AVIT AARUPADAI VEEDU INSTITUTE OF TECHNOLOGY

VINAYAKA MISSION'S RESEARCH FOUNDATION (Deemed to be University under section 3 of the UGC Act 1956)

Accredited by NAAC | Approved by AICTE

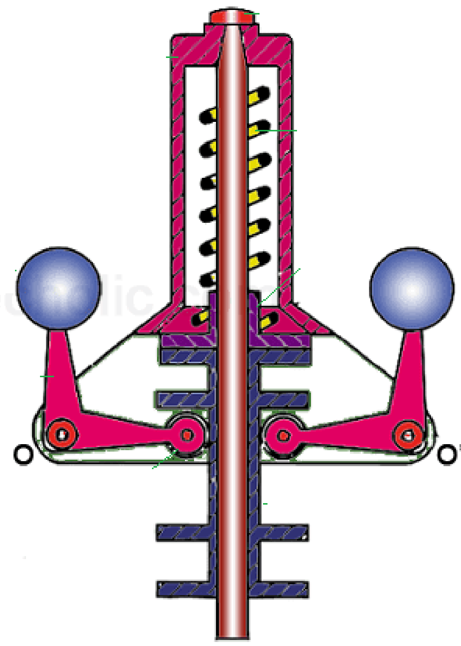
DEPARTMENT OF MECHANICAL ENGINEERING

BRANCH : MECHATRONICS

NAME OF THE LAB : 17MECC92-DYNAMICS LAB

REGULATION : 2017

LAB MANUAL



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DEPARTMENT OF MECHANICAL ENGINEERING
BRANCH : MECHATRONICS

DYNAMICS LAB
LIST OF EXPERIMENTS

1. Perform an experiment on Watt and Porter Governor and to find the Stability and sensitivity

2. Determine the controlling force and speed of a Proell Governor

3. Determine the position of sleeve against controlling force and speed of a Hartnell Governor and to plot the characteristic curve of radius of rotation

4. Analyse the motion of gyroscope couple using Motorized Gyroscope

5. Determination of critical speed of whirling shaft

6. Determination of Natural frequency of single degree freedom system in a spring mass system

7. Determination of Radius of Gyration using Compound pendulum

8. Determine the Moment of Inertia by Tri-filar and Bifilar suspension.

(Prof. L.PRABHU)

HOD MECH

1. TO PERFORM AN EXPERIMENT ON WATT AND PORTER GOVERNOR AND TO FIND THE STABILITY AND SENSITIVITY

AIM

To determine the Stability and Sensitivity of the Watt and Porter Governor.

DESCRIPTION:

The governor mechanism under test is fitted with the chosen rotating weights and spring where applicable and inserted in to the following simple procedure may then be followed. The control unit is switched on and the speed control slowly rotated increasing the governor speed until the center sleeves raises the lower stop and aligns with first division on the graduated scale. The sleeve position and speed are then recorded speed may be determined using a hand tachometer on the spindle. The governor speed is then increased in steps to give suitable sleeve movements and readings repeated at each stage through the range of sleeve movement possible. The result may be plotted as curves or speed against sleeve position. Further tests are carried out changing the value of variable at a time to draw curves.

FORMULA:

$$r = r_o + x*a/b$$

Where,

r= radius of rotation at any point
a= length of the vertical arm of bell crank lever (60mm)
b= length of the horizontal of bell crank lever (170mm)
r_o= initial radius of rotation (15.50mm)
x=sleeve displacement in cm
$\omega = 2\pi \mathbf{N}/60$

Sensitivity= $(N_1-N_2)/N$
Where,
N=mean speed
N_1=minimum equilibrium speed
N_2=maximum equilibrium speed

Effort= $(S_1-S_2)/2$

Where,
S_1=spring force at maximum speed =$2Fc_1.b/a$ (Fc_1=centrifugal force atN_1)
S_2=spring force at minimum speed =$2Fc_2.b/a$ (Fc_2=centrifugal force atN_2)

PROCEDURE:

1. The control unit is switched on.

2. The speed control knob is slowly rotated thereby increasing the governor speed.

3. This is repeated until the center sleeve rises of the lower stop and stabilizers at any division on the graduated scale.

4. The sleeve position and speed are recorded in the table.

5. The speed rotation is measured by using a tachometer.

6. Tabulate all these values.

7. Calculate the range of speed and sensitivity.

8. Verify with theoretical calculations.

9 Draw graphs for experimental values

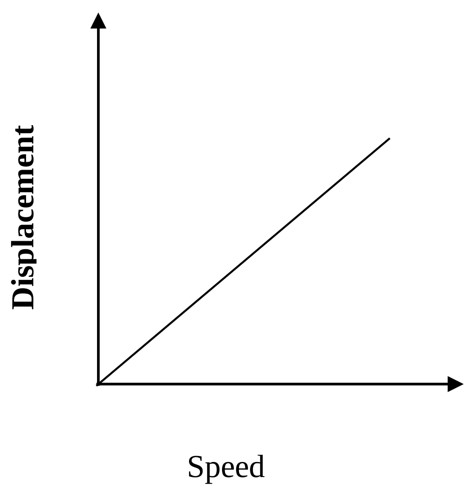
1. Speed vs. displacement

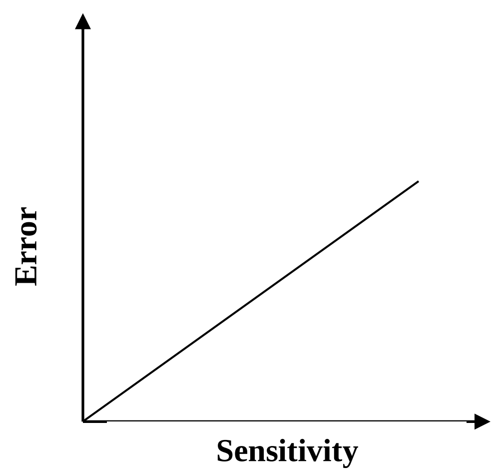
2.Sensitivity and error

TABULATION:

S.N	Motor Speed N RPM	Speed in Rpm $\omega = 2\pi N / 60$	Height x mm	$\cos\alpha = h/I$	Radius of rotation	Force $F= M\omega^2 r$

MODEL GRAPH:





RESULT:

Thus the characteristic curves for the Watt and Porter governor were plotted.

2. DETERMINE THE CONTROLLING FORCE AND SPEED OF A PROELL GOVERNOR

AIM:

To determine the controlling force and speed of a Proell Governor

DESCRIPTION:

Proell governor is similar to the porter governor having a heavy central load at sleeve. But it differs from porter governor in the arrangement of balls. The balls are carried on the extension of the lower arms instead of at the junction of upper and lower arms.

The center sleeve of the Porter and Proell governors incorporates a weight sleeve to which weights can be added. The Hartnell governor consists of a frame, spring and bell crank lever. The spring tension can be increased or decreased to study the governor.

FORMULA:

$$r = r_o + x*a/b$$

Where,

r= radius of rotation at any point

a= length of the vertical arm of bell crank lever (60mm)

b= length of the horizontal of bell crank lever (170mm)

r_o= initial radius of rotation (15.50mm)

x=sleeve displacement in cm

$\omega = 2\pi \mathbf{N}/60$

Sensitivity= $(N_1-N_2)/N$

Where,

N=mean speed

N_1=minimum equilibrium speed

N_2=maximum equilibrium speed

Effort= $(S_1-S_2)/2$

Where,

S_1=spring force at maximum speed $=2Fc_1.b/a$ (Fc_1=centrifugal force atN_1)

S_2=spring force at minimum speed $=2Fc_2.b/a$ (Fc_2=centrifugal force atN_2)

PROCEDURE:

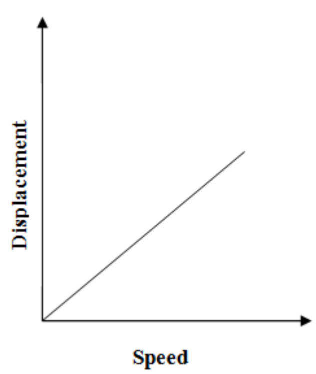
1. Assemble the governor to be tested.
2. Complete the electrical connections.
3. Switch ON the main power.
4. Note down the initial reading of pointer on the scale.
5. Switch On the rotary switch.
6. Slowly increase the speed of governor until the sleeve is lifted from its initial position by rotating Variac.
7. Let the governor be stabilized.
8. Increase the speed of governor in steps to get the different positions of sleeve lift at different RPM.
9. Increase the speed of governor in steps to get the different positions of sleeve lift at different RPM.

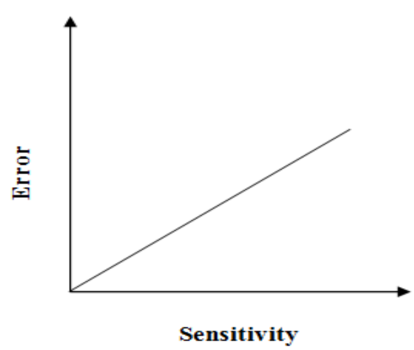
PRECAUTIONS:
1. Take reading carefully.
2. Measure the angle very carefully.
3. Measure the height of governor carefully.
4. Speed of governor measure accurate.

TABULATION:

S.N	Motor Speed N RPM	Speed in Rpm $\omega = 2\pi N / 60$	Height x mm	$\cos\alpha = h/l$	Radius of rotation	Force $F = M\omega^2 r$

MODEL GRAPH:





RESULT:

The characteristic curves for the Proell governor were plotted

3. TO DETERMINE THE POSITION OF SLEEVE AGAINST CONTROLLING FORCE AND SPEED OF A HARTNELL GOVERNOR.

AIM

To find the controlling force and speed and the characteristic curve of a radius of rotation of a Hartnell Governor.

DESCRIPTION:

The governor mechanism under test is fitted with the chosen rotating weights and spring where applicable and inserted in to the following simple procedure may then be followed. The control unit is switched on and the speed control slowly rotated increasing the governor speed until the center sleeves raises the lower stop and aligns with first division on the graduated scale. The sleeve position and speed are then recorded speed may be determined using a hand tachometer on the spindle. The governor speed is then increased in steps to give suitable sleeve movements and readings repeated at each stage through the range of sleeve movement possible. The result may be plotted as curves or speed against sleeve position. Further tests are carried out changing the value of variable at a time to draw curves.

FORMULA:

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Where,

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x=sleeve displacement in cm
$\omega = 2\pi \mathbf{N}/60$

Sensitivity= $(N_1-N_2)/N$
Where,
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Where,
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S_2=spring force at minimum speed $=2Fc_2.b/a$ (Fc_2=centrifugal force atN_2)

PROCEDURE:

1. The control unit is switched on.

2. The speed control knob is slowly rotated thereby increasing the governor speed.

3. This is repeated until the center sleeve rises of the lower stop and stabilizers at any division on the graduated scale.

4. The sleeve position and speed are recorded in the table.

5. The speed rotation is measured by using a tachometer.

6. Tabulate all these values.

7. Calculate the range of speed and sensitivity.

8. Verify with theoretical calculations.

9 Draw graphs for experimental values

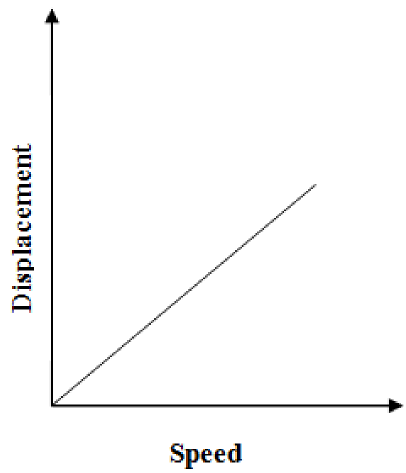
1. Speed vs. displacement

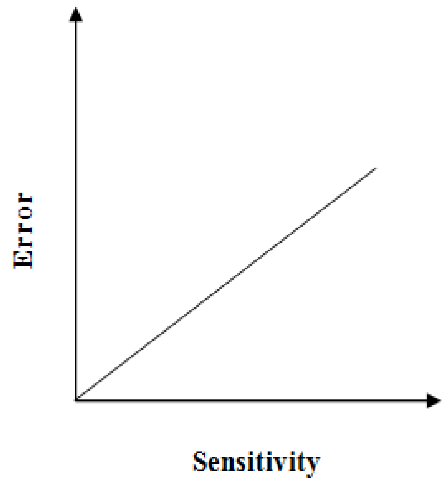
2 .sensitivity and error

TABULATION:

S.N	Motor Speed N RPM	Speed in Rpm $\omega = 2\pi N / 60$	Height x mm	$\cos\alpha = h/I$	Radius of rotation	Force $F = M \omega^2 r$

MODEL GRAPH:





RESULT:

The characteristic curves for the Hartnell governor were plotted.

4. **DETERMINATION OF GYROSCOPIC COUPLE USING MOTORIZED GYROSCOPE**

AIM:

To analyze the motion of a motorized Gyroscope when the couple is applied along its spin axis and determine the gyroscopic couple.

APPARATUS REQUIRED:

1. Metal disc
2. 1/6 HP AC/DC motor
3. Protractor scale
4. counter Weight
5. Stop watch
6. Tachometer

DESCRIPTION:

When a rotor rotating at an angular velocity 'ώ' (called the spin velocity} about an axis {called the spit axis} has the spin axis rotating with an angular velocity of 'ώρ'about an axis perpendicular to the spin axis, it gives rise to a couple called Gyroscopic couple. The motion of the spin axis is called the "processional motion" and the angular velocity 'ώρ' is called the Velocity of precession. The gyroscopic couple is given by

$$C=I\ \omega\ \omega_P$$

Where

C=the gyroscopic couple

ω =spinning velocity

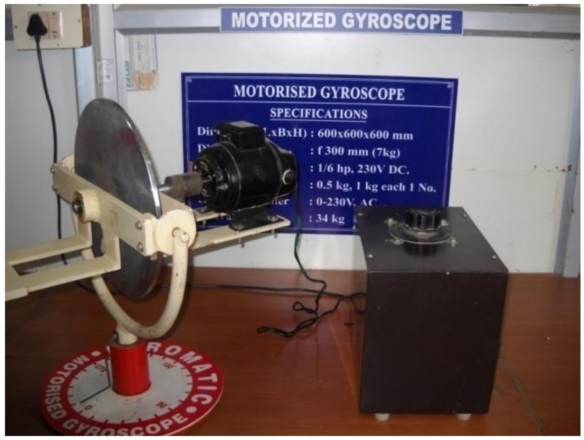
I= mass moment of inertia of the rotor about the spin axis

ω_P = velocity of precession

The following gyroscopic behaviors could be observed.

1) The spinning body exerts a torque or couple in such a direction as to mistake the spin velocity vector coincides with the processional velocity vector.

2) The spinning body processes in such a way as to make the spin vector coincide with the couple vector, when trued through $90^{0.}$



DESCRIPTION OF THE APPARATUS:

The motor is coupled to the disc rotor which is statically and dramatically balanced .The disc shaft rotates about the horizontal axis xx, and is supported by two ball bearing housed in the frame 1.Ball bearing are fixed to the yoke .In steady position frame no. I is balanced by providing a weight on the opposition side of the motor .The yoke frame is free to rotate about the vertical axis zz.This freedom of rotation about three perpendicular axes is given to the rotor.

FORMULA USED:

1. Angular velocity ω = $2\pi n/60$
2. Gyroscopic couple C = $I\ \omega\ \omega_P$
3. Torque = Weight x distance of the bolt center of the weight Pan from the disc center.
4. Percentage error = T-C /T x 100
5. ω_p = $d\Theta/dt$
6. $d\Theta$ = $\Theta \times \pi/180$

PROCDURE:

To study the first mentioned behavior, the following procedure is adopted

1. Balance the initial horizontal position of the rotor frames No .1
2. Start the motor by increasing the voltage with the autotransformer and wait until it attains constant speed.
3. Press the yoke frame No.2 about vertical axis by applying necessary force by hand to the same. {In the clockwise sense seen from above}.
4. It will be observed that the rotor frame swings about the horizontal axis yy. Motor side is seen coming upward and the weight pan side going downwards.
5. Rotate the vertical yoke in the anti clockwise sense seen from above and observe that the rotor frame swings in the opposite sense {as compared to that in previous case, following the above role}.

To study the second behavior, the following procedure is adopted,

1. Balance the rotor position on the horizontal frame.
2. Start the motor by increasing the voltage with the auto transformer and wait till the motor attains constant speed.
3. Put one of the weights {0.5kg, 1kg, 1.5kg} in the weight pan.
4. The vertical yoke zz processes as per the rule No

TABULATION

CONSTANT SPEED:

$$\omega = 2\pi N / 60$$

S.N	Weight applied	Torque kg-cm	Angle of precession	Time taken for precession	df/dt	% of Error

CONSTANT LOAD:

S.N	Speed N rpm	Torque kg-cm	Angle of precession	Time taken for precession	df/dt	% of error

RESULT:

Thus the experiment for the effect of gyroscope on rotating disc was conducted and experimental values are tabulated.

5. **DETERMINATION OF CRITICAL SPEED OF WHIRLING SHAFT**

AIM

To determine the Whirling speed of shaft theoretically and experimentally.

APPARATUS REQUIRED:

1. Shaft
2. Tachometer
3. Variac
4. Scale

DESCRIPTION:

In a rotating shaft at which instability occurs is called whirling or critical speed. When shaft reaches critical speed it will have maximum deflection. It is applicable in power transmitting equipments like turbine, propeller shafts, etc.The mid span disc has a center of masses that due to unbalanced is at a point G a distance ‘e’ from the geometrical center this distance is known as the eccentricity.

The Experiment will infer that by changing the diameter of the shaft its critical speed and its deflections over its length will change. i.e., if the shaft diameter is increasing then its Speed at Which instability occur will also increase. Similarly if the distance between the Center distances is decreasing then its deflection will decrease.

In the construction of whirling of shaft, the following basic features should be considered. The apparatus basically consist of rectangular bed mounted over the rectangular channel. Then three rectangular block of same size is fixed in the bed. The two blocks are fixing in one side and other one is fixed in opposite side.

A channel is fixed before two rectangular blocks. Above which a D.C Motor of 6000 rpm. And 1/12 hp is fixed. Through which a chuck is fixed in the motor. The two rectangular blocks are fixed in such a way that it carries a chuck. The chuck is used to transmit the power from the motor to shafts.

While in the other rectangular block a bush is connected according to the shaft size. i.e. for 8 mm rod the bush with 8 mm ID should be used. The regulator box is connected with D.C motor for the speed adjustment. Through which variation of speed can be arrived. Beyond this a non-contact speedometer is used to find out the speed of the shaft.

PROCEDURE:

- Check all the shaft has no bends over its length. Fix appropriate bush in the rectangular block.
- Then fix the shaft to the chuck in one end and support the same shaft with bush in other end.
- Now switch on the supply.
- Adjusting the regulator the motor speed can be varied.
- Then according to the calculation the critical speed through which maximum deflection is to be find out.

FORMULAE :

$f_n = C\sqrt{\{(E*I)/(m L^4)\}}$

$I = (\pi d^4)/64$

$E = 2.1*10^{11}\ N/m^2$

$\rho = m/v$

$\rho = 8*10^3\ Kg/m^3$

$V = (\pi d^2)/(4*L)$

$C = 2.45$

Where,

L – Distance between the chuck and the free end of the shaft

d – Diameter of the shaft in meters

E- Young's modulus

TABULATION

S.N	**Diameter of the shaft (d) in mm**	**Distance between chuck and free end (L) in mm**	**Theoretical Critical speed rpm**	**Deflection in mm**	**Node**
1					
2					
3					

RESULT:

Thus the theoretical and experimental of whirling speed of shaft was determined

6. **DETERMINATION OF NATURAL FREQUENCY OF SINGLE DEGREE OF FREEDOM SYSTEM IN A SPRING MASS SYSTEM**

AIM:

To determine the natural frequency of undamped free vibration and damped forced vibration of a spring mass system.

APPARATUS REQUIRED:

1. Spring mass system
2. Weights
3. Digital indicator

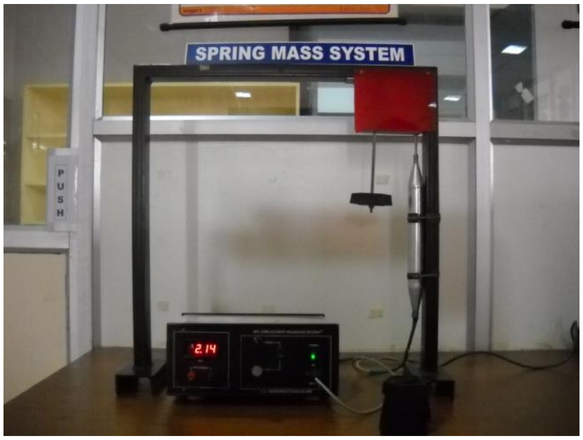
FORMULA:

Natural frequency of spring mass system = (1/2Л)[√ (g/ δ)] Hz

Where g = Acceleration due to gravity (9.81 m/s^2)
δ= Deflection of the spring in m.

DESCRIPTION:

It is well known fact that if a body held in position by elastic constraints and if it is displaced from its equilibrium position and then released the amplitude of the resulting vibration gradually diminishes as the vibration energy is dispersed in overcoming friction. And the vibration is used is said to be undamped, if there is no resistance to the motion of the vibration body.



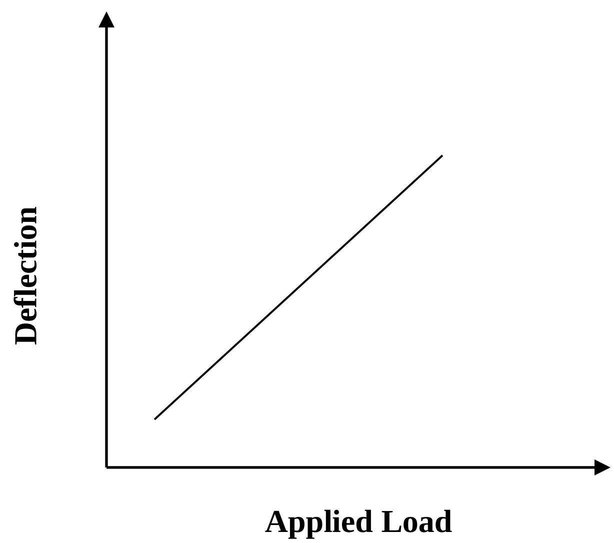
PROCEDURE:

1. Connect the main chord to the 230 Volts / 50 Hz. A.C supply and switch on the instrument.
2. Keep the READ/CAL switch at READ position and turn the zero potentiometer till it displays 00.00.
3. Keep the READ/CAL switch at CAL position and turn the zero till the displays read 10.00.
4. Keep the READ/CAL switch again READ position and ensure 00.00.
5. Supply the load as weights in terms of Kg.
6. Now display read the correct deflection directly in mm.

GRAPH:

APPLIED LOAD Vs DEFLECTION

MODEL GRAPH:



TABULATION

S.N	Applied Load (Kg)	Deflection δ (mm)	Frequency (Hz)
1.	0.5		
2.	1.0		
3.	1.5		
4.	2.0		
5.	2.5		

RESULT:

Thus, the natural frequency of a spring mass system was found out.

7. DETERMINATION OF RADIUS OF GYRATION USING COMPOUND PENDULUM

. **AIM:**

To find the moment of inertia by compound pendulum

APPARATUS REQUIRED:

Stop watch
Circular Disc
Wire or Rope
Scale

COMPOUND PENDULUM

Determine the radius of gyration "K" of the given compound pendulums by using the relation given below and thereby verifying it.

$$T\text{-}2\pi\sqrt{}\,(k^2+(OG)^2/(g*(OG))$$

Where, K=Radius of gyration about centre of gravity in "cm"
OG=Distance from centre of the rod to support in"cm"
G-Centre of Gravity =9.81 m/s^2

FORMULA USED:

Theoretical radius of gyration, K_{th} =L/2*√3cm
Where, L= length of the rod in "cm".

PROCEDURE:

The rod is supported on the knife-edge.
The total length of suspended rod is noted and "OG" is determined.
The bar is allowed to oscillate and the time taken for 10 oscillations is noted
The time period is calculated.
The same procedure repeated for the other pendulum.
Using the experimental time period the radius gyration is calculated using given relation.
The experimental value is verified with the theoretical value.

TABULATION:

S.N	Length of Compound Pendulum ”L” cm	OG cm	Time for 10 oscillations t sec	Time period T EXP =t/10 sec	K EXP m
1					
2					
3					

Mean=

RESULT:

The radius of gyration of Compound pendulum was determined

8. DETERMINE THE MOMENT OF INERTIA BY TRI-FILAR AND BIFILAR SUSPENSION.

AIM:

To find the moment of inertia Tri-filar and Bi-filar suspension system.

APPARATUS REQUIRED:

Stop watch
Circular Disc
Rectangle Disc
Wire or Rope
Scale

TRIFILAR SUSPENSION SYSTEM
THEORY:

When a rigid body is suspended vertically, and it oscillates with small amplitude under the action of the force of gravity, the body is known as compound pendulum.

The following steps to be carried out to determine the mass moment of inertia of the given body.

Select trifler plates.
With the help of string of chucks tighten at tops.
Adjust length of string to desire values are measure length as it is.
Give small horizontal twist.
Start stop watch and note down time required for 5 or 10 oscillations.
Repeat experiment by adding weight and changing length.

OBSERVATIONS:

Weight of trifler plate M2 = ……………………………………kg
Additional weight added, W = ……………………………………kg
Distance of string from centre of gravity, for trifler plate, b = …..m

CALCULATION:

TRIFILAR SUSPENSION:

First with single plate find out frequency and next with added weights find out the frequency of oscillations.

Period T = N/t

Frequency with only plate fn = 1/T

Frequency with added weight fn = 1/ T

Now moment of inertia plate only, $I_P = \frac{R^2 m_2}{4\pi^2 fn^2 xL}$

Now moment of inertia with added weight, $I_W = \frac{R^2 m_2 + W}{4\pi^2 fn^2 xL}$

TABULATION:

Type of suspension	Length(L) m	No Oscillation(N)	Time taken(t) sec	Weight added(W) kg
Tri-filar				

BI- FILAR SUSPENSION SYSTEM

THEORY:

When a rigid body is suspended vertically, and it oscillates with small amplitude under the action of the force of gravity, the body is known as compound pendulum.

The following steps to be carried out to determine the mass moment of inertia of the given body.

Select bifilar plates.
With the help of string of chucks tighten at tops.
Adjust length of string to desire values are measure length as it is.
Give small horizontal twist.
Start stop watch and note down time required for 5 or 10 oscillations.
Repeat experiment by adding weight and changing length.

OBSERVATIONS:

Weight of trifler plate M2 = ……………………………………kg
Additional weight added, W = ……………………………………kg
Distance of string from centre of gravity, for bi-filar plate, b = …..m

CALCULATION:

BI-FILAR SUSPENSION:

First with single plate find out frequency and next with added weights find out the frequency of oscillations.
Period T = N/t
Frequency with only plate fn = 1/T
Frequency with added weight fn = 1/ T
Now moment of inertia plate only, $I_P = \frac{R^2 m_2}{4\pi^2 fn^2 xL}$
Now moment of inertia with added weight, $I_W = \frac{R^2 m_2 + W}{4\pi^2 fn^2 xL}$

TABULATION:

Type of suspension	Length(L) m	No Oscillation(N)	Time taken(t) sec	Weight added(W) kg
Bi-filar				

RESULT:

Thus the moment of inertia of Tri-filar and Bi-filar suspension system was determined