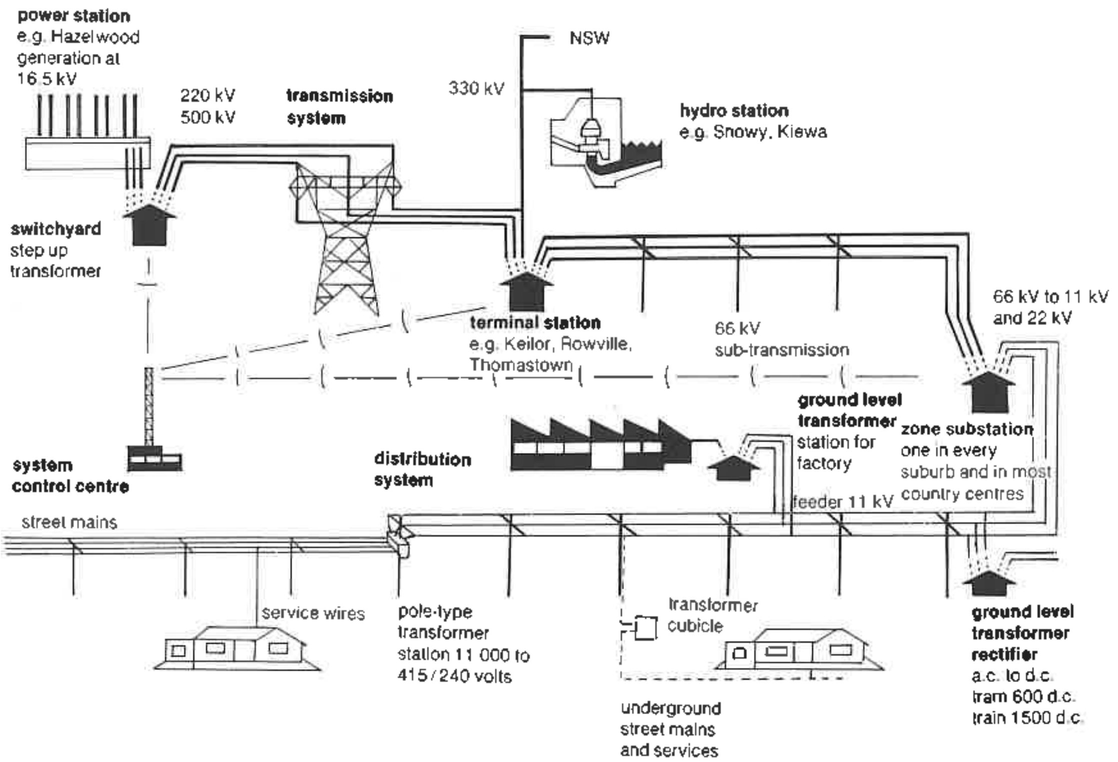
SPECIAL INVESTIGATION 5 ELECTRICITY GENERATION AND SUPPLY

In June 1924 power was first transmitted on a commercial basis from Yallourn A power station in Gippsland to Melbourne. Today the SEC (State Electricity Commission) of Victoria is the largest supplier of electricity in Australia. The SEC's transmission and distribution network, comprising 115,000 km of power lines, services over 1.5 million customers throughout the state. The diagram below shows the transmission system used to transmit power to industrial, commercial and domestic customers. Use this figure and information gained from the SEC's booklet "Electricity" to prepare a report based on the following questions.

1. How is electricity generated in power stations of the state? Where are the power stations located? What fuels are used?
2. Summarize the typical voltages, current and power values in the various parts of the distribution system.
3. Explain why high voltage a.c. is used rather than d.c.
4. How is power supplied to the electric trains and at what voltage?
5. Of what advantage is it to Victoria to be able to 'tap' into hydroelectric power in the Snowy Mountains and Kiewa Valley.
6. How is power distributed to various parts of the state? Include a photocopy of a map of the grid system if possible.



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EXPERIMENT 24 THE A.C. TRANSFORMER

AIM: To investigate the action of a transformer using a.c. current

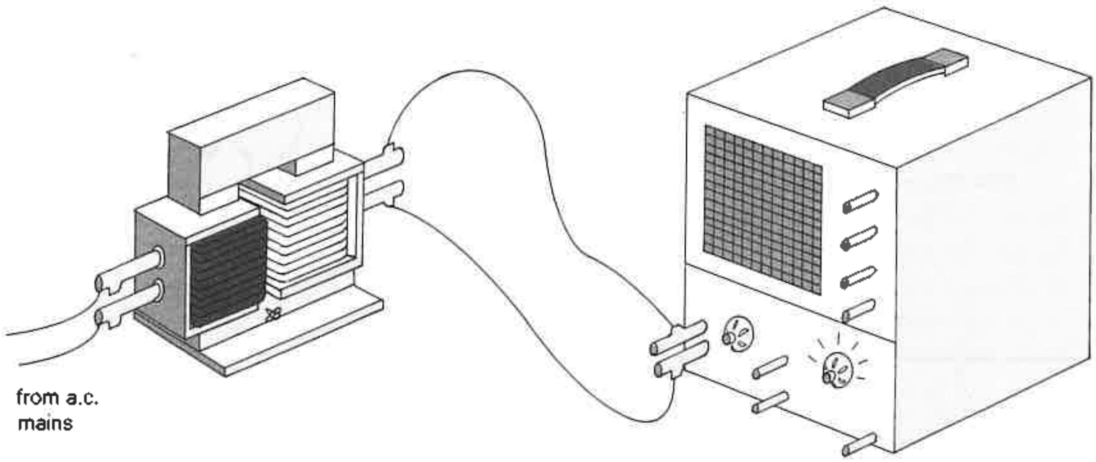
REFERENCE: Chapter 8.

METHOD

1. Connect the secondary coil of a 6.3 V transformer to a cathode ray oscilloscope.
2. Connect the primary coil to the mains supply or a low voltage a.c. power supply.

> <u>Note:</u> The transformer only steps down the voltage from the power supply. It keeps the waveform, i.e. same frequency.

3. Adjust the oscilloscope to give a stable waveform on the screen.
4. Observe the waveform displayed.



QUESTIONS

1. What does the waveform look like?

____

2. Sketch the waveform.

3. What is the period of the a.c.?

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4. What is the frequency of the a.c. supplied?

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5. What is the ratio of voltage input to voltage output for the transformer?

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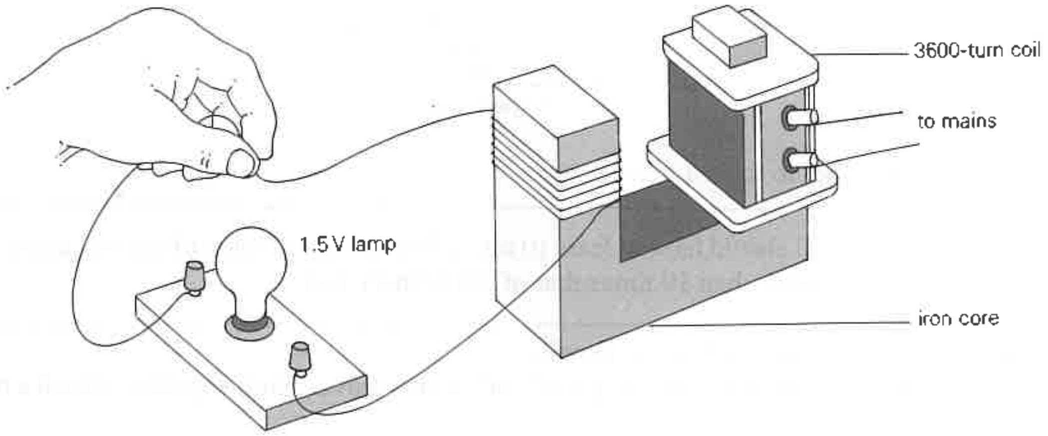
EXPERIMENT 25 VOLTAGE DEPENDENCE OF A TRANSFORMER

AIM: To investigate the relationship between the voltage and number of turns of wire of a transformer

REFERENCE: Chapter 8

PART A
METHOD

1. Place a 3600-turn coil on one limb of a U-core of a demountable transformer.
2. Connect it to the a.c. mains. Use it as the primary coil.
3. Connect a long lead to a 1.5 V lamp. Wind it turn by turn round the other limb of the U-core.
4. Observe the lamp as more turns are added onto the core.



> **Caution:** Do not touch the bare leads connected to the 200 V mains.

QUESTIONS

1. At roughly how many turns does the lamp begin to glow?

____

2. What happens to the lamp when more and more turns are wound on the secondary core?

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3. How does the emf of the secondary coil depend on its number of turns?

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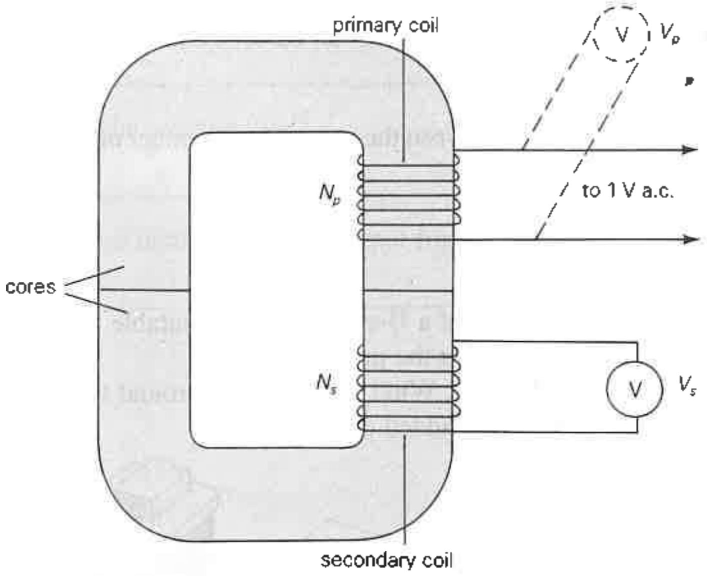
PART B
METHOD

1. Wind two coils on a rectangular tube which just fits the arms of a pair of U-shaped iron cores.
2. Record the number of turns of each coil.
3. Insert the iron cores into the tube.



4. Clip the cores together to form a transformer.

> **Note:** The primary coil should have at least 10 turns. The number of turns of the secondary coil should not be greater than 10 times that of the primary coil.

5. Connect the primary coil to a 1 V a.c. supply.
6. Measure the emf of the primary and secondary coils with a moving-iron voltmeter. (Such a meter can measure a.c. voltages.)
7. Repeat the experiment by changing the number of turns of the coils.
8. Obtain six sets of results.

QUESTIONS

4. Record your results in the table below.
Let N_p = number of turns of primary coil, N_s = number of turns of secondary coil, V_p = emf of primary coil, and V_s = emf of second coil.

N_p	N_s	V_p	V_s	$\frac{N_p}{N_s}$	$\frac{V_p}{V_s}$

5. Taking experimental errors into account, what is the relationship between the turn ratio $(\frac{N_p}{N_s})$ and voltage ratio $(\frac{V_p}{V_s})$?

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6. Does this result agree with your observation in Part A?

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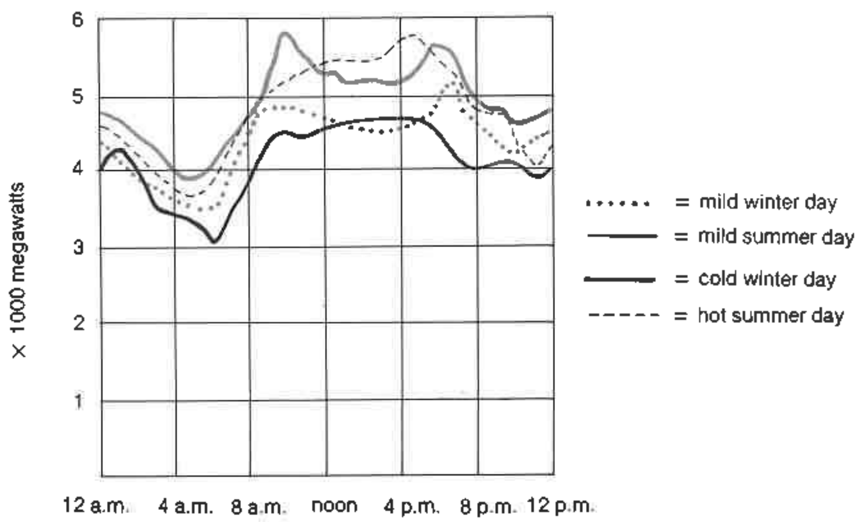
SPECIAL INVESTIGATION 6 ELECTRICITY DEMAND OVER 24 HOURS

The demand for electricity is not constant 24 hours per day. Twice each day demand is very high and these points, called peaks, occur in the morning and early evening. There are also periods when demand for electricity is low and these points, called troughs, usually occur after midnight.

Economics is electricity generation depend on minimizing these peaks and troughs, so demand is levelled out over the full 24 hour period.

Study the following graph which shows typical power generation for a 24 hour period at different times of the year. Use this to answer the following questions.

1. When does the morning peak in demand usually occur? Account for this.
2. When does the evening peak usually occur? Account for this.
3. When is demand usually lowest? Account for this.
4. Why does demand vary with the seasons?
5. Why does the SEC charge a lower tariff for electricity used by off-peak appliances? Give examples of off-peak appliances found in homes.
6. Why is it important that the SEC accurately forecasts demand for electricity?
7. Find out from SEC booklets how fluctuating demand is met.



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EXPERIMENT 26 A MODEL POWER LINE

AIM: To construct a model power line to demonstrate the transmission of electrical power

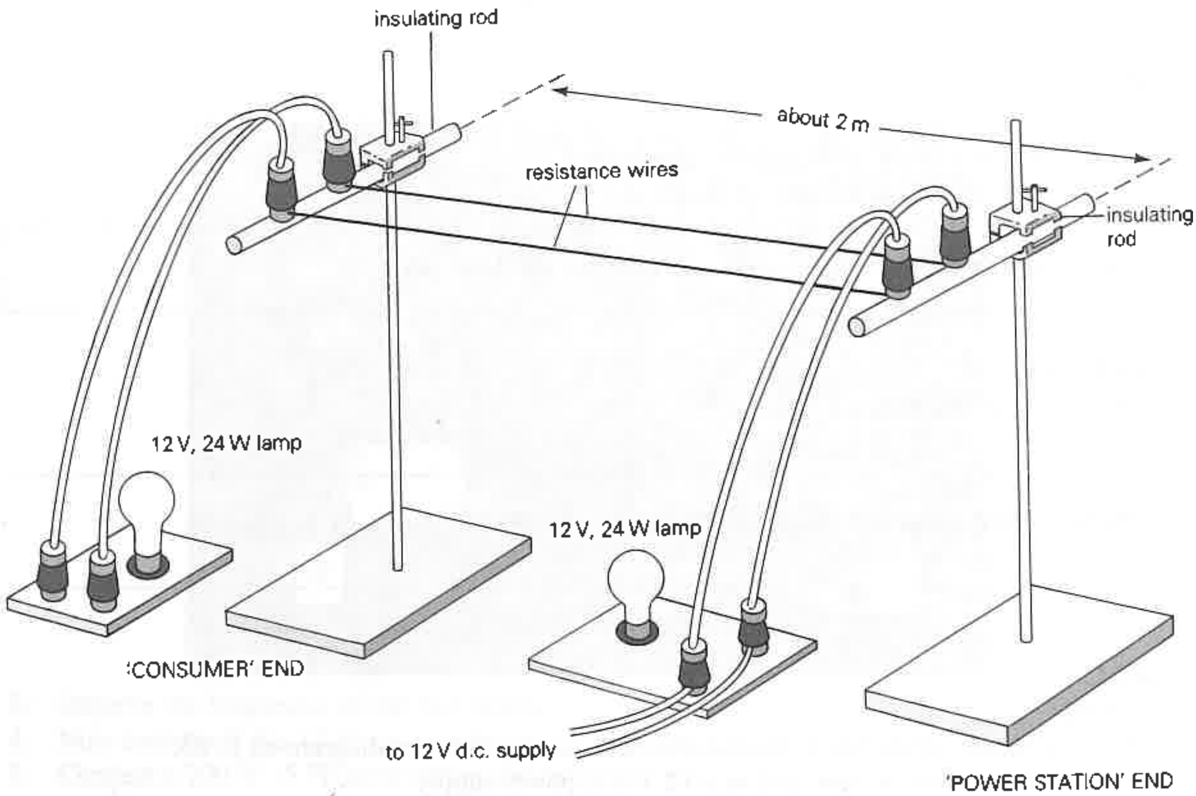
REFERENCE: Chapter 8

PART A
METHOD

1. Set up the apparatus as shown in the diagram below.

> **Note:** This is a model power line by which electrical power is transmitted from a power station. The two resistance wires represent cables in the transmission line.

2. Connect a 12 V, 24 W lamp to the 'consumer' end of the model power line.
3. Connect another such lamp to the 'power station' end.
4. Connect a 12 V d.c. power supply to the 'power station' end.
5. Compare the brightness of the two lamps.
6. Use a demonstration ammeter to measure the current through the circuit.
7. Connect a demonstration voltmeter to the 'consumer' end to measure the voltage across the lamp at that end.
8. Now use it to measure the voltage at the 'power station' end.



QUESTIONS

1. Which of the two lamps is brighter?

____

2. Tabulate your results below.

Current transmitted by the 'power line' = ______________________

Voltage at the 'consumer end' = ______________________

Voltage at the 'power station' end = ______________________

Power used by the 'consumer' = ______________________

Power supplied by the 'power station' = ______________________

3. Is there any power loss in the power line? If so, why?

____

____

____

____

4. Is the voltage at the 'consumer' end lower than the voltage at the 'power station' end? If so, why?

____

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____

PART B

METHOD

1. Repeat Part A using a 12 V a.c. power supply.
2. Observe the brightness of the two lamps.

Note: You are not required to measure currents and voltages.

QUESTIONS

5. Which of the two lamps is brighter?

____

6. Does a.c. power produce different results than d.c. power?

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PART C

METHOD

1. Set up a model power line using transformers, as shown in the diagram on p. 83.
2. Connect the 'power station' end to a 12 V a.c. power supply.

Note: One of the transformers steps up the voltage to about 200 V, and the other steps it down again to about 12 V.

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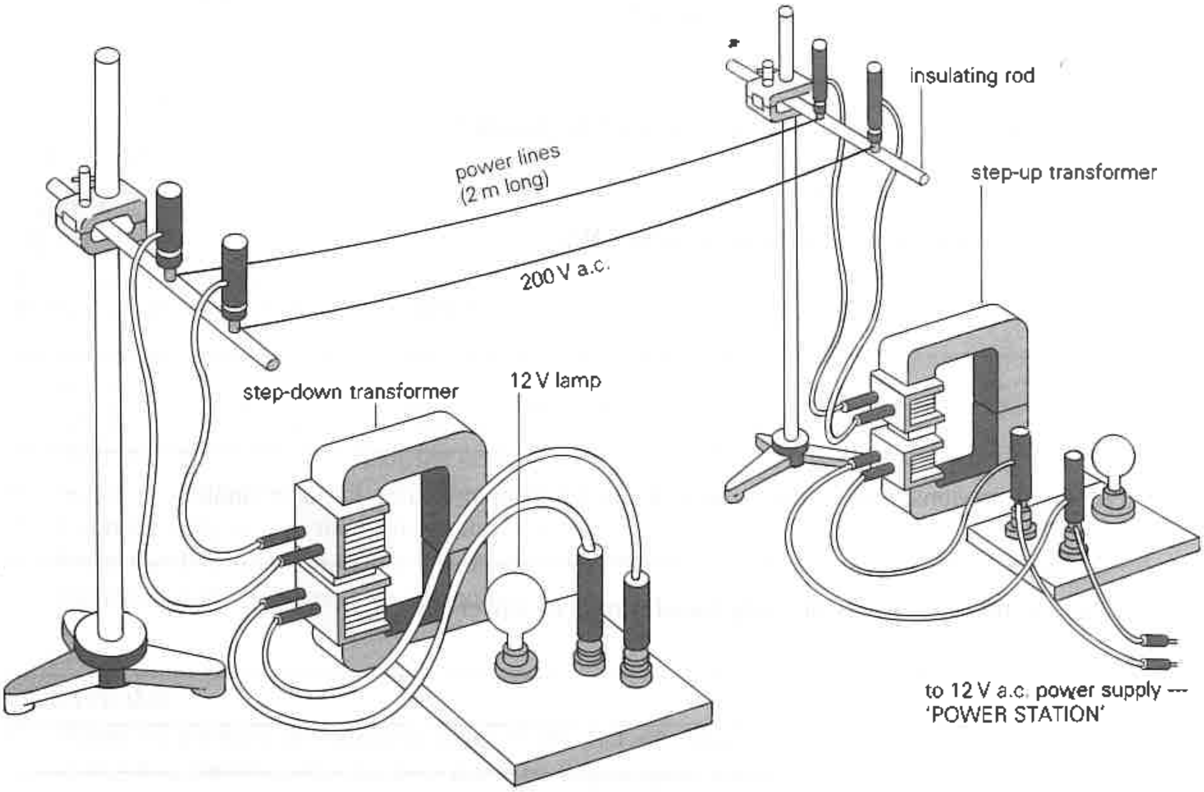

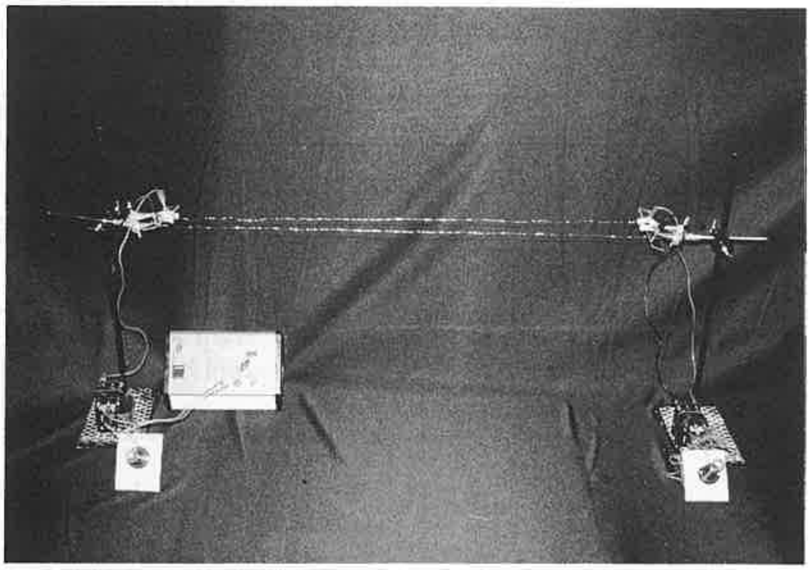

3. Observe the brightness of the two lamps.
4. Now switch off the 12 V a.c. supply.
5. Connect a 200 V 15 W lamp across the resistance wires.
6. Switch on the 12 V a.c. supply again, and see if the line is at about 200 V.

Caution: The resistance wires are at about 200 V, and are dangerous.

QUESTIONS

7. Is the lamp at the 'consumer' end bright?

8. Is the 200 V lamp connected to the 'power line' bright?

9. Is the power loss in the line large or small? Why?

10. For safety reasons, should the voltage at the 'consumer' end be large or small?

11. What are the advantages of using transformers in power lines?

12. Why is an a.c., and not a d.c., transmitted in practical power lines?

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EXPERIMENT 27 USING A CATHODE RAY OSCILLOSCOPE

AIM: To learn how to use a cathode ray oscilloscope to measure d.c. and a.c. voltages and frequencies

REFERENCE: Chapter 9

PART A

METHOD

1. Switch on a cathode ray oscilloscope.
2. Adjust the X- and Y-shift controls until a sharp trace is seen on the screen.
3. Switch off the time base so that a bright spot is focused on the screen. (Do not have the spot too bright.)
4. Set the a.c.–d.c. switch to the d.c. side.
5. Shift the spot to the centre of the screen.
6. Select a suitable Y-sensitivity range (V cm^{-1}).
7. Connect a dry cell to the Y-input terminals.
8. From the displacement of the bright spot, find the magnitude of the input d.c. voltage.
9. Repeat, but this time reverse the poles of the cell.

QUESTIONS

1. When the positive and negative poles of the cell are connected to the upper and lower terminals of the Y-input respectively, how does the bright spot move?

   ____

2. Through how many centimetres does the bright spot move?

   ____

3. What is the corresponding V cm^{-1} range?

   ____

4. What is the voltage of the cell?

   ____

5. How does the bright spot move when the negative and positive terminals of the dry cell are connected to the upper and lower terminals of the Y-input respectively?

   ____

PART B

METHOD

1. Switch the d.c.–a.c. switch to the a.c. side.
2. Connect a 1 V a.c. signal from an a.c. power supply to the Y-input. (Notice that the bright spot moves up and down, following the change in voltage.)
3. Now turn the time base on.
4. Move the time base dial clockwise in successive steps. Note how the spot moves across the screen. (At sufficiently high speed, the sweep of the spot appears continuous.)

5. Observe the waveform displayed on the screen.

> **Note:** In this way, the waveform of the a.c. signal is displayed. The X-axis is the time base. It is calibrated in multiples and sub-multiples of milliseconds per centimetre. This calibration can be used to determine the period of the waveform, and hence the frequency.

6. Measure the period of the waveform.
7. Now, with the time base still on, increase the input voltage in steps up to 5 V.
8. Note what happens to the waveform displayed on the screen.

QUESTIONS

6. Sketch the display on the screen when a 1 V a.c. signal is applied:
   (a) with the time base on,

   (b) without the time base on.

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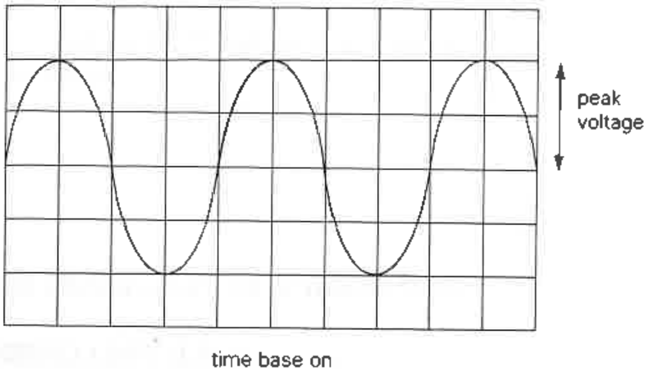
7. Calculate the period and frequency of an a.c. signal?

8. The Y-input is calibrated in V cm^{-1}. Use this to find the peak voltage of your a.c. signal. (See diagram below.)



9. How does the peak voltage you calculated compare with that on the power supply?

10. When the input voltage (with the time base on) is increased up to 5 V, what happens to the display on the screen?

PART C

METHOD

1. Connect an a.c. signal generator to the Y-input with the time base on.
2. Observe the effect on the waveform of increasing the frequency for a fixed voltage.

QUESTIONS

11. What is the effect on the waveform of increasing the frequency of the input signal?

12. In order to keep the display on the screen unchanged, what must you adjust as the frequency is increased?