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 (4 marks)

Explain the difference between transverse and longitudinal waves, giving an example of each type of wave.

Transverse waves: the particles oscillate at right angles (perpendicular) to the direction the wave is moving (1)
e.g. guitar string, water waves (1)
Longitudinal waves: the particles oscillate parallel to the direction the wave is moving (1)
e.g. sound waves, stop-start traffic (1)

Question 2 (4 marks)

During the recent interhouse cross country race at Perry Lakes, Rosie ran 600 m West in 3 minutes, 700 m North in 2 minutes 40 seconds and then 200 m East in 60 seconds.

(a) What was Rosie's average speed? (2 marks)

$d = 600 + 700 + 200 = 1500\,m$ (1)

$t = 180\,s + 160\,s + 60\,s = 400\,s$

$\therefore v = \frac{d}{t} = \frac{1500\,m}{400\,s} = 3.75\,m/s$ (1)

(b) Was her average speed the same as her average velocity? Explain (calculations not required). (2 marks)

Average speed will be a larger value as her distance covered will be greater than her final displacement, which is used to calculate velocity (1)
Also, her average velocity includes the direction she has moved in, as velocity is a vector (1)

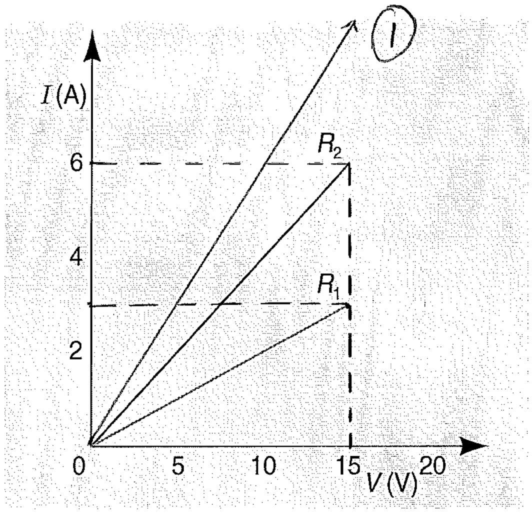
Question 3 **(3 marks)**

The I–V graphs for two ohmic resistors are shown at right.

(a) Find the resistance of R_1 and of R_2. (2 marks)

$R_1 = \frac{V}{I} = \frac{15V}{3A} = 5\Omega$ (1)

$R_2 = \frac{V}{I} = \frac{15V}{6A} = 2.5\Omega$ (1)



(b) R_1 and R_2 are now combined in parallel. On the graph, sketch a third line for the I-V graph of this parallel combination. (1 mark)

in parallel with 15V, total current = 3A + 6A = 9A

Question 4 **(5 marks)**

A car is driving towards a set of traffic lights at 80 km/hr when the lights change to amber. The driver manages to brake hard and bring the car to a stop in 4.2 s.

(a) What was the deceleration of the car? (2 marks)

$u = 80 \text{ km/hr} = 22.2 \text{ m/s}$, $v = 0$, $t = 4.2 \text{ s}$

$\therefore a = \frac{v - u}{t} = \frac{0 - 22.2 \text{ m/s}}{4.2 \text{ s}} = -5.29 \text{ m/s}^2$ (1)

(1)

(deceleration = 5.29 m/s^2)

(b) If the car was 40 m from the lights when it began braking, did it manage to stop within this distance? Show your working. (3 marks)

$s = ut + \frac{1}{2}at^2$ (1)

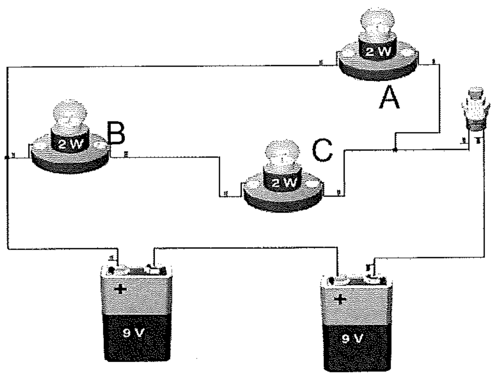
$= (22.2)(4.2) + \frac{1}{2}(-5.29)(4.2)^2$

$= 46.7 \text{ m}$ (1)

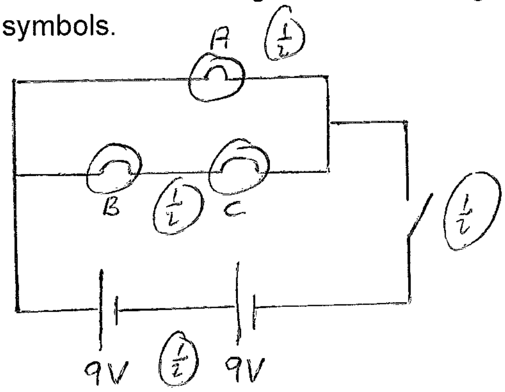
No (1) – car covered an extra 6.7 m (probably stopped in middle of intersection!)

Question 5 **(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)



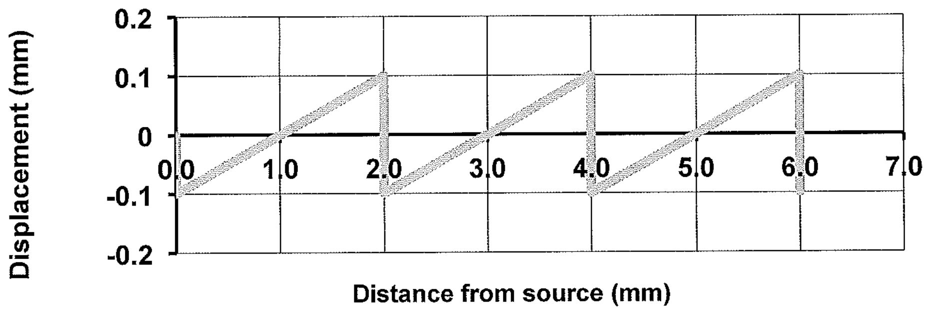
(b) When the switch is pressed, will all the bulbs glow with equal brightness? Briefly explain your answer; calculations are not necessary. (2 marks)

B and C are in series in one branch, parallel to A which is by itself in another branch (1). Hence A will have more current flowing through it (more resistance in branch with both B and C) and so will glow brighter (1)

Question 6 **(6 marks)**

An ultrasonic waveform is shown below on a displacement-distance graph. The graph shows the waveform, consisting of successive triangular pulses, at a **time of 18 μs** after the pulses began. State the value of each of the following properties of the ultrasonic wave.

Ultrasonic Wave Pulse



Amplitude: 0.1 mm (1 mark)

Wavelength: 2.0 mm (1 mark)

Period: 3 pulses in 18 μs ⇒ T = 6 μs (1 mark)

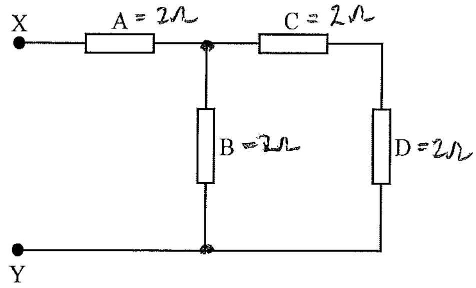
Frequency: f = 1/T = 1.67 × 10^5 Hz (1 mark)

Wavespeed: v = λf = (0.002 m)(1.67 × 10^5 Hz) (1) (2 marks)

= 333 m/s (1)

Question 7 **(3 marks)**

Four resistors, each of resistance **2.0 Ω**, are arranged as shown in the diagram at right.



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

$$\frac{1}{R_{//}} = \frac{1}{2} + \frac{1}{4} = \frac{3}{4}$$

$$\therefore R_{//} = \frac{4}{3} = 1.33\,\Omega \quad (1)$$

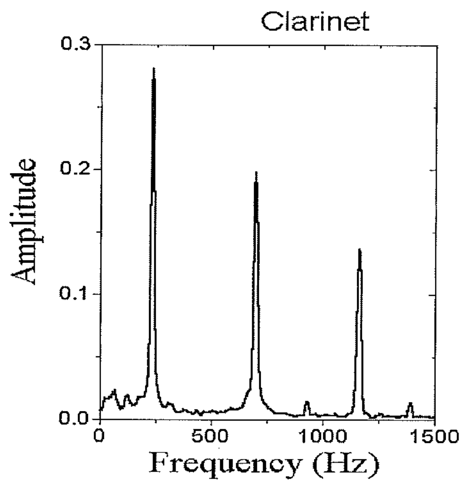
$$\therefore R_T = 2 + 1.33 = 3.3\,\Omega \quad (1)$$

(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 8 **(4 marks)**

A musician recorded herself playing a note on the clarinet and produced the frequency distribution analysis of the note on her computer as shown at right.



(a) Does her clarinet behave as a closed or open pipe? Explain briefly using the diagram at right. (2 marks)

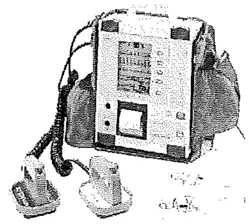
Closed pipe (1) – the harmonics (spikes on the graph) occur at about 240 Hz, 720 Hz, 1200 Hz, which are odd multiples (1, 3, 5) of the fundamental (1)

(b) How long is the air column in the clarinet for the note she is playing? Assume the temperature of the air in the clarinet to be 25°C. (2 marks)

$$f = \frac{v}{\lambda} = \frac{v}{4L} \quad (1) \text{ (fundamental)}$$

$$\therefore L = \frac{v}{4f} = \frac{346}{4 \times 240} = 0.36\text{ m} \quad (1)$$

Question 9 **(6 marks)**



A defibrillator is a life-saving machine that gives the heart an electric shock after cardiac arrest. A typical defibrillator is charged up with 30 mC and delivers that charge at a voltage of about 1800 V.

(a) How much energy is released as the defibrillator discharges? (2 marks)

$$W = qV \quad (1)$$
$$= (0.03\,C)(1800\,V) = \underline{54\,J} \quad (1)$$

(b) The defibrillator discharges in 12.0 ms. Find the average current that flows through the patient's heart in that time. (2 marks)

$$I = \frac{q}{t} = \frac{0.03\,C}{0.012\,s} = \underline{2.5\,A} \quad (1)$$

(1)

(c) Find the power produced by the defibrillator. (2 marks)

$$P = \frac{W}{t} = \frac{54\,J}{0.012\,s} = \underline{4500\,W} \quad (1)$$

(1)

Question 10 **(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 about 1500 m/s)

$$v = \lambda f \rightarrow \lambda = \frac{v}{f}$$

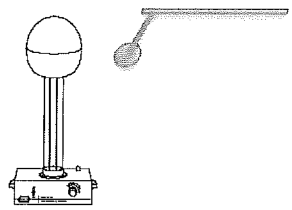
So for the same frequency sound waves, the wavelength emitted by dolphins in water is much larger (1) than that emitted by bats in air, since the speed of sound is much higher in water compared to air. (1)

Objects need to be larger than the wavelength to cause significant reflection and be detected (1), so bats will detect smaller objects than dolphins (1)

Question 11 **(7 marks)**

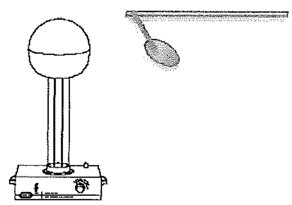
Young Alice brings an uncharged polystyrene foam ball that is dangling on a cotton thread near a positively charged Van de Graaf generator.

(a) Initially she observes that the foam ball is attracted towards the dome of the Van de Graaf generator. Explain this observation. (3 marks)



The positively charged dome causes charge separation on the foam ball (1) - electrons are attracted to the near side of the ball, leaving the far side of the ball with a positive charge (1). As the electrons are closer to the dome, the attraction they feel is larger than the repulsion on the positively charged far side (1)

(b) When the foam ball touches the dome, she notices that the ball is quickly repelled away from the dome. Explain this observation. (2 marks)



When the ball touches the dome it acquires some of the positive charge from the dome (1). As both foam ball and dome are now positively charged, they repel one another. (1)

(c) When the foam ball has been repelled away as in part (b) above, it is estimated that the charge on the dome is 5 μC, the charge on the foam ball is 80 nC and the effective distance between their centres is about 20 cm. Use these values to calculate the force of repulsion between the dome and the foam ball in this situation. (2 marks)

$$F = k\frac{q_1 q_2}{r^2}$$

$$= \frac{(9\times10^9)(5\times10^{-6})(80\times10^{-9})}{(0.2)^2} \quad (1)$$

$$= 0.09\ N \quad (1)$$

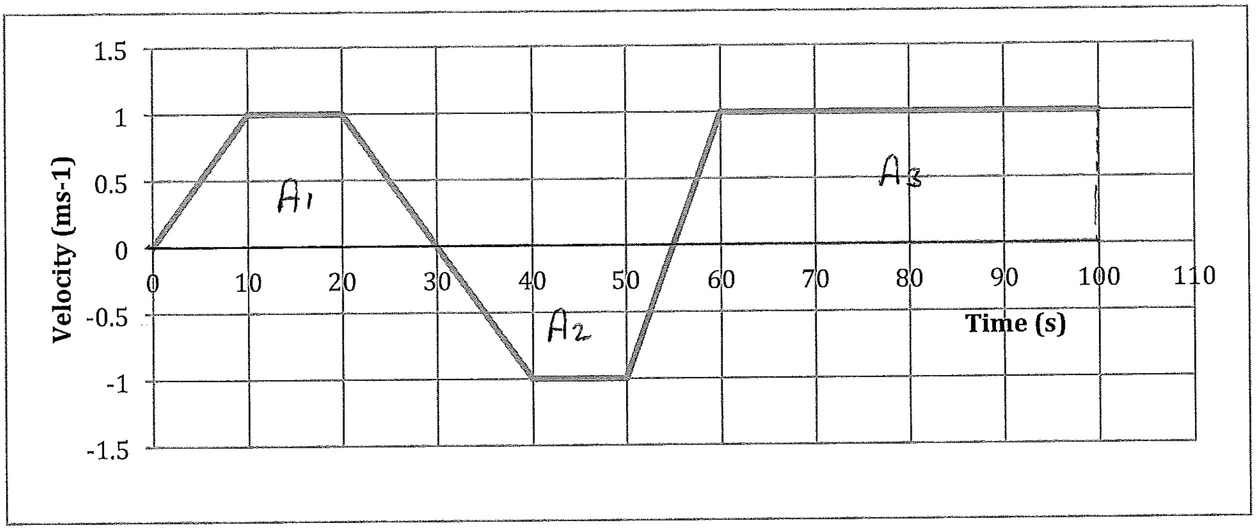
Section Two: Problem Solving **(70 Marks)**

This section has **five (5)** questions. Answer **all** questions. Write your answers in the spaces provided.

Suggested working time: 70 minutes.

Question 12 **(14 marks)**

The graph below shows the motion of a battery operated toy robot during a 100 s time interval.



(a) During which time interval(s) is the acceleration of the toy robot zero? (1 mark)

10 - 20 s , 40 - 50 s , 60 - 100 s

(b) What is the acceleration between t = 50 s and t = 60 s? (2 marks)

$a = \frac{v-u}{t} = \frac{1-(-1)}{10} = 0.2\ m/s^2$ (1) (1)

(c) What is the displacement of the toy robot during the 100 s time interval? (3 marks)

displacement = area under graph = $A_1 - A_2 + A_3$ (1)

$A_1 = \frac{1}{2}(10)(1) + (10)(1) + \frac{1}{2}(10)(1) = 20\ m$

$A_2 = \frac{1}{2}(10)(1) + (10)(1) + \frac{1}{2}(5)(1) = 17.5\ m$ (1)

$A_3 = \frac{1}{2}(5)(1) + (40)(1) = 42.5\ m$

$\therefore s = 20 - 17.5 + 42.5 = 45\ m$ (1)

(d) What is the average velocity of the toy robot during the entire interval? (2 marks)

average $v = \frac{s}{t} = \frac{45\text{m}}{100\text{ s}} = \underline{0.45\text{ m/s}}$ (1)

(1)

(e) At what instant did the toy robot first reverse direction? (1 mark)

$t = 30\text{s}$ (first time velocity become negative)

(f) Did the toy robot return to its starting point? If so, at what instant? (1 mark)

Never does ($A_1 > A_2$, so it never gets all the way back to its starting point)

(g) During which time interval(s) did the robot have a negative acceleration? (1 mark)

20 - 40 s

(h) During which time interval(s) did the robot decrease its speed? (1 mark)

20 - 30 s , 50 - 55 s

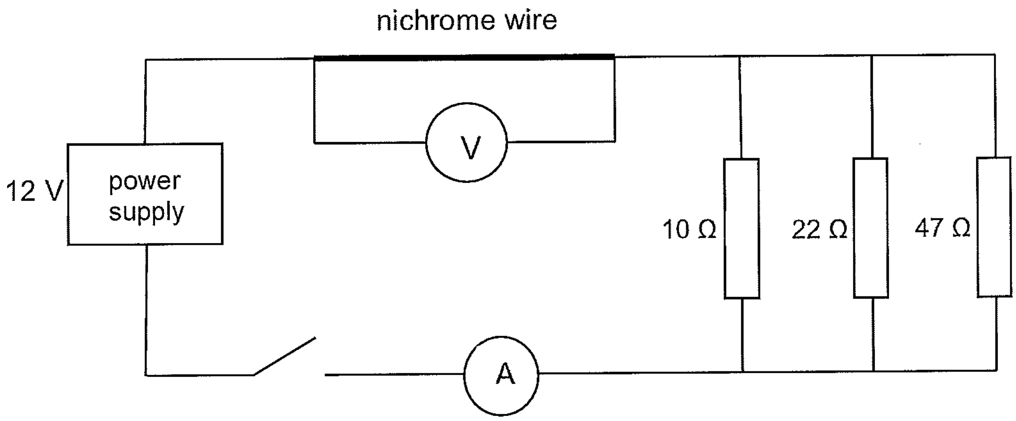
(i) Explain why your answers to (g) and (h) are different from each other. (2 marks)

From 30 - 40 s the robot was speeding up while moving backwords - a negative acceleration (1)

From 50 - 55 s the robot was slowing down while moving backwords - a positive acceleration (1)

Question 13 **(14 marks)**

For a Physics investigation a student set up the circuit shown below, consisting of three resistors (10.0 Ω, 22.0 Ω, 47.0 Ω) in parallel with one another that are connected in series with a length of nichrome wire. An ammeter measures the current from the 12 V power supply and a voltmeter measures the potential difference across the nichrome wire.



(a) When the switch is closed, the ammeter reads 1.80 A. Calculate the total resistance of the circuit. (2 marks)

$R_T = \frac{V}{I} = \frac{12V}{1.80A} = \underline{6.67\,\Omega}$ (1)

(1)

(b) Find the combined resistance of the three resistors in parallel. (2 marks)

$1/R_{\parallel} = 1/10 + 1/22 + 1/47 = 0.167$ (1)

$\therefore R_{\parallel} = \underline{6.00\,\Omega}$ (1)

(c) Calculate the voltage drop across the three resistors in parallel. (2 marks)

$V = IR_{\parallel} = 1.80A \times 6.00\,\Omega$ (1)

$= \underline{10.8\,V}$ (1)

(d) How large is the current flowing through the 22.0 Ω resistor? (2 marks)

$I = \frac{V}{R} = \frac{10.8\,V}{22.0\,\Omega} = 0.491\,A$ (1)

(1)

(e) Find the reading on the voltmeter and the resistance of the nichrome wire. (3 marks)

$V = 12 - 10.8 = 1.2\,V$ (1)

$R = \frac{V}{I} = \frac{1.2\,V}{1.8\,A} = 0.67\,\Omega$ (1)

(1)

[or $R = R_T - R_{\parallel} = 6.67 - 6.00 = 0.67\,\Omega$]

(f) When the switch is left closed for a period of time, the reading on the voltmeter increases somewhat. What does this tell us about the nichrome wire? Is it an ohmic or nonohmic conductor? (3 marks)

The resistance of the nichrome wire is increasing (1) the wire must be heating up (1) and since resistance is changing the wire is acting as a nonohmic conductor (1)

Question 14 **(14 marks)**

A loudspeaker is mounted on a wall as shown below in figure 1 and consists of a cardboard cone that moves backwards and forwards to produce a sound wave in air. In the air there are fine dust particles that are floating at rest. After the loudspeaker is turned on, the particles will be forced to move by the pressure variations associated with the sound wave. The graph below on the right (figure 2) shows the horizontal displacement of the speaker cone as a function of time.

Fig 1

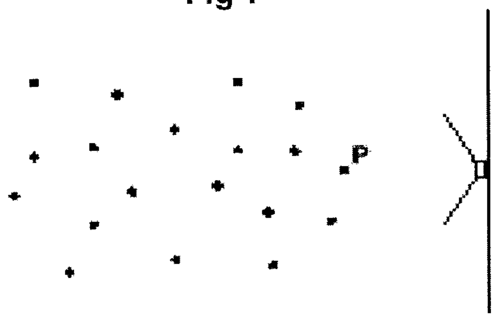
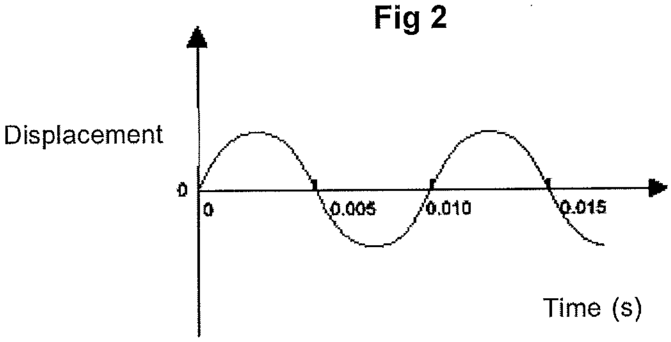


Fig 2



(a) For the dust particle at point P in Fig 1, **directly in front** of the loudspeaker, how would you describe its motion over time? (2 marks)

The dust particle will oscillate (1) back and forth (as sound waves pass by it), moving towards and away from the speaker (1)

(b) Use figure 2 to find the **period, frequency** and **wavelength** of the sound wave (in air at 25°C). (4 marks)

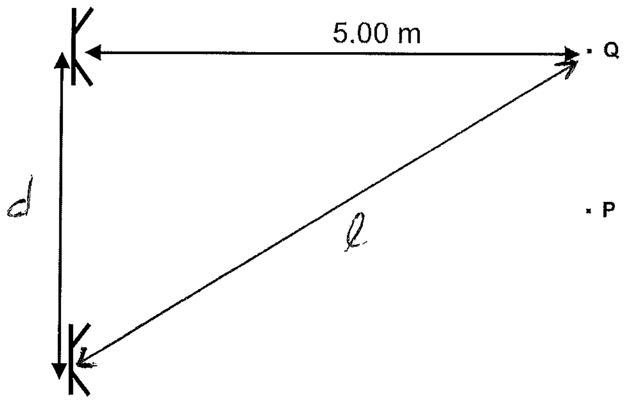
$T = 0.01\ s$ (1)

$f = \frac{1}{T} = 100\ Hz$ (1)

$v = \lambda f \rightarrow \lambda = \frac{v}{f} = \frac{346\ m/s}{100\ Hz} = 3.46\ m$

(1) (1)

The diagram at right shows a pair of loudspeakers that are in phase with each other and producing the same frequency as shown above in figure 2. Two points, P and Q, are located as shown in front of the loudspeakers. Point P is equidistant from the speakers, while point Q is directly in front of one of the speakers. As a listener moves from point P to point Q she hears the sound change steadily from being loud at P to being very soft at Q.



(c) Explain why the sound is loud at point P but becomes very soft at point Q. (4 marks)

At point P the path difference from the speakers is zero (1), so the sound waves from each speaker arrive in phase and constructively interfere (1) to produce a loud sound. At point Q the sound waves must arrive out of phase (1) (due to a path difference of $\frac{1}{2}\lambda$) and destructively interfere (1) to produce a very soft sound

(d) Calculate the distance between the two loudspeakers. (4 marks)

$$\text{path diff} = \ell - 5.00\,\text{m} = \tfrac{1}{2}\lambda \quad (1)$$

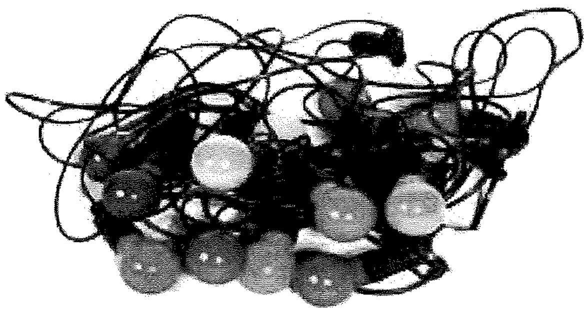
$$\therefore \ell = 5.00\,\text{m} + \tfrac{1}{2}(3.46\,\text{m}) = 6.73\,\text{m} \quad (1)$$

$$\ell^2 = d^2 + (5.00)^2 \quad (1)$$

$$\therefore d^2 = (6.73)^2 - (5.00)^2 \rightarrow d = \underline{4.50\,\text{m}} \quad (1)$$

Question 15 **(14 Marks)**

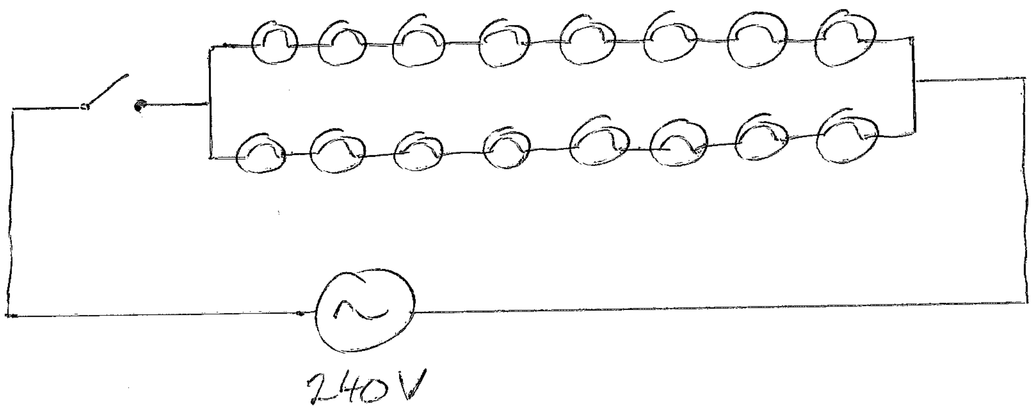
Rachel purchases a set of 16 party lights to decorate the back patio of her house. When all lights are working the set of party lights draws a current of 3.20 A from the 240 V power supply. If one globe is removed, half of the globes go out, leaving the other half working. When one of these working globes is removed, the remaining seven working globes go out.



(a) Explain why the remaining seven globes went out when the second globe was removed, but not when the first globe was removed. (2 marks)

The 16 globes must be arranged on two parallel branches, with each branch having 8 globes in series (1) Hence removing any globe from (1) a set of 8 working globes in series will cause all to go off.

(b) Draw a circuit diagram to show how all 16 globes are wired to the 240 V power supply. (3 marks)



8 in series (1)
2 branches (1)
power supply (1)

(c) Determine the voltage across each globe. (2 marks)

8 globes in series (1) $\therefore V = \frac{240V}{8} = 30V$ (1)

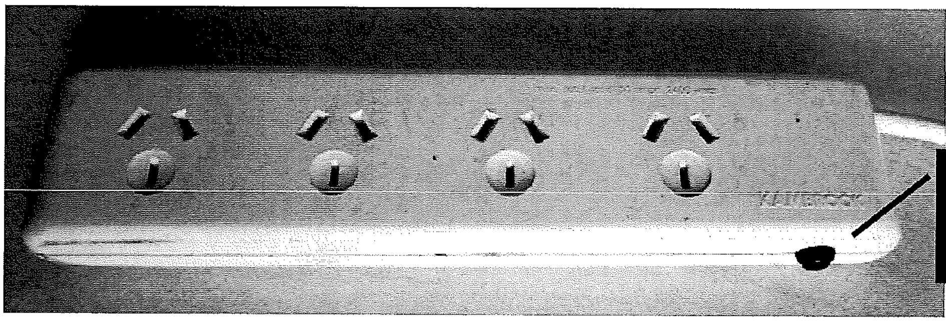
(d) Determine the current through each globe. (2 marks)

Two branches (1) $\therefore I = \frac{3.20A}{2} = 1.60A$ (1)

(e) Calculate the power consumed by each globe. (2 marks)

$P = VI = (30\,V)(1.60\,A) = 48\,W$ (1) (1)

(f) If you wanted to have more than one set of lights, you might use a power board similar to the one below. This power board has a 10.0 A circuit breaker built into it, as shown in the picture.



10 A circuit breaker

(i) How many sets of these party lights can operate from the power board before the circuit breaker is overloaded? (1 mark)

each set of party lights uses 3.20 A

$\therefore \frac{10\,A}{3.20\,A} = 3.1 \rightarrow$ 3 sets (1)

(1)

(ii) Explain the purpose of the circuit breaker. (2 marks)

The circuit breaker is an electromagnet designed to cut off the power if the current exceeds 10 A (1), and thus it protects the wiring in the circuit from overheating (1)

Question 16 **(14 Marks)**

Two musicians, a tuba player and a flautist, are on the stage at an auditorium warming up their instruments and getting ready for a concert. The sound from the tuba is low-pitched and has a very long wavelength of over a metre but the high-pitched sound from the flute has a much shorter wavelength of only a few centimetres.

Tuba

Flute

(a) A person queuing outside the open door of the auditorium, but off to one side, will hear one of these instruments more clearly than the other. Which instrument would the person hear the most clearly? Explain your answer. (3 marks)

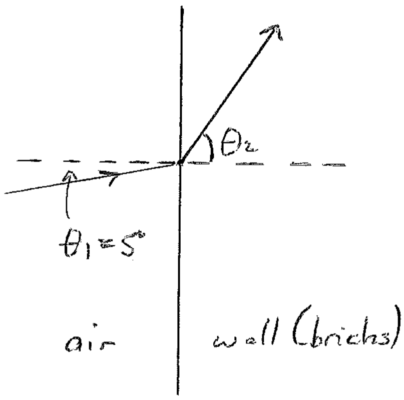
The person would hear the tuba (1) more clearly as it has a lower frequency and hence a larger wavelength (1). Larger wavelengths will diffract through the open door more (1) than short wavelengths (like the flute) which are more directional

(b) The sound from the flute hits the wall at the back of the auditorium at a slight angle from the normal of about 5°. Given that the speed of sound in the bricks of the wall is 3500 m/s, will the sound of the flute be able to refract into the wall or will it totally reflect from the wall? Show calculations to support your answer. (3 marks)

$$\frac{\sin \theta_2}{\sin \theta_1} = \frac{V_2}{V_1}$$

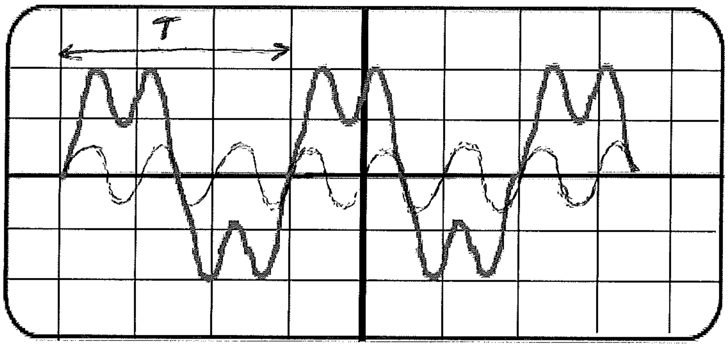
$$\therefore \frac{\sin \theta_2}{\sin 5^\circ} = \frac{3500 \text{ m/s}}{346 \text{ m/s}} \quad (1)$$

$$\therefore \sin \theta_2 = 0.88 \rightarrow \theta_2 = 62^\circ \quad (1)$$



The sound can refract into the wall (1)

The sound from the tuba is captured by a microphone and displayed on the screen of a cathode ray oscilloscope. Each small square on the screen represents one centimetre and the horizontal scale of the oscilloscope is set at 1.00 ms/cm. The waveform is not a simple sinusoidal wave due to the presence of a relatively loud higher harmonic.



(c) What is the frequency of the first (fundamental) harmonic? (2 marks)

$T = 3\text{ cm} \times 1.00\text{ ms/cm} = 3.00\text{ ms}$ (1)

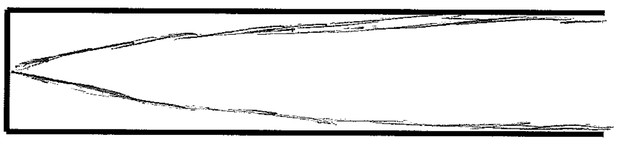
$\therefore f_1 = \frac{1}{T} = \frac{1}{0.003\text{ s}} = 333\text{ Hz}$ (1)

(d) What is the frequency of the "relatively loud higher harmonic" superimposed on the first harmonic? (1 mark)

3rd harmonic $\rightarrow f_3 = 3 \times 333 = 1000\text{ Hz}$ (1)

(e) The tuba can be treated as a closed pipe. Using the diagrams provided below, sketch the particle displacement vs distance envelope for the fundamental frequency and for the third harmonic of the tuba. (2 marks)

fundamental frequency



(1)

third harmonic

(1)

(f) The flute acts as an open pipe. Calculate the fundamental frequency of a particular note played on the flute where the flute has an effective length of 18 cm. (3 marks)

$\lambda_1 = 2L = 2 \times 0.18\text{ m} = 0.36\text{ m}$ (1)

$v = \lambda f \rightarrow f = \frac{v}{\lambda} = \frac{346\text{ m/s}}{0.36\text{ m}} = 960\text{ Hz}$

(1) (1)

(2 sig figs!)

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 **LOCATION OF A SOUND** **(12 marks)**

(Paragraph 1)
The precise method by which a human being is able to discover the location of a particular sound in relation to themselves has exercised the minds of scientists for many years. Lord Rayleigh, in his Theory of Sound published in 1896, comments briefly on the theory prevalent at the time. This was that the effect of the bulk of the head between the two ears produced a sound shadow, and thereby caused an amplitude difference in the sound reaching the two ears from a given source. Rayleigh pointed out that this theory could only operate at frequencies above about 1000 Hz, that is at frequencies above that at which the physical distance between the ears is equal to one wavelength. He suggested that a possible explanation for the perception of sound direction at low frequencies might be the difference in time of arrival of the sound wave from a source at the two ears.

(Paragraph 2)
Early workers conducting investigations into sound localisation were very limited in their activities by their lack of electrical equipment, and were forced to use clicks and other noises as sound sources. Furthermore, the rooms that they used for their experiments were far from good acoustically, and so the positions of the sound sources were confused by reverberation effects. However the early experimenters established that it is possible to locate noises more easily than pure tones, and that it is possible to distinguish sounds appearing from the right or the left.

(Paragraph 3)
Stevens and Newman, in 1934, devised an open-air experiment in order to overcome the difficulties of sound reflections. They mounted a swivel chair on top of the roof of one of the buildings at Harvard University. The source of the sound was mounted at the end of a four metre arm that could be moved noiselessly in a complete circle on a horizontal plane level with the listener's ears. The sound generator was a loudspeaker that could produce pure tones and various noises, such as clicks. It was found that the listener hardly ever confused the positions of sounds that were to the right or left, but, depending upon the type of sound used, fairly frequent confusion of whether the sound was in front or behind took place. It was found that pure tones at low frequencies could be localised with reasonable accuracy, as could tones at very high frequencies, but there was a band of middle frequencies between 2000 and 4000 Hz where localisation appeared to be more difficult.

(Paragraph 4)
Stevens and Newman concluded that the observed results from their experiments were "consistent with the hypothesis that the localisation of low tones is made on the basis of a phase difference at the two ears, and that the localisation of high tones is made on the basis of intensity differences". These experimental results seemed to confirm the earlier theories attributed to Rayleigh and others.

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

(i) …"an amplitude difference in the sound reaching the two ears"… (paragraph 1) (1 mark)

sound is louder in one ear than the other

(ii) …"pure tones"… (paragraphs 2 & 3) (1 mark)

single frequencies (without harmonics mixed in)

(iii) …"a phase difference at the two ears"… (paragraph 4) (2 marks)

the sound waves reaching the two ears are at different parts of the wave cycle (different phases) i.e. compression at one ear, rarefaction at other ear (2)

(b) What were the "difficulties of sound reflections" (paragraph 3) found by early experimenters in rooms which were "far from good acoustically" (paragraph 2)? (2 marks)

sound waves would reflect off walls and other surfaces in the rooms (1), causing the sound to appear to come from multiple positions in the room (1)

(c) Why does the frequency have to be above about 1000 Hz for the amplitude difference effect to be significant? (paragraph 1) (3 marks)

For frequencies above 1000 Hz the wavelength will be smaller than the size of the head, (1) so the waves will not easily diffract around the head (1), and hence the ear furtherest away from the source will be in a "sound shadow" and experience reduced amplitude of sound (1)

(d) The information provided in paragraph 1 would enable you to make a very rough estimate of the speed of sound provided you make one further estimate of a simple measurement. Make an estimate of this simple measurement, and hence estimate the speed of sound. (3 marks)

Assume distance between ears = 20 cm (15–30 cm?) (1)

$\therefore \lambda = 20\text{cm} = 0.2\text{m}$ (1)

$\therefore v = \lambda f = (0.2\text{m})(1000\text{Hz}) = 200\text{ m/s}$

(1)

(size of answer not important so no marks for answer)

Question 18 **RESISTIVITY OF A METAL** **(18 marks)**

Resistivity, ρ, is an intrinsic property of a material, like density or specific heat, and is independent of the dimensions of a particular piece of the material, depending only on the nature of the material. Resistivity is equivalent to the resistance of a piece of material that is 1 m long and of cross-sectional area 1 m^2. For a metal wire of length l and cross-sectional area A, the relationship between the resistance R of the wire and the resistivity ρ of the metal is given by

$$R = \rho \frac{l}{A}$$

Two students carried out an investigation using the voltmeter-ammeter method to determine the resistance of different lengths of the same metal wire, of **diameter 0.28 mm**. Their results are shown in the table below:

Length of wire (m)	Ammeter reading (A)	Voltmeter reading (V)	Resistance (Ω)
0.5	2.79	2.12	0.760
1.0	1.51	2.33	1.54
1.5	1.23	2.85	2.32
2.0	0.980	3.09	3.15
2.5	0.840	3.27	3.89
3.0	0.760	3.52	4.63

(a) For the investigation as described above, identify the following variables. (4 marks)

Independent variable: length of wire

Dependent variable: resistance

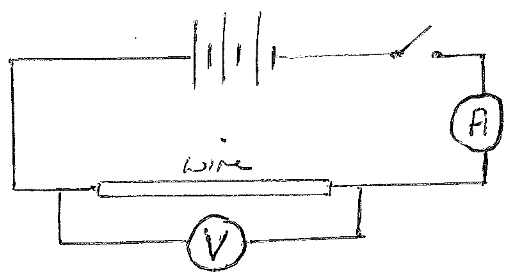
Two controlled variables: diameter of wire (cross-sectional area)

material (same metal)

(b) Complete the resistance column in the table above. (2 marks)

values (1) sig figs (1)

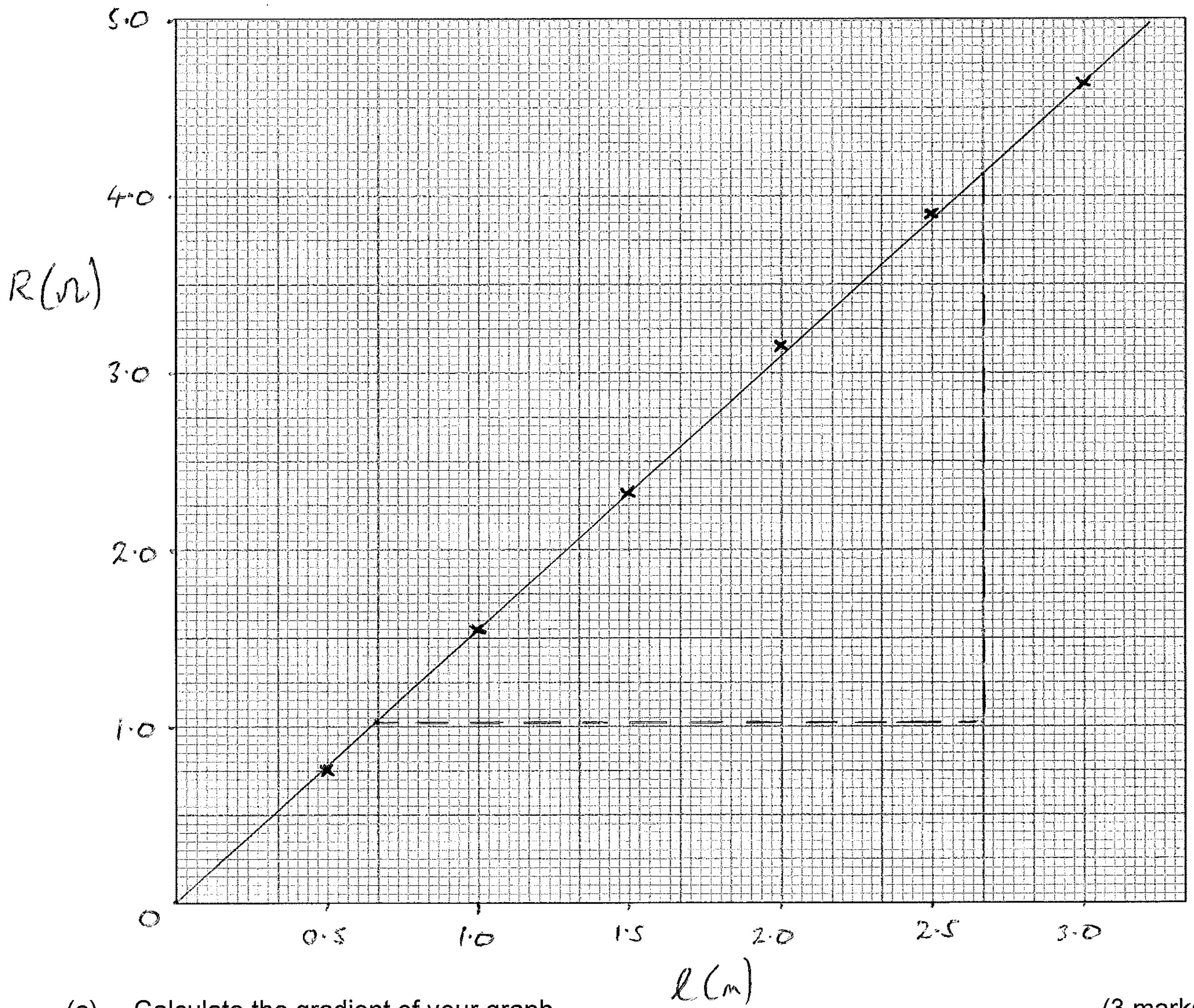
(c) Draw the circuit that the students used to obtain these results. (2 marks)



voltmeter in parallel (1)

ammeter in series (1)

(d) Use this data to plot a linear graph of resistance versus length of wire on the graph paper provided below. (4 marks)



(e) Calculate the gradient of your graph. (3 marks)

$$\text{gradient} = \frac{\text{rise}}{\text{run}} = \frac{(4.125 - 1.025)\,\Omega}{(2.67 - 0.67)\,m} = \frac{3.1\,\Omega}{2.0\,m}$$ (1)

↖ calculation not using points from the table

GRADIENT = 1.55 Ω/m (1) (1)

(f) Use the gradient of the graph to find the resistivity of the metal. (3 marks)

$$\text{gradient} = \frac{\rho}{A}$$

$$\therefore \rho = \text{gradient} \times A$$ (1)

$$= \text{gradient} \times \pi r^2$$ (1)

$$= 1.55\,\Omega/m \times \pi(1.4\times10^{-4}\,m)^2 = 9.54\times10^{-8}\,\Omega m$$ (1)

$$r = \frac{0.28\,mm}{2} = 1.4\times10^{-4}\,m$$

END OF PAPER