EXPERIMENT NO. 6

AIM → a. To measure the phase difference between two a.c. voltages.

b. To measure the frequency of an ac signal

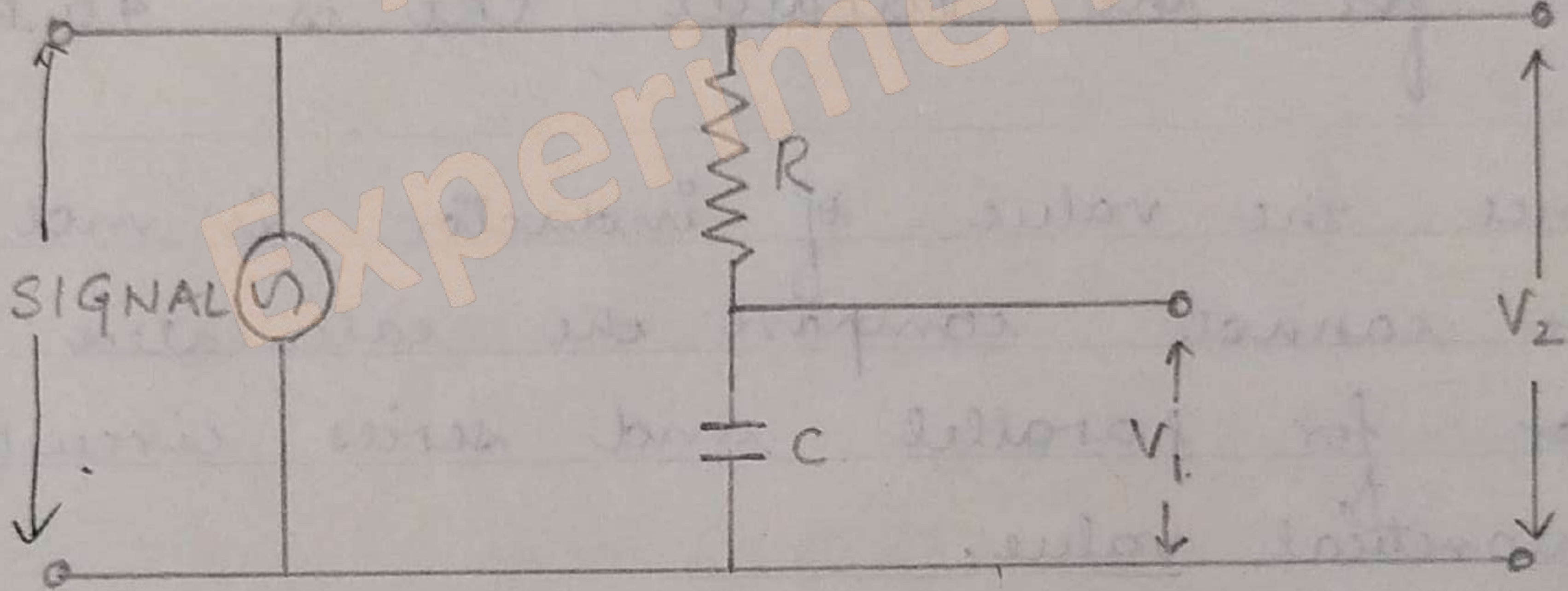
APPARATUS → Step - down transformer, audio oscillator, CRO, multimeter, capacitor, resistance box.

THEORY → 1. PHASE MEASUREMENT

Reactive elements introduce phase difference between the applied voltage and the resulting current. eg. the current passing through an ideal capacitor leads the voltage across its terminals by 90°. The method employed for measuring the phase angle between two a.c. voltages having the same frequency utilizes the formation of Lissajous figures. Here, two simple harmonic motions are superposed in mutually perpendicular direction.

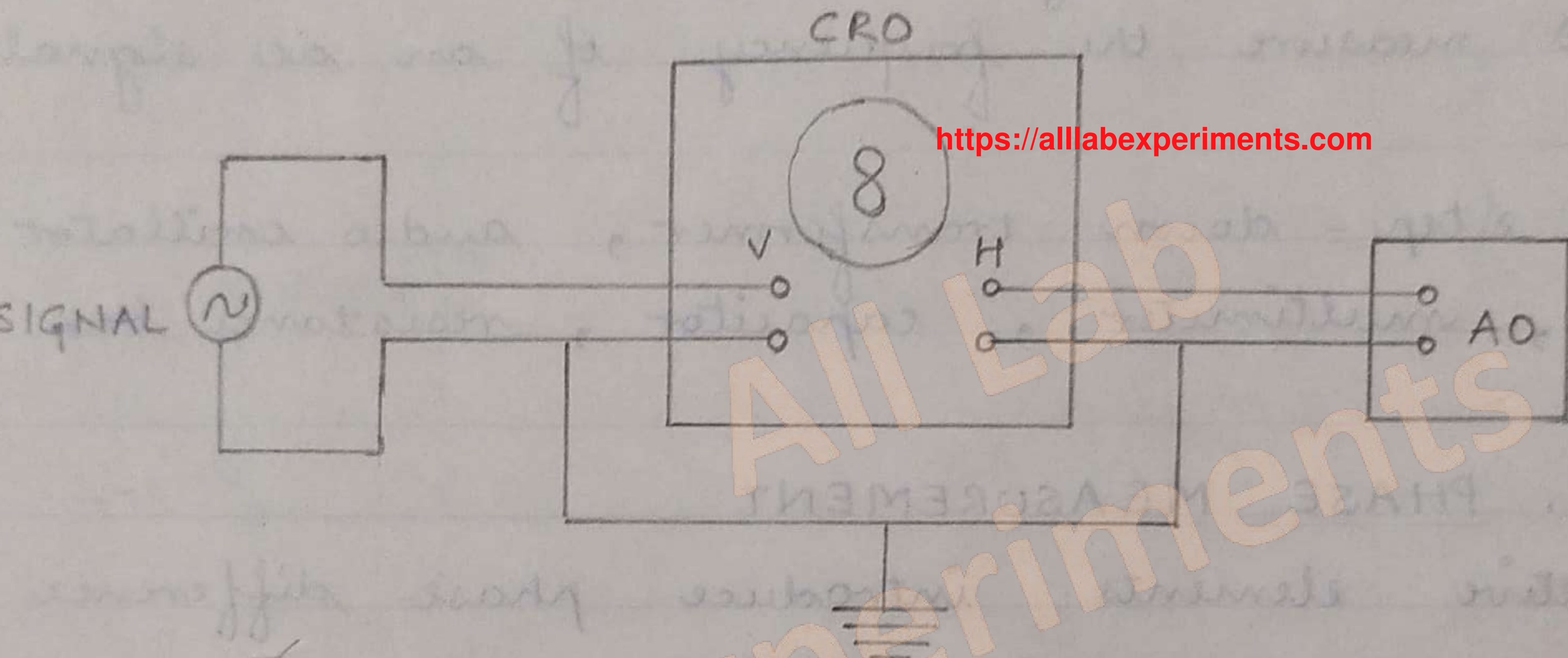
If $v_1 = V_1 \sin \omega t$ is applied to the horizontal input and $v_2 = V_2 \sin(\omega t + \phi)$ is applied to the vertical input of the CRO, the resulting pattern would be an ellipse or one of its degenerate forms.

PHASE MEASUREMENT.



FREQUENCY MEASUREMENT –

LISSAJOUS FIGURES.



At $t = 0$, $v_2 = V_2 \sin\phi$

The maximum amplitude v_2 is B.

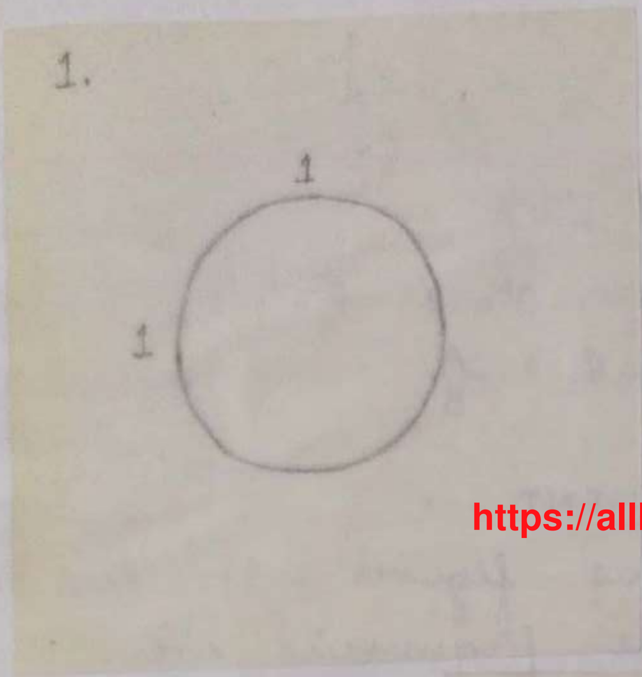
$$\therefore, \frac{V_2 \sin\phi}{V_2} = \sin\phi = \frac{A}{B}$$

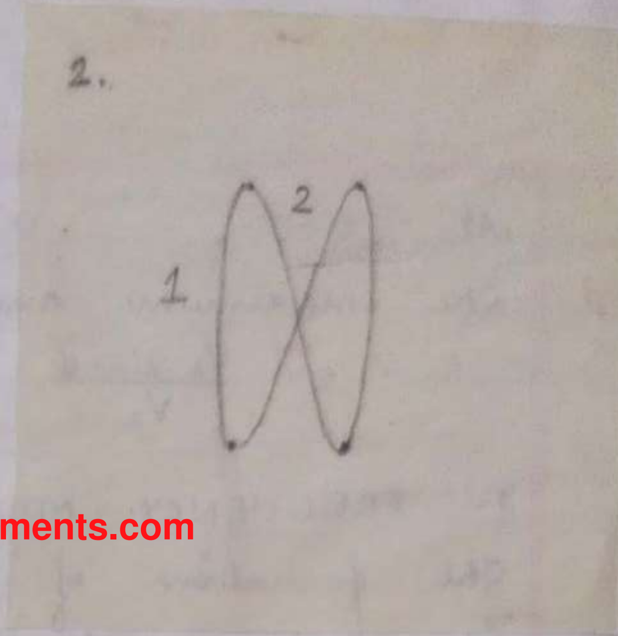
2. FREQUENCY MEASUREMENT

The formation of Lissajous figures when two ac voltages of different frequencies are superposed in mutually perpendicular directions may be used for measurement of frequency. The signal whose frequency is to be measured ~~frequency~~ is given to one of the plates, say the vertical ones, and the signal whose frequency is known and is capable of being varied is given to the other horizontal input of the CRO. Closed loop Lissajous figures are formed when one of the frequencies is adjusted such that one frequency is a rational fraction or multiple of the other. The ratio of the two frequencies is given by

$$\frac{f_{vertical}}{f_{horizontal}} = \frac{\text{no. of loops touching horizontal line}}{\text{no. of loops touching vertical line.}}$$

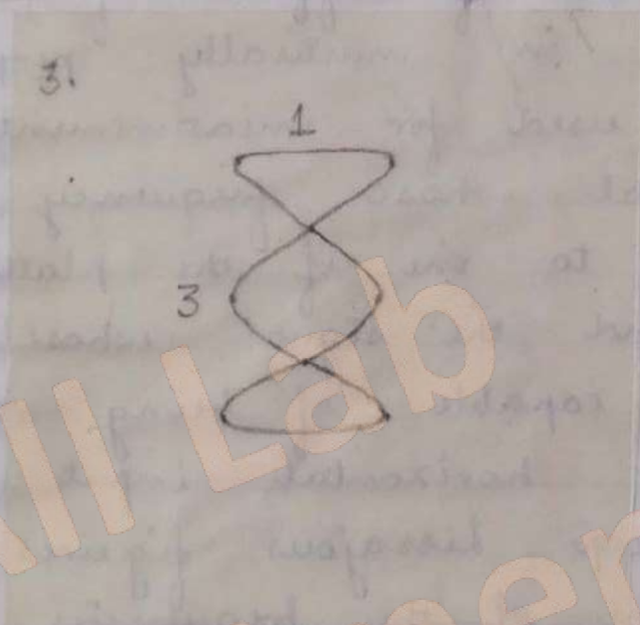
LISSAJOUS FIGURES.





$F_1 = 30$ Hz
$F_2 = 29$ Hz

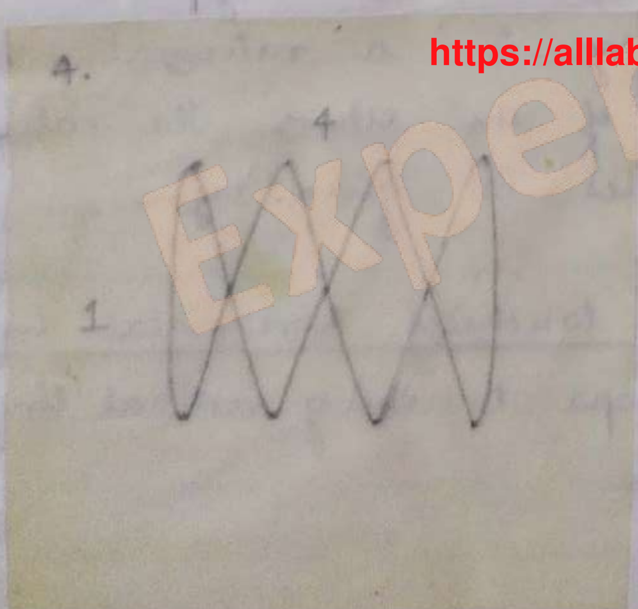
$F_1 = 17.5$ Hz
$F_2 = 34$ Hz

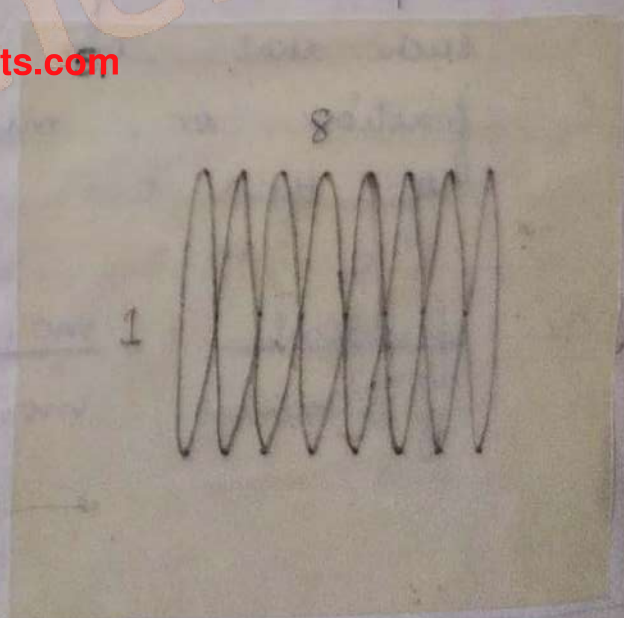


$F_1 = 50$Hz
$F_2 = 170$Hz

$F_1 = 50$Hz
$F_2 = 195$ Hz

$F_1 = 50$ Hz
$F_2 = 400$Hz





PROCEDURE → 1. PHASE – LISSAJOUS PATTERN

1. Wire the circuit as shown in the figure. The phase angle between the voltage applied to the vertical and horizontal inputs of the CRO are given by

$$\phi = \tan^{-1} \omega RC \quad \text{--- (3)}$$

2. Adjust the oscilloscope controls to get an ellipse convenient for measurements. Measure the parameters A and B of the ellipse for different values of R and evaluate ϕ using eq^n (1). Compare with the theoritcal values obtained using eq^n (3).

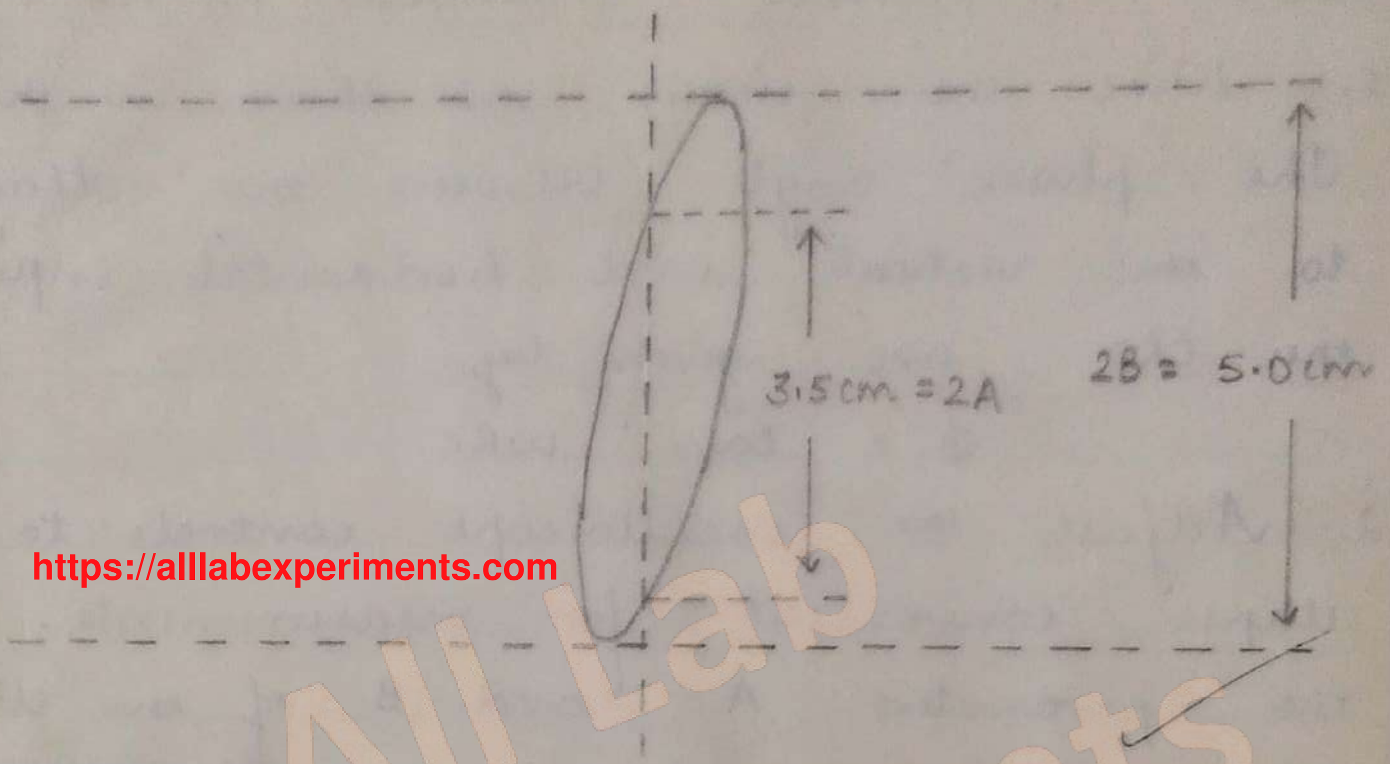
2. FREQUENCY MEASUREMENT – LISSAJOUS FIGURES.

1. Wire the circuit as shown in the figure.
2. The transformer frequency is of the order of 50 Hz.

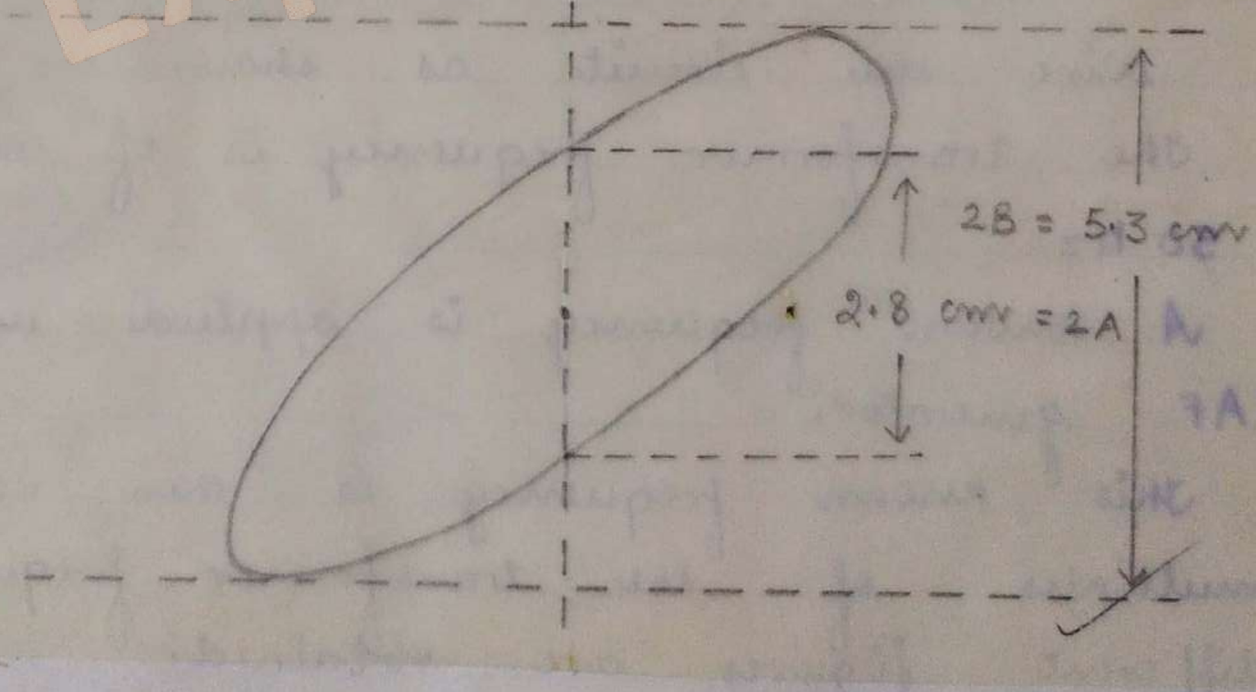
3. A known frequency is applied using the AF generator.
4. This known frequency is then varied in multiples of the transformer frequency and different figures are obtained.

PHASE PATTERN - ELLIPSE.

1.



2.



CALCULATIONS → Phase measurement

1. Theoretical value

$f = 500 Hz$ ∴, $\omega = 2\pi f$

$R = 3 k\Omega$ $C = 0.1 \mu F$ $= 2 \times 3.14 \times 500 = 3.14 \times 10^3 Hz$

$\omega RC = 3.14 \times 10^3 \times 3 \times 10^3 \times 0.1 \times 10^{-6}$

$= .942$

$\phi = \tan^{-1} \omega RC = \tan^{-1}(.942) = 43.289°$

Practical value $\phi = \sin^{-1} \frac{A}{B} = \sin^{-1}\left(\frac{3.5}{5.0}\right) = 44.43$

2. Theoretical value

$f = 140 Hz$ ∴, $\omega = 2 \times 3.14 \times 140$ Hz.

$R = 7 k\Omega$ $C = 0.1 \mu F$

∴ $\omega RC = 2 \times 3.14 \times 140 \times 7 \times 10^3 \times 0.1 \times 10^{-6}$

$= .6154$

$\phi = \tan^{-1} \omega RC = \tan^{-1} .6154 = 31.60°$

Practical value $\phi = \sin^{-1} \frac{A}{B} = \sin^{-1}\left(\frac{2.8}{5.3}\right) = 31.87°$

RESULT → The phase difference as obtained from the theoretical value and the practical value are in good agreement. The Lissajous figures as obtained have been shown.