Christ Church Grammar School

Science Department
Year 11 Physics

Semester 2 Examination, 2019

Question/Answer Booklet

PHYSICS

UNIT 2

Fix student label here

Student Name: SOLUTIONS

Time allowed for this paper
Reading time before commencing work: ten minutes
Working time for paper: two and a half hours

Materials required/recommended for this paper
To be provided by the supervisor
This Question/Answer Booklet
Formulae and Data Booklet

To be provided by the candidate
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, correction fluid/tape, eraser, ruler, highlighters

Special items: non-programmable calculators approved for use in the ATAR examinations

Important note to candidates
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

See next page

Structure of this paper

Section	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available		Percentage of exam	Percentage achieved
Section One: Short Answer	12	12	50		50	33	
Section Two: Problem Solving	5	5	70		70	46	
Section Three: Comprehension	2	2	30		32	21	
						100	

Instructions to candidates

1. The rules of conduct of Christ Church Grammar School assessments are detailed in the Reporting and Assessment Policy. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer booklet preferably using a blue/black pen. Do not use erasable or gel pens.

3. When calculating or estimating answers, show all your working clearly. Your working should be in sufficient detail to allow your answers to be checked readily and for marks to be awarded for reasoning.

   In calculations, give final answers to three significant figures and include appropriate units where applicable.

   In estimates, give final answers to a maximum of two significant figures and include appropriate units where applicable.

4. You must be careful to confine your answers to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

6. The Formulae and Data booklet is not to be handed in with your Question/Answer booklet.

Section One: Short Response **33% (50 marks)**

This section has **twelve (12)** questions. Answer **all** questions. Write your answers in the space provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to three significant figures and include appropriate units where applicable.

When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

Supplementary pages for planning/continuing your answers to questions are provided at the end of this Question/Answer booklet. If you use these pages to continue an answer, indicate at the original answer where the answer is continued, i.e. give the page number.

Suggested working time: 50 minutes.

Question 1 **(1 mark)**

You drop a rock off a bridge. When the rock has fallen 4.0 m, you drop a second identical rock. Neglecting air resistance, as the two rocks continue to fall, select what happens to their velocities by circling the correct answer.

(A) Both increase at the same rate.

(B) The velocity of the first rock increases faster than the velocity of the second.

(C) The velocity of the second rock increases faster than the velocity of the first.

(D) Both velocities stay constant.

Question 2 **(4 marks)**

Two statements are shown below in relation to a ball that is thrown vertically up and then falls back down to the ground.

Statement 1: That acceleration and velocity are always in the same direction.

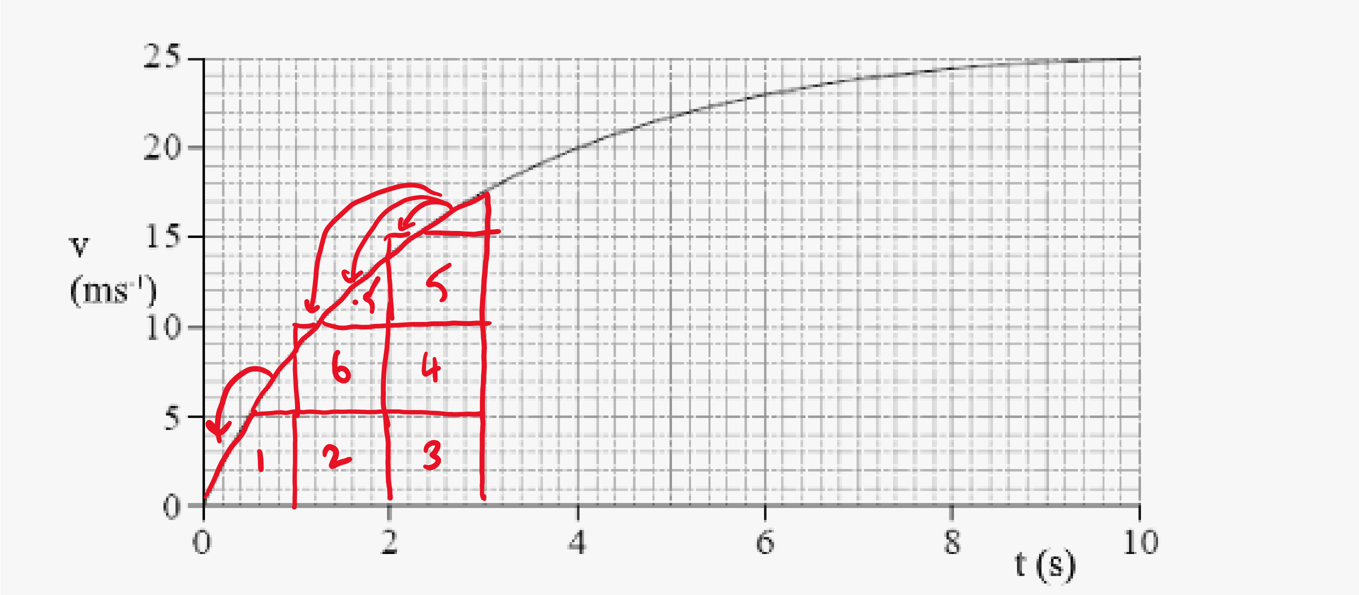
Statement 2: That the balls' upward acceleration is zero at its highest point.

For **each** statement, state whether or not it is correct or incorrect and explain your choice of answer.

Description	Marks
Statement 1: Incorrect	1
acceleration is always down, velocity depends on direction of motion	1
Statement 2: Incorrect	1
The acceleration is down and has a value of 9.80 ms^{-2}.	1
Total	4

Question 3 **(4 marks)**

The graph below shows the variation with time *t* of the speed *v* of a cricket ball of mass 0.150 kg, that has been released from rest and allowed to fall through air. The force of air resistance is **not** negligible.



(a) Consider the ball at time t = 2.0 s. On the picture of the ball below, indicate as labelled arrows all the forces acting on the ball.

Description	Marks
At t = 2.0 s the ball is still accelerating, so there is a resultant force acting down. The two forces acting are weight and air resistance.	1
With the weight vector being longer than the air resistance vector 	1
Total	2

Suppose the cricket ball was released from rest from the top of a tall building and observed to strike the ground after 3.00 seconds.

(b) Using the graph above, estimate the height that the cricket ball was released from.

(2 marks)

Description	Marks
The area under the graph is estimated.	1
6.5 large squares at 5m/square = 33 m (s sig fig)	1
Total	2
Statement of area under = displacement (1 mark maximum)	

Question 4 **(5 marks)**

A speaker is emitting a sound whose intensity is measured as 1.00 x 10^{-6} W m^{-2} at a distance of 1.50 m from the source.

(a) Calculate this sound's predicted intensity at a distance of 4.50 m. The following equation may be useful for this question.

$$I_1r_1^2 = I_2r_2^2$$

(3 marks)

Description	Marks
$\frac{I_1}{I_2} = \frac{{r_2}^2}{{r_1}^2}$; where $I_1 = 1.00 \times 10^{-6}\ Wm^{-2}$; $I_2 = ?$	1
$\frac{1.00 \times 10^{-6}}{I_2} = \frac{4.50^2}{1.50^2}$	1
$I_2 = 1.11 \times 10^{-7}\ Wm^{-2}$	1
Total	3

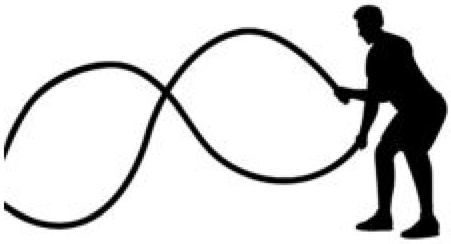
(b) The figure you calculated in part a) would not be the value measured in reality. Comment on your calculated value for intensity at a distance of 4.50 m and explain how it would be different in reality.

(2 marks)

Description	Marks
In reality, the sound intensity would be larger	1
As sound would be relflected off the walls, floor and increase the pressure where the sound is being measured.	1
Total	2

Question 5 **(3 marks)**

An athlete is training with 4.00 m long battle-ropes fixed to a wall as shown in the diagram such that his hands move up and down to displace the rope. He observes that in a 45.0 second interval, he is able to move his hands through exactly 60 oscillations. Calculate the period and frequency of the waves being produced in this time interval.



Description	Marks
T = 45.0 / 60 = 0.750 s	1.5
$f = \frac{1}{T}$ = 60/45 = 1.33 Hz	1.5
Total	3

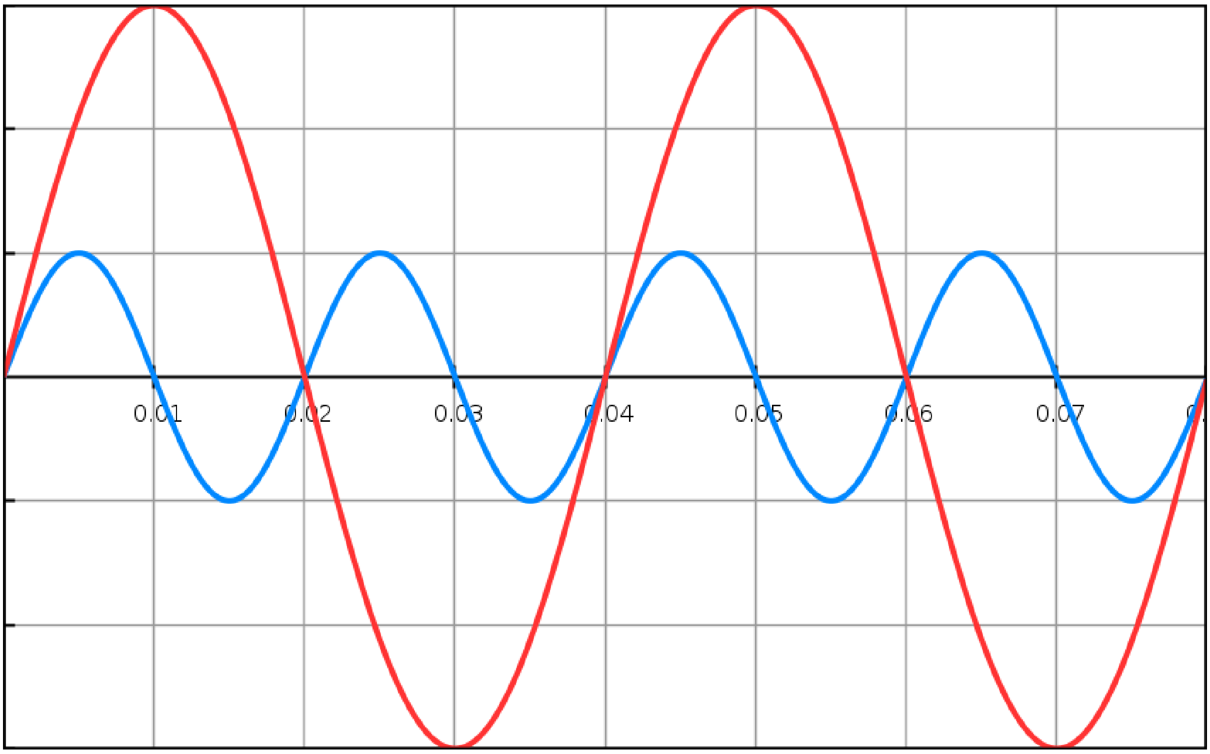
Question 6 **(3 marks)**

A brass tube stands vertically in a tall jar of water so that its top is level with the water surface. The tube is raised vertically and a continuously vibrating tuning fork is held above the open end. A second resonance point is heard when the tube is raised 0.293 m from the position of the first point of resonance. If the speed of sound in air is 346 ms^{-1}, calculate the frequency of the tuning fork.

Description	Marks
Antinode – Antinode distance = $\lambda/_2$ $\lambda = 2 \times 0.293\, m$ = 0.586	1
$v = f\lambda;\ \therefore f = \frac{v}{\lambda} = \frac{346}{0.586}$	1
f = 590 Hz	1
Total	3

Question 7 **(4 marks)**

A string is vibrating at a frequency and amplitude that produces the pressure difference (ΔP) v time (t) graph shown in the diagram below. The pressure difference axis has not units – the scale is proportional.



(a) Calculate the frequency (in Hz) of the sound produced by the string.

(2 marks)

Description	Marks
T = 0.02 s	1
$f = \frac{1}{T}$ = 1/0.02 = 50.0 Hz	1
Total	2

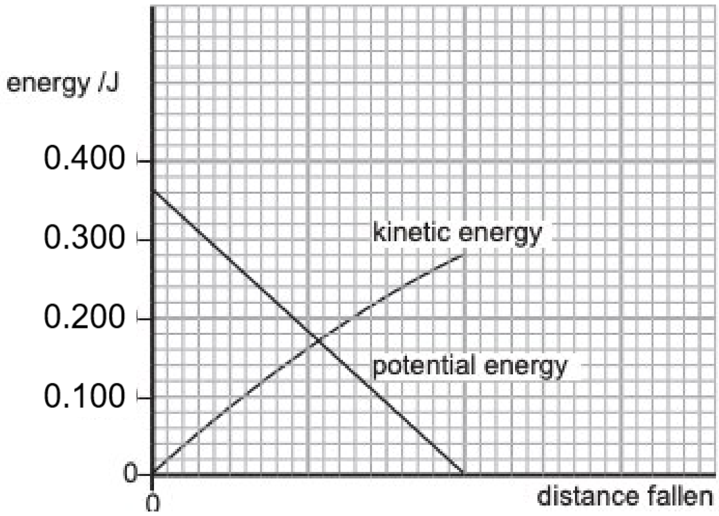
(b) On the same set of axes, sketch the wave form for a sound produced by the string that has three times the amplitude and half the frequency.

(2 marks)

Description	Marks
T = 0.04 s	1
Amplitude, ΔP = -3 to 3	1
Total	2

Question 8 **(7 marks)**

A ball of mass 0.0240 kg is dropped from rest and falls to the floor. The graph below shows the variations in potential energy and kinetic energy with distance fallen until the ball reaches the floor.



(a) Calculate the height the ball was dropped from.

(3 marks)

Description	Marks
For height Ep = mgh	1
0.36 = 0.024 x 9.8 x h	1
h = 1.53 m	1
Total	3

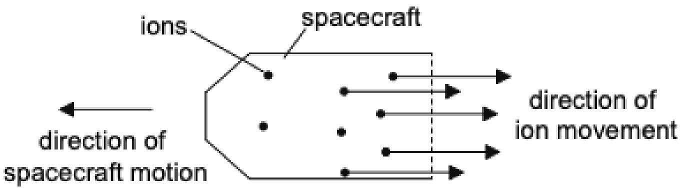
(b) Calculate the difference between the speed reached by the ball in case (a) and the speed that the ball would have reached had it been dropped in a vacuum.

(4 marks)

Description	Marks
$E_k = \frac{1}{2} mv^2$ $0.28 = \frac{1}{2} \times .024 \times v^2$ $v = 4.83\ ms^{-1}$ (Actual)	1.5
V from Ep $.36 = \frac{1}{2} \times .024 \times v^2$ $v = 5.48\ ms^{-1}$ (vacuum)	1.5
Speed difference is 5.48– 4.83 = 0.65 ms^{-1}	1
Total	4

Question 9 **(4 marks)**

Ion-thrust engines can power spacecraft. In this type of engine, ions are created in a chamber and expelled from the spacecraft. The spacecraft is in outer space when the propulsion system is turned on. The spacecraft starts from rest.

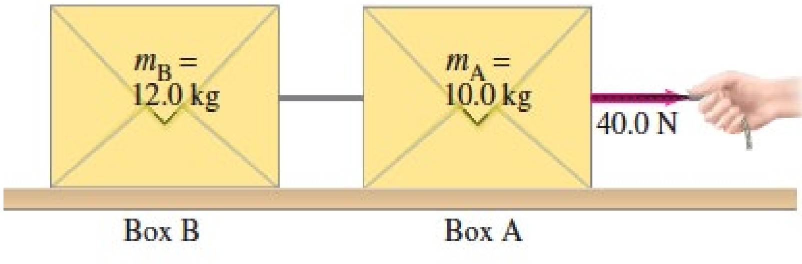


The mass of ions ejected each second is 6.60×10^{-6} kg and the speed of each ion is 5.20×10^{4} ms^{-1}. The initial total mass of the spacecraft and its fuel is 740 kg. Assume that the ions travel away from the spacecraft parallel to its direction of motion.
Determine the acceleration of such a spacecraft.

Description	Marks
Change in momentum each second = m Δv $= 6.60 \times 10^{-6} \times 5.20 \times 10^{4} = 0.340$ $kgms^{-1}$	1-2
$F = \Delta p / \Delta t$ thus $ma = \Delta p/ \Delta t$ thus $a = 0.340/740 = 4.60 \times 10^{-4}$ ms^{-2}	1-2
Total	4

Question 10 **(4 marks)**

Two boxes, A and B, are connected by a lightweight string and are resting on a smooth (frictionless) table. The boxes have masses of 12.0 kg and 10.0 kg. A horizontal force of 40.0 N is applied to the 10.0-kg box, as shown in the diagram. Calculate the tension in the middle cable.



Description	Marks
Find a $\Sigma F = m_s a_s$ 40 = (12+10) a_s a_s = 1.82 ms^{-2}	1-2
Find T $\Sigma F = m_B a_B = T$ T = 21.8 N	1-2
Total	4

Question 11 **(4 marks)**

A 4.20 kg mass travelling 2.30 ms^{-1} East collides and combines with a 3.55 kg mass. The combined mass is then observed to continue travelling East with a speed of 0.400 ms^{-1}. Calculate the initial velocity of the 3.55 kg mass.

Description	Marks
$\Sigma pi = \Sigma pf$ p = mv $m_1u_1 + m_2u_2 = m_cv_c$	1
4.20(+2.30) + 3.55u_2 = (4.20+3.55)(+0.400)	1
$u_2 = \frac{(4.20+3.55)(+0.400) - (4.20 \times 2.3)}{3.55}$	1
u_2 = -1.85 = 1.85 ms^{-1} West	1
Total	4

Question 12 **(7 marks)**

Two speakers of a stereo system are separated by 6.00 m. They are connected to a single frequency generator and are set up so that they are facing each other. Assume the speed of sound in air is 344 ms^{-1}.

(a) If a person stands in the exact middle of the two speakers, state and explain what they would hear at this position.

(3 marks)

Description	Marks
As person is equidistant from speakers, the path difference is zero	1
Meaning both waves arrive in phase and produce constructive interference	1
Hence, a loud tone	1
Total	3

The person now moves 2.00 m closer to the left hand speaker and the frequency from the generator is 43.0 Hz,

(b) Determine with appropriate calculation, whether he hears a load or quiet tone.

(4 marks)

Description	Marks
$v = f\lambda;\ \therefore \lambda = \frac{v}{f} = \frac{344}{43} = 8.00\ m$	1
Path difference = (5-1) = 4m	1
n = P.D / λ = 4 / 8 = 0.5	1
As n is a half integer, he will hear a quiet tone.	1
Total	4

End of Section One

Section Two: Problem-solving **46% (70 marks)**

This section has **five** questions. Answer all questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.

When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

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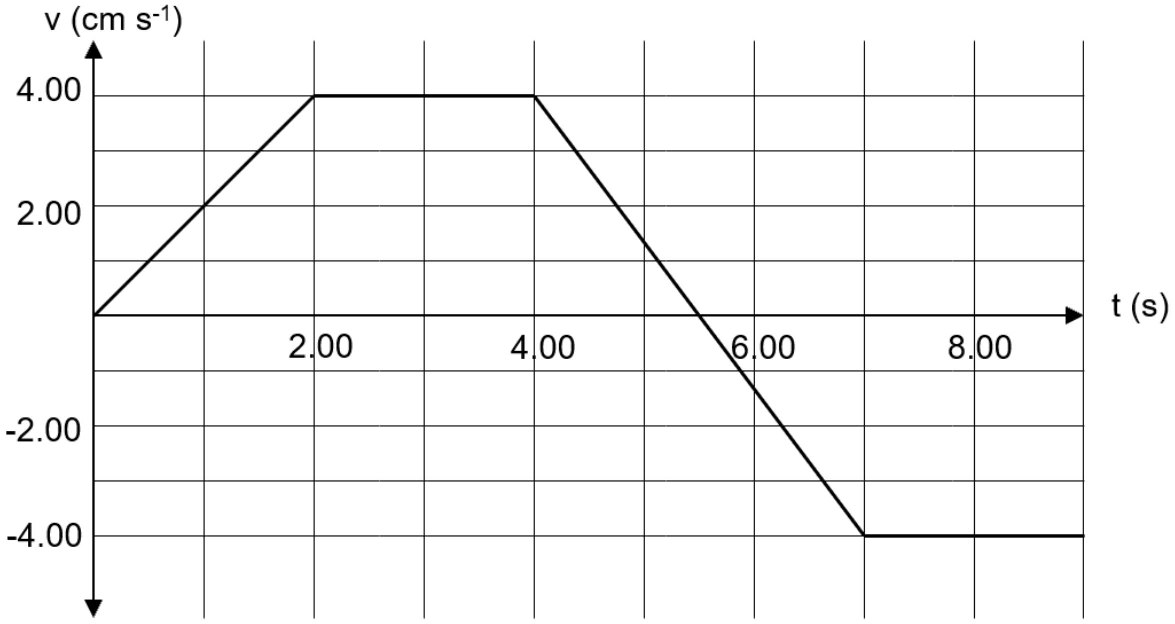
Suggested working time: 70 minutes.

Question 13 **(15 marks)**

The graph below shows the motion of an ant during a 9.00 second period. As can be seen, the ant's velocity has been measured in centimetres per second (cm s^{-1}) over this time. The ant is initially travelling in an easterly direction.



(a) State the time period during which the ant is moving in a westerly direction.

(1 mark)

Description	Marks
From 5.50s to 9.00 s	1
Total	1

(b) State the times when the ant is stationary.

(2 marks)

Description	Marks
t = 0.00 s	1
t = 5.50 s	1
Total	2

(c) State the time periods when the ant's acceleration is equal to zero.

(2 marks)

Description	Marks
Between t = 2.00s and 4.00s	1
Between t = 7.00s and 9.00s	1
Total	2

(d) Calculate the ant's acceleration (in ms^{-2}) at:

(i) t = 1.00 s

(2 marks)

Description	Marks
$a = \frac{(0.04-0)}{2}$	1
= 0.0200 ms^{-2} East	1
Total	2

(ii) t = 5.50 s

(2 marks)

Description	Marks
$a = \frac{(-0.04-0.04)}{5}$	1
= 0.0267 m s^{-2} West	1
Total	2

(e) Calculate the ant's change in displacement (in cm) between:

(i) t = 0 s – 5.50 s.

(3 marks)

Description	Marks
$\Delta s = (0.5 \times 2 \times 4) + (2 \times 4) + (0.5 \times 1.5 \times 4)$	1
$= 15.0$ cm	1
East	1
Total	3

(ii) t = 0 s – 9.00s.

(3 marks)

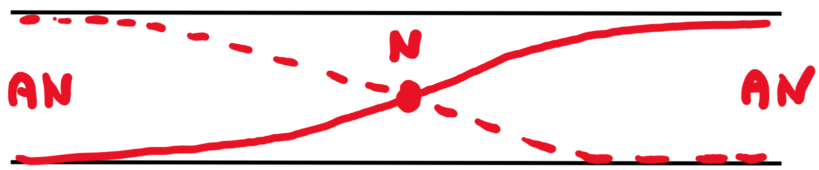
Description	Marks
$\Delta s = 15.0 + (-0.5 \times 1.5 \times 4) + (-4 \times 2)$	1
$= 4.00$ cm	1
East	1
Total	3

Question 14 **(16 marks)**

An organ pipe X, with both ends open, sounds its fundamental frequency of 330 Hz. The pipe is filled with dry air at 25 ºC such that the speed of sound is 342 ms^{-1}.

(a) On the diagram below, draw a wave envelope representing the particle displacement in the pipe when it is sounding at its fundamental frequency.

(1 marks)



(b) Calculate the length of this organ pipe.

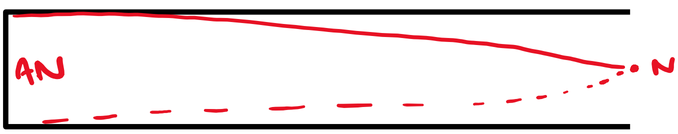
(4 marks)

Description		Marks
$v = f\lambda;\ \therefore \lambda = \frac{v}{f}$	or $f_n = nv/2L$	1
$\lambda_1 = \frac{342}{330} = 1.04$ m	$L = nv / 2f$	1
$\lambda_n = \frac{2L}{n};\ \therefore \lambda_1 = 2L$	$= 1(342) / 2(330)$	1
$L = \frac{\lambda_1}{2} = \frac{1.04}{2} = 0.520$ m	$= 0.518$ m	1
	Total	4

A second pipe Y is closed at one end. Dry air at 25 ºC is in the pipe such that the speed of sound is 342 ms^{-1}.

(c) On the diagrams below, draw pressure wave envelopes for the first two harmonics produced by this pipe. Number each of the harmonics in the space provided.

(3 marks)



1st harmonic

3rd harmonic

1 mark off for each error 1 mark off for each error

The third harmonic (first overtone) of the closed end pipe Y has the same frequency as the second harmonic (first overtone) of the open-ended pipe X.

(di) Calculate the frequency of the second harmonic of pipe X.

(3 marks)

Description	Marks
f_3 (closed) = f_2 (open)	1
f_3 (closed) = 2 x 330	1
$= 660\ Hz$	1
Total	3

(ii) Hence, calculate the wavelength of this new sound. (If you could not complete (i), use f = 700.0 Hz)

(2 marks)

Description	Marks
$\lambda_3 = \frac{v}{f_3} = \frac{342}{660}$	1
= 0.518 m (0.489 m)	1
Total	2

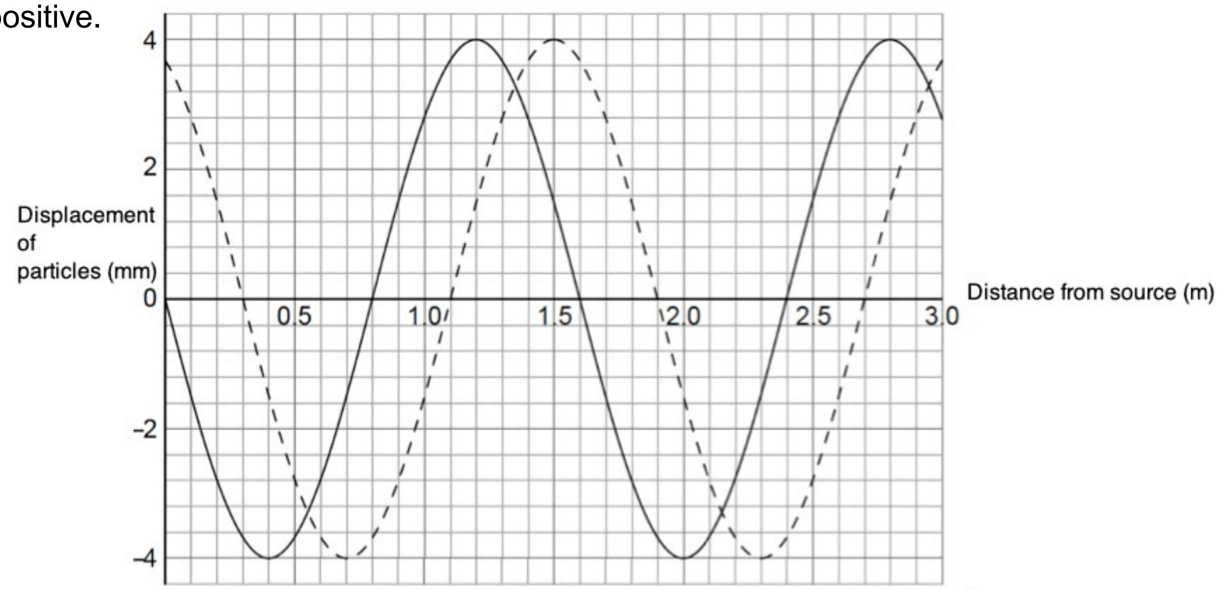
(iii) Hence, calculate the length of the pipe Y. (If you could not complete (ii), use λ = 0.300)

(3 marks)

Description	Marks
$\lambda_n = \frac{4L}{n}; \therefore \lambda_3 = \frac{4L}{3}; L = \frac{3\lambda_3}{4}$	1
$\therefore L = \frac{3 \times 0.518}{4}$	1
= 0 .389 m (0.225 m)	1
Total	3

Question 15 **(11 marks)**

A longitudinal wave is travelling in a medium from left to right. The graph shows the variation with distance of the particles and the displacement of the particles in the medium. The solid line and the dotted line show the displacement at t = 0 and t = 0.882 x10^{-3} s, respectively. The period of the wave is greater than 0.882 x10^{-3} s and a displacement to the right of the equilibrium position is positive.



(a) Explain what is meant by a "longitudinal wave"? (2 marks)

Description	Marks
a wave where the displacement of particles/oscillations of particles/movement of particles/vibrations of particles	1
is parallel to the direction of energy transfer/wave travel/wave movement	1
Total	2

(b) Calculate the speed of this wave.

(3 marks)

Description	Marks
Distance travelled by wave = 0.3 m time that wave travels = 0.882 x 10^{-3}	1
Speed = distance/time = 0.3/0.882 x 10^{-3} = 340 ms^{-1} = 3.40 x10^2 ms^{-1}	1-2
Total	3
Or could do this from calculating period (T = 16/3(0.882 x10^{-3} = 4.7 ms) and frequency (212.5 Hz) using the wave equation	

(c) Calculate the frequency of this wave.

(2 marks)

Description	Marks
λ = 1.60m	1
v = f x λ 340 = f x 1.6 f = 213 Hz	1
Total	2

(d) The equilibrium position of a particle in the medium is at x = 0.80m. For this particle at t = 0, state and explain the direction of its motion. (2 marks)

Description	Marks
the displacement of the particle decreases OR «on the graph» displacement is going in a negative direction OR on the graph the particle goes down	1
to the left	1
Total	2

The travelling wave in (b) is directed at the open end of a tube of length 1.20 m. The other end of the tube is closed.

(e) Describe what features of the wave (if any) are changed when the wave reflects off the open end.

(2 marks)

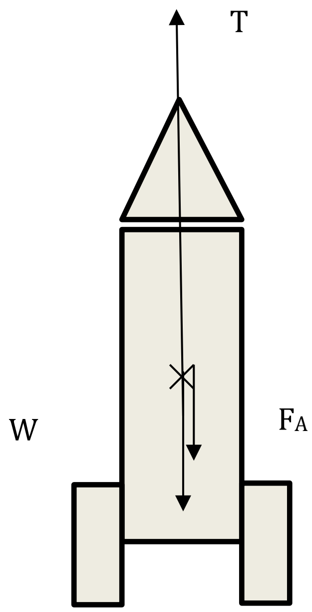
Description	Marks
The pulse/pressure wave will be inverted or compression converted to rarefaction	1
Such that the wave is shifted by $\lambda/2$ or (180 degrees)	1
Total	2

Question 16 **(16 marks)**

A toy rocket with a mass of 0.550 kg is fired straight upward. The chemical engine provides 9.50 N of thrust for 1.70 s with negligible loss of mass.

(a) Draw labelled vectors from point X on the rocket to show all the forces acting on the rocket in the first 1.70 s of flight. Include any frictional forces. The length of each arrow should represent the approximate magnitude of the force that is acting.

(2 marks)



Description	Marks
1 upward, 1 or 2 downward.	1
Sum of downward vectors LARGER than upward vectors.	1
Total	2

(b) Calculate the acceleration of the rocket just before its engine stops working. Consider only the thrust of the engine and gravity. Show **all** workings.

(4 marks)

Description	Marks
$\Sigma F = ma = W + \text{Thrust}$	1
0.55(a) = (0.55 x -9.8) + 9.50	1
= 4.11 N	1
a = 4.11 / 0.55 = 7.47 ms^{-2}	1
Total	4

(c) Calculate the height, in metres, reached by the rocket at the moment when the engine stops working. If you were unable to complete part (b), use an acceleration value of 9.00 m s^{-2}.

(3 marks)

Description	Marks
$s = ut + {}^1/_2\ at^2;\ \ a = 7.47\ ms^{-2}$	1
$s = ut + {}^1/_2\ at^2 = 0 \times 1.70 + {}^1/_2 \times 7.47 \times 1.70^2$	1
$= 10.8$ m (13.0 m)	1
Total	4

(d) Calculate the velocity (in ms^{-1}) of the rocket, 1.70 s after the engine starts. If you could not calculate an answer to Part (b), use an acceleration of 9.00 m s^{-2} upward. Show **all** workings.

(2 marks)

Description	Marks
$v = u + at = 0 + 7.50 \times 1.70$	1
$v = 12.7\ ms^{-1}$ upwards ($15.3\ ms^{-1}$)	1
Total	4

(e) Calculate the maximum height, in metres, reached by the rocket. Show **all** workings.

(5 marks)

Description	Marks
$v^2 = u^2 + 2as;$	1
$0 = 12.8^2 + 2 \times -9.80 \times s$	1
$s = \frac{12.8^2}{19.6} = 8.23$ m (11.9 m)	1
Maximum height = 10.8 + 8.23 = 19.0 m	1-2
Total	5

Question 17 **(12 marks)**

An investigation is designed to measure the collision forces when a car is crashed head-on into a flat, rigid barrier and the resulting "crush distance" is measured. The crush distance (d) is the amount that the car collapses in coming to rest.

In the above photographs, L_1 is the original length of the car and L_2 is the length of the car after the crash. Thus, the crush distance d = $L_1 - L_2$.

(a) Show that the average crush force exerted on a car of mass m with impact speed v is equal to $\frac{mv^2}{2d}$.

(2 marks)

Description	Marks
Work done = F x d = ΔEk = ½ mv^2 or F = ma a = v^2-u^2 /2d	1
Thus F = mv^2/2d = m. v^2/2d	1
Total	2

The table below gives values of the crush distance, d, for different impact speeds v, of cars of the same make.

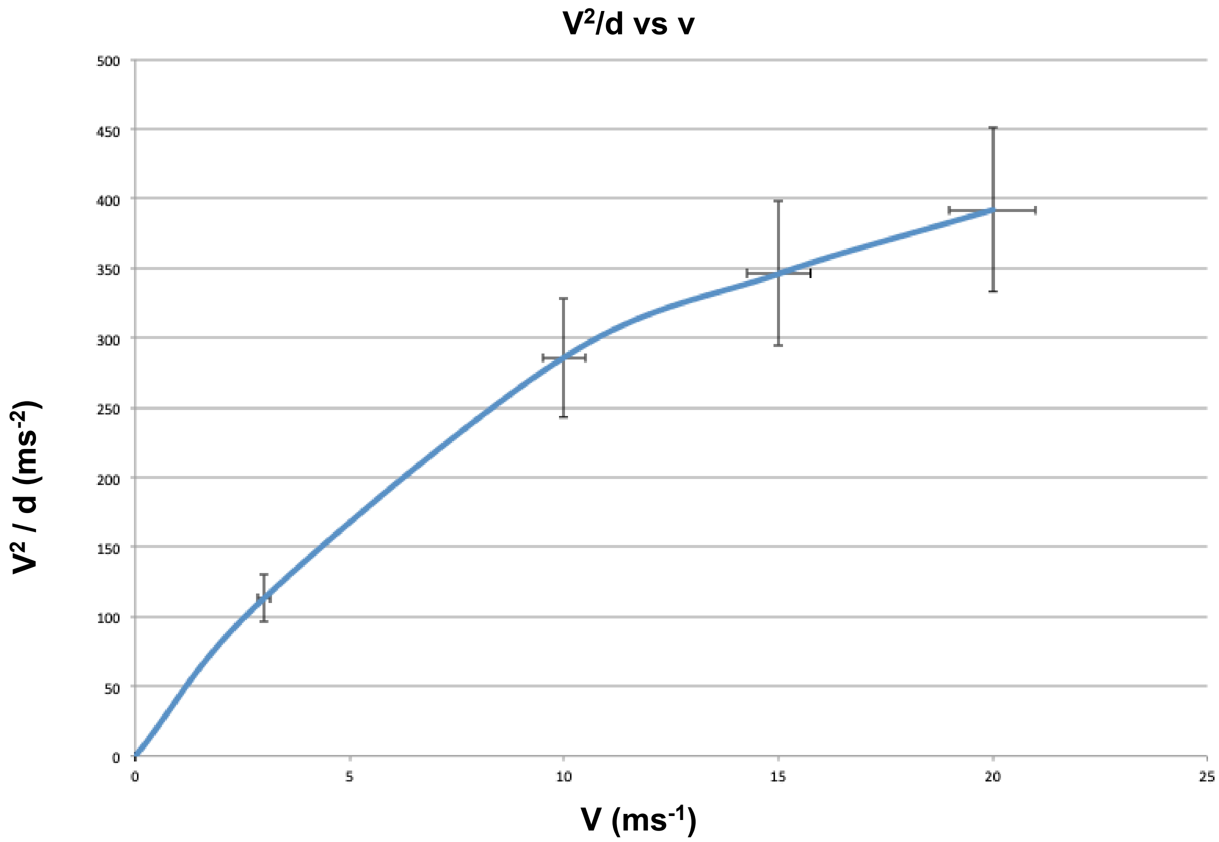
v (ms^{-1}) ± 5%	d (m) ± 3%	$\frac{v^2}{d}$ (ms^{-2}) ± 15%	Error in $\frac{v^2}{d}$ (ms^{-2})
0	0	0	**0**
3.00	0.0800	**113**	**17**
10.0	0.3500	**286**	**43**
15.0	0.6500	**346**	**52**
20.0	1.0200	**392**	**59**

(b) Complete the last two columns column of the table.

(2 marks)

(c) On the graph paper on the next page, plot a graph of $\frac{v^2}{d}$ against v, including error bars

(6 marks)



Description	Marks
correctly labelled axes	1
appropriate scales	1
data points	1
line of best fit	1
Error bars	1
Total	5
(If the point (0 ,0) is not shown deduct 1. If a straight line is drawn deduct 1.)	

(d) Consider the situation in which a car of mass 1250 kg has an impact speed of 12.0 ms^{-1}. Use information from the graph you have drawn to find the average force exerted on the car during the collision as it is brought to rest.

(2 marks)

Description	Marks
From the graph $v^2/d = 330$ (±20)	1
$v^2/2d = 165$ $F = mv^2/2d$ $F = 1250 \times 165$ $F = 2.06 \times 10^5$ N	1
Total	2

End of Section Two

SECTION THREE: Comprehension **21% (32 marks)**

This section has **two (2)** questions. You must answer **both** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Give final answers to **three** significant figures and include appropriate units where applicable.
When estimating numerical answers, show your working or reasoning clearly. Give final answers to a maximum of **two** significant figures and include appropriate units where applicable.

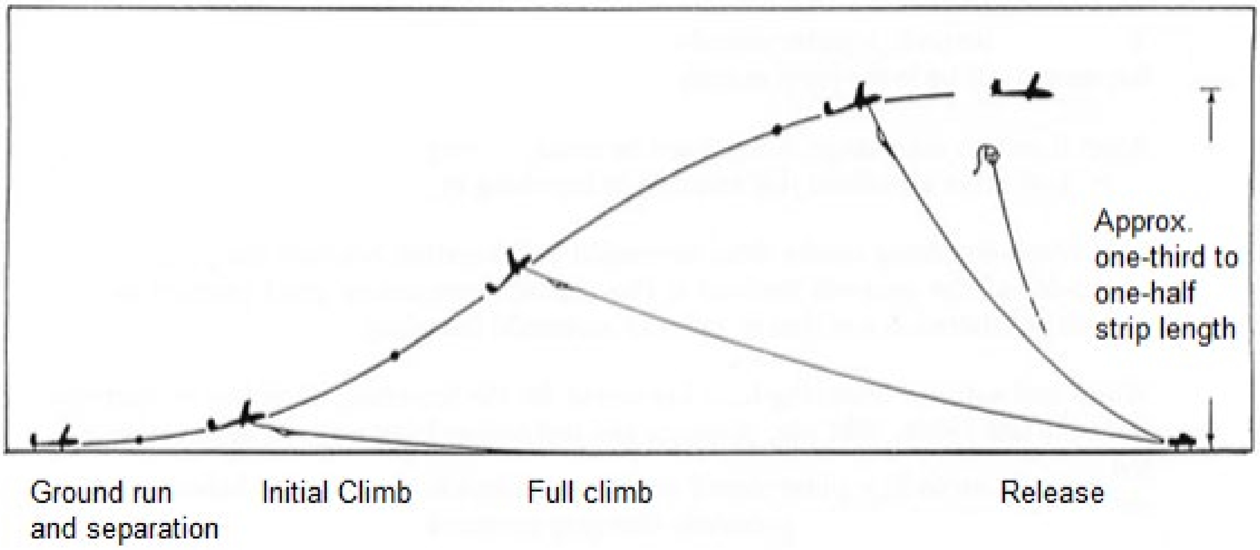
Additional working space pages at the end of this Question/Answer booklet are for planning or continuing an answer. If you use these pages, indicate at the original answer, the page number it is planned/continued on and write the question number being planned/continued on the additional working space page.

Suggested working time: 30 minutes.

Question 18: Glider Launching **(15 marks)**

A glider is an aircraft with no engine. To be launched, a glider is uniformly accelerated from rest until it reaches its launch speed of about 27.0 ms^{-1} by a cable. This is called a winch launch. The basic principle of a winch launch is simple. The glider is attached to a cable which is wound back into the winch at such a speed that it provides the glider with flying speed. Most winches are fitted with powerful 80.0 kW electric motors and automatic transmissions that can generate tremendous force.

As the winch accelerates the glider toward its safe launching speed, the glider is flown in such a way that it follows a gradually steepening flight path, gaining height rapidly until it is almost overhead the winch, whereupon the cable is released and the glider goes on its way. This is simplified description, but it will suffice for a starting point. For those to whom a picture is worth a hundred words, the following diagram may help.



The minimum strip length for winch launching is 1.20 kilometres. The guideline given in the diagram, that a glider should achieve about one-third to one-half of the strip length as its launch height, is notional. The exact height will vary with pilot and winch driver technique, as well as with wind velocity and aircraft characteristics.

Referring to the winch launch diagram, it will be noted that the flight path followed by the glider in the early stages is progressively steepened as height is gained. This should be a smoothly executed process, with the accent on the word “progressive”. There should be no “steps” in the process of transitioning from the separation into the full climb and no sudden changes of climb angle at any time.

(a) The glider reaches its launch speed after accelerating for 11.0 s. Assume that the glider moves horizontally until it leaves the ground. Calculate the total distance travelled by the glider before it leaves the ground.

Description	Marks
v = u +at, thus 27 = 0 +11a a = 2.45 ms^{-2}	1 1
s =ut +1/2at^2 s = 0 +1/2 2.45(11)^2 s= 148 m	1 1
Total	4

(b) The glider and pilot have a total mass of 492 kg. During the acceleration the glider is subject to an average resistive force of 162 N. Determine the average tension in the cable as the glider accelerates.

(3 marks)

Description	Marks
$\Sigma F = ma = T + F_F$	1
492(+2.45) = T + (-162)	1
T = 1.37 x10^3 N	1
Total	3

(c) The cable is pulled by an electric motor. Calculate the efficiency of winch in getting the glider off the ground.

(4 marks)

Description			Marks
W = ma x s = 1.205 x 10^3 x 148 = 1.78 x 10^5 J			0-2
Energy supplied by motor = P x t = 80 x 10^3 x 11 =8.80 x 10^5 J	OR	Power supplied to glider = 1.78x10^5 / 11 = 16181 W	1
$Efficiency = \frac{1.78\ x\ 10^5}{8.80\ x\ 10^{\ 5}} \times 100 = 20.2\ \%$		$\frac{1.62 \times 10^4}{80.0 \times 10^{\ 3}} \times 100 = 20.3\%$	1
Total			4

If T = 1370 used, E = 23.0 % Maximum 3 marks

(d) Making any necessary assumptions estimate the gravitational potential energy of the glider and pilot at the instance of release.

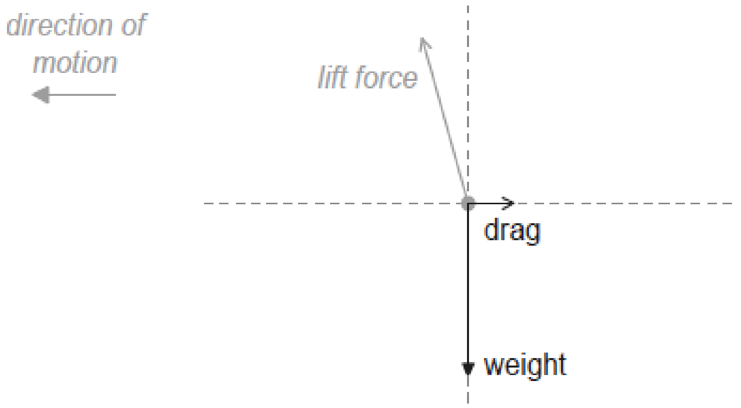
(2 marks

Description	Marks
Assume a strip length of 1200 m which gives a vertical height of 400 - 600 m	1
Ep = mgh = 492 x 9.8 x 600 = 1.9 to 2.9 x 10^6 J	1
Total	2

After take-off the cable is released and the unpowered glider moves horizontally at constant speed. The wings of the glider provide a lift force. The diagram shows the lift force acting on the glider and the direction of motion of the glider.

(e) Draw the forces acting on the glider to complete the free-body diagram. The dotted lines show the horizontal and vertical directions.

(2 marks)

Description	Marks
	0-1
Correct size of each vector	0-1
Total	2

Question 19: Glass Shattering **(17 marks)**

Can you shatter a wine glass by screaming? If the conditions are just right, it's possible to shatter glass with the human voice. It's a famous operatic scene: The soprano on stage hits a high note so long and piercing that it cracks the opera glasses of the regal guests in the box seat. Hollywood can do that with a trick of editing, but is it possible in real life? Well, yes it is. To understand these conditions and how they work together, a crash course in acoustics is required. Sound is acoustic energy, which "energises" the substance's particles and causes them to vibrate at a certain frequency.

Every substance has a natural, or resonant, frequency: the frequency at which its own atoms vibrate. For example, suppose your bass guitar-playing neighbour cracks the plaster on your walls when she plays a low, driving bass line. The frequency of a bass guitar's lower, deeper notes run from 40 to 150 hertz. Thus, the plaster's resonant frequency must fall somewhere in that range, because when a substance encounters a frequency it matches, it absorbs the energy rather than reflecting it.

Glass-shattering waves carry more energy in the same period of time. They're shorter and "choppier". To shatter glass, the note's frequency must be the same as that of the glass. That's one condition. The note also has to be loud too, a quality known as intensity. Intensity is measured in decibels or Wm^{-2}. While conversational tones average 50 to 60 decibels (10^{-7} to 10^{-8} Wm^{-2}), a trained vocalist might have the acoustic power to approach the approximately 100 decibels (10^{-2} Wm^{-2}) needed to break glass. Even then, he or she would have to be so close as to risk serious facial cuts if the glass explodes. More likely, a boost of electronic amplification would be needed.

Finally, the glass must be strategically selected. A wine glass is a good choice. It's fine and thin unlike, say, a beer stein which maximizes the amount of stress per particle. An empty glass cracks more readily (although less dramatically) than one containing wine. And if you can find a wine glass with a flaw in its structure, even an invisible one, that helps by providing a weak spot.

Incidentally, real-world tests involving resonant frequencies offer more than an excuse to shatter glass. Resonant frequency is the basis of ultrasonic testing. Ultrasonic testing is a type of non-destructive testing (NDT), which allows engineers to monitor the integrity of materials where, and while they're used – which is preferable to otherwise dismantling a building or airplane for analysis in a laboratory. Materials that contain defects or structural weakness will have different acoustic properties compared to those that don't.

(a) In paragraph 1, the author describes sound as "acoustic energy" with "frequency". Describe how a sound wave is able to transfer energy and explain the meaning of the term frequency. (3 marks)

Description	Marks
Sound transfers energy from one location to another without a net movement of matter	1
Via inelastic particle collisions that transfer kinetic energy.	1
Frequency is the number of complete vibrations/oscillations each second	1
Total	3

(b) In paragraph 2, the author indicates that the plaster in a wall can crack if the resonant frequency of the bass matches the resonant frequency of the plaster. Explain what is meant by resonant frequency.

(2 marks)

Description	Marks
Resonance is a physical occurrence where a driving frequency matches the natural frequency of an object.	0-1
Which causes a rapid increase in the amplitude/energy of the object	0-1
Total	2

(c) Paragraph 3. How is it possible for glass shattering waves to carry more energy?

(2 marks)

Description	Marks
They have a greater frequency	1
thus more of them pass through per second delivering more energy.	1
Total	2

(d) Paragraph 3: Suppose a trained vocalist can produce an intensity of 0.200 x 10^{-2} Wm^{-2} at a distance of 10.0 cm from his mouth. Calculate the intensity of the sound 2.50 cm from the wine glass.

(3 marks)

Description	Marks
$I_1r_1^2 = I_2r_2^2$ $I_2 = I_1 (r_1^2 / r_2^2)$	1
$= 0.200 (10.0^2 / 2.50^2)$	1
$= 3.20 \times 10^{-2}$ Wm^2	1
Total	3

A wine glass might have a cross-sectional area of 4.05 x 10^{-4} m^2.

(e) Calculate the power that could theoretically provided to the glass if the trained vocalist holds the glass a distance of 2.50 cm from his mouth. (If you could not complete (d), use an intensity of 1.10 x 10^{-2} Wm^{-2})

(3 marks)

Description	Marks
Intensity = power / area, Power = intensity x area	1
= 3.20 x10^{-2} (4.05 x 10^{-4})	1
=1.30 x10^{-5} W (4.46 x10^{-6} W)	1
Total	3

(f) Paragraph 4: Explain why "An empty glass cracks more readily than one containing wine".

(2 marks)

Description	Marks
air, being less dense than liquid, transfers sound energy more efficiently	0-1
OR Water, having a greater density can absorb the sound energy from the vibrating glass.	0-1
Total	2

(g) Paragraph 5: Describe how ultrasonic testing could be used to test the safety of structures.

(2 marks)

Description	Marks
Materials that contain defects or structural weakness will have different acoustic properties and will resonate at a different frequency compared to objects that don't contain a defect.	0-1
Engineers could vary the frequency of sound on an object to determine the resonant frequency, to indicate if a defect exists.	0-1
Total	2

End of Section Three