VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2003

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Figures									Letter:
Words									

PHYSICS

Written examination 1

Wednesday 11 June 2003

Reading time: 11.45 am to 12.00 noon (15 minutes)
Writing time: 12.00 noon to 1.30 pm (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Area	*Number of questions*	*Number of questions to be answered*	*Number of marks*	*Suggested times (minutes)*
1. Sound	13	13	30	30
2. Electric power	11	11	30	30
3. Electronic systems	13	13	30	30
			Total 90	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners, rulers, up to two pages (one A4 sheet) of pre-written notes (typed or handwritten) and an approved graphics calculator (memory cleared) and/or one scientific calculator.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.

Materials supplied
- Question and answer book of 25 pages, with a detachable formula sheet in the centrefold.

Instructions
- Detach the formula sheet from the centre of this book during reading time.
- Write your **student number** in the space provided above on this page.
- Answer all questions in this question and answer book where indicated.
- **Always show your working** where space is provided and place your answer(s) to multiple-choice questions in the box provided.
- All written responses must be in English.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

AREA 1 – Sound

A burning candle is placed on a table in front of a loudspeaker as shown in Figure 1.

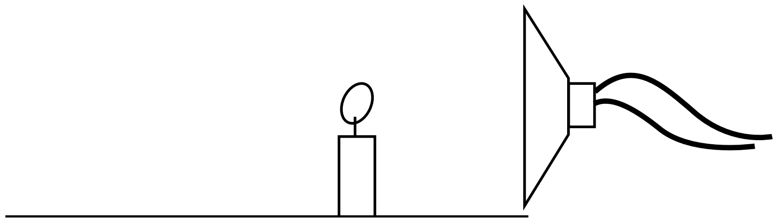

Figure 1

When the loudspeaker emits sound with a frequency of 10 Hz, the flame of the candle moves towards and away from the loudspeaker with a frequency of 10 Hz.

Question 1

Explain the reasons for the movement of the candle flame.

3 marks

Lucy is playing a note of constant frequency on a flute. Figure 2 shows the variation of air pressure of the sound wave as a function of **distance**. The graph shows the situation at time t, starting distance *d* from the flute. The flute is emitting sound with a period T.

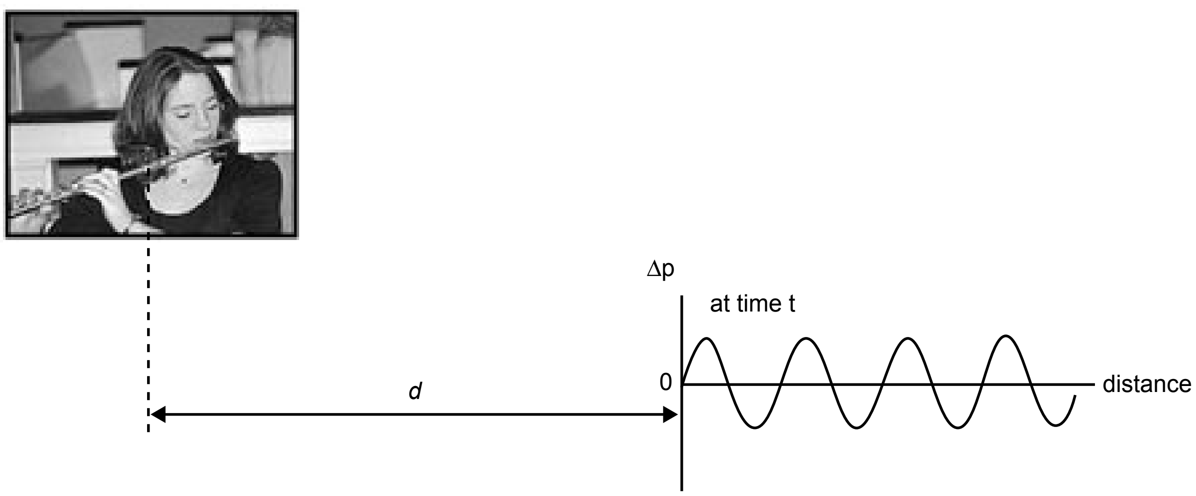

Figure 2

Figure 3 shows the pressure variation as a function of distance, over the same region as Figure 2, but at several **later times**.

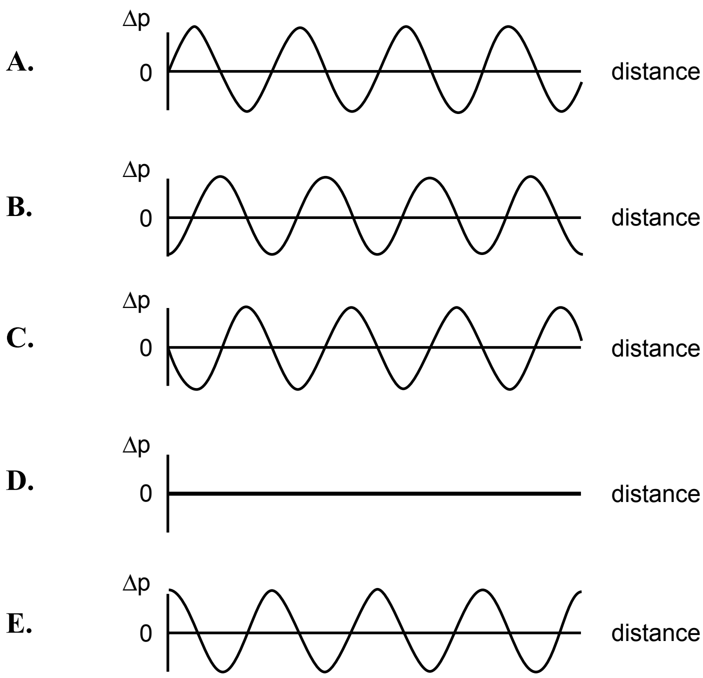

Figure 3

Question 2

In the boxes below, write the letters of the graphs in Figure 3 that show the variation of air pressure of the travelling wave at times $t + \frac{T}{4}$, and $t + \frac{T}{2}$.

$t + \frac{T}{4}$	

$t + \frac{T}{2}$	

2 marks

If a pipe open at both ends, and of the correct length, was placed distance *d* from the flute, as shown in Figure 4, a standing wave would be set up in the pipe. The graph in the figure shows the pressure variation as a function of distance along the pipe, at time t.

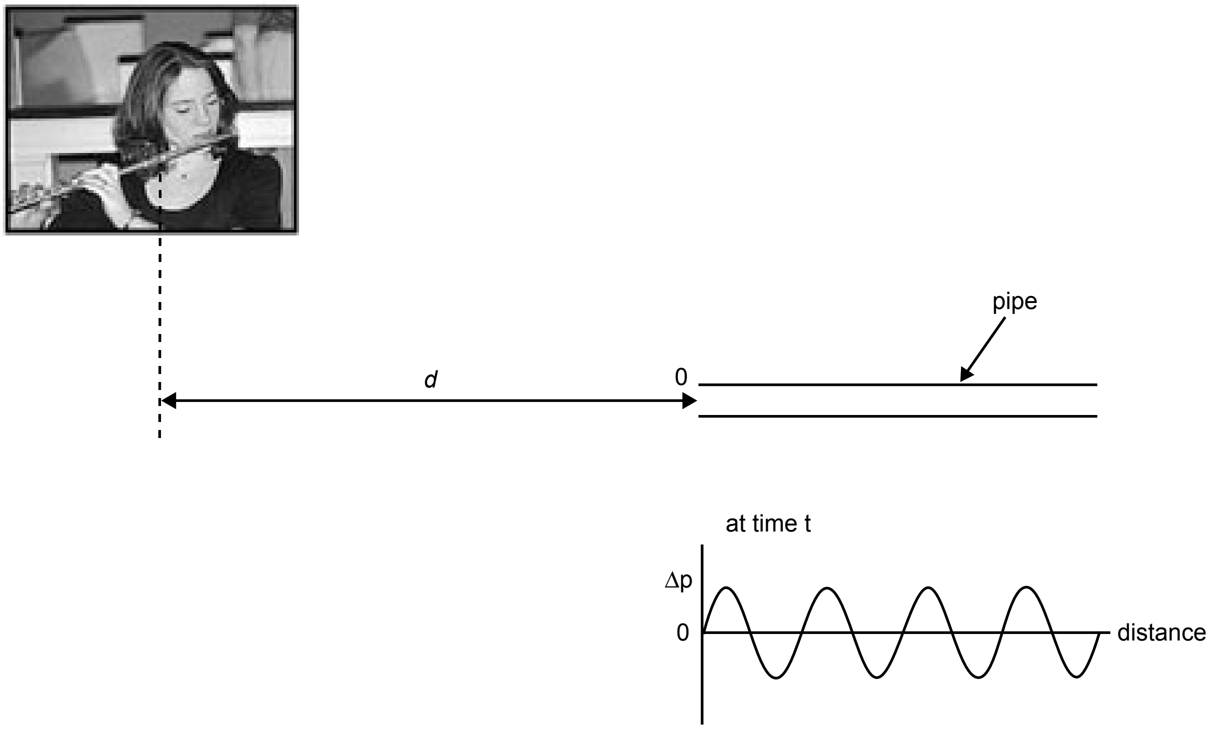

Figure 4

Question 3

In the boxes below, write the letters of the graphs in Figure 3 (on the previous page) that show the variation of air pressure of the standing wave at times $t + \frac{T}{4}$, and $t + \frac{T}{2}$.

$t + \frac{T}{4}$	

$t + \frac{T}{2}$	

2 marks

In a demonstration of the perception of loudness, a teacher sets up a loudspeaker (P) on a stand at the centre of the school oval (Figure 5). The loudspeaker emits sound equally in all directions.

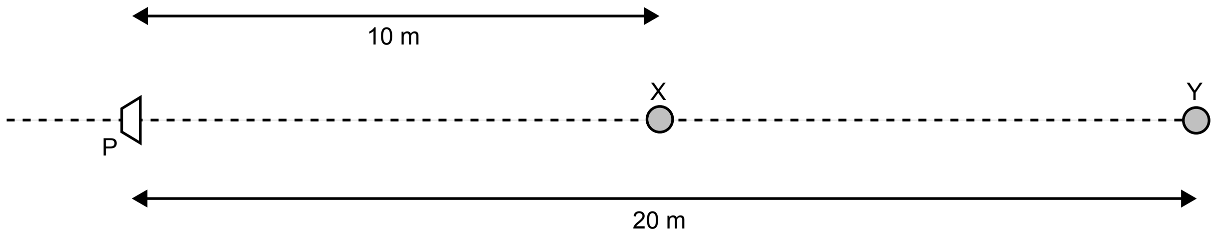

Figure 5

At the point X, which is 10 m from the loudspeaker, a student, Val, measures the sound intensity level to be L_0 dB.

Val now moves to point Y, which is 20 m away from the loudspeaker.

Question 4

Which of the sound intensity levels listed below (**A–D**) is the sound intensity level at point Y? Write the corresponding letter in the box provided.

A. $\frac{L_0}{2}$ dB **B.** $\frac{L_0}{4}$ dB **C.** $L_0 - 3$ dB **D.** $L_0 - 6$ dB

2 marks

CONTINUED OVER PAGE

The teacher now adds a second loudspeaker Q, and the loudspeakers P and Q are placed as in Figure 6. They are connected to the same source using cables of the same length, and emit sound in phase. The point M is midway between the two speakers and the line MN is perpendicular to the line PQ.

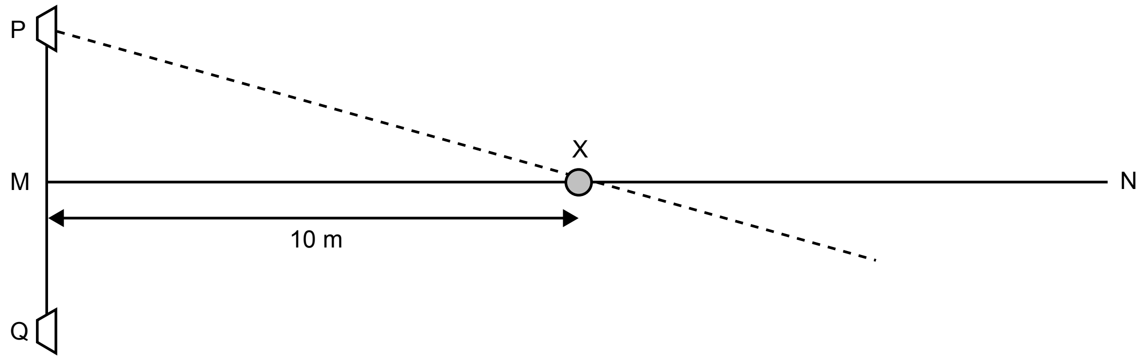

Figure 6

The wavelength of the sound is 1.0 m.

Val again stands at the point X, and the teacher slowly moves loudspeaker P **directly towards Val** along the dashed line PX, until Val finds that the sound is very soft. When the teacher moves the loudspeaker even closer towards point X the sound becomes louder again.

Question 5

In the space below, explain Val's observations.

3 marks

Question 6

When Val heard the sound at its softest, how far had the teacher moved the loudspeaker along the line PX?

m

3 marks

Mustafa has bought a new speaker system. The system has two loudspeakers: one 30 cm in diameter (for the frequency components below 500 Hz) and one 12 cm in diameter (for the higher frequency components). He invites his friend Rebecca to listen to some music. They are located as shown in Figure 7.

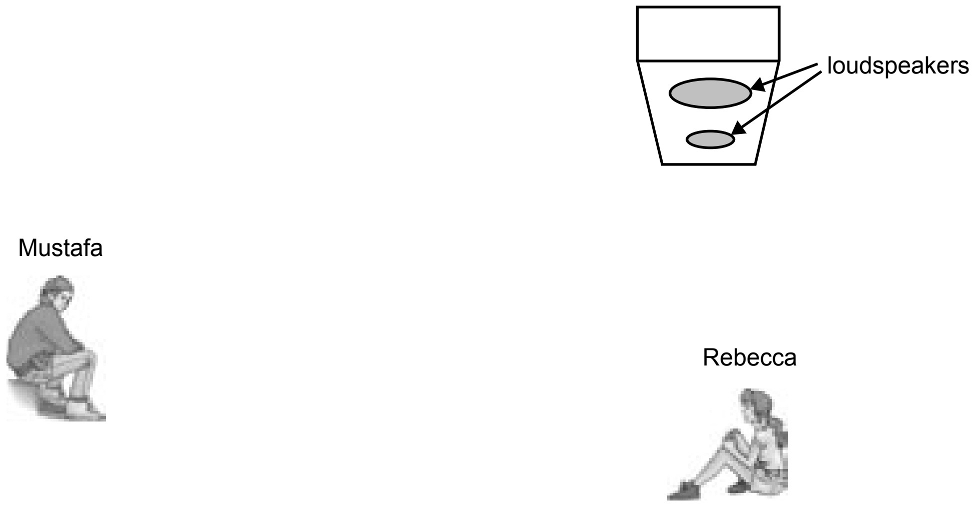

Figure 7

Rebecca says that the sound is great, but Mustafa is disappointed, as the frequencies above 6000 Hz are very soft. He thinks that the small speaker is broken, however on checking he finds that the speaker is working.

Question 7

What is the wavelength of sound with a frequency of 6000 Hz? Take the speed of sound as 340 m s^{-1}.

m

1 mark

Question 8

In the space below explain why each listener hears the sound differently.

3 marks

Noise pollution near freeways is a problem. In modern freeway design, sound barriers are built to reduce the noise reaching nearby houses. Consider the situation shown in Figure 8.

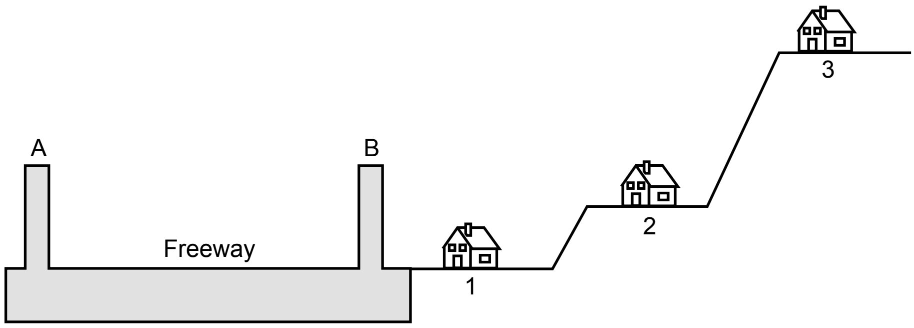

Figure 8

When **concrete** sound barriers (A and B) were installed, the noise at houses 1 and 2 decreased by 10 dB. For house 3 the decrease was only 6 dB.

Question 9

In the space below, explain why the sound level decreased in all cases, and why the decrease was less for house 3.

3 marks

On the renovated Melbourne–Geelong freeway, many of the sound barriers are made of loosely packed rocks. When barrier A was replaced with a wall of loosely packed rocks similar to that shown in Figure 9, the sound level at houses 1 and 2 hardly changed but at house 3 it decreased further.

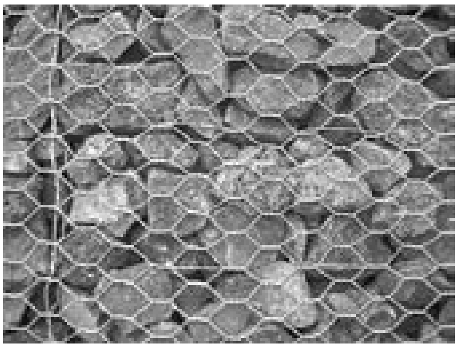

Figure 9

Question 10

In the space below, explain why this was so.

2 marks

Figure 10 below shows the threshold of hearing as a function of frequency for a number of animals, including humans. The curves represent the minimum sound intensity level at the ear, for which the sound can be heard.

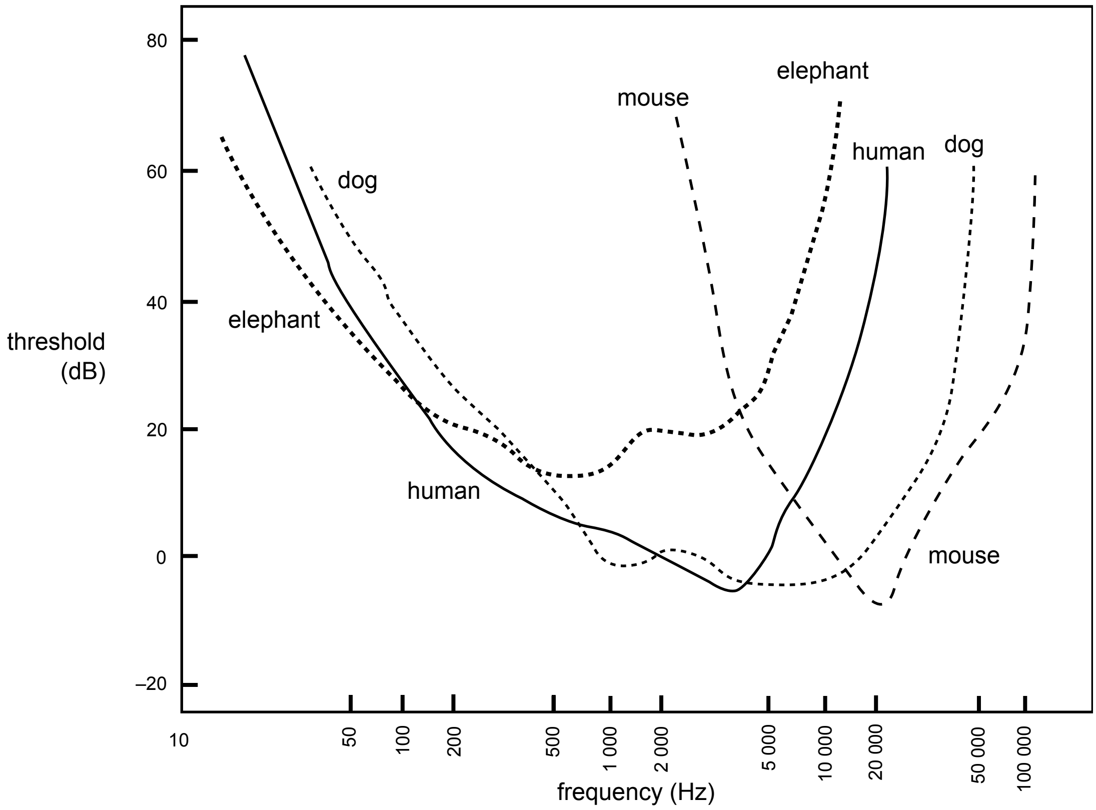

Figure 10

In a laboratory test, a sound source of frequency 20 000 Hz, and intensity level 20 dB, was placed at one ear of each animal.

Question 11

Tick the boxes corresponding to the animal or animals that could hear the sound.

human	
dog	
mouse	
elephant	

2 marks

The ear can be modelled as a tube closed at one end. The length of the ear canal determines the length L, of this model tube. Figure 11 shows the real and modelled situation for a human.

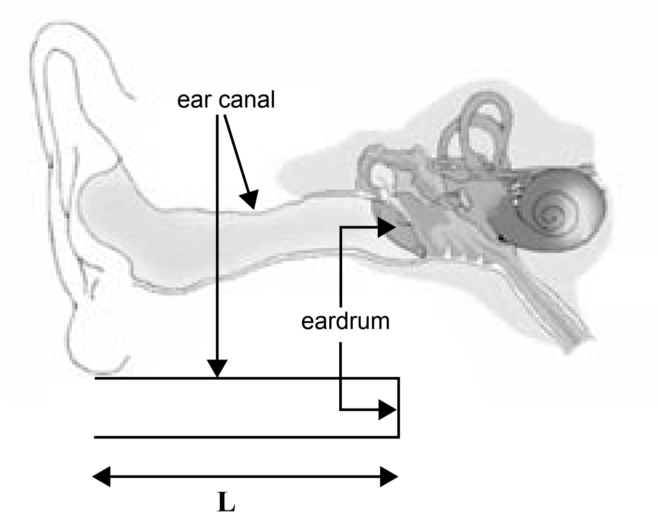

Figure 11

Question 12

In the boxes below, write the frequencies at which the hearing of the elephant and the human are most sensitive. In the space below, explain the reason for the difference in frequency.

elephant Hz	human Hz

2 marks

Question 13

If the ear canal in a human is approximately 2 cm long, what is the approximate length of the ear canal of an elephant?

cm

2 marks

END OF AREA 1

TURN OVER

AREA 2 – Electric power

The electric power for Melbourne trams is supplied at a DC voltage of 600 V. The current flows from the overhead wire through the tram motor and returns through the metal rails. Because of the voltage drop that occurs in the overhead wire, the wire is made up of separate 3.0-km sections. One of these sections is shown in Figure 1. A separate 600-V supply is connected to **one end only** of each section.

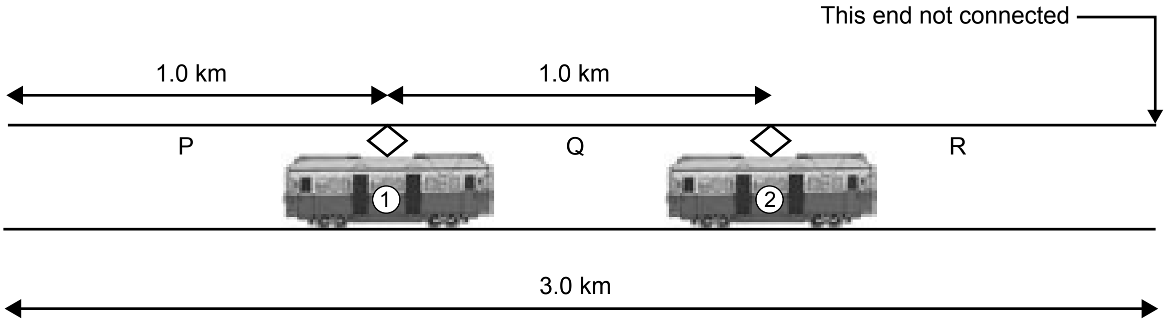

Figure 1

Tram 2 is accelerating and is drawing a current of 500 A. Tram 1 is drawing a current of 200 A.

Question 1
What is the current in sections P, Q and R of the wire?

P	A
Q	A
R	A

3 marks

The voltage at the position of tram 2 is 540 V.

Question 2
How much electrical power is tram 2 using?

W

2 marks

Question 3

What is the resistance of 1.0 km of the overhead wire?

Ω

3 marks

Question 4

What is the voltage at the position of tram 1?

V

3 marks

Kim decides to design a circuit to control the light intensity of a portable lamp. The circuit consists of a 12-V light globe rated at 18 W, a variable resistor, a 12-V battery, and a 2-amp fuse with negligible resistance. Kim is considering two different circuits, shown in Figure 2 as circuit A and circuit B.

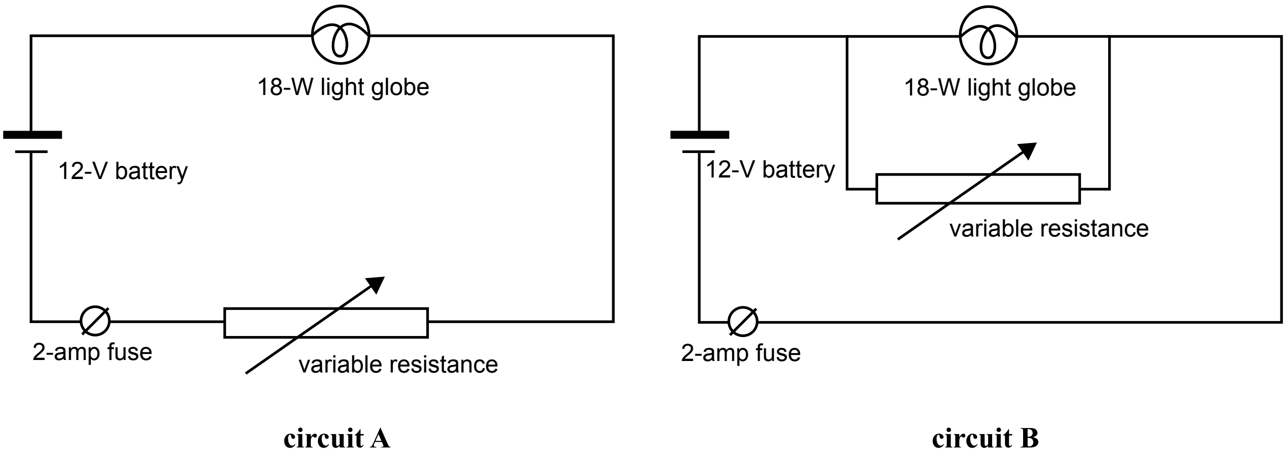

Figure 2

When the variable resistance in circuit A is zero, or when the variable resistance in circuit B is infinite, the light globe operates at its rated value. The resistance of the filament is 8.0 Ω, and can be assumed to be independent of its temperature.

Question 5

Using circuit A, what is the value of the variable resistance when the power dissipated in the light globe is 9.0 W?

Ω

3 marks

Question 6

When using circuit B, what is the value of the variable resistance when the fuse burns out?

Ω

3 marks

Question 7

Which circuit, A or B, should Kim choose? Justify your answer.

3 marks

Figure 3 is a diagram of a simple alternator. A coil (UVWX) 0.30 m by 0.40 m, **consists of 20 turns of wire**. It is in a uniform magnetic field of strength 0.25 T, and can rotate as shown.

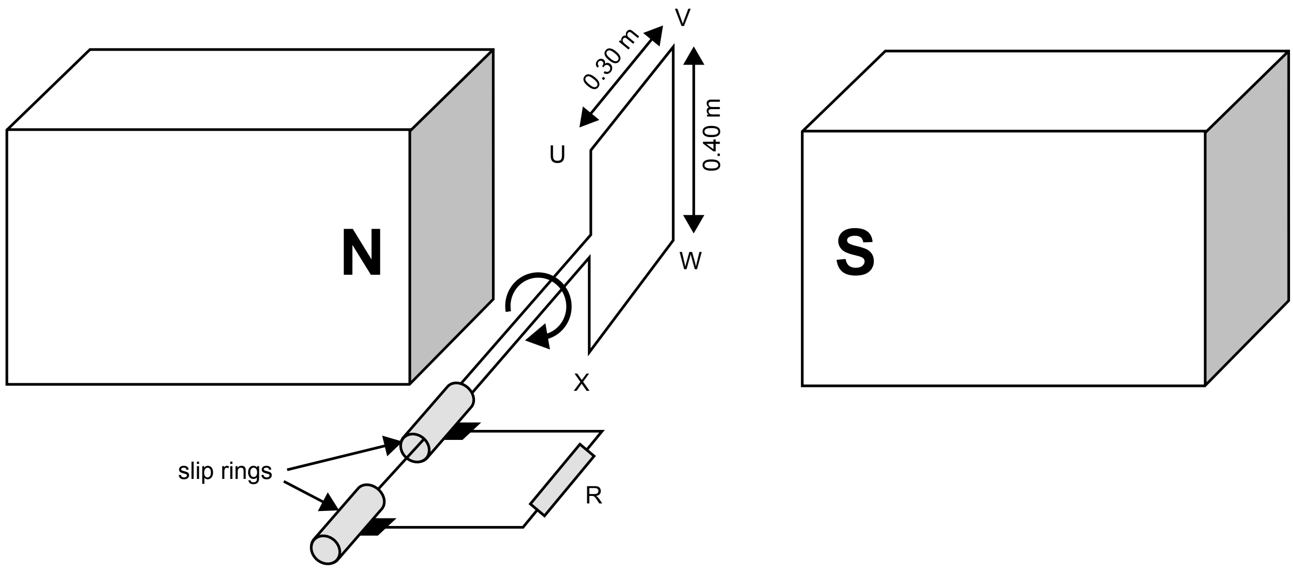

Figure 3

Question 8

With the coil oriented as in Figure 3, what is the magnitude of the magnetic flux through each turn of the coil?

Wb

2 marks

The coil is rotated at **a constant rate of 50 revolutions per second** in the direction shown.

Question 9

What is the **average voltage** developed across the resistor R when the coil rotates through 90 degrees from the orientation shown in the figure?

V

3 marks

Figure 4 shows graphs of possible variations of **the magnetic flux** through the coil as a function of time as it rotates. They all begin at time t = 0, when the coil is oriented as in Figure 3.

Question 10

Which of the graphs below (**A–D**) best shows the variation of **the magnetic flux** through the coil as a function of time? Take the direction from N to S in the figure as positive.

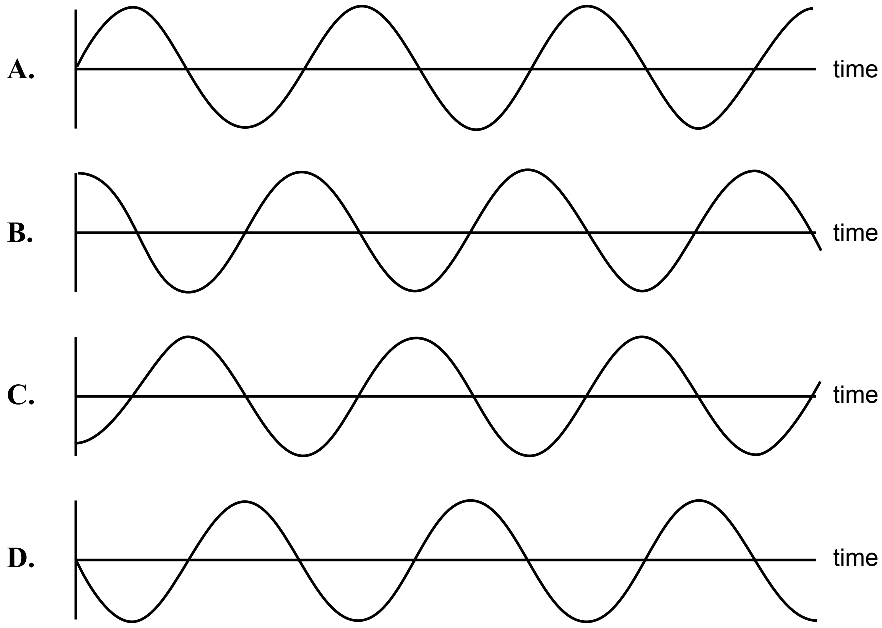

Figure 4

2 marks

Question 11

Assuming the same conditions as in the question above, which of the graphs (**A–D**) best shows the variation of the current flowing **from U to V in the coil**, as a function of time? Explain the logic of your choice.

3 marks

END OF AREA 2

TURN OVER

AREA 3 – Electronic systems

All questions in this section concern the modelling of a solar-heating system for a swimming pool.

Water is pumped and circulated through the solar panels only if both conditions below are satisfied.

- the air temperature is 20˚C or above, and
- the temperature of the pool water is 30˚C or below

Air temperature is measured using the circuit shown in Figure 1a. **The temperature sensors for the air and water have identical characteristics**, and are shown in Figure 1b.

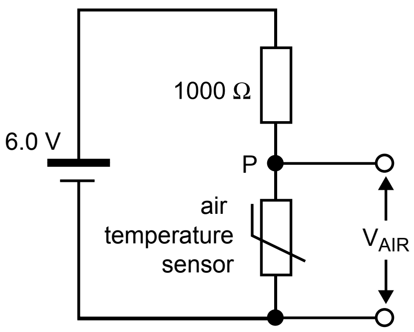

Figure 1a

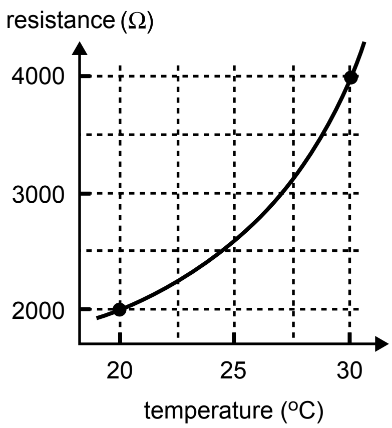

Figure 1b

Question 1

On the circuit shown in Figure 1a, indicate, using an arrow, the direction of the current through the 1000-Ω resistor.

1 mark

Question 2

Calculate the current in the circuit shown in Figure 1a if the air temperature is 20°C. Express your answer in units of mA.

current = mA

2 marks

Question 3

If the air temperature is 20°C, how much power is dissipated in the 1000-Ω resistor? Give your answer in units of mW.

power = mW

3 marks

Question 4

Show that at a temperature of 20°C the voltage across the air-temperature sensor (V_{AIR}) is 4.0 V.

2 marks

The circuit used to measure **the water temperature** is shown in Figure 2. It is similar to that of Figure 1a, but includes an additional resistor of 4000 Ω, in parallel with the water-temperature sensor.

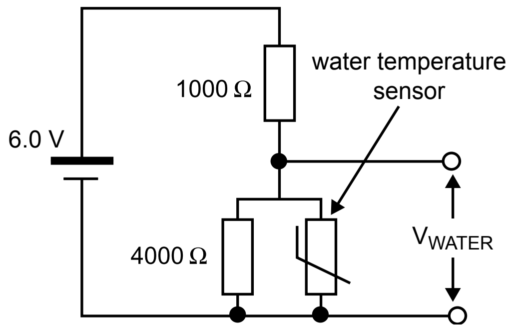

Figure 2

Question 5

If the temperature of the pool water is 30˚C, what is the effective resistance of the parallel combination of the 4000-Ω resistor and the water-temperature sensor?

effective resistance = Ω

2 marks

Question 6

If the voltage (V_{WATER}) across the water-temperature sensor in Figure 2 is 3.6 V, what is the temperature of the pool water? Give your answer to an accuracy of 1˚C.

water temperature = ˚C

4 marks

The circuits shown in Figure 1a and Figure 2 both require a DC power supply of 6.0 V. One possible design for the DC power supply is shown in Figure 3a. This power supply is operated from the 240-V_{RMS} mains. Figure 3b shows the oscilloscope trace of the voltage between points A and B of Figure 3a.

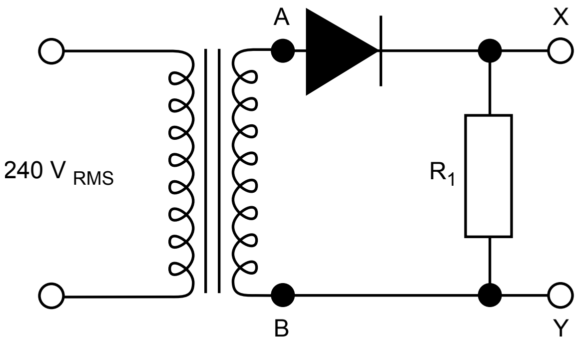

Figure 3a

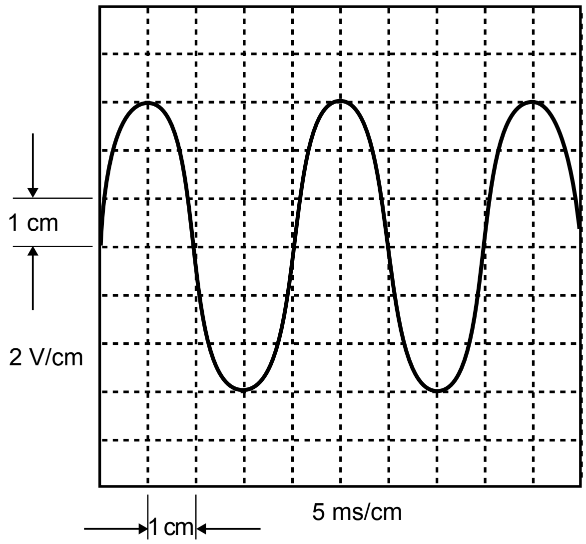

Figure 3b

Question 7

On Figure 3b, sketch the voltage waveform between the points X and Y of Figure 3a.

2 marks

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A second circuit design, shown in Figure 4, is chosen as the 6.0-V DC power supply.

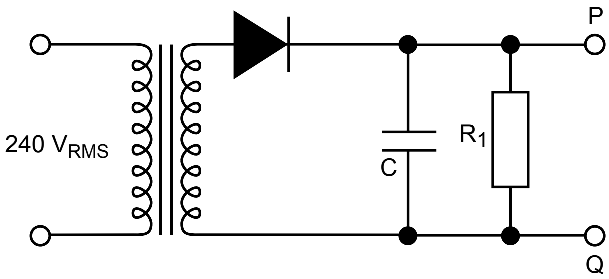

Figure 4

Question 8

What is the purpose of the resistor-capacitor (R_1 – C) combination in Figure 4?

2 marks

Question 9

The time constant of the resistor-capacitor combination for the circuit in Figure 4 is 2.0 s. If C = 1000 μF, what is the value of R_1?

R_1 = Ω

2 marks

To check the performance of the 6-V DC power supply, the voltage ripple was measured between points P and Q of Figure 4. This signal was amplified using an amplifier with a voltage gain of +100. **The amplified voltage** was displayed on an oscilloscope, as shown in Figure 5.

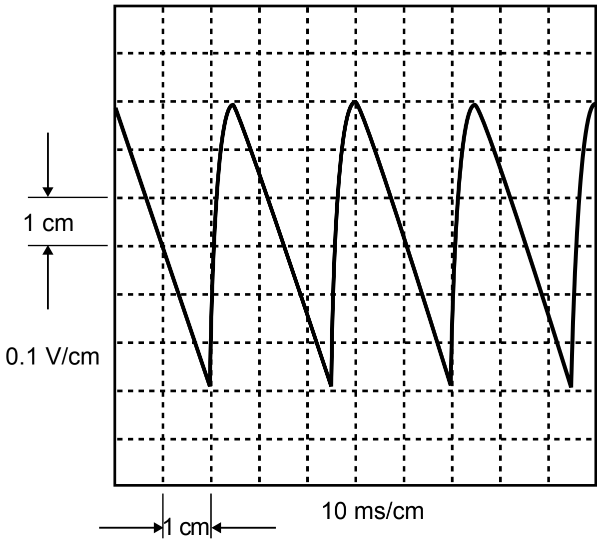

Figure 5

Question 10

From Figure 5, what is the peak-to-peak value of the voltage ripple of the signal between points P and Q? Give your answer in units of mV.

$V_{\text{peak to peak}}$ = mV

3 marks

The voltage across the air-temperature sensor (V_{AIR}), and that across the water-temperature sensor (V_{WATER}), are the inputs to a digital electronic system that controls the water pump for the solar panel. The logic levels of these input digital signals are

air temperature	logic level, L_{AIR}
<20°C	0
≥20°C	1

water temperature	logic level, L_{WATER}
>30°C	0
≤30°C	1

The output of the digital circuit is the pump-control signal, L_{PUMP}. If this is logic 0 the pump is OFF (water does not circulate through the solar heater), if this is logic level 1 the pump is ON.

Question 11

Complete the last two rows of the truth table for this digital system.

L_{AIR}	L_{WATER}	L_{PUMP}
0	0	0
0	1	0
1	0	
1	1	

2 marks

Question 12

Which digital circuit **(A–D)** in Figure 6 will correctly implement your completed truth table from Question 11?

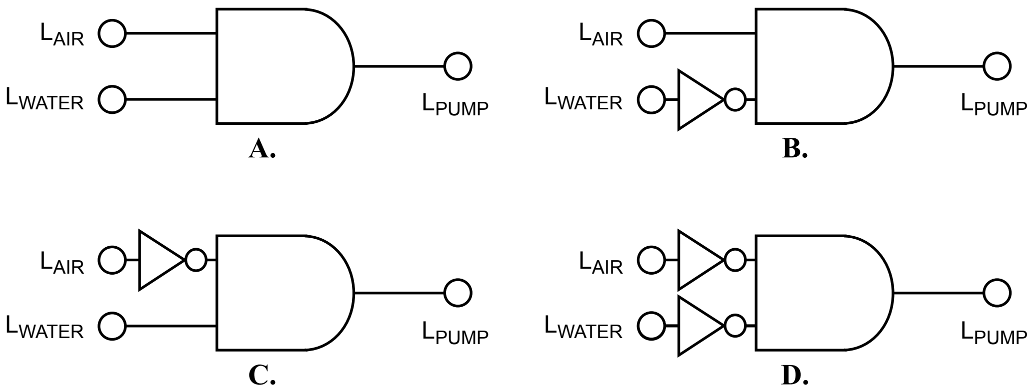

Figure 6

2 marks

The air-temperature-sensing circuit requires a light-emitting diode (LED) to indicate if the air-temperature is above 20˚C (LED ON) or below 20˚C (LED OFF). The circuit used is shown in Figure 7a, and the non-linear I-V characteristic of the LED is shown in Figure 7b.

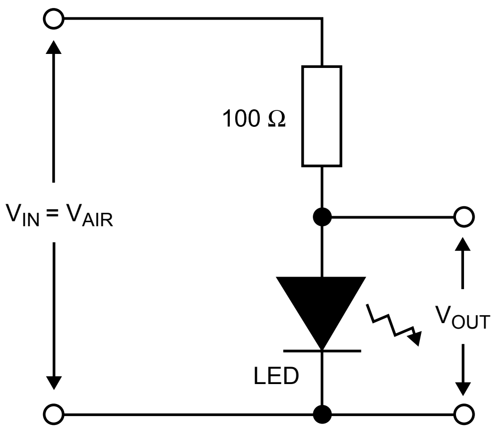

Figure 7a

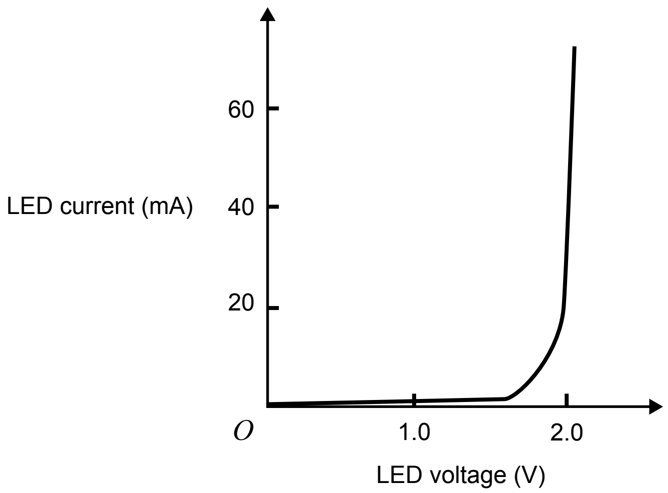

Figure 7b

Question 13

What is the current in the circuit of Figure 7a when V_{AIR} = 4.5 V? Show your working, and give your answer in units of mA.

Current =	mA

3 marks

END OF QUESTION AND ANSWER BOOK