EXPERIMENT 8

AIM

To determine the frequency of alternating current using a sonometer and an electromagnet.

APPARATUS AND MATERIAL REQUIRED

A sonometer with a soft iron wire stretched over it, an electromagnet, a step-down transformer, slotted 1/2 kg weights hanger, a physical balance, two sharp edge wedges and a weight box.

PRINCIPLE

The frequency n of the fundamental mode of vibration of a stretched string, fixed at two ends, is given by

$$n = \frac{1}{2l}\sqrt{\frac{T}{m}} \qquad \text{(E 8.1)}$$

Here l is the length of the vibrating string, T is the tension in the wire and m is its mass per unit length.

If an alternating current is passed in the coil of the electromagnet, the magnetisation produced in the core is proportional to instantaneous value of the current. If the electromagnet is held close to the middle of the sonometer wire, the wire will be attracted twice during each cycle towards the electromagnet. The attractive force experienced by the wire will be proportional to the magnetisation produced in the core of the electromagnet. Since in each cycle, the wire will be pulled twice and hence at resonance, it will vibrate with a frequency which is twice the frequency of alternating current. Hence, if f is the frequency of the alternating current, then

$$f = \frac{n}{2} = \frac{1}{4l}\sqrt{\frac{T}{m}} \qquad \text{(E 8.2)}$$

$$4n^2 l^2 m = T$$

or $$l^2 = \frac{1}{4n^2 m} \times T$$

A graph between T (taken on x-axis), and l^2 (taken on y-axis), would be a straight line. The slope of this straight line would be

$\frac{1}{4n^2 m}$, so that

(E 8.3) $$n^2 = \frac{1}{4m \times slope}$$

$$n = \frac{1}{2}\frac{1}{\sqrt{m \times slope}}$$

The frequency of alternating current, $f = \frac{n}{2} = \frac{1}{4}\frac{1}{\sqrt{m \times slope}}$ can be determined using the value of the slope.

PROCEDURE

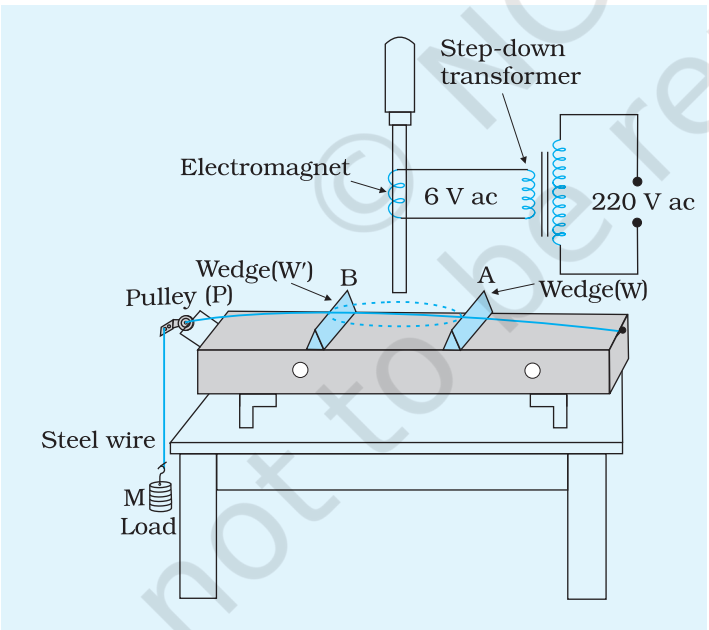

Fig. E 8.1 *Set up for finding frequency of ac mains using a sonometer*

1. Set up the sonometer and stretch the wire AB by placing a load of ½ kg on the hanger (Fig. E 8.1).
2. Support the electromagnet in a stand and connect it to the secondary of a stepdown transformer. Adjust its position, such that its one pole lies close to the middle of the sonometer wire.
3. Switch on the alternating current supply and adjust the length of vibrating portion of AB by sliding the wedge W or W′. Make this adjustment until the amplitude of the vibrating string is maximum.
4. Measure the vibrating length and note the tension in the string.
5. Increase the load in steps of ½ kg and each time find the vibrating length.
6. Switch off the ac supply. Untie the wire of the sonometer from its peg and find its mass in a physical balance. Calculate mass of 100 cm sonometer wire. Hence find the mass per unit length, m for the wire.

OBSERVATIONS

1. Length of the wire = ...cm = ... m
2. Mass of the wire = ...g = ...kg
3. Mass per unit length, m = ... g/cm = ...kg/m
4. Acceleration due to gravity, g = ...ms^{-2}

Table E 8.1: Resonant length

Sl. No.	Load *(M)* including mass of hanger (kg)	Tension $T = mg$ (N)	Resonant length l			Mean l *in* (m)	$n = \frac{1}{2l}\sqrt{\frac{T}{m}}$ (Hz)
			First trial (cm)	Second trial (cm)	Mean (cm)		
1							
2							
3							
4							
						Mean	

CALCULATIONS

1. For each set, calculate the value of n using the formula given above. Find the mean of these values.
2. Plot a graph of l^2 against T with l^2 on y-axis and T on x-axis. Determine the slope of the graph. Using the value of the slope determine the frequency of alternating current.

RESULT

1. The graph between T and l^2 is a straight line.
2. Slope of the graph = $\frac{1}{4mn^2}$ = ...
3. Frequency of ac supply $f = \frac{n}{2}$

(i) from calculation ...Hz

(ii) from graph ...Hz

PRECAUTIONS

1. Pulley should be as frictionless as possible.
2. Edges of the wedge should be sharp.
3. Tip of the electromagnetic pole should be close to the middle of the sonometer wire.
4. After taking each of the observations, circuit should be switched off for a few minutes.

SOURCES OF ERROR

1. Friction of the pulley is the main source of error in the experiment. Due to this, the value of tension acting on the wire is less than that actually applied.
2. AC frequency may not be stable.

DISCUSSION

1. The frequency of alternating current is half that of the frequency of the vibrating string.
2. Sonometer wire is made of soft iron for better results.

SELF ASSESSMENT

1. How is ac different from dc?
2. What is the meaning of frequency of ac?
3. How does the wire vibrate? Identify and explain the rule with the help of which you can determine the direction of force acting on the wire.
4. What should be the property of the iron for making it a good electromagnet?
5. Is there any relation between frequency and magnetism of the electromagnet, and frequency of the alternating current?

SUGGESTED ADDITIONAL EXPERIMENTS/ACTIVITIES

Perform the above experiment using a permanent horse shoe magnet and passing the alternating current in the sonometer wire. In this case the resonant frequency is equal to the frequency of the alternating current. Sonometer wire need not be made of soft iron. You can use constantan or manganin wire for this purpose.