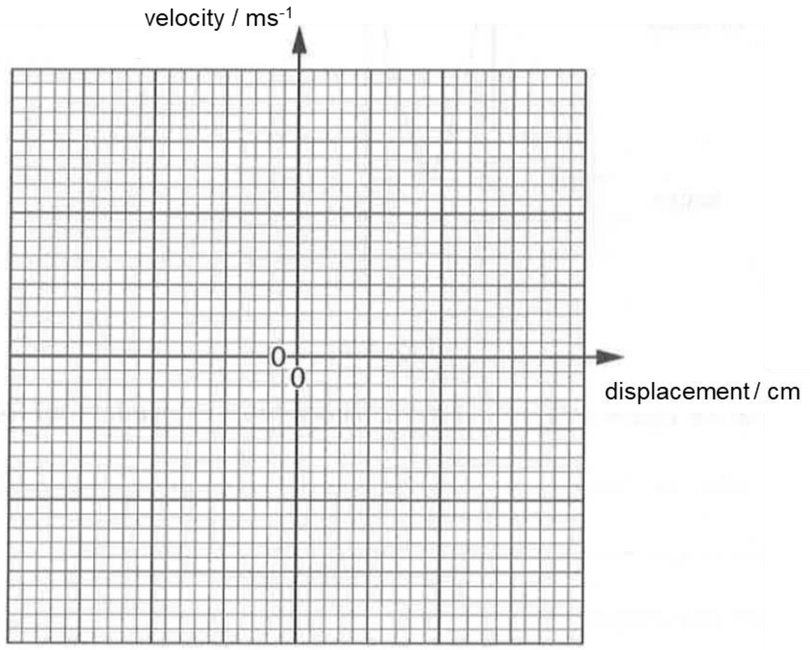
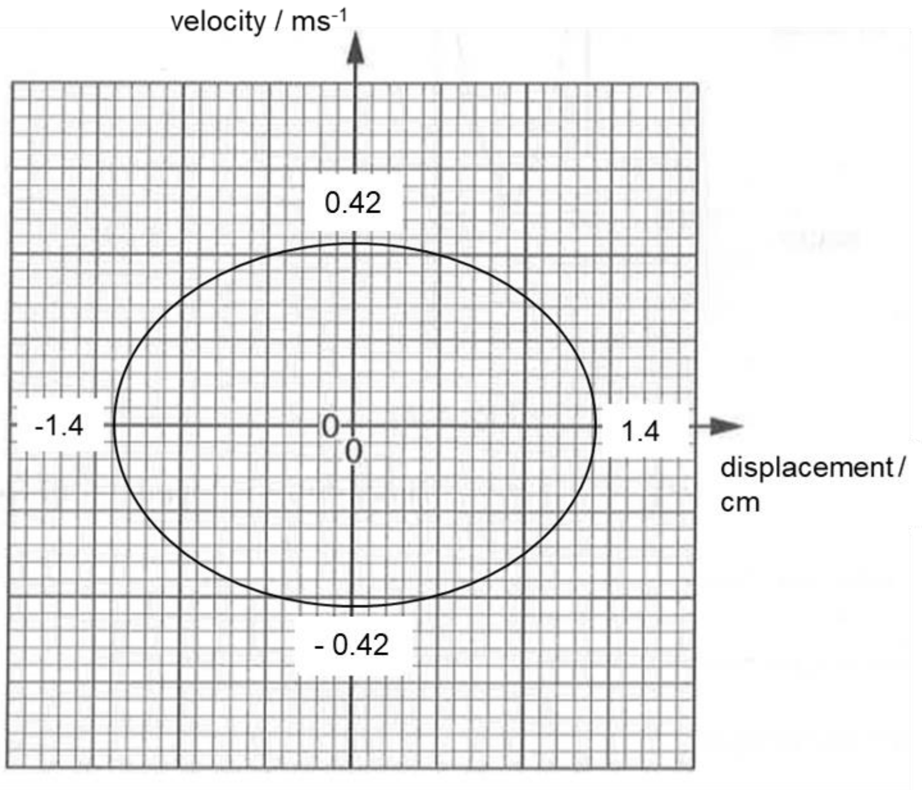
1. at the lowest point of its oscillation

time .... s and time .... s [1]

			L1	**Solution:** 0s, 0.21 s, 0.42 s, 0.63s, 0.84 or 1.05 s	A1
				Examiner's Comments Fairly well done, with several students missing out the fact that the d is measured from the ceiling, and the lowest point of the oscillation is the largest value of d. A few did not read off the graph carefully.	
			2.	moving upwards with maximum speed time ………… s and time ………… s	[1]
			L2	**Solution:** 0.05 s, 0.26 s, 0.47 s, 0.68 s, 0.89 s	A1
				Examiner's Comments Fairly well done, though some student included times when the object was moving downwards at maximum speed, rather than upwards. This is mostly due to making a similar mistake as Part 1, and not understanding that moving upwards is represented as a decrease in the value of d. A few did not read off the graph carefully as well.	
		(ii)	Determine, for the mass:		
			1.	the angular frequency ω angular frequency = …………….. rad s^{-1}	[2]
		L2	**Solution:** Angular frequency $= 2\pi/T$ $= 2\pi/0.21$ [M1 for correct determination/identification of T] $= 30$ rad s^{-1}		M1 A1
			Examiner's Comments		

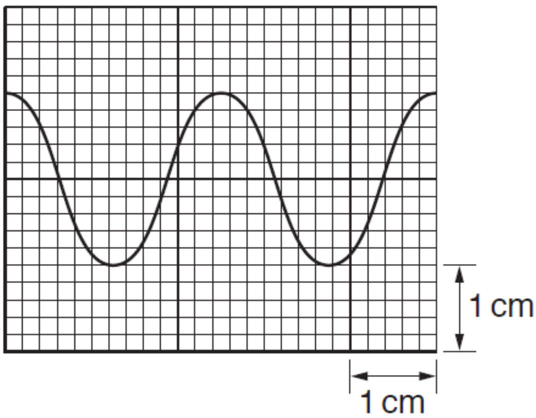
[Turn over

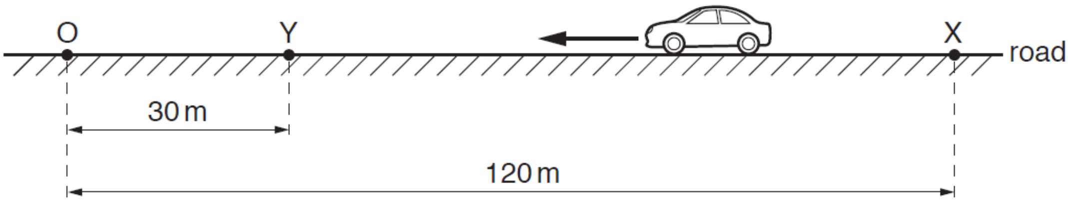
			Well done, with a few students not receiving credit either for not recalling the formula for angular frequency correctly or reading the period off the graph incorrectly.	
			2. the maximum speed maximum speed = ………………….. m s^{-1}	[2]
		L2	**Solution:** maximum speed v_0 $= \omega x_0$ $= (30)\left(\frac{4.6\text{-}1.8}{2}\times 10^{-2}\right)$ [M1 for correct determination of amplitude] $= 0.42$ m s^{-1}	**M1** **A1**
			Examiner's Comments A majority of students knew the formula for maximum speed, though a few used the speed-time or speed-displacement formula instead. While a few used the formulae correctly, many substituted incorrect values because they did not know that the displacement value is measured from the equilibrium position. For those who used the maximum speed formula, the common errors preventing them from getting the full marks were either using incorrect methods to find the amplitude, or neglected to convert cm to m.	
		(iii)	Use your answer to **(b)(ii)2** to sketch, on the axes of Fig. 4.3, a graph of how the velocity of the mass varies with the displacement from the equilibrium position. Label the axes with the appropriate scale and values.	

			 **Fig 4.3**	[3]
		L3	**Solution:**  B1 – correct shape: ellipse centred at the origin B1 – correct x-intercepts: 1.4 (or ecf from above) B1 – correct y-intercepts: 0.42 (or ecf from above)	
			Examiner's Comments	

			A majority knew that this question was asking them to draw an ellipse, those who did not drew the other graphs from the chapter e.g. sinusoidal curves or parabolas which will receive 0 marks regardless of the intercept values For those who drew an ellipse, some marks were deducted for awkward/lazy scales, poorly drawn/incomplete ellipses and/or omitted/incorrect values of the intercept.	
		(iv)	A periodic external force is applied to the spring-mass system in the vertical direction. State the frequency of the periodic external force when the system oscillates with maximum amplitude.	
			frequency = ………… Hz	[1]
		L2	**Solution:** Maximum amplitude occurs (resonance) when driving frequency = natural frequency Therefore, driving frequency = 1/T = 1/0.21 = 4.8 Hz (shown)	**A1**
			Examiner's Comments A fair number did not recognize that this question is related to resonance, and the resonance frequency = driving frequency = natural frequency of the system. A few used $v = f\lambda$ even though this has nothing to do with waves.	

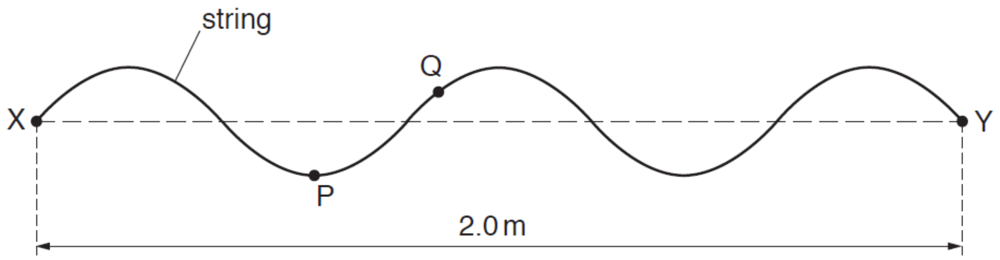
5	**(a)**	A wave of frequency f and wavelength λ has speed v. Using the definition of speed, deduce the equation $v = f\lambda$.	
			[1]
	L1	**Solution:**	

		Speed of wave, $v = \dfrac{\textit{distance travelled by a wave profile in one period, } \lambda}{\textit{one period, } T}$ Since $f = \frac{1}{T}$ $v = f\lambda$	B1
		Examiner's Comments Please memorise the derivation properly. Any symbols used in the derivation must be properly defined. Some students were inconsistent in their derivation referencing distance d for a time period of T, or a distance λ, for an arbitrary time t.	
	(b)	A car horn emits a sound wave of frequency 800 Hz. A microphone and a cathode-ray oscilloscope (c.r.o.) are used to analyse the sound wave. The waveform displayed on the c.r.o. screen is shown in Fig. 5.1.  **Fig. 5.1** Determine the time-base setting, in s cm^{-1}, of the c.r.o.	
		time-base setting = ... s cm^{-1}	[3]
	L2	**Solution:** $T = \dfrac{1}{f} = \dfrac{1}{800} = = 1.25 \times 10^{-3}$ s time-base setting = $\dfrac{1.25x10^{-3}}{2.5}$ $= 5 \times 10^{-4}$ s cm^{-1}	C1 C1 A1
		Examiner's Comments	

		Some students attempted a solution using v = fλ, but wavelength cannot be determined via the CRO. Such solutions were penalized accordingly.	
	(c)	The intensity I of the sound at a distance r from the car horn in (b) is given by the expression $$I = \frac{k}{r^2}$$ where k is a constant. Fig. 5.2 shows the car in **(b)** on a road.  **Fig. 5.2** An observer stands at point O. Initially the car is parked at point X which is 120 m away from point O. The car then moves directly towards the observer and stops at point Y, a distance of 30 m away from O. The car horn continuously emits sound when the car is moving between points X and Y. The sound wave at point O has amplitude A_X when the car is at X and has amplitude A_Y when the car is at Y. Calculate the ratio $\frac{A_Y}{A_X}$.	
		ratio = ...	[2]
	L2	**Solution:** $I \alpha A^2$ $\frac{I_x}{I_y} = \left(\frac{r_Y}{r_X}\right)^2 = \left(\frac{A_X}{A_Y}\right)^2$	

		Ratio $\frac{A_Y}{A_X} = \frac{120}{30}$ $= 4.0$		C1 A1
		Examiner's Comments Some students were unable to link amplitude of wave to distance. The other mistakes came from students who made computation errors in the steps.		
	(d)	**(i)**	Describe what is meant by a polarized wave.	
			………………………………………………………………………………… ………………………………………………………………………………… ………………………………………………………………………………… …………………………………………………………………………………	[2]
		L1	**Solution:** Polarisation is a phenomenon where the <u>oscillations</u> in a transverse wave are <u>confined to one direction</u> only, the direction being at <u>right angles to the direction of propagation</u> of the wave.	B1 B1
			Examiner's Comments Many did not memorise the definition.	
		(ii)	State why a sound wave **cannot** be polarized.	
			………………………………………………………………………………… …………………………………………………………………………………	[1]
		L2	**Solution:** Sound wave is a longitudinal wave where oscillations in the wave are along the direction of energy transfer. Only transverse wave can be polarized.	B1
			Examiner's Comments Mostly well done.	

6	**(a)**	State the conditions required for the formation of a stationary wave.	

		………………………………………………………………………………………… ………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………		[2]
	L1	**Solution:** **(Two) progressive** waves travelling (at the same **speed**) in **opposite directions** overlap and the waves (are of the **same type** and) have the same **frequency/wavelength** and **amplitude**.		B1 B1
		Examiner's Comments: Students should make an effort to memorise the conditions for a stationary wave. The majority missed out key conditions and hence did not score the full marks.		
	(b)	A horizontal string is stretched between two fixed points X and Y. The string is made to vibrate vertically so that a stationary wave is formed. At one instant, each particle of the string is at its maximum displacement, as shown in Fig. 6.1.  **Fig.6.1.** P and Q are two particles of the string. The string vibrates with a frequency of 40 Hz. Distance XY is 2.0 m.		
		(i)	State what is meant by an antinode of the stationary wave.	
			……………………………………………………………………………… ………………………………………………………………………………	[1]
		L1	**Solution:** It is a position where there is <u>maximum amplitude</u>.	B1
			Examiner's Comments: Many students incorrectly use the word "displacement" rather than "amplitude". Students need to recognize that oscillations within a loop has varying amplitudes and the antinode has the max amplitude when comparing oscillations within the loop.	
		(ii)	State the number of antinodes in the stationary wave.	

			number = ...	[1]
		L1	**Solution:** 5 antinodes	**A1**
			Examiner's Comments: Majority were able to identify the 5 antinodes.	
		(iii)	Determine the minimum time taken for the particle P to travel from its lowest point to its highest point.	
			time taken = ... s	[2]
		L2	**Solution:** T = $\frac{1}{40} = 2.5x10^{-2}$ time taken = $\frac{2.5 \times 10^{-2}}{2}$ $= 1.3 \times 10^{-2}$ s	**C1** **A1**
			Examiner's Comments: Students need to recognize that the time taken for the particle P to travel from its lowest point to highest point is half a period of oscillation. Most were able to complete this part successfully.	
		(iv)	State the phase difference, with its unit, between the vibrations of particle P and of particle Q.	
			phase difference = ...	[1]
		L1	**Solution:** 180° or π rad	**A1**
			Examiner's Comments: Majority of students were not able to recognize that the particles across adjacent loops are oscillating in phase. Note that within a loop, the particles are oscillating in phase with one another.	
		(v)	Determine the speed of a progressive wave along the string.	
			speed = ...m s^{-1}	[2]
		L2	**Solution:** $v = f\lambda$ $\lambda = 2.0 / 2.5$ (= 0.80 m) $v = 0.80 \times 40$	**C1**

$= 32\ m\ s^{-1}$ **A1**

Examiner's Comments:

Students should recognize that there are 2.5 wavelengths on the string. Most students have no issues completing this question.

(c) A tube is open at both ends. A loudspeaker, emitting sound of a single frequency, is placed near one end of the tube, as shown in Fig. 6.2.

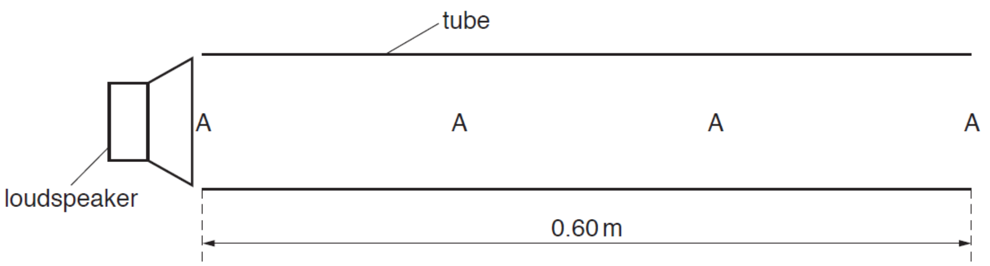


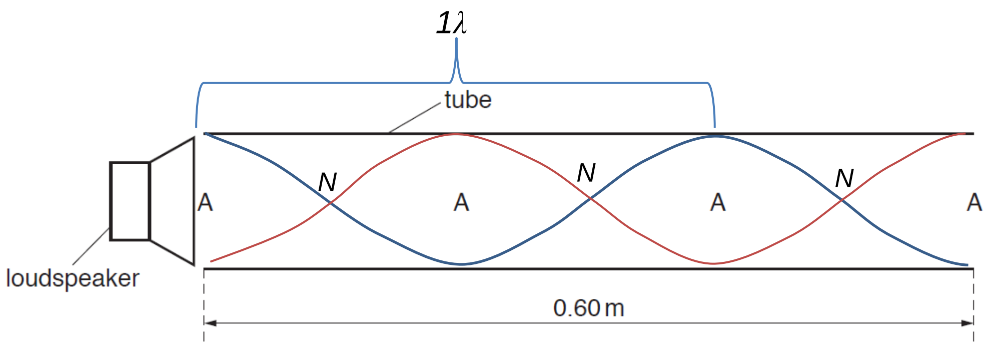
Fig. 6.2

The speed of the sound in the tube is 340 m s^{-1}. The length of the tube is 0.60 m. A stationary wave is formed with an antinode A at each end of the tube and two antinodes inside the tube.

(i) State the distance between a node and an adjacent antinode.

distance = ... m [1]

L2 **Solution:**



0.6/6 = 0.1 m **B1**

Examiner's Comments:

Mostly well done. Students are able to recognize the position of the nodes in Fig 6.2, that they lie between the antinodes.

(ii) Determine, for the sound in the tube,

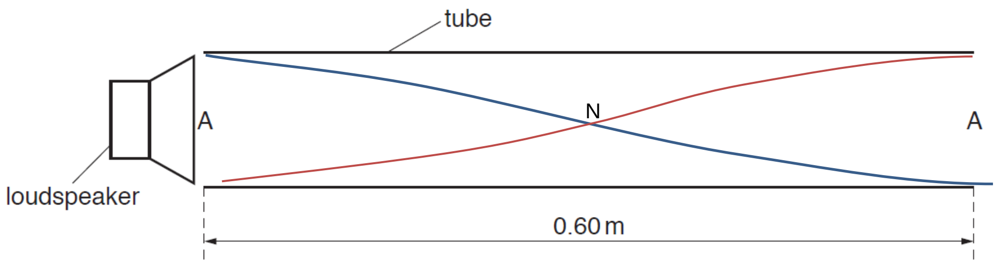
1. the wavelength,

wavelength = ... m [1]

L2 **Solution:**

$\lambda = 0.4$ m **A1**

Examiner's Comments:

				Mostly well done. Students are able to recognize that between a node and antinode, that is one quarter wavelength and hence find what one wavelength is.	
			2.	the frequency.	
				frequency = ... Hz	[2]
			L2	**Solution:** $v = f\lambda$ $f = \frac{340}{0.4}$ $= 850$ Hz	**C1** **A1**
				Examiner's Comments: Mostly well done by students. ECF was allowed for wrong values of wavelength.	
		(iii)	Determine the minimum frequency of the sound from the loudspeaker that produces a stationary wave in the tube.		
			minimum frequency = ... Hz		[2]
		L2	**Solution:** Minimum frequency occurs at fundamental frequency  Half a wavelength = 0.6 m λ = 2 × 0.60 = 1.2 m f = 340/1.2 = 283 Hz		**C1** **A1**
			Examiner's Comments: Quite a number of students were not able to complete this question. They did not recognize the shape of the stationary wave for minimum or fundamental frequency. They need to know the relationship between wavelength and frequency that when one decreases, the other increases. For the open tube, at minimum frequency, we can fit half a wavelength into the tube.		

7	Read the passage below and answer the questions that follow.	

[Turn over

Resistive Forces and Fuel Consumption in Vehicles

With the increasing cost of fuel, increasing the efficiency of fuel use in vehicles has become more pertinent to manufacturers and drivers. While some of the energy generated by the fuel in the engine goes into accelerating the vehicle from rest, a larger percentage of the energy is lost to the resistive forces acting against the motion of the vehicle.

There are two main types of resistive forces acting on a moving vehicle: the rolling resistance acting against the tires as they turn and the air resistance acting against the vehicle as it moves. Overcoming both forces use up some of the energy provided by the fuel in the engine, but to different extents depending on the speed of the vehicle.

For a certain vehicle of unladen mass 1000 kg, the variation of the energy consumed per 100 kilometres of travel due to these resistive forces with its speed is shown in Fig. 7.1.

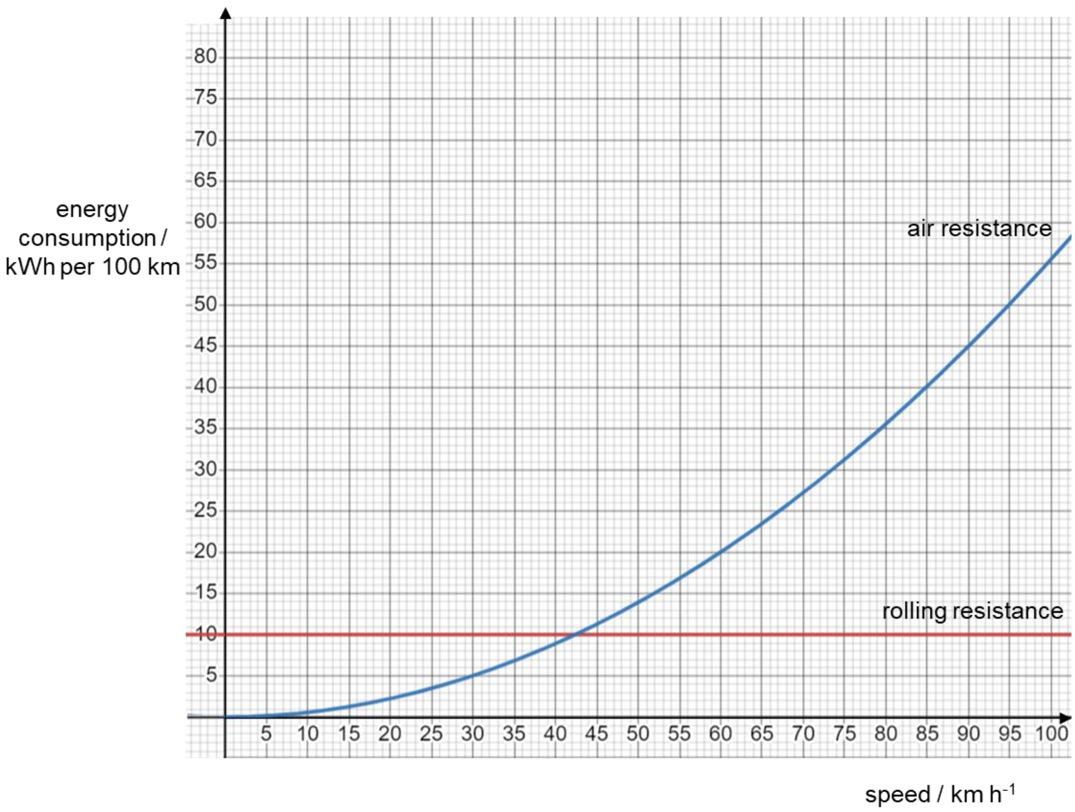


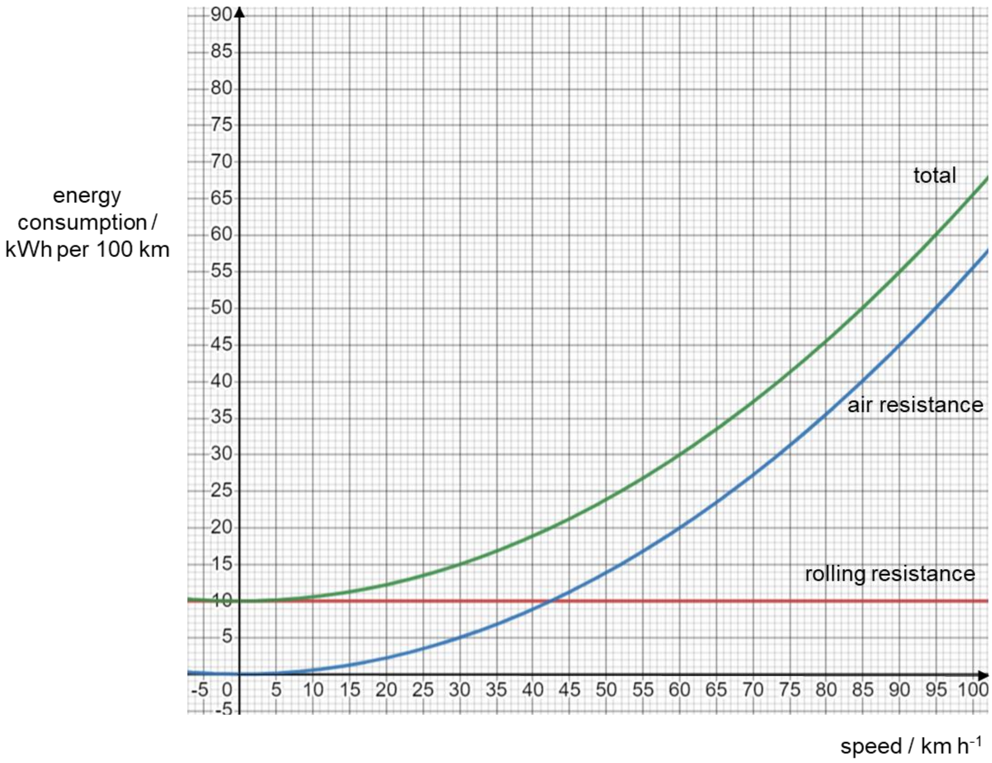
Fig. 7.1

The magnitude of the rolling resistance F_{rr} is given by

$$F_{rr} = C_{rr} N$$

where N is the normal contact force between the surface and the vehicle, and C_{rr} is coefficient of rolling friction, which is a quantity dependent on the types of material of the road and the tires.

(a) On Fig 7.1, sketch the graph representing the variation of the **total** energy consumed per 100 km due to rolling resistance and air resistance with speed. [2]

	L2	**Solution:**  Mark awarded for correct shape – curve starting at (0,10) and increasing at the same rate as the air resistance curve. (Ignore negative values on x -axis in solution)	**A1**
	(b)	Using the expression of the rolling resistance, explain why the energy consumed due to the rolling resistance is independent of the vehicle's speed. …………………………………………………………………………… …………………………………………………………………………… ……………………………………………………………………………	[2]
	L2	**Solution:** **The rolling resistance** is dependent on the normal contact force and the material of the tires/road, which **does not depend on speed**. Since the resistance is independent on speed, **the work done against the resistance is likewise independent of the speed.**	**B1** **B1**
	(c)	**(i)** Show that 1.0 kW h is equivalent to 3.6×10^6 J of energy.	[1]
		L1 **Solution:** Energy in 1.0 kWh	

			$= Pt$ = (1000 W)(3600 s) = 3.6×10^6 J (shown)	**M1** **A0**
		(ii)	Using the definition of work done and data from Fig 7.1, calculate the magnitude of the rolling resistance F_{rr} acting on the vehicle. F_{rr} = ………………… N	[2]
		L2	**Solution:** Since work done = force x displacement Force of rolling resistance = Work done against rolling resistance/displacement = 10 kW h / 100 km = (10 x 3.6×10^6 J)/(100 x 1000 m) = 360 N	 **M1** **A1**
		(iii)	Hence, determine the coefficient of rolling resistance C_{rr} for this vehicle C_{rr} = ………………………	[2]
		L1	**Solution:** Since $F_{rr} = C_{rr}N$ and the normal contact force = mg since the vehicle is in equilibrium in the vertical direction C_{rr} $= F_{rr}/N$ = 360/ (1000 x 9.81) = 0.037	 **M1** **A1**
	(d)	Based on the information provided in the passage, explain why energy consumption per 100 km is higher		
		(i)	when the vehicle is driven at a constant high speed,	

			…………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………	[2]
		L2	**Solution:** At high speeds, the **air resistance acting on the vehicle increases** since **more energy is consumed to overcome air resistance** at this high speed, fuel consumed increases	 **B1** **B1**
		(ii)	when the vehicle is fully laden with passengers. …………………………………………………………………………………… …………………………………………………………………………………… ……………………………………………………………………………………	[2]
		L3	**Solution:** When the **weight of the vehicle is higher, the normal contact force is higher**, increasing the rolling resistance thus, the **amount of energy needed to overcome the rolling resistance increases**, leading to higher fuel consumption	 **B1** **B1**

-- END OF PAPER 2 –