St. Lawrence College

Date: 2078/11/3
Class: 12
Roll No.: 48

St. Lawrence College
PHYSICS PRACTICAL SHEET

Experiment No.: 4
Group: 9
Set: II

Object of the Experiment (Block Letter)

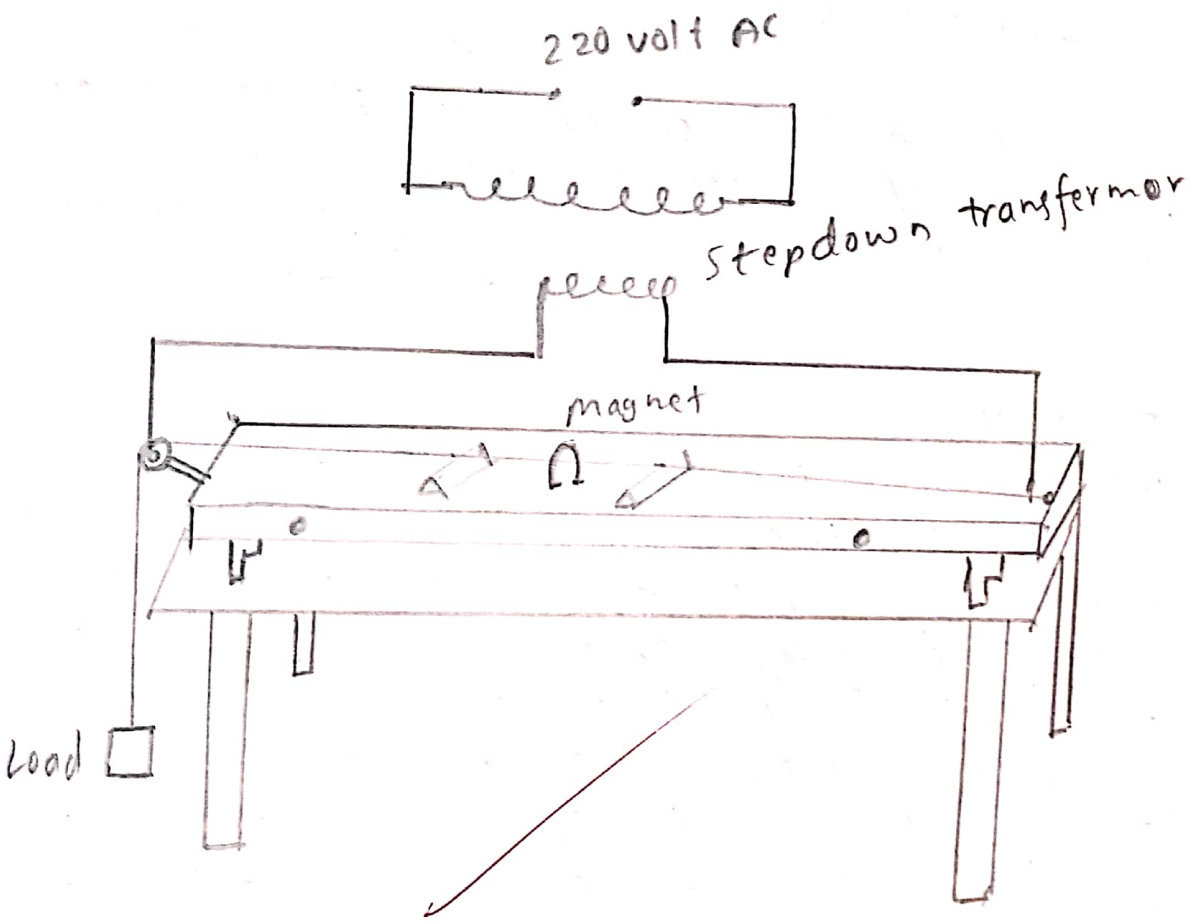
TO DETERMINE THE FREQUENCY OF A.C. MAINS BY USING A SONOMETER

APPARATUS REQUIRED

i. Sonometer
ii. Non-magnetic wire
iii. Stepdown transformer
iv. Horse shoe magnet
v. A set of slotted weights
vi. Weight hanger
vii. Bridges
viii. Micrometer screw gauge

THEORY

When A.C. is passing through the conductor, since the current direction reverses periodically, the direction of force also reverse periodically and hence, the conductor vibrates. Since the current flowing is alternating, the wire vibrates with a frequency equal to the frequency of A.C. By adjusting, the ~~wire~~ length of the vibrating wire segment, this frequency can be made equal to the natural frequency of the wire segment. Then the resonance takes place and the wire vibrates with maximum amplitude. At this stage, the length of the wire segment is called the resonating length and it increases with increase in the mass of the suspended weights. In the presence of magnetic field, current carrying conductor experiences a magnetic ~~field~~ force



which is periodic. The frequency of forced vibration is same as the frequency of a.c.

When the length 'l' of the sonometer wire vibrates with maximum amplitude, the frequency of the applied A.C. is equal to the natural frequency of the wire. Then the frequency of A.C.

$$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$$

Where $T = Mg$ the tension of the wire and 'μ' is the linear density or mass per unit length of the wire.

If d is the diameter of the wire and ρ is the density of its material then mass per unit length of the wire then,

$$\mu = \frac{m}{l} = \frac{V\rho}{l} = \frac{(Al)\rho}{l} = A\rho$$

$$\therefore \mu = \frac{\pi d^2}{4}\rho \quad \left[\because A = \frac{\pi d^2}{4}\right]$$

OBSERVATIONS

Pitch of the micrometer screw gauge (P) : 1mm
: 0.001 m

Least count of the micrometer screw gauge : 0.01 mm
: 0.01×10^{-3} m

Zero error of the micrometer screw gauge (a) = -5 mm
= -5×10^{-3} m

a. Determination of the diameter of wire

S.No.	Main Scale reading (x) mm	Circular scale reading (y)	y × L.C. mm	Total diameter d' = x + y × L.C. mm	Corrected diameter d = d' ± a × L.C. mm	Mean dia-meter d(m
1	0	52	0.52	0.52	0.57	
2	0	47	0.47	0.47	0.52	0.56
3	0	54	0.54	0.54	0.59	

∴ Diameter of wire (d) = 0.56 mm = 0.56×10^{-3} m

b. Determination of frequency of A.C. mains

S.No.	Mass on the scale pan M(kg)	Tension on wire T = Mg(N)	Resonance length two bridges l(m)	$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$	Mean frequency f(Hz)
1	0.2	2	0.344	44.66	
2	0.4	4	0.446	48.71	
3	0.6	6	0.554	48.03	47.68
4	0.8	8	0.638	48.16	
5	1	10	0.703	48.87	

CALCULATIONS

The density of the material of the wire (ρ) = 8600 kg/m³

Diameter of the wire (d) = 0.56×10^{-3} m

Linear density of the wire, $\mu = \frac{\pi d^2}{4} \rho = \frac{\pi \times (0.56 \times 10^{-3})^2}{4} \times 8600$

$\mu = 2.118 \times 10^{-3}$ kg/m

RESULT

Hence, the frequency of A.C. mains by using a sonometer is

$$f_1 = \frac{1}{2 \times 0.344}\sqrt{\frac{2}{2.118 \times 10^{-3}}} = 44.66 \text{ Hz}$$

$$f_2 = \frac{1}{2 \times 0.446}\sqrt{\frac{4}{2.118 \times 10^{-3}}} = 48.71 \text{ Hz}$$

$$f_3 = \frac{1}{2 \times 0.554}\sqrt{\frac{6}{2.118 \times 10^{-3}}} = 48.03 \text{ Hz}$$

$$f_4 = \frac{1}{2 \times 0.688}\sqrt{\frac{8}{2.118 \times 10^{-3}}} = 48.16 \text{ Hz}$$

$$f_5 = \frac{1}{2 \times 0.703}\sqrt{\frac{10}{2.118 \times 10^{-3}}} = 48.87 \text{ Hz}$$

RESULT

Hence, the frequency of A.C. mains by using a sonometer is 47.68 Hz

PERCENTAGE ERROR

Standard frequency of A.C. = 50 Hz

Observed frequency of A.C. = 47.68 Hz

Percentage error = $\left|\frac{\text{Standard frequency} - \text{Observed frequency}}{\text{Standard frequency}}\right| \times 100\%$

$= \left|\frac{50 - 47.68}{50}\right| \times 100\%$

$= 4.64\%$

SOURCES OF ERROR AND PRECAUTIONS

1. The sonometer wire should be uniform and without kinks.
2. The pulley should be frictionless.
3. The wire should be horizontal and pass freely in between the poles of magnet.
4. The horse shoe magnet should be placed vertically at the center of the wire with its face normal to the length of wire.
5. The current should not exceed one Ampere to avoid the overheating of the wire.
6. The movement of bridges on the wire should be slow so that the resonance point can be found easily.
7. The diameter of the wire must be measured accurately at different points in two mutually perpendicular directions.
8. The sonometer wire and the clamp used to hold the magnet should be non-magnetic.