राज्य अभियांत्रिकी एवं प्रौद्योगिकी संस्थान, नीलोखेड़ी

State Institute of Engineering & Technology, Nilokheri

(Formerly Govt. Engineering College)

LABORATORY MANUAL

TRIBOLOGY & MECHNICAL VIBRATION LAB

ME 311L

Department of Mechanical Engineering

STATE INSTITUTE OF ENGINEERING AND TECHNOLOGY

(Affiliated to K.U. University)

NILOKHERI – 132117, KARNAL

Experiment-1

AIM: TO STUDY THE UNDAMPED FREE VIBRATIONS OF AN EQUIVALENT SPRING MASS SYSTEM AND DETERMINE THE NATURAL FREQUENCY OF THE VIBRATIONS.

DESCRIPTION:

The equipment is designed to study free damped and undamped vibration. It consists of M.S. rectangular beam supported at one end by a trunion pivoted in ball bearing. The bearing housing is fixed to the side member of the frame. The other end of beam is supported by the lower end of helical spring; upper end of the spring is attached to screw, which engages with screwed hand wheel. The screw can be adjusted vertically in any convenient position and can be clamped with the help of lock nut.

The exciter unit can be mounted at any position along the beam. Additional known weights may be added to the weight platform under side exciter.

EXPERIMENTAL PROCEDURE:

1. Support one end of beam in the slot of trunion and clamp it by means of screw.
2. Attached the other end of the beam to lower end of spring.
3. Adjust the screw to which the spring is attached with the help of hand wheel such that beam is Horizontal in Position
4. Weight the exciter assembly along with discs, bearing and weights platform.
5. Clamp the assembly at any convenient position.
6. Measure the distance L I of the assembly from pivot. Allow system to vibrate freely.
7. Measure the time for any 10 oscillations and periodic time and natural frequency of vibration.
8. Repeat the experiment by varying L1 and also putting different weights on platform.

FORMULAE:

1. Time Period,

$$T_{theo} = 2 * \pi \sqrt{\frac{m_e}{k}}$$

2. Equivalent mass at the spring.

$$m_s = m\left[\frac{L_1^{\,2}}{L}\right]$$

$$m = \frac{W + w}{g}$$

4. Actual Time Period,

$$T_{act} = \frac{t}{n} \text{ sec}$$

OBSERVATION & CALCULATION TABLE:

Wt. (Kg)	**L1 (cm)**	**No. of Osc. n**	**Time for n Osc.**	T_{act} **=t/n (sec)**	**Freq.** f_{act} **(Hz)**	T_{theo} **(sec)**	f_{theo}

NOMENCLATURE:

g = Acceleration due to gravity.

k = Stiffness of spring = 5 Kg/ cm

L1 = Distance of w from pivot.

L = Distance of spring from pivot = 93.5cm

t = time taken for n oscillations

W = Weight of exciter assembly along with wt. platform = 18.7 kg.

w = Weight attached on exciter assembly

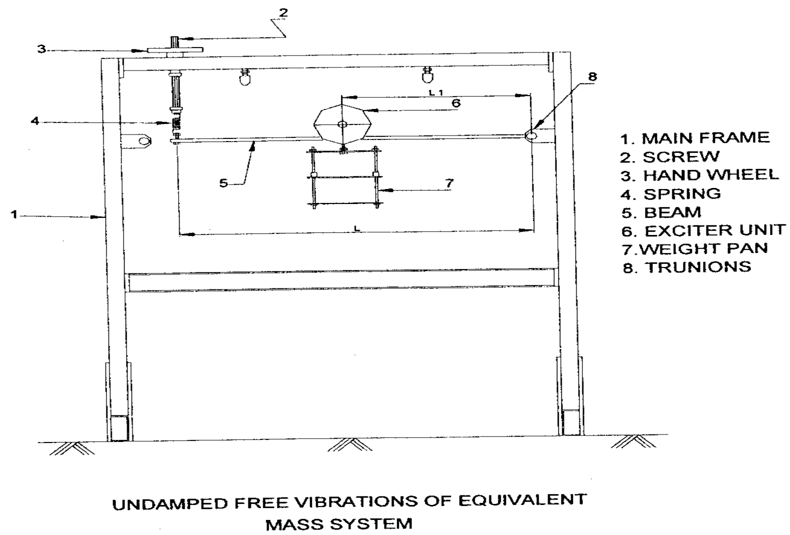


FIG. 1

CONCLUSION:

fn(calculated) = fn(experimental) approx.

AIM: TO VERIFY THE RELATIONSHIP OF SIMPLE PENDULUM.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Where, T = Time Periodic time in sec.

L = Length of pendulum in cm.

DESCRIPTION:

For performing the experiment, a ball is supported by nylon thread into a chuck. It is possible to change the length of pendulum. This makes it possible to study the effect of variation of length on periodic time. A small ball may be substituted by large ball to illustrate that period of oscillation is independent of the mass of ball.

EXPERIMENTAL PROCEDURE:

1. Attach the ball to one of end of the thread.
2. Allow ball to oscillate and determine the periodic time T by knowing the time for say 10 oscillations.
3. Repeat the experiment by changing the length.
4. Complete the observation table given bellow.

FORMULAE:

1. Time period Actual,

$$T_{actual} = \frac{t}{n} \text{sec}$$

2. Time period Theoretical,

$$T_{Theo} = 2\pi\sqrt{\frac{L}{g}} \text{ sec}$$

OBSERVATION & CALCULATION TABLE:

Sr. No.	L cm.	No. Of Osco 'n'	Time for n Osco. 'T' Sec.	T sec (Act.) t/n	T sec. (Theo.)
1.					
2.					

NOMENCLATURE:

L = Length of the pendulum

g = Acceleration due to gravity

N = Nos. of oscillation.(n)

T = Time period

T_{actual} = Actual time period

T_{theo} = Theoretical time period

t = Time required for n oscillations

CONCLUSION:

$T_{actual} = T_{theo}$ approx.

Hence the relation for simple pendulum is verified.

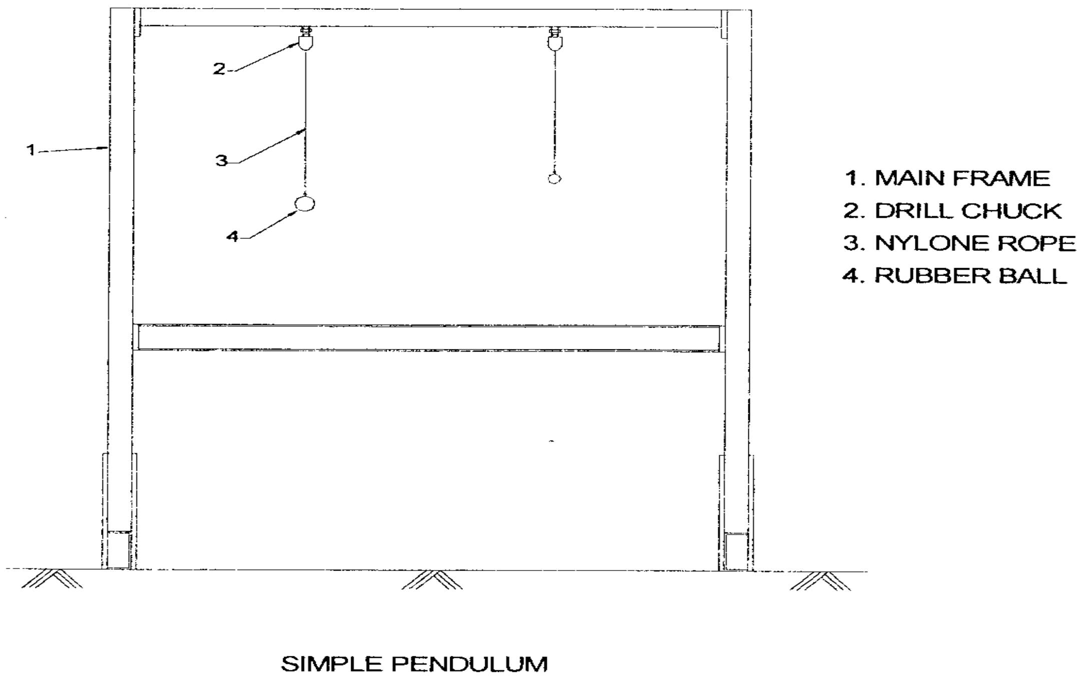


FIG: 1

Experiment-2

AIM: - TO STUDY THE TORSIONAL VIBRATIONS OF A SINGLE ROTOR SHAFT SYSTEM AND TO DETERMINE THE NATURAL FREQUENCY OF THE VIBRATIONS.

THEORY:

If we imagine a system consisting of mass moment of inertia J connected to shaft of torsion stiffness Kt when the rotor is displaced slightly in the angular manner about the axis of the shaft and released, it executes torsion oscillations.

DESCRIPTION:

In this experiment, one end of the shaft is gripped in the chuck & heavy flywheel free to rotate in ball bearing is fixed at the other end of the shaft. The brackets with fixed end of the shaft can be clamped at any convenient position along lower beam. Thus, length of the shaft can be varied during the experiments. The ball bearing support to the flywheel provided negligible damping during the experiment. The bearing housing is fixed to side member of the main frame.

EXPERIMENTAL PROCEDURE:

1. Fixed the bracket at convenient position along the lower beam.
2. Grip one end of the shaft at the bracket by chuck.
3. Fix the rotor on the other end of shaft.
4. Twist the rotor through some angle and release.
5. Note down the time required for 10, 20 oscillations.
6. Repeat the procedure for the different length of the shaft.

FORMULAE:

1. Torsional stiffness, where

$$K_t = \frac{GI_p}{L}$$

G = Modulus of Rigidity of the shaft = 8.5×10^{10} N/m^2

Ip = Polar moment of inertia = $(\pi / 32)\, d^4$

2. Theoretical Time period,

$$T_{theo} = 2 * \pi \sqrt{\frac{I}{k_t}}$$

3. Moment of Inertia of disc,

$$I = \frac{W * D^2}{g * 8}$$

4. Actual Time period

$$T_{act} = \frac{t}{n}$$

5. Theoretical Frequency

$$f_{theo} = \frac{I}{T_{theo}}$$

6. Actual Frequency,

$$f_{act} = \frac{I}{T_{act}}$$

OBSERVATION & CALCULATION

OBSERVATION TABLE:

S No.	Length of Shaft –L(Cm)	No. of Osc., N	Time for n Osc. ,T sec	Periodic Time T = t/n (act.)

CALCULATION TABLE:

S No.	Length of Shaft	k_t	$T_{theo.}$	$T_{act.}$	$F_{Theo.}$	F_{act}

	(cm)		Sec.	Sec.	Hz	Hz

NOMENCLATURE:

D = Diameter of disc=.19m

d = diameter of shaft=.003m

f_{theo} = Theoretical frequency

f_{act} = Actual frequency

G = Modulus of rigidity

g = acceleration due gravity

W = Weight of disc = 2.335Kg x 9.81

Ip = Polar Moment of system

I = Moment of inertia of disc

K_t = Torsional Stiffness

L = Length of shaft

n = Number of oscillations

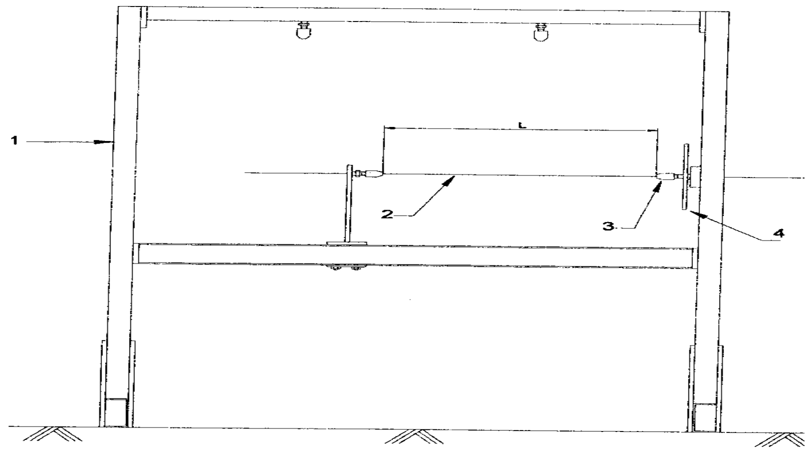
T_{theo} = Theoretical time period

T_{act} = Actual time period

t = Time required for n oscillations

CONCLUSION:

Frequency is inversely proportional to the length of the shaft.



UNDAMPED VIBRATION OF SINGLE ROTOR SYSTEM

FIG. 1

1. MAIN FRAME 2. SHAFT 3. DRILL CHUCK 4. ROTOR

Experiment-3

AIM: TO STUDY THE PRESSURE DISTRIBUTION OF A JOURNAL BEARING USING A JOURNAL BEARING APPARATUS.

INTRODUCTION:

This apparatus helps to demonstrate and study the effect of important variables such as speed, viscosity and load, on the pressure distribution in a journal bearing. The portion of a shaft, which revolves in the bearing and is subjected to load at right angle to the axis of shaft, is known as journal. The whole unit consisting of journal and its supporting part is known as Bearing. The whole arrangement is known as journal bearing.

THEORY:

Journal Bearing Apparatus is designed on the basis of hydrodynamic bearing action used in practice. In a simple journal bearing the bearing surface is bored out to a slightly larger diameter than that of the journal. Thus, when the journal is at rest, it makes contact with the bearing surface along a line, the position of which is determined by the line of action of the external load. If the load is vertical as in the figure 1c, the line of contact is parallel to the axis of the journal and directly below that axis. The crescent shaped space between the journal and the bearing will be filled with lubricant. When rotation begins the first tendency is for the line of contact to move up the bearing surface in the opposite direction to that of rotation as shown at fig 1b. When the journal slides over the bearing, the true reaction of the bearing on the journal is inclined to the normal to the two surfaces at the friction angle θ and this reaction must be in the line with the load. The layer of lubricant immediately adjacent to the journal tends to be carried round with it, but is scraped off by the bearing, so that a condition of boundary lubrication exists between the high spots on the journal and bearing surfaces which are actually in contact.
As the speed of rotation of the journal increases, the viscous force which tends to drag the oil between the surfaces also increases, and more of the load is taken by the oil film in the convergent space between the journal and bearing. This gradually shifts the line of contact round the bearing in the direction of motion of the journal. Due to this two surfaces are completely separated and the load is transmitted from the journal to the bearing by the oil. The film will only break through if it is possible for the resultant oil pressure to be equal to the load, and to have same line of action. The pressure of the oil in the divergent part of the film may fall below that of the atmosphere, in which case air will leak in from the ends of the bearing. Assuming that the necessary conditions are fulfilled and that the complete film is

formed, the point of nearest approach of journal to the bearing will by this time have moved to the position shown fig. 1a

DESCRIPTION:

The apparatus consists of a M.S. bearing mounted freely on a steel journal shaft. This journal shaft is coupled to a DC motor. Speed regulator is provided with the set-up to control the speed of journal shaft. The journal bearing has compound pressure gauge measure pressure at different point. The weight is hanged on the centre of the bearing. One oil inlet mounted on journal to supply lubricating oil. One ball valve is also provided to release the trap air. An oil reservoir accompanies the set-up to store the sufficient oil for experiment. This reservoir supplies oil to the bearing.

EXPERIMENTAL PROCEDURE:

1. Fill two-liter lubricating oil (SAE 40) in feed tank.
2. Release the air from the supply tube and journal with help of ball valve.
3. Check that some oil leakage is there for cooling.
4. Set the speed with help of dimmer stat and let the journal run for about 5 minutes to achieve the steady state.
5. Add the required loads and keep it horizontal position.
6. Note the RPM of the journal shaft.
7. Note pressure readings at different peripheral positions (after 100 or 150) rotation of the journal, with help compound pressure gauge.
8. After each reading, release pressure & take the next reading.
9. Repeat the experiment for the various speeds and loads.
10. After the test is over set dimmer to zero position and switch off main supply.

OBSERVATIOIN & CALCULATION:

OBSERVATION:

W_2 = --------------- kg

N = ---------------RPM

Observation Table 1:

S. No.	Speed N (R.P.M.)	Load W (Kg)	Torque Arm		Oil temp ^{0}C
			Weight w (Kg)	Distance (m)	
1.					
2.					

Time for 10 ml. oil flow = t (sec)

Pressure distribution:

Angle θ	0^0	10^0	20^0	30^0	40^0	-10^0	-20^0	-30^0
Press **P, kg/cm^2**								

Observation Table 2:

S. No.	Speed N (R.P.M.)	Load W (Kg)	Torque Arm		Oil temp ^{0}C
			Weight w (Kg)	Distance (m)	
1.					
2.					

Time for 10 ml. oil flow = t (sec)

Plot a graph between θ vs. P.

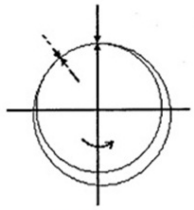


FIG: 1a

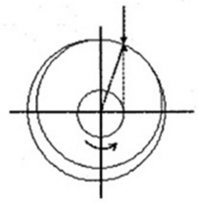


FIG: 1b

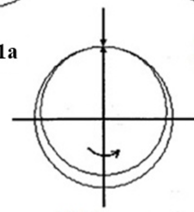


FIG: 1c

CALCULATIONS:

Let some terms be defined first

1. R = Radius of bearing = 0.025 m.
2. C = Radial clearance = 0.0003m.
3. h = Oil film thickness.
4. e = Eccentricity of Journal. (Distance between journal and bearing centers, when oil film is established) = c - h_{min}
5. ε = Eccentric ratio = e / c
6. ψ = Attitude angle (angle at h_{min} from load line)
7. θ = Angle measured from maximum oil film thickness.

i) Load carrying capacity of the bearing:

$$w = \frac{U\eta L^3}{C^2} x \frac{\pi}{4} x \frac{\varepsilon}{\left(1-\varepsilon^2\right)^2} x\left(0.62\varepsilon^2 + 1\right)^{0.5}$$

Where

W = Total load N (initial weight of the loading arrangement over the bearing is 4.39 kg)

U = Surface speed of shaft m/s

$U = \frac{\pi D N}{60}$ (D = shaft Diameter = 0.0498m)

L = Length of bearing = 0.05 m

η = Viscosity of the oil Ns/m^2 = Centipoises / 1000

Rearrangement the above formula

$w = \frac{U\eta L^3}{C^2} x \frac{\pi}{4} x\varepsilon$ (As all others values are very small)

From known (applied) load determine ε by some trial and error

ii) As journal start rotating firstly it rolls inside the bearing opposite to its direction of rotation till the oil film is formed & then it starts floating & moves forward of load line in the direction of its rotation. Minimum oil film thickness occur at this position which is at angle ψ forward of the load line.

$$\tan\psi = \frac{\pi}{4} x \frac{\left(1-\varepsilon^2\right)^{0.5}}{\varepsilon}$$

Note that 0^0 position of pressure gauge is $\theta = (180 - \psi)^0$ as θ is measured from maximum oil film thickness.

iii) Pressure around the bearing:

$P - P_0 = \frac{6u\eta R}{C^2} X \frac{\varepsilon \sin\theta(2+\varepsilon\cos\theta)}{\left(2+\varepsilon^2\right)(1+\varepsilon\cos\theta)^2} N/m^2$ and $P / 9.81 \text{ X } 10^4$ = Pressure in kg/cm^2

Where, P_0 is oil Supply pressure, N/m^2

As oil density is 890 kg/m^3, I mtr oil head corresponds to 8730.9 N/m^2.

iv) Coefficient of friction, $\mu_{Theo.}$

$$\mu_{the.} = \frac{2\pi}{(1-\varepsilon^2)^{0.5}} X \frac{\eta U R L}{CW}$$

v) Actual Co-efficient of friction-

Frictional force acting at shaft diameter,

F = Balancing wt. X Distance / R

Therefore, $\mu_{expt} = f / W$

vi) Frictional power

FP $= 2\pi\eta U^2 RL/C$ Watts

vii) Boundary Lubrication:

Plot the graph of Sommerfeld number $\eta N / P_b (R/C)^2$ **vs** $f(R/C)$ to plot the graph, keep the load on the bearing constant, say 25 kg (Plus initial rate of bearing and loading frame) start the journal to rotates at 50 – 60 r.p.m. and balance it with small weights in the left side arm. Measure oil temperature. Note down similar reading in observation table 2 at 75, 100, 150, 200, 300, 400, 500, 600 and 800 r.p.m. Calculate friction force (f) and Sommerfeld number and plot the graph.

Initially, the graph drops drastically to a certain minimum value and then rises nearly as straight line. Normally under hydrodynamic condition, oil film supports the load. But if film thickness radius such that it can not support the load with out, atleast occasional, to surface contact , then general friction so developed is called boundary friction such condition occurs at starting at very small speed are at very high loads. The lubrication existing in this range is called boundary lubrication. From graph, it is seen that there is certain minimum value of [f (R/C)]. The region to the right side of the $[f(R/C)]_{min}$ is called fluid film lubrication. The left region is the region of the boundary lubrication. The value of the sommerfeld number 'S' at $[f(R/C)]_{min}$ is grate importance as far as design and operation of bearing is considered, because the bearing is not stable blow the critical value of 'S' as it operates at boundary

lubrication and it should not be used in that range. The curve can also be drawn in another way in which the sommerfeld number's replaced by another parameter. $\mu N / P_b$ called bearing modulus and f (R/C) is replaced by coefficient of friction μ.

viii) Oil flow:

Oil flow is made up from two component first, oil which flow from the start to end of the pressure curve i.e. Q1 and second oil that flow out of bearing near the entry due to pressure feeding i.e. Q2.

$Q1 = U\ c\ L\ \varepsilon$ m3 / sec

$Q2 = (h^3\ Po\ d) / 12\eta\ L$ Q_d

Where

$H = c\ (1 + \varepsilon \cos \psi)$

Po = Supply Pressure N/m^2

As oil density is 890 kg/m^3, 1 mtr oil head corresponds to 8730.9 N/m^2

d = Diameter of oil feed hole

Qd = Non-dimensional flow coefficient

$= 1.2 + 11\ d / L$

$\therefore$ Total flow Q = Q1 + Q2

Normally Q2 being very small can be neglected.

Where $Q = 10^{-5} / t$ m^3/sec

Practically due to difficulty of correct measurement of oil temperature of oil temperature inside the bearing & great dependence of oil viscosity over temperature & pressure, correct viscosity cannot be known & hence all the parameters cannot be correctly, but those can give an idea about the behavior of the bearing.

NOTE- The equation for pressure distribution is Harrison-Sommerfeld equation for infinitely long bearing with no end leakage. For short bearing, because of short axial length and end leakage of oil, pressure at center of axial length of bearing does not cover 360^0 and the negative pressures are not developed.

NOMENCLATURE:

N = Revolutions per minute

P = Nominal bearing pressure, kg/cm^2

W_2 = Total vertical load on the journal, kg

θ = Angle

PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

1. Never run the apparatus if power supply is less than 180 volts & above than 230 volts.
2. Increase the speed gradually.
3. Do not run the journal & bearing without lubricating oil.
4. Use clean lubricant oil.
5. Always keep apparatus free from dust.

Experiment-4

AIM: TO VERIFY THE DUNKER LEY'S RULE

$$\frac{1}{f^2} = \frac{1}{f_L^2} + \frac{1}{f_b^2}$$

Where: -

f = Natural frequency of given beam (considering the weight of beam) with central load W.

f_L = Natural frequency of given beam (neglecting the weight of beam) with central load W.

$$f_L = \frac{1}{2\pi}\sqrt{\frac{48E.I.g}{L^3 W}}$$

f_b = Natural frequency of the beam.

DESCRIPTION:

At rectangular bar is supported in trunion fitting at each end. Each trunion is provided in a ball bearing carried in housing. Each bearing housing is fixed to the vertical frame member. The beam carries at its center a weight platform.

EXPERIMENTAL PROCEDURE:

1. Arrange the set –up as shown in fig. with some wt. W clamped to wt platform.
2. Pull the platform & release it to set the system in to natural vibrations.
3. Find periodic time T & frequency of vibration F by measuring time for some oscillation.
4. Repeat experiment by putting additional masses on weight platform.
5. Plot graph of 1/f2 vs. W

FORMULAE:

1. Frequency of beam,

$$f_L = \frac{1}{2\pi}\sqrt{\frac{48E.I.g}{L^3 W}}$$

2. Natural frequency of the beam,

$$f_b = \frac{\pi}{2}\sqrt{\frac{g.E.I}{wL^4}}$$

3. Moment of Inertia of beam section

$$I = \frac{bh^3}{12}$$

4. Actual Time period,

$$T_{act} = \frac{t}{n}$$

5. Actual Frequency,

$$f_{act} = \frac{1}{T_{act}}$$

OBSERVATION & CALCULATION TABLE

S No.	Wt. attached W Kg.	No. Of Osc n	Time for n Osc. ‘t’	$T_{act} = t / n$ (Sec)	Frequency F_{act} (Hz)
1.					
2.					
3.					
4.					

NOMENCATURE:

B = Width of beam = 2.5 cm

E = Modulus of elasticity of beam material = 2 x 10^{11} N/m^2

FL = Frequency of beam

FB = Natural frequency of beam

f_{act} = Actual frequency

g = Acceleration due to gravity

h = Thickness of beam = 1.1 cm

I = Moment of inertia

L = Length of the beam= 106cm

n = number of oscillations

t = time taken for n oscillation

T_{act} = Actual time period

W = Weight of beam per unit length = 1.4 Kg x 9.81

w = Central load of the beam, OR weight attached.

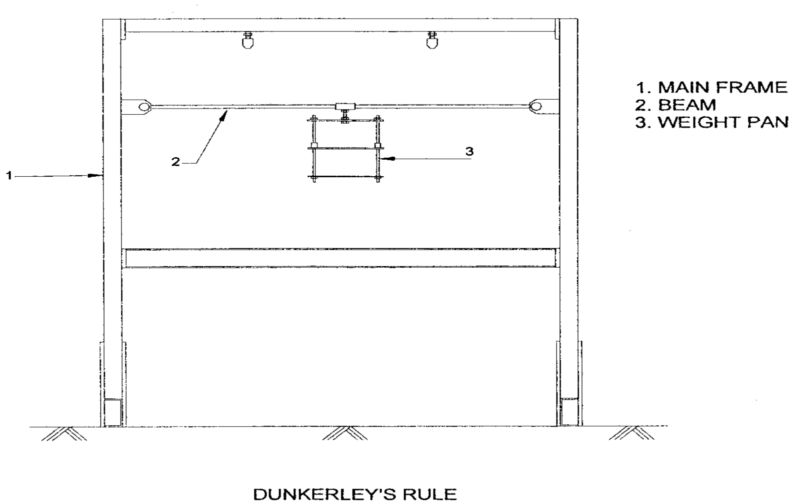


FIG. 1

CONCLUSIONS: $T_{expt} \cong T_{theo}$

T_{expt} = _____________sec

T_{theo} = _____________sec

Experiment-5

AIM: TO DETERMINE THE RADIUS OF GYRATION OF A GIVEN BAR BYUSING BI-FILAR SUSPENSION.

DESCRIPTION:

A uniform rectangular section bar is suspended from the pendulum support frame by two parallel cords. Top ends of the cords pass through the two small chucks fitted at the top. Other ends are secured in the Bi-Filer bar. It is possible to adjust the length of the cord by loosening the chucks.
The suspension may be used to determine the radius of gyration of any body. In this case, the body under investigation is bolted to the centre. Radius of gyration of the combined bar and body is then determined.

EXPERIMENTAL PROCEDURE:

1. Suspend the bar from chuck, and adjust the length of the cord 'L' conveniently. Note that the suspension length of each cord must be same.
2. Allow the bar to oscillate about the vertical axis passing through centre and measure the periodic time 'T' by knowing the time for say 10 oscillations.
3. Repeat the experiment by mounting the weights at equal distance from centre.
4. Complete the observation table given below.

FORMULAE:

1. **Actual time period,**

$$T_{act} = \frac{t}{n} \text{ sec}$$

2. **Actual radius of gyration, K_{act} from equation.**

$$T_{act} = 2\pi \frac{K_{act}}{a} \sqrt{\frac{L}{g}}$$

3. Theoretical radius of gyration, for beam

$$k_{theo} = \sqrt{\frac{L_{b^2}}{3} + \frac{h_{b^2}}{12}}$$

When weights are added away from center for each weight radius of gyration

$K_w = (b^2 = (r^2/2))^{½}$

Where, Distance of weight from beam center, b = 0.077m or 0.154 m
Radius of weight, r = 0.02m
For the weight at the centre $k_w = r / (2)^{0.5}$

Where, r = radius of the weight that is equal to 0.02 m
Now total moment of inertia of system

I_t = I beam + I weights
= $(m_{beam} \times Kb^2) + (m_{w1} \times K^2_{w1} \times n_1) + (m_{w2} \times K^2_{w2} \times n_2)$ + -----

Where, n_1 = no of weights at K_{w1}
n_2 = no of weights at K_{w2}
Now, $I_T = m\,(K_{eff.})^2$
$K_{eff.}$ = Effective radius of gyration
m = Total mass of this system = Mass of beam + Mass of weights

OBSERVATION & CALCULATION TABLE:

S.No.	L cm.	A cm.	No. of oscillations	Time for n oscillations	T_{act}	k_{act}	k_{theo}
1. **2.** **3.**							

NOMENCLATURE:

2a = Distance between the two string = 45.5 cm
g = Acceleration due to gravity
K_{act} = Actual radius of gyration of Bi-Filler suspension
K_{theo} = Theoretical radius of gyration of Bi-Filler suspension
L = Length of suspended string
$2L_b$ = Length of the Bi-filler bar
h_b = Thickness of bar
n = Nos. of oscillation
T_{act} = Actual time period
t = time taken for 10 oscillations

RESULT:

The Experimentally calculated Radius of Gyration of Bi-filer bar is
K_{act} = __________cm

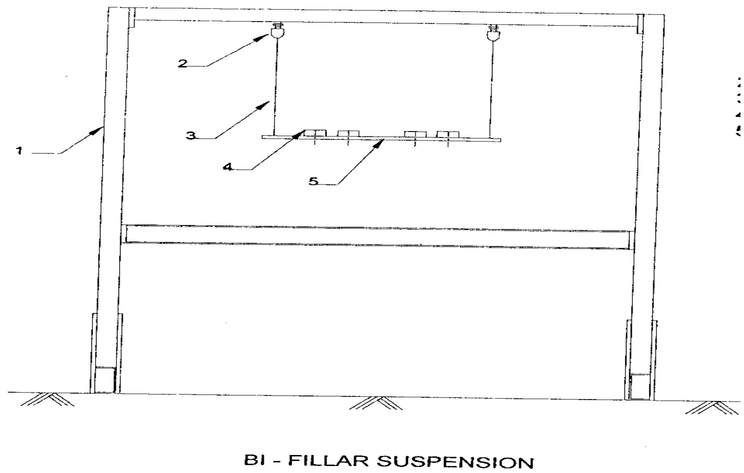


FIG. 1

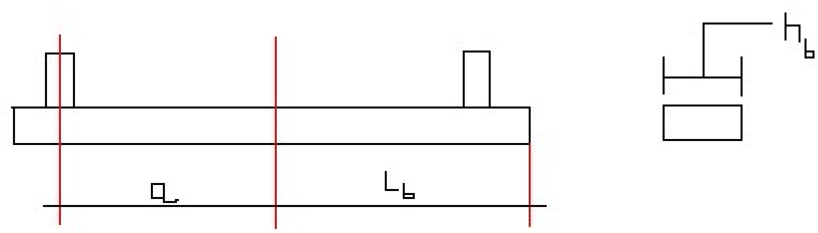


FIG. 2

1. Main Frame
2. Drill Chuck
3. Nylon Thread
4. Weight
5. Swinging Bar Bifiler

AIM: TO DETERMINE THE RADIUS OF GYRATION 'K' OF A COMPOUND PENDULUM.

$$T = 2\pi\sqrt{\frac{k^2 + (OG)^2}{g(OG)}}$$

Where T = periodic time in sec.

K	=	Radius of gyration about the C.G. in cm.
OG	=	Distance of C.G. of the rod from support.
L	=	Length of suspended pendulum.

DESCRIPTION:

The compound pendulum consists of a steel bar. The bar is supported by knife – edge. Two pendulums of different lengths are provided with the set- up.

EXPERIMENTAL PROCEDURE:

1. Support the rod on knife- edge.
2. Note the length of suspended pendulum and determine OG.
3. Allow the bar to oscillate and determine T by knowing the time for say 10 oscillations.
4. Repeat the experiment with different length of suspension.
5. Complete the observation table given below.

FORMULAE:

1. Time period Actual,

$$T_{actual} = \frac{t}{n} \text{ sec}$$

2. Actual radius of gyration, k_{act}

$$T_{act} = 2\pi\sqrt{\frac{k_{act}^{\,2} + (OG)^2}{g(OG)}}$$

3. Theoretical radius of gyration

$$k_{Theo} = \frac{L}{2\sqrt{3}}$$

OBSERVATION & CALCULATION TABLE:

Sr. No.	L cm.	OG cm	No. Of Osco. N	Time for Osco. t	T_{act}	K_{act}	K_{theo}
1.	L1=82.7	38.75	10				
2.	L2= 62.7	28.75	10				

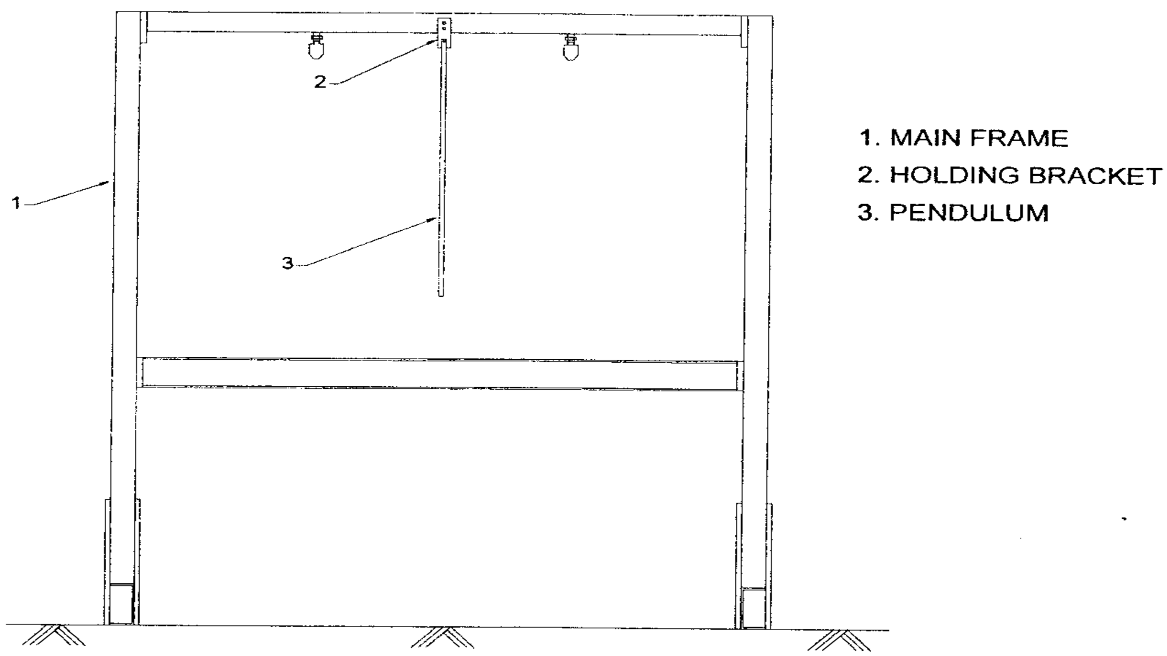
NOMENCLATURE:

K_{act}	=	Experimental Radius of gyration about the C.G. in cm
K_{theo}	=	Theoretical Radius of gyration about the C.G. in cm
L	=	Length of suspended pendulum.
n	=	Number of oscillations
OG	=	Distance of centre of Gravity of the rod from support.
T_{Theo}	=	Theoretical periodic time in sec.
T_{act}	=	Actual time period
t	=	Time required for 10 oscillation

RESULT:

The Experimentally calculated Radius of Gyration of compound bar

K_{act} = __________cm



COMPOUND PENDULUM

FIG: 1

Experiment-6

AIM: TO STUDY THE FORCED VIBRATION OF SYSTEM WITH DAMPING AND PLOT CURVES OF LOAD MAGNIFICATION FACTOR VS FREQUENCY AND PHASE ANGLE vs FREQUENCY CURVES. ALSO DETERMINE THE DAMPING FACTOR.

DESCRIPTION:

In this experiment, a slightly heavy rectangular section bar that is supported at both ends in trunion fittings. Exciter unit with the weight platform can be clamped at any conventional position along the beam. Exciter unit is connected to the damper, which provides the necessary damping.

DAMPING ARRANGEMENT:

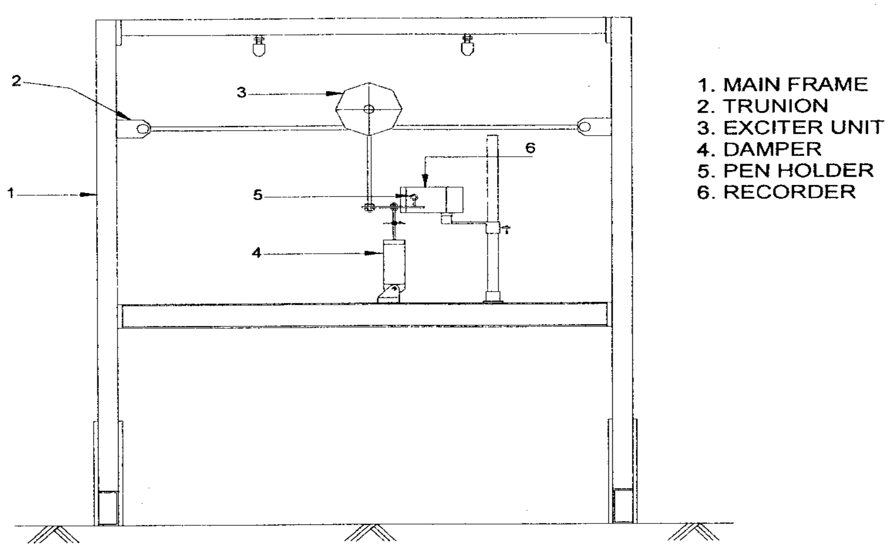
1. Close the one hole of damper for light damping.
2. Close the two holes of damper for medium damping.
3. Close all the three holes of damper for heavy damping.

EXPERIMENTAL PROCEDURE:

1. Arrange the set – up as shown in fig. 11.
2. Connect the exciter Motor to control panel.
3. Start the Motor and allow the system to vibrate.
4. Wait for 5 minutes for amplitude to build up for particular forcing frequency.
5. Adjust the position of strip chart recorder. Take the recorder of amplitude vs. time on strip chart recorder by starting recorder motor
6. Take record by changing forcing frequency for each damping.
7. Repeat the experiment for different damping.
8. Plot the graph of amplitude vs. frequency for each damping.

OBSERVATION TABLE:

Sr. No.	Forcing frequency	Amplitude



FORCED LATERAL VIBRATION OF BEAM
FOR DIFFERENT DAMPING

FIG. 1

Precautions and Maintenance:

1. Do not run the Motor at low Voltage i.e. less than 180 volts.
2. Do not increase the speed at once.
3. Damper is always in perpendicular direction.
4. A beam is properly tight in Bearing with bolt.
5. Always keep the apparatus free from dust.
6. A motor is properly tightened with weight.

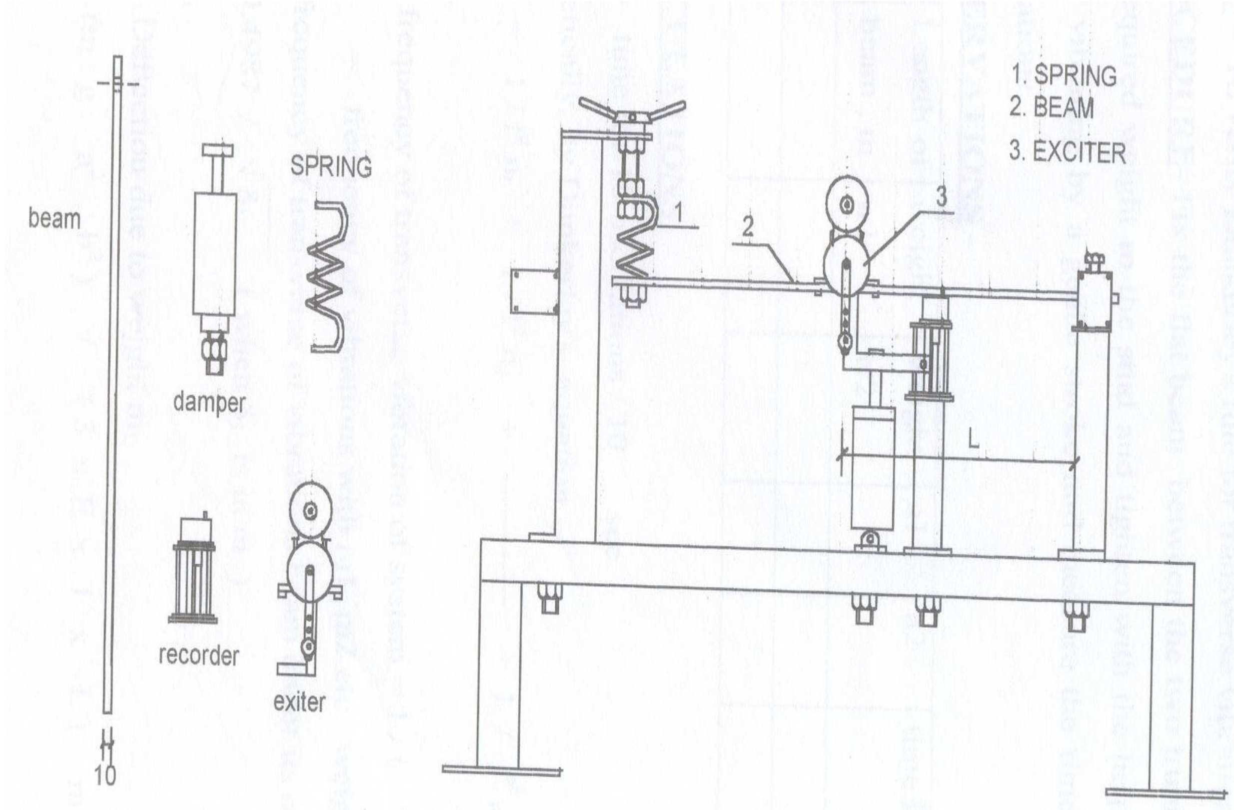


FIG. 2: FORCED DAMPED VIBRATION APPRATUS

Experiment-7

AIM: TO STUDY THE DAMPED TORSIONAL OSCILLATION AND TO DETERMINE THE DAMPING CO-EFFICIENT.

DESCRIPTION:

This experiment consists of a long elastic shaft gripped at the upper end by chuck in the bracket. The bracket is clamped to upper beam of the main frame. A heavy steel flywheel clamped at the lower end of the shaft suspended from bracket. Damping drum is fixed to the lower face of the flywheel. This drum is immersed in water, which provides damping. Rotor can be taken up and down for varying the depth of immersion of damping drum. Recording drum is mounted to the upper face of the flywheel. Paper is to be wrapped around the recording drum. Oscillations are recorded on the paper with the help of specially designed piston of dashpot. The piston carries the attachment for fixing sketch pen.

EXPERIMENTAL PROCEDURE:

1. With no water in the container allow the flywheel to oscillation & measure the time for say 10 oscillation.

2. Put thin mineral oil (no.10 or 20) in the drum and note the depth of immersion.

3. Put the sketch pen in its bracket.

4. Allow the flywheel to vibrate.

5. Allow the pen to descend. See that the pen always makes contact with paper & record oscillation.

6. Determine i. e. amplitude at any position &Entry. Amplitude after 'r' cycle.

7. After completing the experiment, drain the water.

FORMULAE:

1. Torsional stiffness,

$$K_t = \frac{G * I_p}{L}$$

2. Polar Moment stiffness,

$$Ip = \frac{\pi * d^4}{32}$$

3. Actual Time period,

$$T_{act} = \frac{t}{n} \sec$$

4. Theoretical Time period,

$$T_{theo} = 2 * \pi \sqrt{\frac{L}{K_t}}$$

5. Moment of Inertia of flywheel,

$$I = \frac{W * D^2}{g * 8}$$

6. Critical damping factor,

$$C_t = 2\frac{W}{g}\sqrt{\frac{K_t}{I}}$$

7. Logarithmic decrement

$$\delta = \frac{1}{r}\log_e\left[\frac{Xn}{Xntr.}\right]$$

8. Damping ratio, $\frac{C}{C_t} = \frac{\delta}{\sqrt{4\pi^2 + \delta^2}}$

OBSERVATION TABLE:

S No.	Length of Suspension of Shaft- Cm.	Xn (Cm.)	Xntr.(cm.)	NO. Of Cycles (r)	No. Of 'n' Oscillation.	Time of 'n' oscillation

CALCULATION TABLE:

S No.	K_t	T act.	T tho.	Critical Damping co-efficient (ct)	Logarithmic decrement δ	Damping co-efficient, C

NOMENCATURE:

K_t = Torsional Rigidity

G = modulus of rigidity= 8.5×10^{10} N/m^2

I_p = Polar moment of inertia

L = Length of shaft

d = Diameter of shaft = .003m

t = time required for n oscillation

n = number of oscillation

T_{act} = Actual time period

T_{theo} = Theoretical time period time period

I = Moment of inertia

W = Weight of disc = 9.65 Kg x 9.81 N/ m^2

D = Diameter of Flywheel = .25 m

g = Acceleration due gravity

Ct = Critical damping factor

δ = Logarithmic decrement

Xn = Amplitude of the vibration at the beginning of the measurement to be found from record

X_{ntr} = Amplitude of the vibration after r cycles from the record.

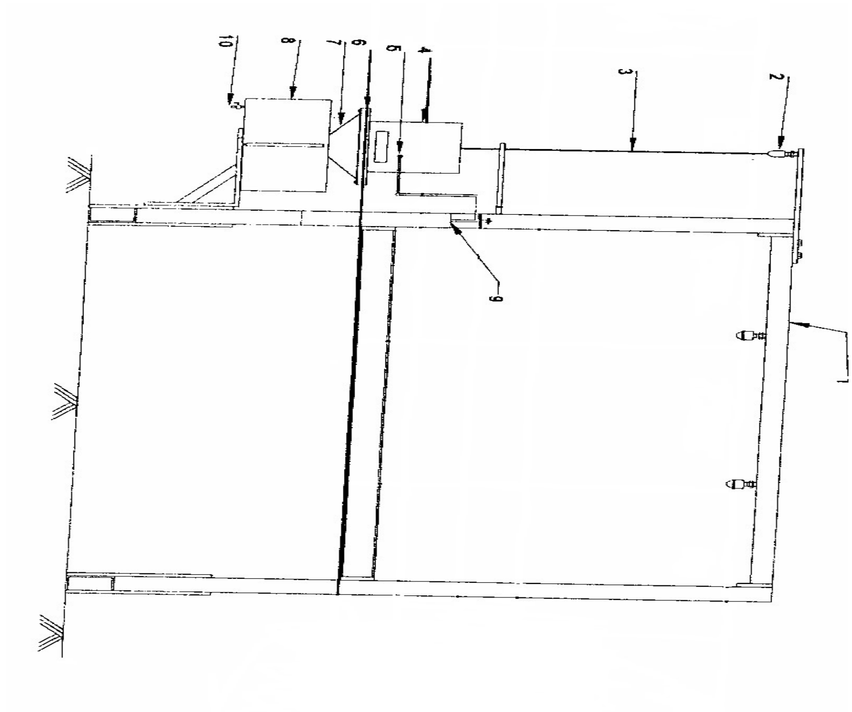


FIG: 1 : DAMPED TORSIONAL VIBRATION

Experiment-8

AIM: - TO DETERMINE THE RADIUS OF GYRATION OF DISC USING TRIFILAR SUSPENSION.

INDTRODUCTION:

Tri-filer suspension is a disc of mass m (weight W) suspended by three vertical cords, each of length 1, from a fixed support. Each cord is symmetrically attached to the disc at the same distance r from the mass of the disc.

THEORY:

The disc is now turned through a small angle about its vertical axis, the cords becomes inclined. One being released the disc will perform oscillations about the vertical axis. At any instant

Let: θ = Angular displacement of the disc

F = Tension in each cord = W/3

Inertia torque = 1 x θ

Restoring torque = 3 x Horizontal component forces of each string x r

Inertia torque = Restoring torque

DESCRIPTION:

A uniform circular disc is suspended from the pendulum support frame by three parallel cords. Top ends of the cords pass through the three small chucks fitted at the top. Other ends are secured in the Tri-Filer disc. It is possible to adjust the length of the cord by loosening the chucks.

EXPERIMENTAL PROCEDURE:

1. Suspend the disc from chucks, and adjust the length of the cord 'L' conveniently.
2. Note that the suspension length of each cord must be same.
3. Allow the disc to oscillate about the vertical axis passing through center
4. Measure the oscillation with time.
5. Repeat the experiment for different lengths & different radius.

OBSERVATION & CALCULATION

Observation Table:

S. No.	L, m	r, m	n	t, sec
1				
2				

CALCULATION:

$$T = \frac{t}{n}, \text{sec} = \text{-------------------------- sec.}$$

$$f = \frac{1}{T}, \text{sec}^{-1} = \text{-------------------------- sec}^{-1}$$

$$k = \frac{1}{2\pi f}\sqrt{\frac{gr^2}{L}} \text{ m} = \text{-------------------m.}$$

NOMENCLATURE:

r = Distance of cord from the mass of disc = 14cm

n = Number of oscillation.

t = Time for n oscillation, sec.

T = Time period of oscillation, sec.

f = Frequency of oscillation, sec^{-1}

L = Length of cord, m.

k = Radius of gyration, m.

m = mass of disc = 2.2Kg

PRECAUTIONS & MAINTENANCE INSTRUCTIONS:

1. Tight the drill chucks properly.
2. Length of each cord should be equal.