Christ Church
Grammar School

Science Department
Year 11 Physics

Semester 2 Examination, 2020

Question/Answer booklet

PHYSICS UNIT 2

SECTION ONE

SHORT ANSWER

Fix student label here

Student Name: ________________________________

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
Three Question/Answer booklets
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: up to three calculators, which do not have the capacity to create or store programmes or text, are permitted in this ATAR course examination, drawing templates, drawing compass and a protractor.

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	8	8	50	48		30	
Section Two: Problem Solving	5	5	70	71		50	
Section Three: Comprehension	2	2	30	33		20	
						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. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. 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.

5. Information for questions has been repeated on the removable Information Booklet which has been inserted inside the front cover of this booklet so that you can refer more easily to it while answering the questions. Do not write your answers in the Information Booklet.

6. Provide all answers to three significant figures unless otherwise instructed.

Section One: Short Response **30% (48 marks)**

This section has **eight (8)** 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 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.

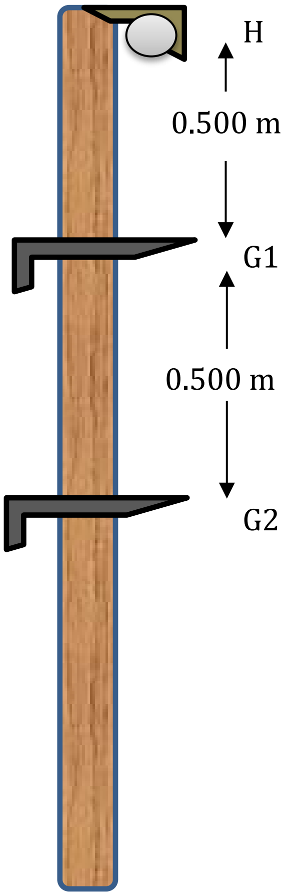
Question 1 **(4 marks)**

Calculate how much faster a 0.300 kg object must be travelling to have twice the energy of a 1.500 kg object travelling at a speed ‘v’.

Question 2 **(6 marks)**

A physics class was using the apparatus shown below to calculate the acceleration due to gravity. In the apparatus, photogates are placed 0.500 m apart and measure the time and speed of the steel ball though each gate as it falls under the influence of gravity. The times start the instant that a magnetic holder releases the steel ball. The data collected is recorded in the table below.

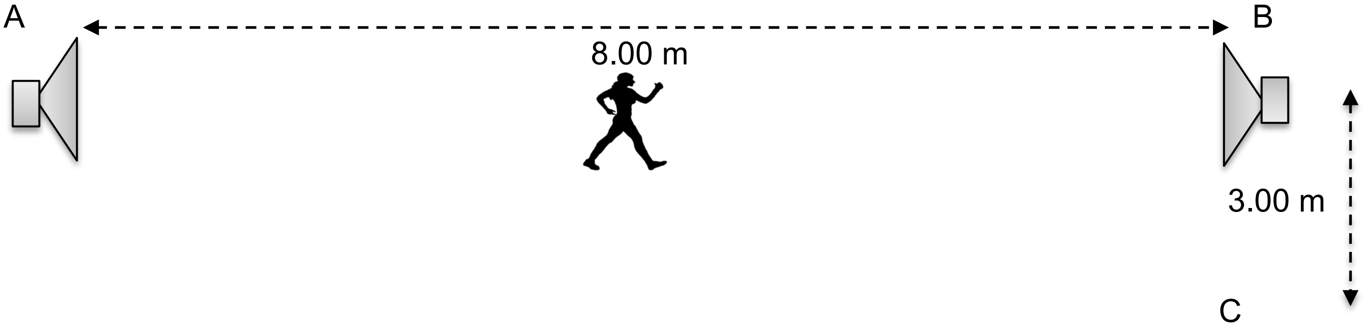
Using **two** different equations of accelerated motion, calculate two values for the acceleration due to gravity.



	Time(s)	Speed (m s^{-1})
Holder (H)	0.00	0.00
Gate 1 (G1)	-	3.12
Gate 2 (G2)	0.452	4.41

Question 3 **(8 marks)**

A student sets up the following experiment in a large open area. She connects two speakers that are facing each other, as shown below. Both speakers are connected 8.00 m apart to the same signal generator and amplifier, which is producing a sound with a wavelength of 1.00 m.



The student stands in the centre, **equidistant** to speakers A and B as shown in the diagram. She then moves towards Speaker B and experiences a sequence of loud and quiet regions. She stops at the second region of quietness.

(a) Show, through an appropriate calculation, how far she is from speaker B at this second region of quietness. The following equation may assist: Path difference = $n\lambda = |L_1 - L_2|$.

(4 marks)

The student now walks 3.00 m down from speaker B perpendicular to the two speakers and stands at point C.

(b) Determine with a suitable calculation whether she will be in a loud or quiet region.

(4 marks)

Question 4 **(3 marks)**

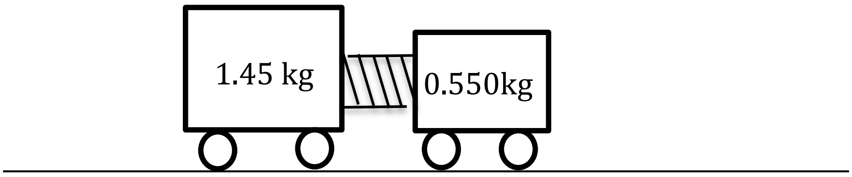
Sometimes a tone from an instrument or an audio device will cause another object in the room to begin vibrating loudly. Name this phenomenon and explain its occurrence in this scenario.

Question 5 **(4 marks)**

A 0.100 kg tennis ball is struck by a tennis racket and experiences an impulse of 3.00 N s West. If the initial speed of the tennis ball was 3.50 m s^{-1} East, calculate the final velocity of the tennis ball.

Question 6 **(8 marks)**

Two stationary carts are initially coupled together with a compressed spring between each cart. The spring is allowed to extend and the 0.550 kg cart is observed to travel away at a velocity of 2.40 m s^{-1} right.



(a) Using conservation of momentum, calculate the velocity of the 1.45 kg mass.

(3 marks)

(b) Assuming no energy losses to the surroundings, calculate the energy contained within the spring when it is compressed. (If you could not complete (a), use v = 1.00 m s^{-1} left).

(3 marks)

(c) State and explain the effect on the velocities if the coupled carts were initially travelling 1.00 m s^{-1} right as opposed to being stationary.

(2 marks)

Question 7 **(9 marks)**

A car traveling at an initial velocity of 10.0 m s^{-1} North changes its velocity to 6.50 m s^{-1} East. With the aid of a scaled vector diagram calculate:

(a) The change in velocity of the car.

(4 marks)

(b) Assuming a uniform acceleration, calculate the average velocity of the car during this period.

(5 marks)

Question 8 **(6 marks)**

A student is investigating the intensity of sound at various distances from a musical instrument. At 1.40 m from the source, the intensity registers as 3.00 x10^{-4} W m^{-2} and the frequency is measured to be 448 Hz.

(a) Calculate how many pressure waves travel to the students in a time period of 0.560 seconds.

(3 marks)

(b) Calculate the distance from the source the student is to measure the intensity to be 30.5 mW m^{-2}. The following equation may be useful:

$$\frac{\mathrm{I}_1}{\mathrm{I}_2} = \frac{{r_2}^2}{{r_1}^2}$$

(3 marks)

End of Section One

Supplementary page

Question number: ____________________

Supplementary page

Question number: ___________________

Christ Church
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PHYSICS UNIT 2

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Section Two: Problem-solving **50% (71 marks)**

This section has **five (5)** 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 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: 70 minutes.

NAME:____

TEACHER:
(please circle) CJO JRM PCW SA

Question 9 **(10 marks)**

Christ Church Grammar School is looking to go off-grid for their electricity. The majority of their electricity needs are supplied by solar panels but during cloudy days this needs to be supplemented with a diesel generator. Engineers in charge of this upgrade must minimise the noise disruption to classrooms when the generator is operating.

(a) State two things that the engineers could do to minimise the noise disruption. (You may not use the suggestion provided in part (c)).

(2 marks)

All generators that are considered for this purchase are provided with a specified intensity which is "free field". this means that the sound is directly from the source and includes no reflection from outside objects.

(b) Explain why the engineers will need to increase the value of this intensity to use in their calculations.

(2 marks)

The engineers have been told that they must install the generator in an enclosed room to minimise the noise that reaches classrooms.

(c) Explain what sort of materials would likely be used in the walls of this room.

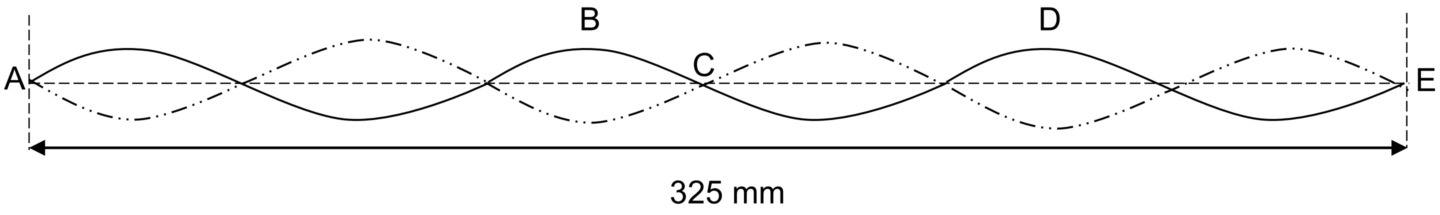
(3 marks)

A diesel generator was purchased and installed on the campus grounds. In order to produce the required output voltage, the diesel generator must run within an operating range of between 3.00×10^3 and 3.08×10^3 rpm (revolutions per minute). It was discovered in early testing that one of the wall panels of the room began vibrating excessively when the generator was set to run at 3.00×10^3 rpm.

(d) State and explain one modification that the engineers could do to prevent this occurring. (3 marks)

Question 10 **(12 marks)**

When a note is played on a violin, the sound it produces consists of the fundamental frequency and many overtones. The diagram below shows the shape of the string for a stationary wave that corresponds to one of these overtones. The frequency of this overtone in 435 Hz.



Points A and E are fixed ends of the string. Points B, C and D are free to move.

(a) Describe the phase relationship between

i. A and B

(1 mark)

ii B and D

(1 mark)

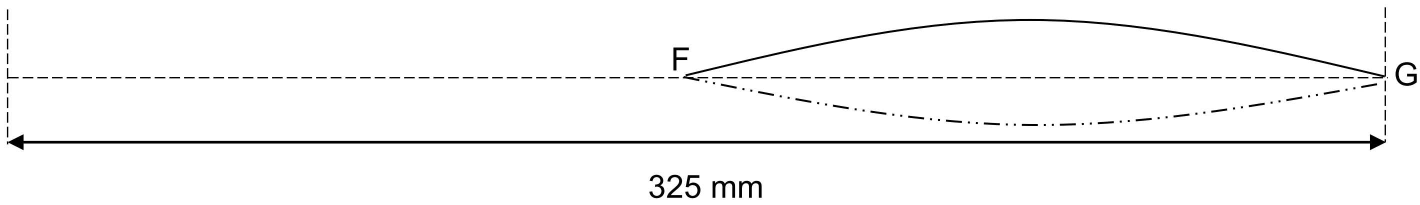
(b) On the diagram above, label two points, X and Y, that are out of phase by 180 degrees.

(1 mark)

(c) Calculate the speed of the wave on this string.

(3 marks)

The violinist presses on the string at F to shorten the part of the string that vibrates. The diagram below shows the string between F and G vibrating in its fundamental mode. The distance between F and G is 240 mm.



(d) State the name given to the region midway between F and G.

(1 mark)

(e) Calculate the wavelength of this stationary wave.

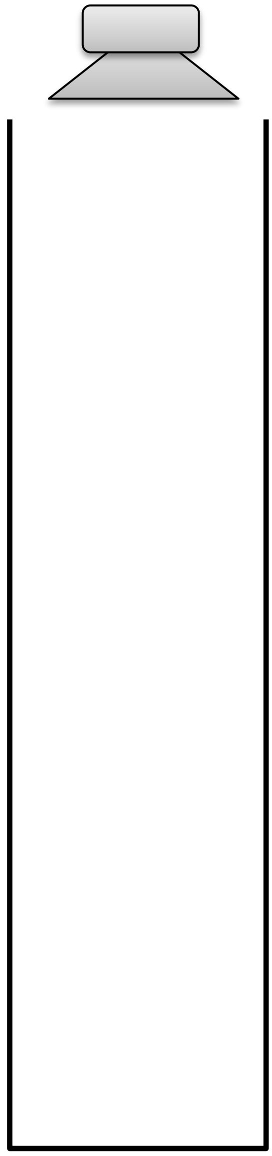
(2 marks)

(f) Calculate the frequency of this fundamental mode, using the wave speed calculated in (c). If you could not complete (c), use $v = 57.0\ \mathrm{m\ s^{-1}}$.

(3 marks)

Question 11 **(12 marks)**

A speaker is placed at the top of a closed end tube of length 0.800 m and the frequency slowly increased from 0 Hz until the 3rd loud tone was heard. The speed of sound in air was recorded as 346 m s^{-1}. For this question, ignore any end error corrections.



(a) In the diagram to the right, sketch the particle displacement envelope of the 3rd harmonic, including all important features.

(1 mark)

(b) Calculate the frequency of the 3rd harmonic in the tube.

(3 marks)

(c) Explain is what is meant by the term "particle displacement antinode".

(2 marks)

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With the frequency remaining constant, the tube is slowly filled with water and the sound intensity is observed to decrease and then increase.

(d) Calculate the effective length of the tube where this loud region would be heard.

(3 marks)

A group of students come in on another day when the air temperature in the tube was significantly higher.

(e) Explain, making reference to a suitable calculation, the effect this would have on the properties of the resulting waveform.

(3 marks)

Question 12 **(24 marks)**

When a spring is displaced from its equilibrium position it will experience a restoring force, which will act to return the spring to its equilibrium position. The restoring force is proportional to the 'stiffness' of the spring, which is known as the spring constant (k). The period of oscillation is the time for the spring to return to its original (displaced) position after it has been released.

The time period for such an oscillation is given by the formula:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Where T = Period (s)
m = mass (kg)
k = the spring constant.

In a spring that is allowed to oscillate, there exists a *damping factor ζ* (zeta) that is a measure of how oscillations in a system decay after a disturbance. Depending on the amount of damping present, a system exhibits different oscillatory behaviour:

- Where the spring–mass system is completely lossless, the mass would oscillate indefinitely. This hypothetical case is called *undamped* $\zeta = 0$
- If the system contained high losses, for example if the spring–mass experiment were conducted in a thick fluid, the mass could slowly return to its rest position without ever overshooting. This case is called *overdamped* $\zeta > 1$.
- Commonly, the mass tends to overshoot its starting position, and then return, overshooting again. With each overshoot, some energy in the system is dissipated, and the oscillations die towards zero. This case is called *underdamped* $\zeta < 1$
- Between the overdamped and underdamped cases, there exists a certain level of damping at which the system will just fail to overshoot and will not make a single oscillation. This case is called *critical damping* $\zeta = 1$.

The following information was collected by a group of year 11 students:

m (kg)	T(s) Trial 1 for 10 oscillations	T(s) Trial 2 for 10 oscillations	T(s) Trial 2 for 10 oscillations	T(s) Average time for 1 oscillation	
0.100	6.50	6.53	6.66		
0.150	8.78	8.75	8.73		
0.200	10.22	10.25	10.24		
0.250	11.53	11.57	11.58		
0.300	13.20	12.89	12.89		

(a) Process the data in the empty columns above so you are able to plot a graph of T^2 v m.
(3 marks)

(b) On the grid below, plot a graph of T^2 v m. A spare grid is provided on the end of this Question/Answer booklet. If you need to use it, cross out this attempt and clearly indicate that you have redrawn it on the spare page.

(5 marks)

(c) Calculate the gradient of the graph.

(3 marks)

Question 12 continued

(d) Using the gradient, determine the spring constant of the spring used.

(3 marks)

(e) On the graph on the previous page, sketch the data you would expect for a stiffer spring. You do not need to provide any calculations.

(1 mark)

(f) Given the method employed by the students, state and explain which suitable damping factor applies to this experiment.

(2 marks)

Knowing that the spring has a possible $\zeta \leq 1$, a student is concerned that by using 10 oscillations to calculate the period, this would introduce an error in the measurement of the period of the spring.

(g) Explain with reference to the properties of the spring, why this is not the case and what feature of the oscillation will change over time.

(4 marks)

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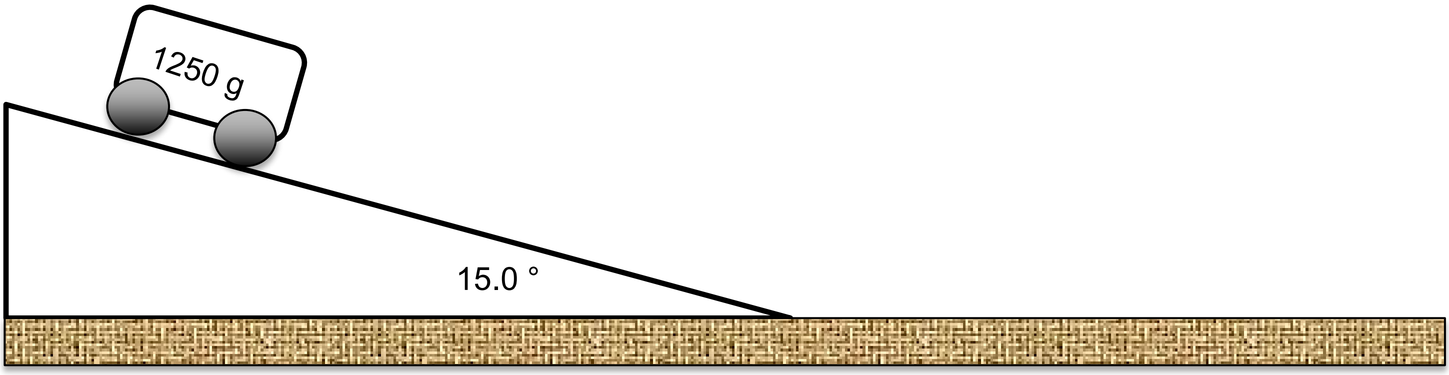
(h) By rearranging the original equation provided, show that the spring constant can also have units of [N m^{-1}] where 1 N = 1 kg m s^{-2}.

(3 marks)

Question 13 **(13 marks)**

A cart of mass 1250 g is allowed to accelerate from rest down a frictionless incline of angle 15.0° a distance of 1.20 m. It then travels along a horizontal surface where a frictional force of 4.55 N acts.



(a) Calculate the magnitude of the normal force of the surface and the force acting down the incline.

(4 marks)

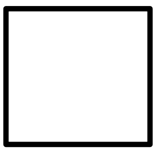
Normal force : ______________________ Force down the incline: ______________________

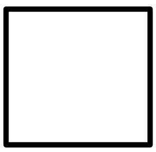
(b) On the diagrams below, draw a free body diagram showing the forces acting on the cart when:

i. on the incline

ii. on the horizontal surface.

(2 marks)





(c) Using concepts of work and energy, calculate the speed of the cart as it leaves the incline.
(3 marks)

(d) Using concepts of Newton's Laws and accelerated motion, calculate the time that the cart is moving along the horizontal surface only.
(4 marks)

End of Section Two

Supplementary page

Question number: ____________________

Spare Graph Paper

Christ Church Grammar School

Science Department
Year 11 Physics

PHYSICS UNIT 2

Semester 2 Examination, 2020

Question/Answer booklet

SECTION THREE: Comprehension **20% (33 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.

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: 30 minutes.

NAME:____

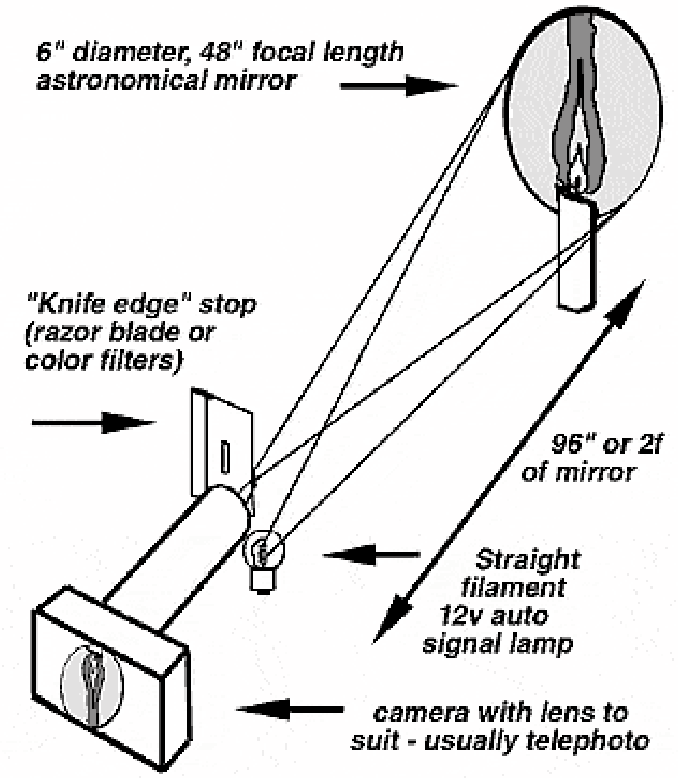
TEACHER: CJO JRM PCW SA
(please circle)

Question 14 **(16 marks)**

Filming high speed bullets.

When bullets travel at supersonic speed (faster than the speed of sound), it becomes quite difficult and expensive to view their motion. One technique to film their motion is known as *Schlieren Optics* which takes advantage of the changes in the speed of light as it passes through regions of different air pressure. This can be caused by temperature fluctuations or by a fast-moving object that produces high pressure regions in front and low pressure regions behind it.

The setup requires a large parabolic mirror set up far enough away so the light source can be focused directly into the camera. A "knife edge" is then placed in front of the camera. This then allows any refracted light to be blocked from entering the camera and hence, be observed as a dark region in the image.

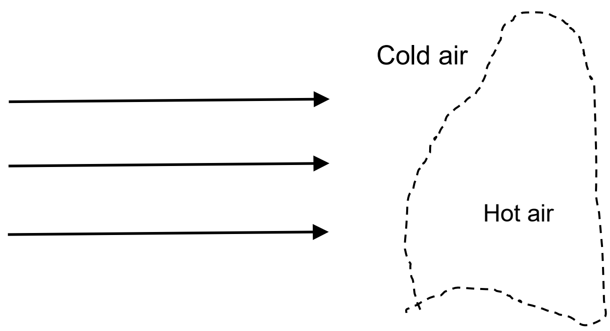


When light enters a region of high temperature it travels slightly faster than in the denser colder air. The difference in the light speed is very minimal, but this bending can be noticeable with large temperature differences such as the hot air rising from a campfire.

The diagram below shows a side on view of a temperature gradient above the candle with regions of differing temperature.

(a) Complete the ray diagram by sketching the path that the rays take as they pass over the candle.

(2 marks)

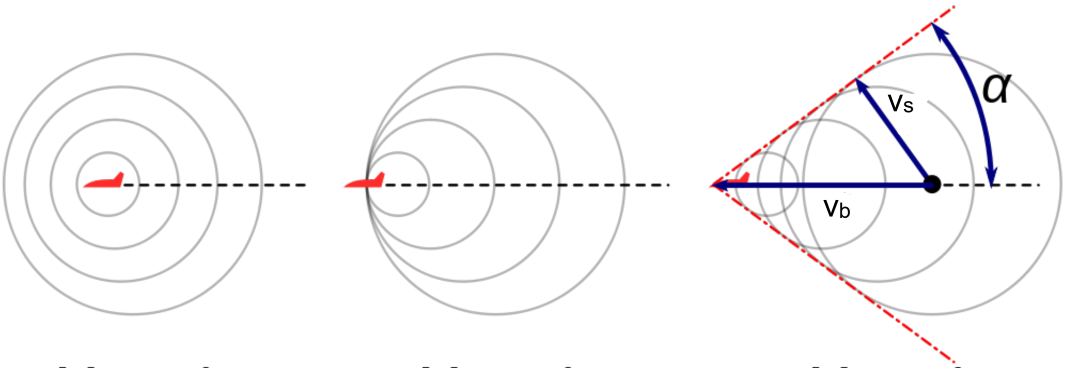


(b) State the definition of refraction.

(2 marks)

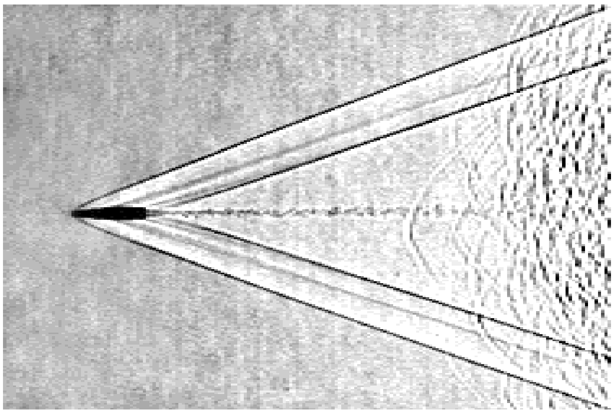
High speed objects are given a Mach Number “Ma” which is a ratio of the object’s speed to the speed of sound. If a high-speed object is travelling supersonic (Ma > 1) it produces a cone of pressure caused by relative motion of the object through the medium. The angle of the cone when measured from the horizontal is known as the Mach angle (α), shown in the figure below. In a given time, the bullet travels forward a distance x = v_bt. In that same time period, the sound wave produced at the same point travels out radially a distance of v_st. Ma can then be determined by the following relationship:

$$\text{Ma} = \frac{1}{sin\alpha}$$



Ma < 1 Ma = 1 Ma > 1

The cone of pressure of a fast-moving bullet can be seen using schlieren optics and a high-speed camera. Seen below is a 165 grain bullet (mass = 10.7 grams) fired at a supersonic speed in an environment where the speed of sound is 340.0 m s^{-1}.



Question (e)

(c) By making use of the diagram above, estimate the Mach angle and calculate the Mach number.

(3 marks)

(d) Hence, calculate the speed of the 165 grain bullet.

(2 marks)

(e) In the box on the previous page, sketch the pressure wave produced by a bullet travelling at 450.0 m s^{-1}. Show all required working in the space below.

(4 marks)

(f) If the 165 grain bullet shown in the diagram was to be fired in an environment where the speed of sound was higher, state and explain the effect this would have on the Mach angle

(3 marks)

Question 15 **(17 marks)**

Falling Cupcakes

As objects fall, they increase their speed due to the downward pull of gravity. Air resistance opposes gravity's pull by resisting the downward motion of the object. The amount of air resistance depends upon a variety of factors, most noticeably, the object's speed. As objects move faster, they encounter more air resistance. When the amount of upward air resistance force is equal to the downward weight force, the object encounters a balance of forces and is said to have reached a terminal velocity. The terminal velocity value is the final, constant velocity value achieved by the falling object.

A group of physics students are investigating the terminal velocity values obtained by falling cupcakes liners. They videotape the falling liners and use video analysis software to analyse the motion. The video is imported into the software program and the liner's position in each consecutive frame is tracked on (see Figure 1).

The software uses the position coordinates to generate graphs of the motion of the cupcake liners. Figure 2 shows the displacement versus time graph that resulted from the analysis of the motion of a single cupcake liner.

Figure 1

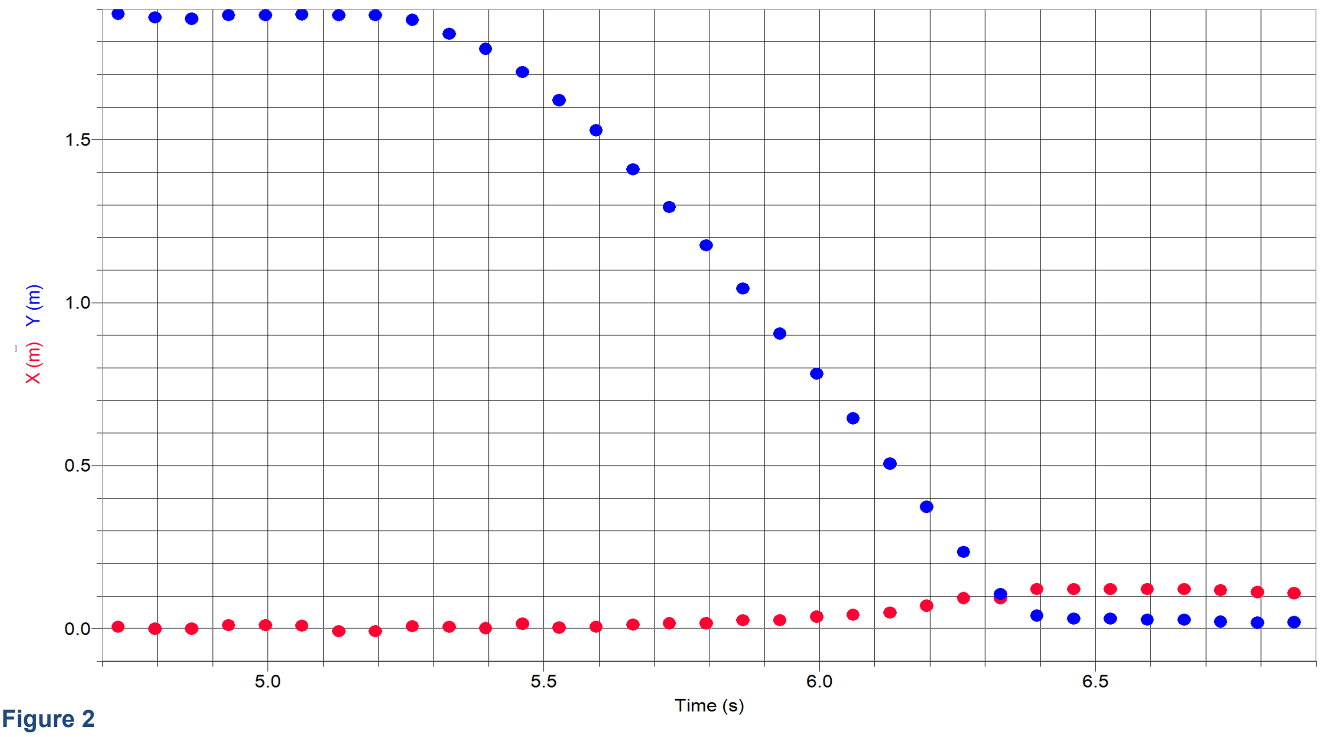


Figure 2

The lab group then investigated the effect of mass on the motion of the falling liners. They stacked varying numbers of liners tightly together and analysed the motion of the stacks of liners. They determined the terminal velocity of the stacks of liners. The students also measured the mass of the liners to determine their weight and used the value to determine the amount of air resistance encountered by the liners. Their results are plotted in Figure 3.

See next page

(a) Using the features of the graph in figure 2, show that the terminal velocity is 1.9 m s^{-1}

(3 marks)

One group of students conducted some further investigation and found an equation that describes the variables that affect the drag force of an object for a given speed.

$$F_D = \frac{1}{2}\rho v^2 A C_D$$

where:

F_D is the drag force [kg m s^{-2}]
ρ is the density of the fluid [kg m^{-3}]
v is the speed of the object relative to the fluid [m s^{-1}]
A is the cross-sectional area of the object relative to the fluid [m^2]
C_D is the drag coefficient that is unique for different shaped objects.

The terminal velocity as a function of mass is shown in Figure 3.

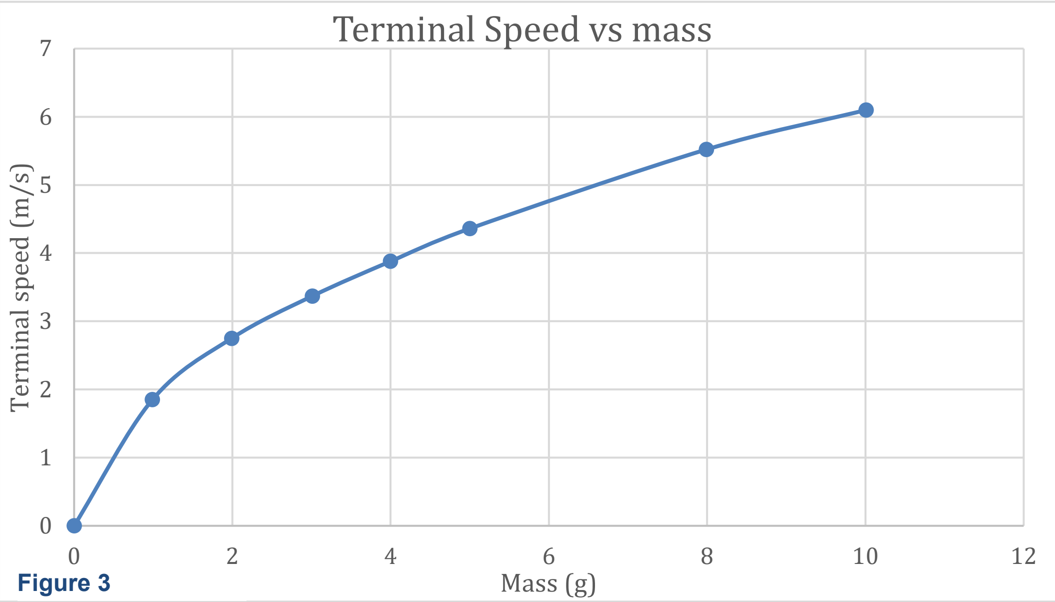


Figure 3

(b) State the mathematical proportionality between terminal velocity and mass and describe two different graphs that could be plotted to obtain a linear relationship between the two variables.

(2 marks)

(c) Derive an equation for terminal velocity that relates the variables of the falling cupcake liner once it has reached its terminal velocity.

(4 marks)

(d) State what the students must plot and explain how they could analyse their graph to determine the drag co-efficient. State which additional variables they also need to measure.

(3 marks)

When the students dropped 12 cupcake liners, the video analysis provided a velocity-time graph shown in figure 4. The cupcake liners were released from rest at the 4.55 second mark and hit the ground at the 5.1 second mark, before they had reached their terminal velocity.

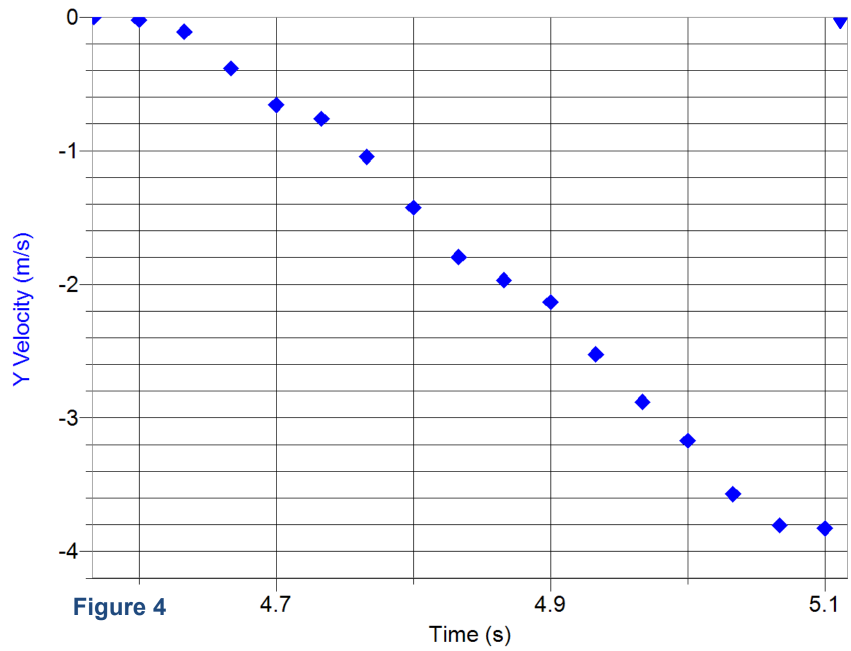


Figure 4

(e) Making reference to appropriate equations, state how students could modify their experiment in order to determine the terminal velocity of the stack of 12 liners.

(3 marks)

(f) On the diagram below, draw a force diagram, showing the forces acting on stack of 12 cupcake liner at t = 4.50 seconds and t = 5.00 seconds of the video.

(2 marks)

t = 4.50 s 

t = 5.0 s 

End of Section Three

Supplementary page

Question number: ____________________

Supplementary page

Question number: ___________________

Supplementary page

Question number: ____________________