



Semester 2 Examination, 2019

Question/Answer Booklet

PHYSICS

UNIT 2

Fix student label here

Student Name: _____

Time allowed for this paper

Reading time before commencing work: ten minutes

Working time: 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.

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.

See next page

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.

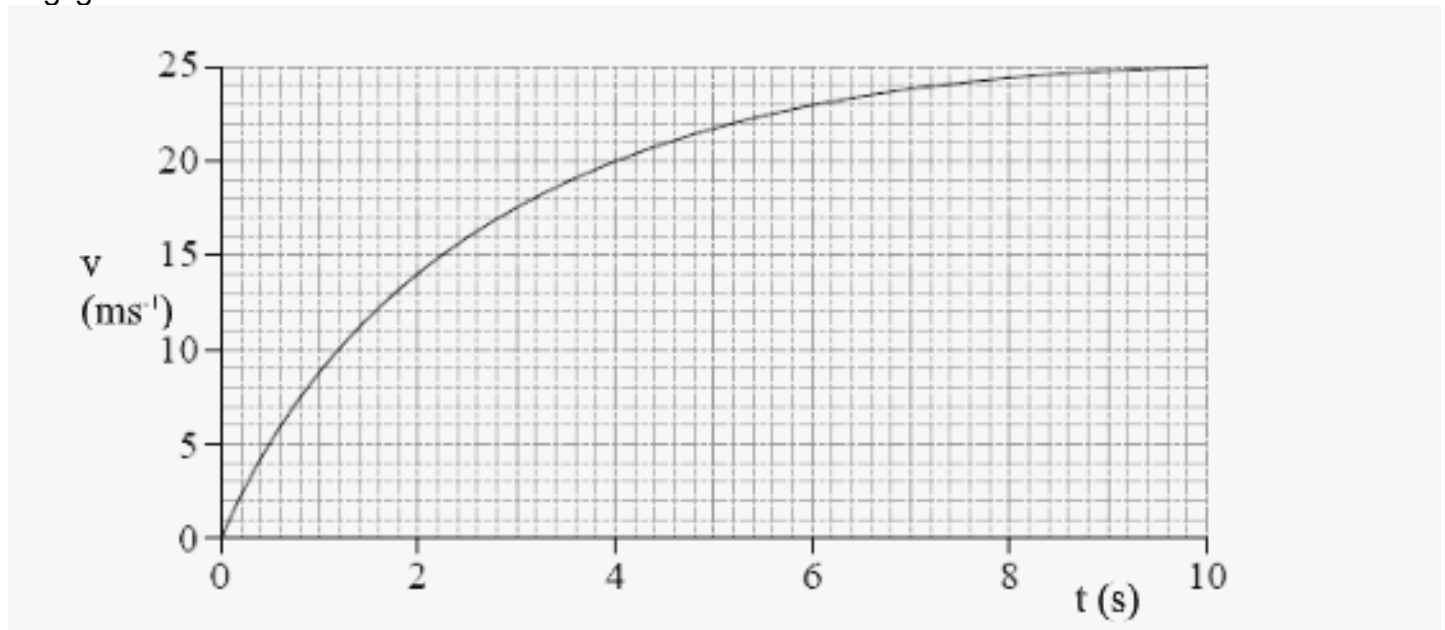
For **each** statement, state whether or not it is correct or incorrect and explain your choice of answer.

See next page

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 $t = 2.0\text{ s}$. On the picture of the ball below, indicate as labelled arrows all the forces acting on the ball.

(2 marks)



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)

Question 4

(5 marks)

A speaker is emitting a sound whose intensity is measured as $1.00 \times 10^{-6} \text{ W m}^{-2}$ 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.

$$I_1 r_1^2 = I_2 r_2^2$$

(3 marks)

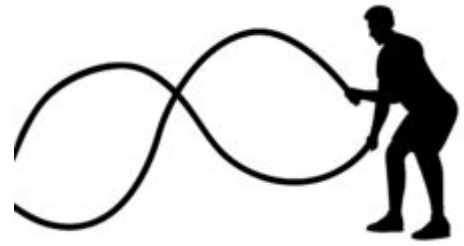
- (b) The figure you calculated in part a) would not be the value measured in reality. Comment on your calculated value for intensity at a distance of 4.50 m and explain how it would be different in reality.

(2 marks)

See next page

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.

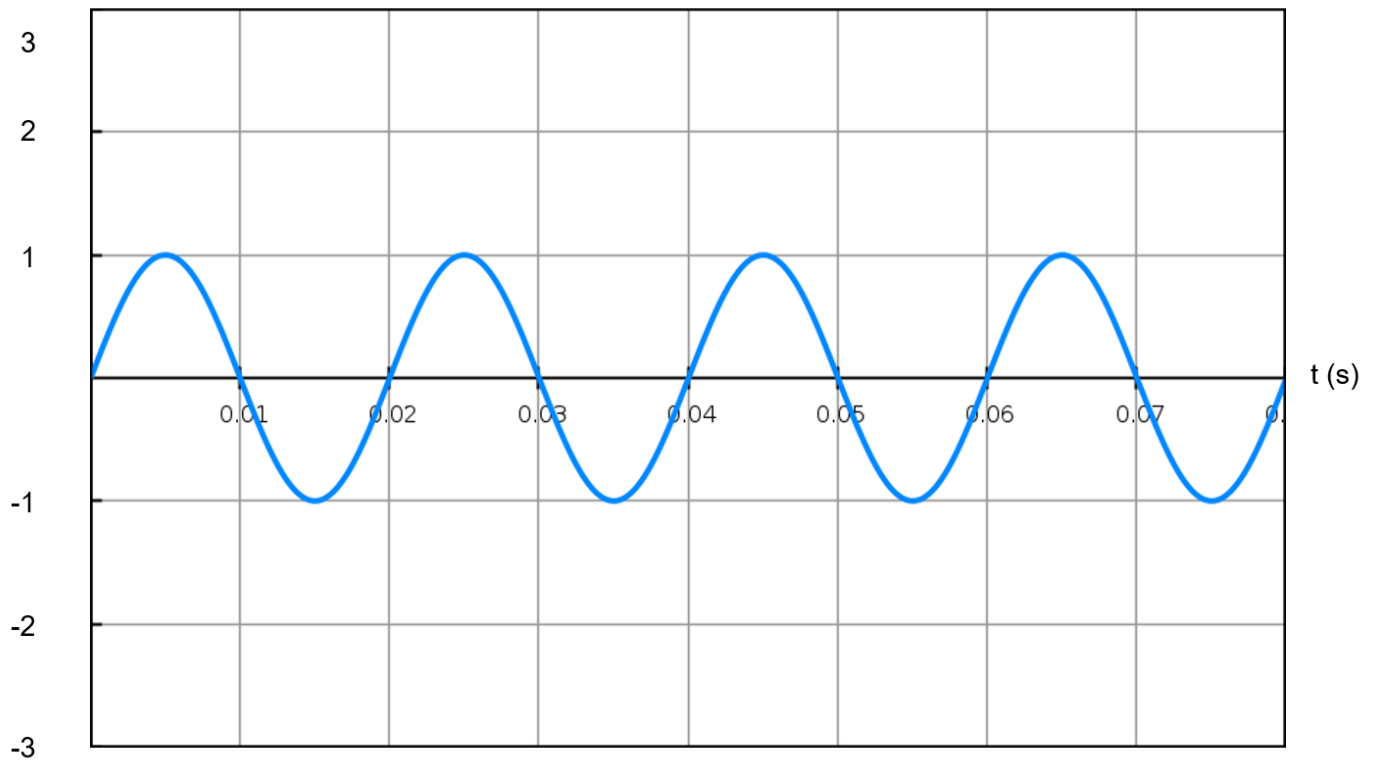
**Question 6****(3 marks)**

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.

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.

 ΔP (kPa)

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

(2 marks)

(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)

See next page

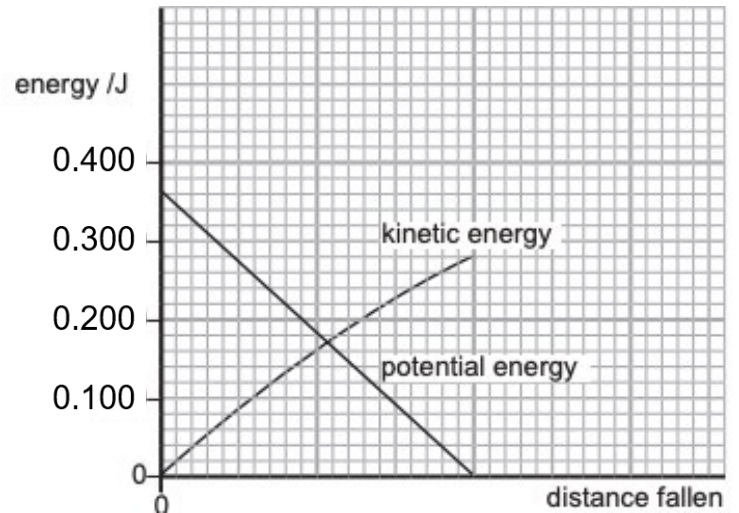
Question 8

(7 marks)

A ball of mass 0.0240 kg is dropped from rest and falls to the floor. The graph 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)



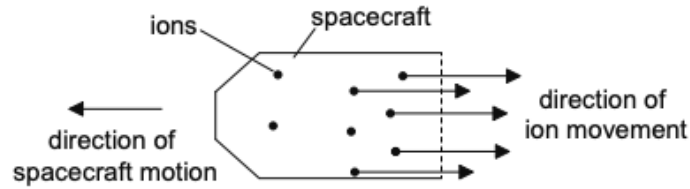
- (b) Calculate the difference between the speed reached by the ball in case (a) and the speed that the ball would have reached had it been dropped in a vacuum.

(4 marks)

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.

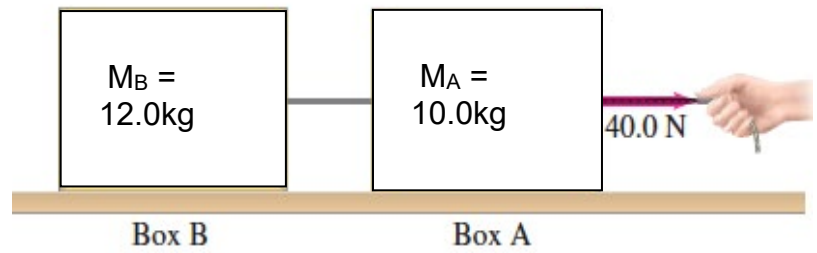


The mass of ions ejected each second is 6.60×10^{-6} kg and the speed of each ion is 5.20×10^4 ms^{-1} . The initial total mass of the spacecraft and its fuel is 7.40×10^2 kg. Assume that the ions travel away from the spacecraft parallel to its direction of motion. Calculate the acceleration of such a spacecraft.

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.



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.

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)

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 loud or quiet tone.

(4 marks)

End of Section One

See next page

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.

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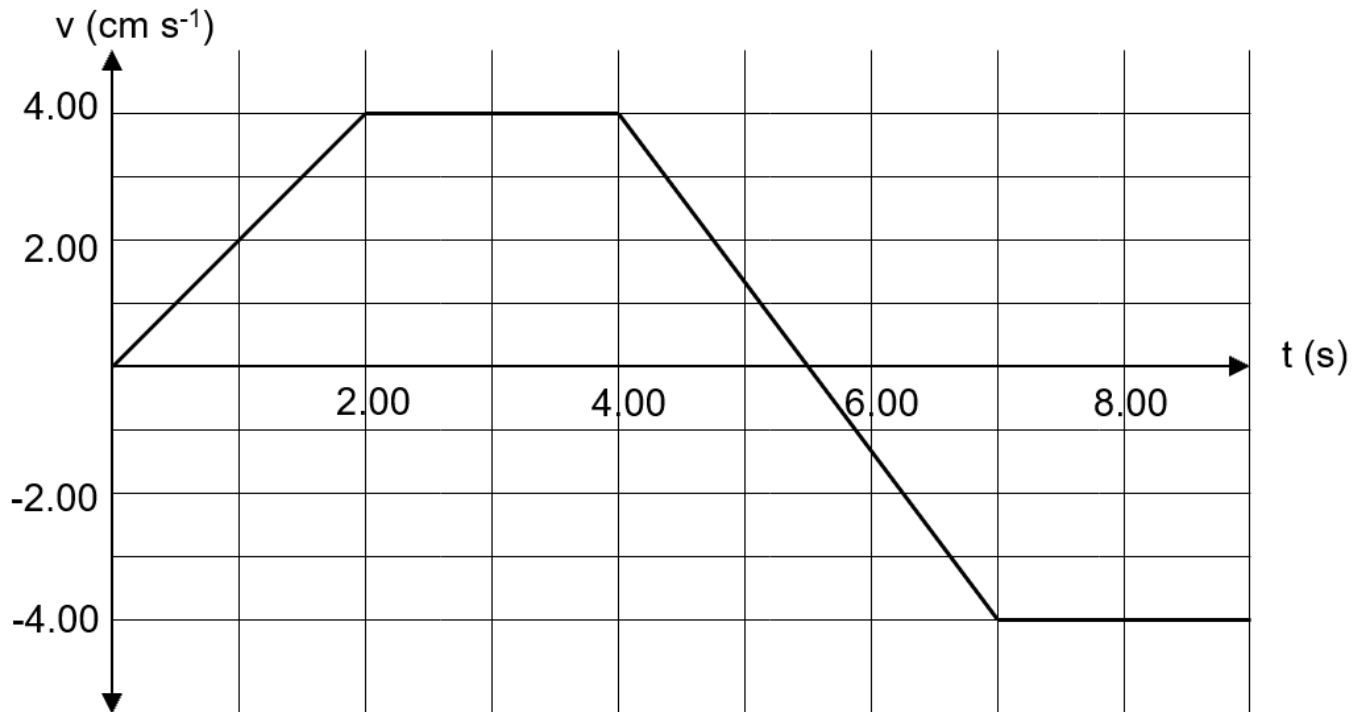
Suggested working time: 70 minutes.

See next page

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)
- (b) State the times when the ant is stationary. (2 marks)
- (c) State the time periods when the ant's acceleration is equal to zero. (2 marks)

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

(i) $t = 1.00 \text{ s}$

(2 marks)

(ii) $t = 5.50 \text{ s}$

(2 marks)

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

(i) $t = 0 \text{ s}$ and $t = 5.50 \text{ s}$.

(3 marks)

(ii) $t = 0 \text{ s}$ and $t = 9.00\text{s}$.

(3 marks)

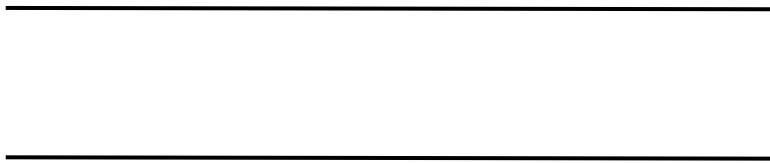
Question 14

(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 °C 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)

A second pipe Y is closed at one end. Dry air at 25 °C 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)



_____ harmonic



_____ harmonic

(d) 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.

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

(3 marks)

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

(2 marks)

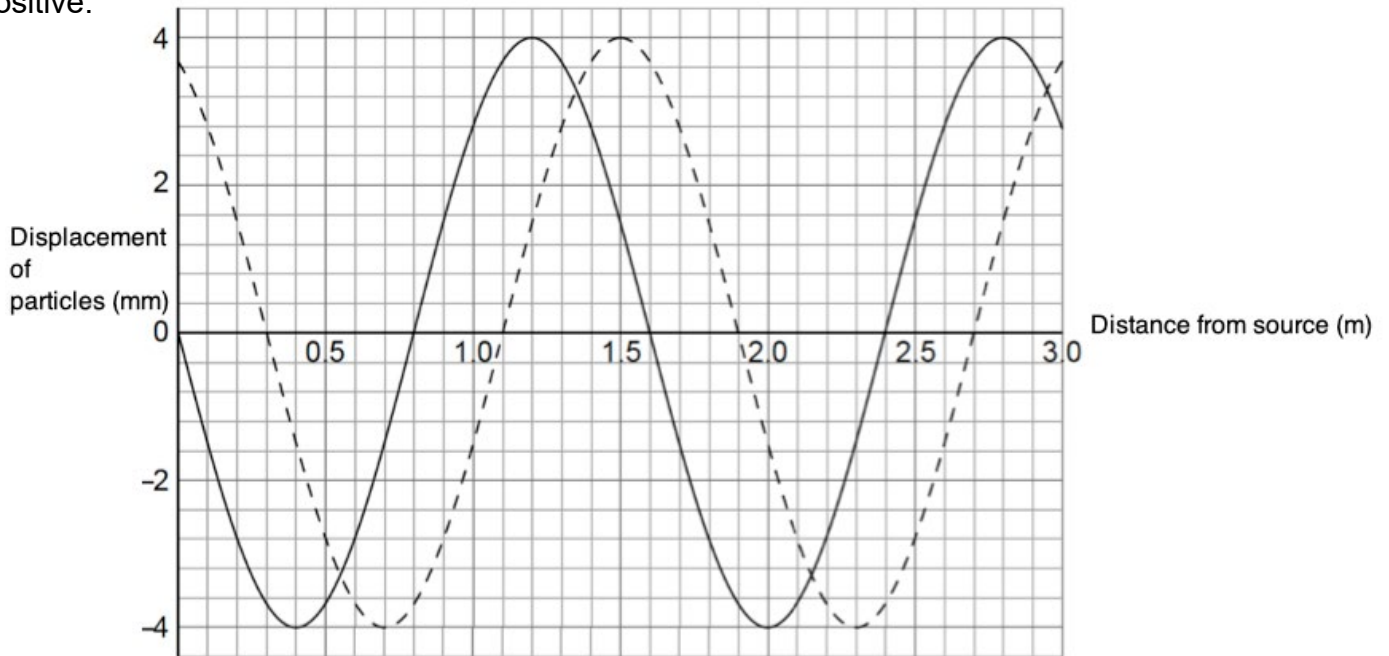
(iii) Hence, calculate the length of the pipe Y. (If you could not complete (ii), use $\lambda = 0.300$)

(3 marks)

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 $t = 0.882 \times 10^{-3}$ s, respectively. The period of the wave is greater than 0.882×10^{-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)

- (b) Calculate the speed of this wave. Provide your answer to 3 significant figures. (3 marks)

(c) Calculate the frequency of this wave. Provide your answer to 3 significant figures.

(2 marks)

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

(2 marks)

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)

See next page

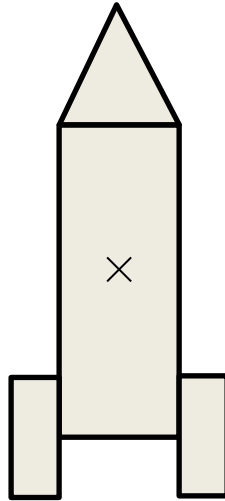
Question 16

(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)



- (b) Calculate the acceleration of the rocket just before its engine stops working. Ignore any effects of air resistance.

(4 marks)

- (c) Calculate the height, in metres, reached by the rocket at the moment when the engine stops working. (If you could not complete (b), use an acceleration value of 9.00 m s^{-2} .) (3 marks)
- (d) Calculate the velocity (in ms^{-1}) of the rocket, 1.70 s after the engine starts. (If you could not complete (b), use an acceleration value of 9.00 m s^{-2} .) (2 marks)
- (e) Calculate the maximum height, in metres, reached by the rocket. (5 marks)

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)

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

v (ms^{-1}) $\pm 5\%$	d (m) $\pm 3\%$	$\frac{v^2}{d}$ (ms^{-2}) $\pm 15\%$	Error in $\frac{v^2}{d}$ (ms^{-2})
0	0	0	0
3.00	0.0800		
10.0	0.3500		
15.0	0.6500		
20.0	1.0200		

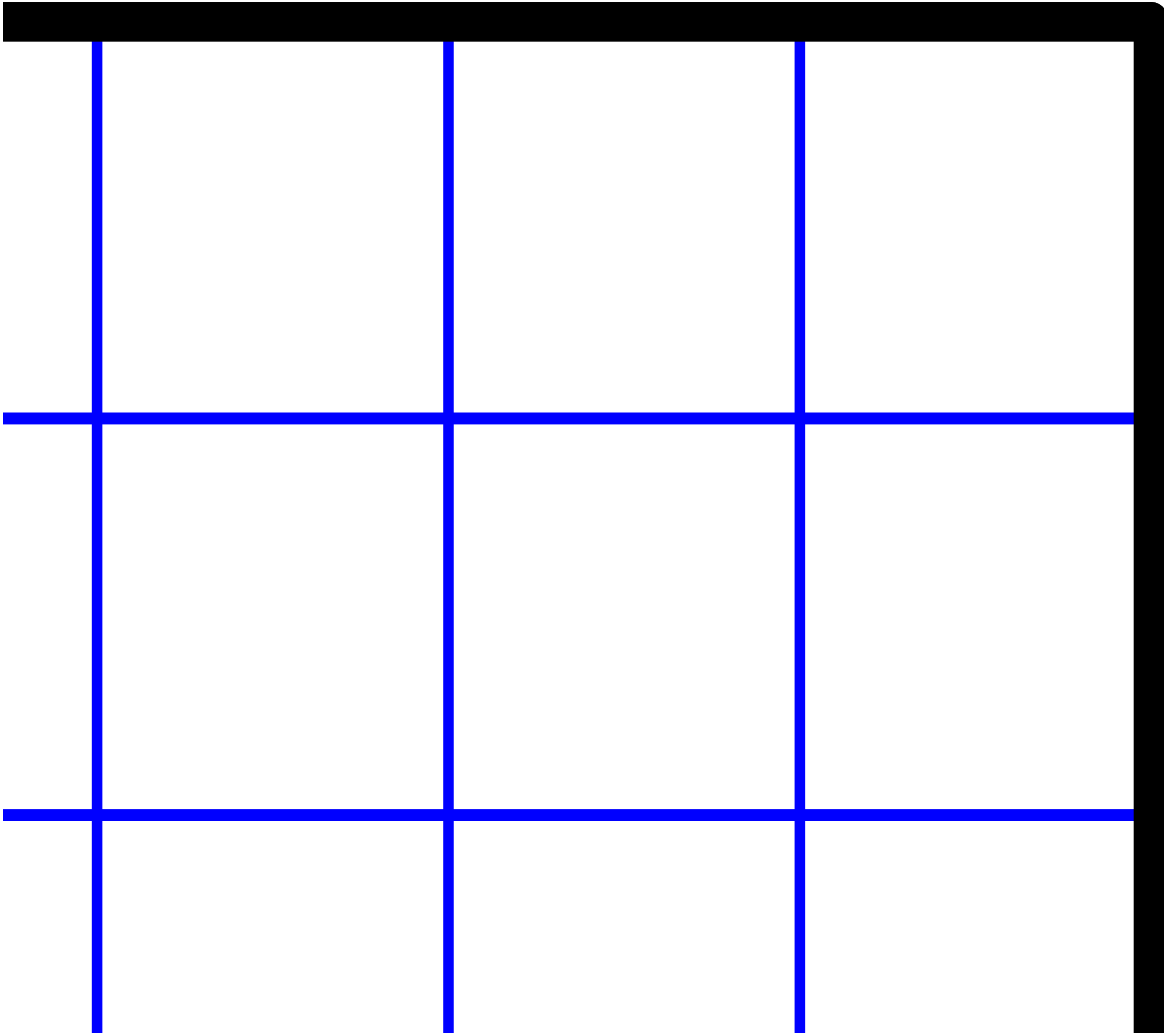
- (b) Complete the last two columns column of the table.

(2 marks)

- (c) On the graph paper on the next page, plot a graph of $\frac{v^2}{d}$ against v , including error bars. (Spare graph paper is located on page 31 should you require it)

(6 marks)

See next page



- (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)

End of Section Two

See next page

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.

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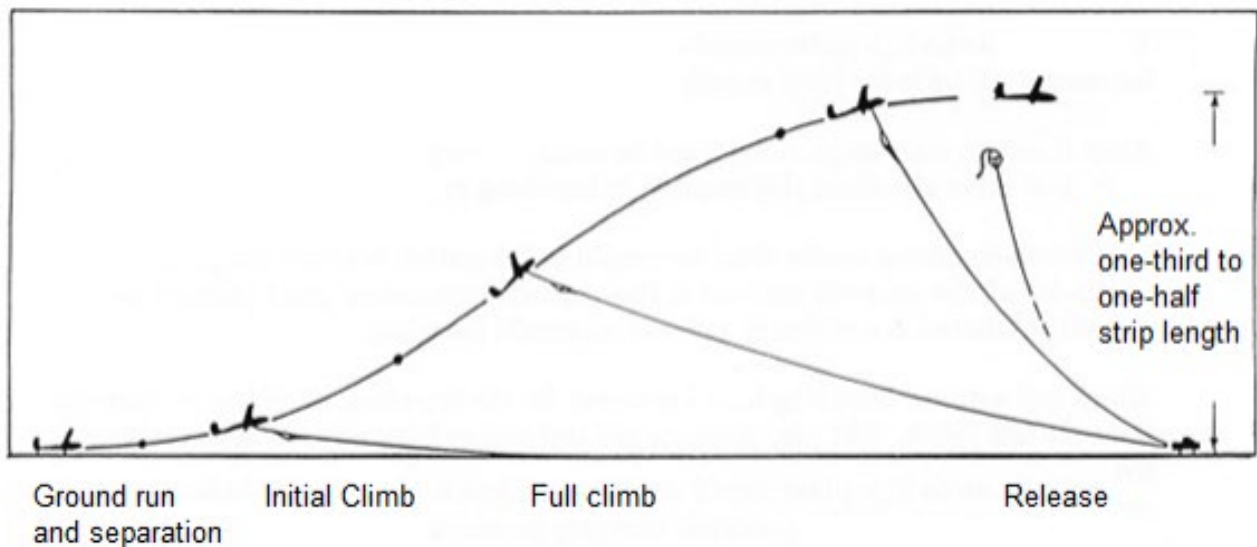
Suggested working time: 30 minutes.

See next page

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 motor 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 (from motor to planes initial starting position) 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 release height, is optional. 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.

(4 marks)

Question 18 continued

- (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.

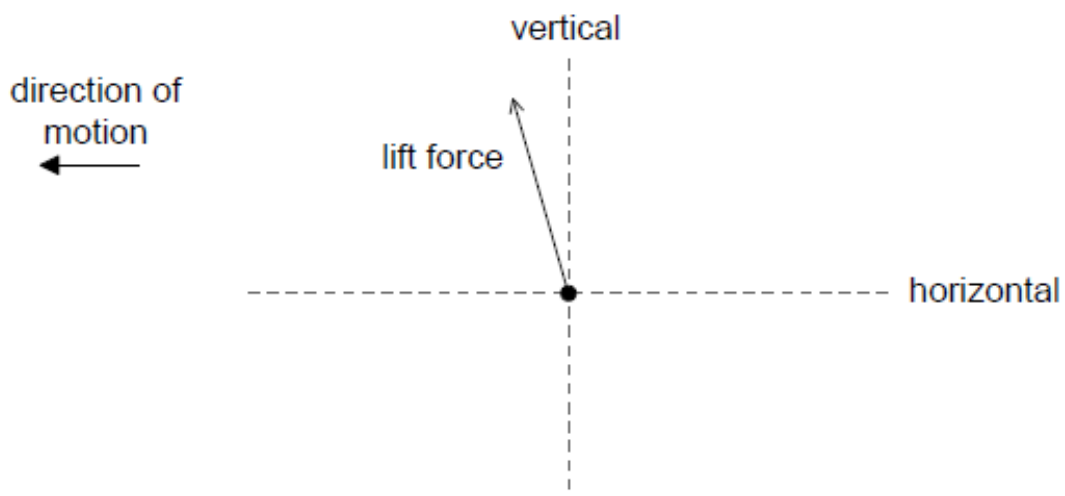
(3 marks)

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

(4 marks)

- (d) Making any necessary assumptions estimate the gravitational potential energy of the glider and pilot at the instance of release. (2 marks)

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)

See next page

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)

- (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)

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

(2 marks)

- (d) Suppose a trained vocalist can produce an intensity of $0.200 \times 10^{-2} \text{ Wm}^{-2}$ 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)

Question 19 continued

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

- (e) Calculate the power that could theoretically be 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 $1.10 \times 10^{-2} \text{ Wm}^{-2}$)

(3 marks)

- (f) Explain why “An empty glass cracks more readily than one containing wine”.

(2 marks)

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

(2 marks)

End of Questions

Spare Graph Paper

