METHODIST LADIES' COLLEGE

Methodist Ladies' College
ATAR course examination, Semester 1, 2018

Question/Answer Booklet

PHYSICS
ATAR Year 11

Student Name: _____

Teacher Name: _____

Time allowed for this paper

Reading time before commencing work: 10 minutes
Working time for paper: 2.5 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 this 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 material. 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	**Marks Attained**
Section One: Short answers	11	11	50	50 (33%)	/50
Section Two: Problem-solving	5	5	70	70 (47%)	/70
Section Three: Comprehension	2	2	30	30 (20%)	/30
				150 (100%)	/150

Instructions to candidates

1. The rules for the conduct of ATAR course examinations are detailed in the *Year 11 Information Handbook 2018*. Sitting this examination implies that you agree to abide by these rules.

2. Write your answers in this Question/Answer Booklet.

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 responses to the specific questions asked and to follow any instructions that are specific to a particular question.

5. Supplementary pages for the use planning/continuing your answer to a question have been provided at the end of the 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.

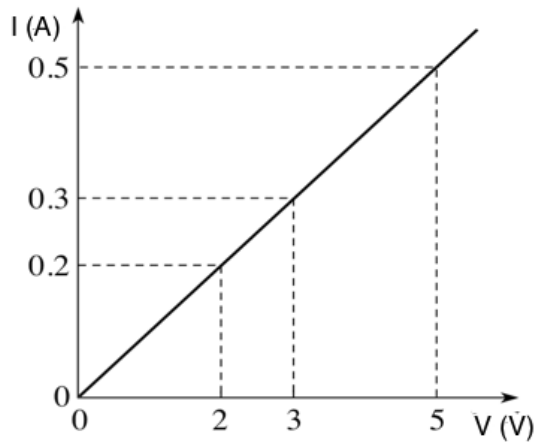
Section One: Short answers **(50 Marks)**

This section has **eleven (11)** questions. Answer **all** questions. Write your answers in the spaces provided.

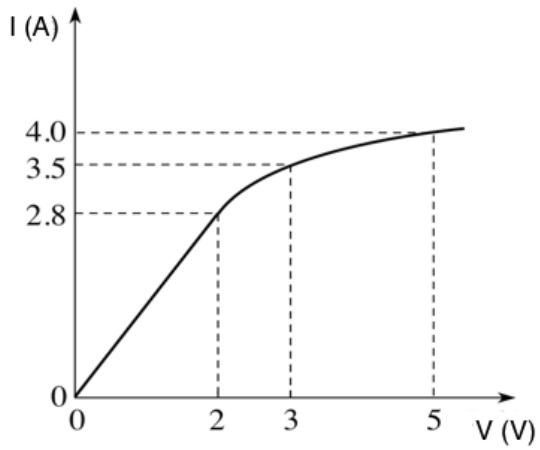
Suggested working time: 50 minutes.

Question 1 **(6 marks)**

The graphs below show the current versus voltage behaviour of two electrical devices.



Device X



Device Y

(a) Find the resistance of device X at each of the nominated values of voltage. (2 marks)

2.0 V: 5.0 V:

(b) Find the resistance of device Y at each of the nominated values of voltage. (2 marks)

2.0 V: 5.0 V:

(c) Which device is nonohmic? Briefly explain why. (2 marks)

Question 2 **(4 marks)**

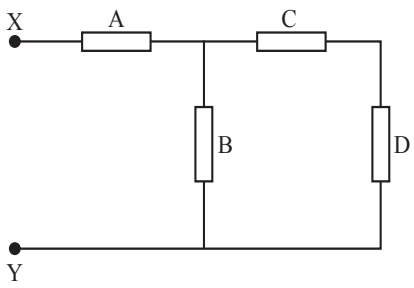
Two small balls, one made of rubber and the other of plastic, are rubbed together vigorously so that they acquire charges of equal size but opposite charge.

(a) Briefly explain why the opposite charges on each ball must be of equal size. (2 marks)

(b) The balls are suspended a small distance apart. Sketch the electric field that exists in the space between and around the balls. (2 marks)

Question 3 **(3 marks)**

Four resistors, each of resistance **2.00 Ω**, are arranged as shown in the diagram at right.



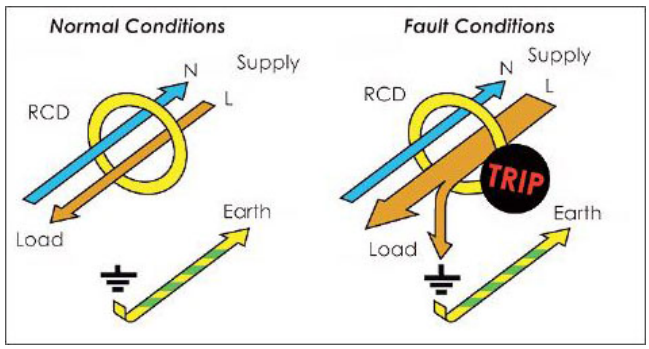
(a) Find the total resistance of the circuit. (2 marks)

(b) Which resistor has the largest current when the circuit is connected to a voltage source between points X and Y? Circle your choice for the answer. (1 mark)

A **B** **C** **D**

Question 4 **(4 marks)**

The basic operating principle of a residual current device (RCD), which is a safety device found in the meter box of a house, is illustrated in the sketch at right.



(a) Briefly describe how the residual current device (RCD) protects residents from electric shock. (2 marks)

(b) Explain the difference between the neutral wire and the earth wire in a typical household circuit. (2 marks)

Question 5 **(4 marks)**

In a rather dangerous demonstration to his class, an enthusiastic Physics teacher used an incandescent 100 W light bulb to demonstrate the heating effect of a current through a wire. He carefully broke and removed the glass bulb, leaving the filament intact. This filament, when dipped into water, drew a current of 1.75 A from the **mains power supply**!!

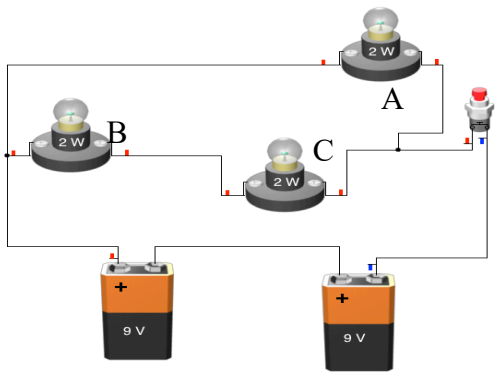
(a) Show that the power consumed by the filament, when dipped into water as described above, is much greater than 100 W. (2 marks)

(b) Explain why the power consumed by the filament, when dipped into water as described above, is much greater than the rated 100 W. (2 marks)

See next page

Question 6 **(4 marks)**

Two 9 V dry cells are connected to three identical 2 W light bulbs as shown in the diagram at right. A switch is also included in the circuit.



(a) Draw a labelled circuit diagram below, using appropriate circuit symbols. (2 marks)

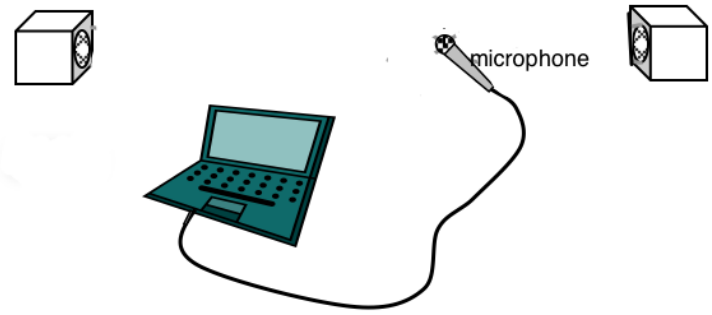
(b) When the switch is pressed, will all the bulbs glow with equal brightness? Briefly explain your answer; calculations are not necessary. (2 marks)

Question 7 **(4 marks)**

Dolphins and bats both use ultrasound waves with frequencies of up to 120 000 Hz as a form of sonar, in order to navigate through their respective environments. Which animal would be better at distinguishing small objects and why? (Note that the speed of sound in water is approximately 1500 ms^{-1})

Question 8 **(6 marks)**

A Physics student produces an interference pattern by using two speakers in phase facing each other, each emitting the same frequency note of 256 Hz. She detects the nodes and antinodes by moving the microphone between the two speakers to detect the loud (antinodal) and soft (nodal) points.



(a) If the room temperature is 25°C, calculate the distance between two nodal points. (3 marks)

(b) The student changes the frequency of **one** of the speakers to 260 Hz and detects that beats are now produced.

Draw a labelled sketch below to show the combined sound wave when beats are produced. (2 marks)

(c) Calculate the frequency of the beats produced. (1 mark)

Question 9 **(5 marks)**

Two whistles with the same frequency of 1.50 kHz are 4.00 m apart. The whistles are blown simultaneously. An observer moving along a line, as indicated below, observes a series of loud then quiet sounds.

(a) Explain why the person walking along this line experiences a series of loud then quiet sounds. (3 marks)

(b) Sketch and label wavefronts on the diagram above to help explain your answer to (a) (2 marks)

Question 10 **(5 marks)**

A ball is propelled vertically upwards at a speed of 8.00 ms^{-1} from a cliff that is 40.0 m above the ocean before eventually falling back down into the ocean below. Ignore air resistance.

(a) Find the maximum height the ball will rise above the cliff top. (2 marks)

(b) At what speed will the ball hit the ocean below the cliff? (2 marks)

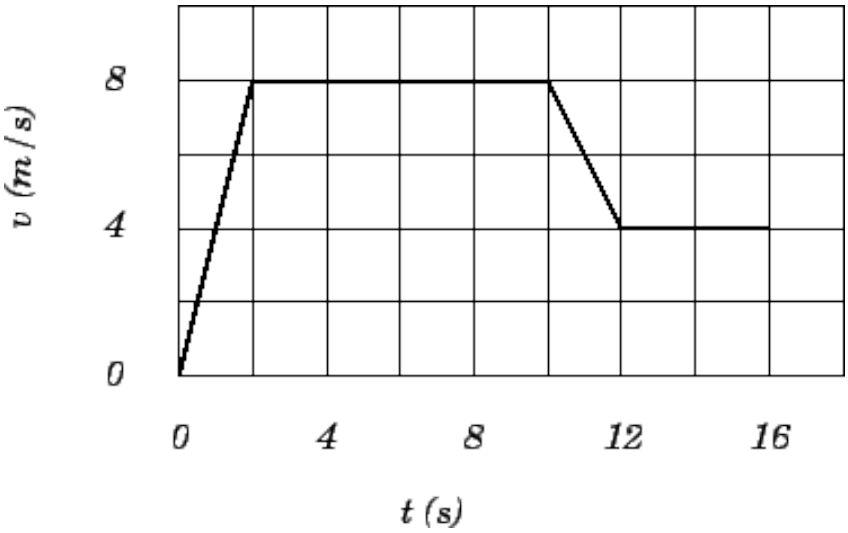
(c) How long will the ball spend in the air? (1 mark)

See next page

Question 11 **(5 marks)**

A Physics student observed and recorded the velocity of a remote control car over a period of time and plotted the graph below.

Velocity-time graph



(a) What is the acceleration of the car between times t = 0s and t = 2s? (1 mark)

(b) What is the acceleration of the car between times t = 10s and t = 12s? (1 mark)

(c) What is the net displacement of the car between times t = 0s and t = 16s? (3 marks)

END OF SECTION ONE

Section Two: Problem Solving **(70 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. Express numerical 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.

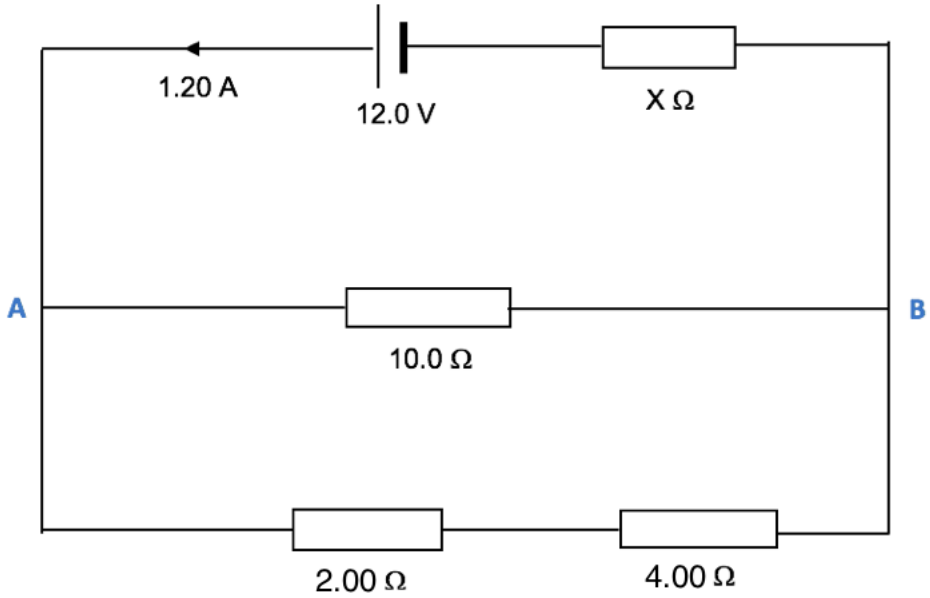
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the questions that you are continuing to answer at the top of the page.

Suggested working time: 70 minutes.

Question 12 **(16 marks)**

A 12.0 V battery is connected in a circuit with four resistors, as shown in the diagram below. The current flowing from the battery is measured to be 1.20 A.



(a) Calculate the resistance between points A and B in the circuit. (2 marks)

(b) Find the potential difference (voltage) between points A and B. (2 marks)

(c) State the potential difference across each of the resistors in the circuit. (4 marks)

10.0 Ω resistor: _____

2.00 Ω resistor: _____

4.00 Ω resistor: _____

X Ω resistor: _____

(d) Find the resistance of resistor X. (2 marks)

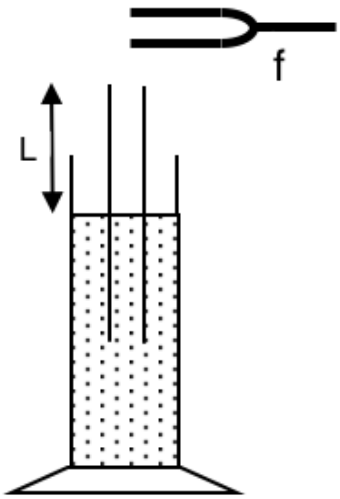
(e) Calculate the current that passes through the 2.00 Ω resistor. (2 marks)

(f) Which resistor produces heat at the highest rate in this circuit? Support your answer with appropriate calculations. (4 marks)

See next page

Question 13 **(15 marks)**

A student is investigating the speed of sound using tuning forks and open pipes.



A tuning fork of frequency f is struck and held above a plastic tube partly submerged in water, as shown in the diagram on the right. The length of tube out of the water (L) is adjusted until a fundamental resonance position is obtained at L_1 = 16.7 cm.

The tube is then pulled further out of the water to find a successive resonance point at L_2 = 50.7 cm.

(a) Explain how the student could tell where a resonance point occurs. (1 mark)

(b) Explain what causes the resonance in the tube. (2 marks)

(c) Using the diagrams provided below, sketch the particle displacement vs distance envelopes for the standing wave produced in the tube at the first and second resonance points. Label in the nodes and antinodes. (3 marks)

first resonance point

second resonance point

(d) Calculate the wavelength in air of the wave produced by the tuning fork. (2 marks)

(e) The room temperature of the laboratory was a chilly 16.7 ^{o}C.
Use the formula below to determine the speed of sound in the laboratory.
Speed of sound = 330 ms^{-1} + (0.60 ms^{-1}/ ^{o}C x room temperature in ^{o}C) (1 mark)

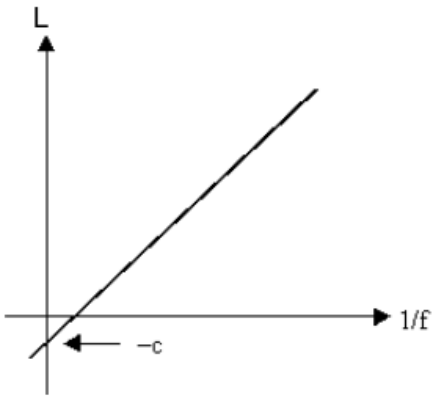
(f) The student forgot to record the frequency of the tuning fork that she used. A selection of tuning forks were in the laboratory. These were 256 Hz, 288 Hz, 440 Hz and 512 Hz.

Which tuning fork did the student most likely use?
Use a calculation to support your answer. (2 marks)

The student then carries out a second investigation using each of the various frequency tuning forks and measures the length of tube out of the water (L) when a fundamental resonance position is obtained for each tuning fork.

She then plots a graph of L v 1/f. (see graph on right)

She plans to use this graph to determine the speed of sound in the room.



(g) What does **c** represent on the graph above and why is this important for her to consider? (2 marks)

(h) Demonstrate mathematically how she can use the gradient of her graph to determine the speed of sound. (2 marks)

See next page

Question 14 **(15 marks)**

The velocity v of a wave down a guitar string is given by the formula:

$$v = \sqrt{\frac{F_T}{\mu}}$$

Where F_T = tension in the string (in N)

μ = mass per unit length of the string (in kgm^{-1})

The top E string on a guitar has a total mass of 0.208 g, a total length of 62.8 cm and is stretched to a tension of 226 N.

(a) What is the velocity of the wave down this string? (2 marks)

(b) A guitar player produces the first **overtone** on the guitar string by placing her fingers on the fret before strumming. Sketch the first overtone below. Label the displacement nodes and antinodes. (2 marks)

(c) Calculate the frequency of the first overtone. (2 marks)

The piano is a stringed instrument with a large number of strings which allow one to play a very large range of frequencies.

(d) The period of a sound wave from a piano is 1.20×10^{-3} s. If the speed of the wave in air is 340 ms^{-1}, what is its wavelength? (2 marks)

(e) To obtain the low-frequency notes on a piano, the strings are often wound with additional wire to increase the mass of the string. If a string 0.800 m long normally has a resonant frequency of 50.0 Hz, what would be the resonant frequency of this same string if it were wrapped so that its mass per unit length increased by a factor of two. (3 marks)

(f) Which of the following are True or False? Mark True with T and False with F (4 marks)

i. The speed of a wave on a piano string depends upon the tension in the string. _____

ii. The fundamental frequency of a piano string depends only upon the length of the string _____

iii. The fundamental frequency of a piano string depends upon the speed of sound in air. _____

iv. A piano string produces only odd harmonics. _____

See next page

Question 15 **(14 Marks)**

The power output and resistance of a coiled heating element were investigated by measuring the current flowing through the heating element for different values of voltage applied across it.

The relationship between power, current and resistance is given by

$$P = I^2 R$$

The measurements obtained over half a dozen trials during this investigation are recorded in the table below.

Voltage (V)	5.2	10.5	15.3	20.8	25.7	30.5
Current (mA)	165	327	491	652	828	956

(a) Calculate the power produced by the heating element during each of these trials and enter the values in the table above. (2 marks)

(b) Calculate the value of the square of the current for each of these trials and enter the values in the table above. (2 marks)

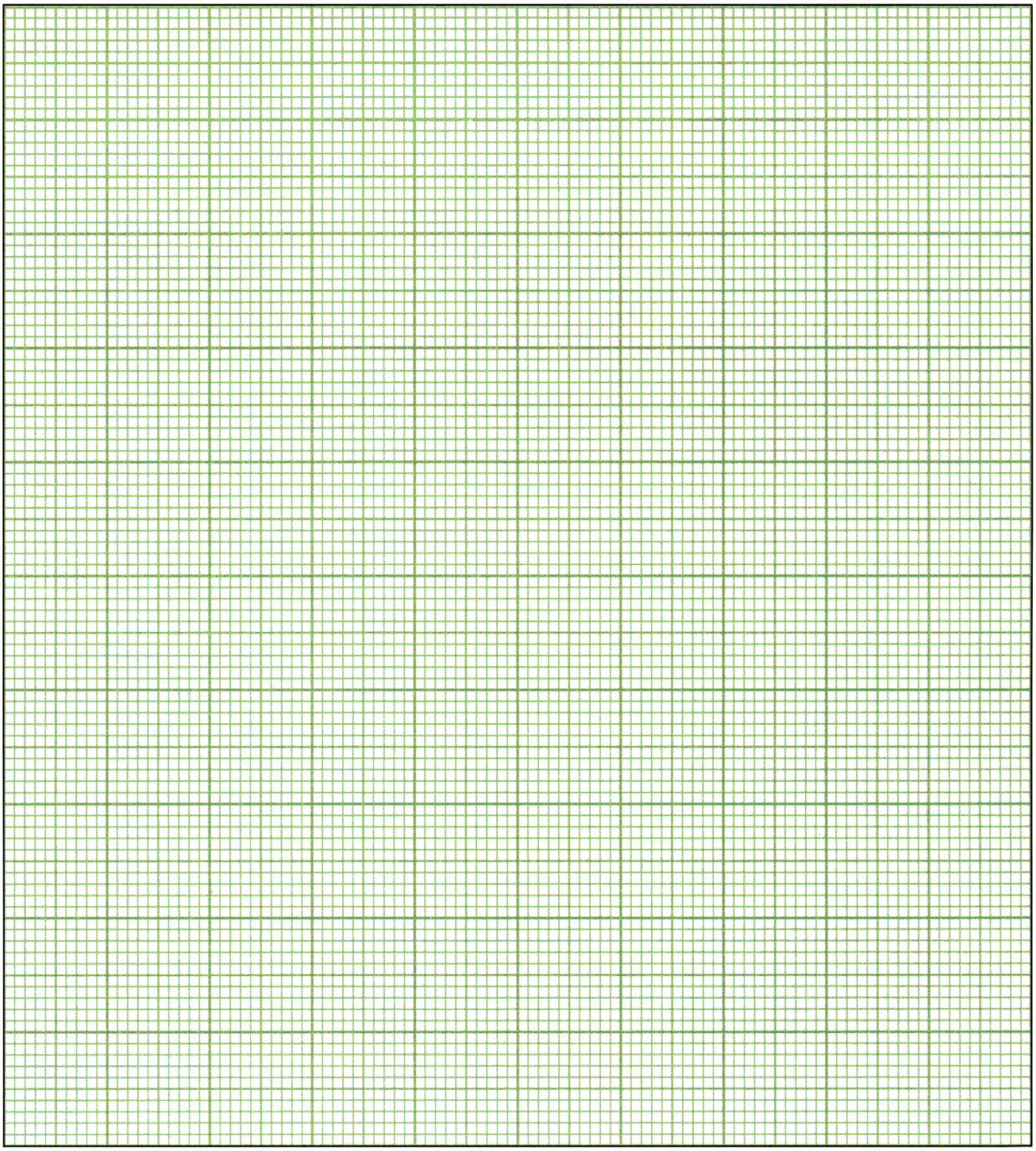
(c) Sketch a graph of power versus current squared for the heating element, on the graph paper on the next page, using your data from the table above. (4 marks)

(d) Use your graph to calculate the resistance of the coiled heating element. (2 marks)

(e) If the voltage across the heating element was 18.0 V, then

(i) use your answer from part (d) to find the current drawn by the heating element (if no answer from part (d), use a resistance value of 35.0 Ω) (2 marks)

(ii) use your answer from (i) and the graph to find the power output of the heating element (2 marks)



See next page

Question 16 **(10 Marks)**

Cheetahs are the fastest land animal and can reach a top speed of approximately 110 kmh^{-1} with the ability to accelerate from rest to top speed in about 3.4 seconds.

Thomson's gazelles, the Cheetahs favourite prey, can reach a top speed of 70.0 kmh^{-1}.

(Ignore any lag due to decision making time on the part of the cheetah, so that the moment the gazelle passes the cheetah, the cheetah starts accelerating.)

(a) If a gazelle runs at top speed right past a stationary cheetah, how long would it take for the cheetah to catch up with the gazelle? (7 marks)

(b) How far did the cheetah have to run to catch up to the gazelle? (3 marks)

END OF SECTION TWO

Section Three: Comprehension **(30 Marks)**

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

Suggested working time: 30 minutes.

Question 17 **SHOCK WAVES CAUSE ACOUSTIC SHOCK** **(10 marks)**

(Paragraph 1)

A British viola player has won a historic lawsuit against the **Royal Opera House** for hearing damage he sustained while playing with the orchestra. The judge wrote in her ruling, "the sensation from so many brass instruments playing directly behind him, in a confined area, at the same time at different frequencies and volumes, created a wall of sound which was completely different to anything he had previously experienced."

(Paragraph 2)

On 1st September 2012, Chris Goldscheider was seated directly in front of the brass section of the orchestra for a rehearsal of Wagner's booming opera *Die Walkure*. Goldshceider was exposed to noise levels exceeding 130 decibels, which is louder than a jackhammer, causing him to sustain irreversible hearing damage due to an affliction referred to by musicians as 'acoustic shock'.

Fig 1. Goldscheider at the Royal Opera House.

(Paragraph 3)

Shock waves emanating from trombones and trumpets have been caught on video and as photographic images. The intense pressure waves produced can briefly exceed the speed of sound. Compression waves are built up to an abrupt supersonic shock wave, travelling briefly at about 1% more than the speed of sound.

Shock waves are a particular kind of pressure wave - which is what sound itself comprises.

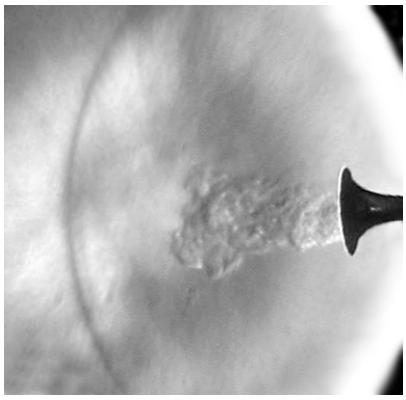


Fig 2. Schlieren image showing shock wave from a Trumpet.

(Paragraph 4)

Fig 3. Schlieren image showing shock waves from an exploding firecracker.

In the mid-19th century, German physicist August Toepler invented a photography technique called Schlieren Flow Visualization to visually capture these changes in density. It is used to visualise the flows of the media, which are themselves transparent, but form refractive index gradients, which become visible in schlieren images either as shades of grey or even in colour. Because shock waves represent a stark and sudden change in refractive index, they show up clearly in schlieren photographs.

See next page

(a) Briefly explain what is meant by each of the following expressions

(i) …“ acoustic shock”… (Paragraph 2) (1 mark)

(ii) “compression waves” (Paragraph 3) (1 mark)

(iii) …“ refractive index gradients”… (Paragraph 4) (1 mark)

(b) Explain how sound produced by a trombone could cause a stark and sudden change in the refractive index in the surrounding air. (2 marks)

(c) Abrupt shock waves are produced travelling at about 1% more than the speed of sound. Determine the approximate speed of the shock wave if the air temperature was 25^{o}C. (1 mark)

(d) Describe two steps the Royal Opera House could take in order to prevent other performers from suffering acoustic shock in the future. (2 marks)

(e) A sound of 130 dB is equivalent to an intensity of 10.0 W/m^2. The human ear drum has a cross-sectional area of 40.0 mm^2. How much sound energy did each ear drum receive per second? (2 marks)

See next page

Question 18 **EMERGENCY BRAKING** **(20 marks)**

(Paragraph 1)
Stopping a car in an emergency situation can be a frightening experience. Inexperienced drivers often say it took a longer distance to stop the car than they thought it would. It takes a measurable amount of time for a driver to recognise and react to a hazard. The *reaction time* is the time it takes for the driver to apply the brakes after the hazard is first identified.

(Paragraph 2)
Reaction times vary considerably between drivers and situations. Factors that affect driver reaction time include driver skill, alertness, drug and alcohol effects and inattention. A prompt reaction time is about 0.2 s or less. Inattention due to many factors (including texting while driving) can cause reaction times of well over 1.0 s. The distance the car travels before the driver takes appropriate action, such as applying the brakes, is the *reaction distance*.

(Paragraph 3)
Stopping time is the total time elapsed from the recognition of the hazard to coming to a stop. *Braking distance* is the distance covered while the brakes are applied. *Stopping distance* is the total distance covered from the recognition of the hazard to coming to a stop. It is the sum of the reaction distance and the braking distance. Small increases in speed of the vehicle can have a significant impact on stopping distance, as illustrated by Figure 1 below.

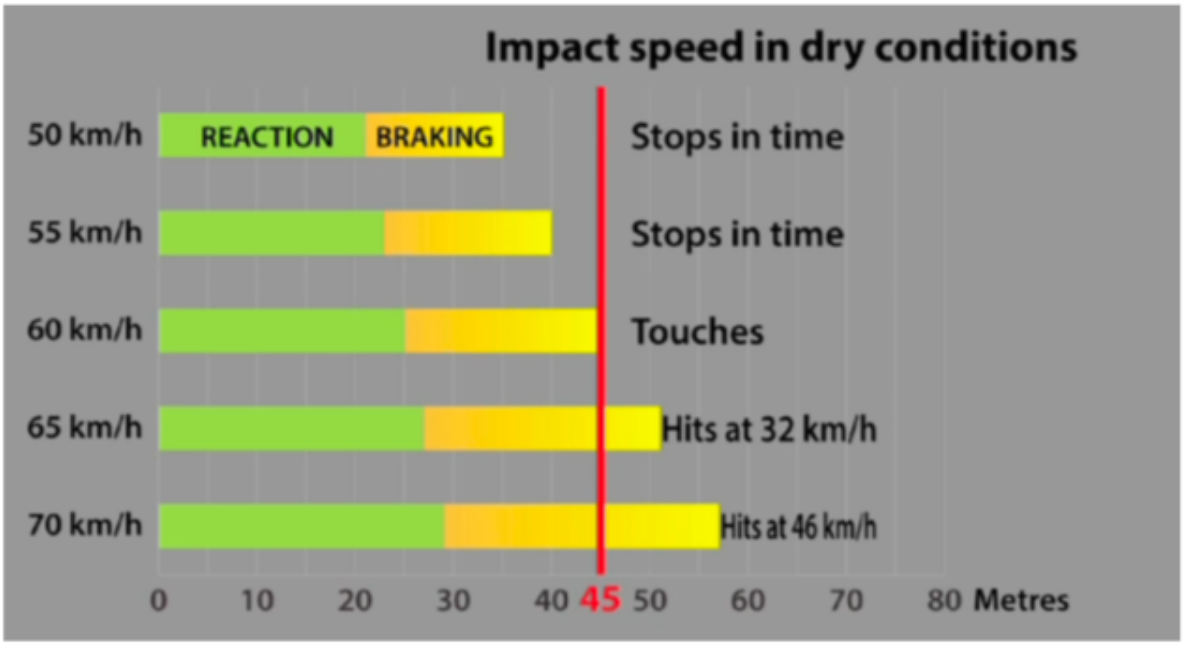


Figure 1. Graph showing impact speeds at 45 m from hazard.

(Paragraph 4)
Once the brakes are applied, the car will come to a stop in a distance that is affected by many conditions. The conditions of the brakes, the road surface, the vehicles tyres, whether it is wet or dry, modern technologies such as ABS (anti-skid braking system) all affect braking distance. Road authorities often use $3.4 ms^{-2}$ as a comfortable rate of stopping. An emergency braking stop could be twice this rate. A crash stop may involve deceleration rates too great for occupants to survive.

(a) Explain why driver inattention can lead to a longer stopping distance. (1 mark)

(b) Examine Figure 1. Answer the points (i) – (vi) below relating to the driver driving at 60 km/h in dry condition.

(i) Reaction distance (1 mark)

(ii) Braking distance (1 mark)

(iii) Stopping distance (1 mark)

(iv) Reaction time (2 marks)

(v) Braking time (2 marks)

(vi) Stopping time (1 mark)

(vii) Deceleration while braking (1 mark)

(c) Sketch and label a graph on the axes below to show each of the points (i) – (vi) above. (Your graph does not need to be to scale). (3 marks)

See next page

An inattentive driver is glancing at her mobile phone while driving towards a set of traffic lights at 80 km/hr when the lights change to amber. Her reaction time is 1.2 s. The driver manages to brake hard at twice the Road Authorities comfortable rate of stopping and bring the car to a stop.

(d) What was the deceleration of the car while braking? (1 mark)

(e) If the car was 75 m from the traffic lights when the light changed to amber, did it manage to stop within this distance? Show your working. (6 marks)

END OF PAPER

EXTRA WORKING SPACE

See next page

EXTRA GRAPH PAPER