Estd: 2008

METHODIST

COLLEGE OF ENGINEERING & TECHNOLOGY

Approved by AICTE New Delhi | Affiliated to Osmania University, Hyderabad

Abids, Hyderabad, Telangana, 500001

DEPARTMENT OF MECHANICAL ENGINEERING

LABORATORY MANUAL

DYNAMICS OF MACHINES LABORATORY

BE V Semester

For the Students admitted in AICTE Scheme

Name: ....

Roll No: ....

Branch:...SEM:......................

Academic Year: ....

Empower youth - Architects of Future World

METHODIST

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VISION

To produce ethical, socially conscious and innovative professionals who would contribute to sustainable technological development of the society.

MISSION

To impart quality engineering education with latest technological developments and interdisciplinary skills to make students succeed in professional practice.

To encourage research culture among faculty and students by establishing state of art laboratories and exposing them to modern industrial and organizational practices.

To inculcate humane qualities like environmental consciousness, leadership, social values, professional ethics and engage in independent and lifelong learning for sustainable contribution to the society.

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DEPARTMENT OF MECHANICAL ENGINEERING

LABORATORY MANUAL

DYNAMICS OF MACHINES LABORATORY (PC592ME)

Prepared by

Mr. Abdul Fazal, Assistant Professor. Mech. Engg.
Mr. Kamal Kumar Ojha, Assistant Professor. Mech. Engg.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be a reputed centre of excellence in the field of mechanical engineering by synergizing innovative technologies and research for the progress of society.

MISSION

- To impart quality education by means of state-of-the-art infrastructure.
- To involve in trainings and activities on leadership qualities and social responsibilities.
- To inculcate the habit of life-long learning, practice professional ethics and service the society.
- To establish industry-institute interaction for stake holder development.

DEPARTMENT OF MECHANICAL ENGINEERING

After 3-5 years of graduation, the graduates will be able to:

PEO1: Excel as engineers with technical skills, and work with complex engineering systems.

PEO2: Capable to be entrepreneurs, work on global issues, and contribute to industry and society through service activities and/or professional organizations.

PEO3: Lead and engage diverse teams with effective communication and managerial skills.

PEO4: Develop commitment to pursue life-long learning in the chosen profession and/or progress towards an advanced degree

DEPARTMENT OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES

Engineering Graduates will be able to:

Po1. Engineering knowledge: Apply the basic knowledge of mathematics, science and engineering fund a mentals along with the specialized knowledge of mechanical engineering to understand complex engineering problems.

PO2. Problem analysis: Identify, formulate, design and analyse complex mechanical engineering problems using knowledge of science and engineering.

Po3. Design/development of solutions: Develop solutions for complex engineering problems, design and develop system components or processes that meet the specified needs with appropriate consideration of the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Formulate engineering problems, conduct investigations and solve using research-based knowledge.

PO5. Modern tool usage: Use the modern engineering skills, techniques and tools that include IT tools necessary for mechanical engineering practice.

Po6. The engineer and society: Apply the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities during professional practice.

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10.Communication: Communicate effectively on complex engineering activities to various groups, ability to write effective reports and make effective presentations.

PO11. Project management and finance: Demonstrate and apply the knowledge to understand the management principles and financial aspects in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in Independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

Mechanical Engineering Graduates will be able to:

PSO1: Apply the knowledge of CAD/CAM/CAE tools to analyse, design and develop the products and processes related to Mechanical Engineering.

PSO 2: Solve problems related to mechanical systems by applying the principles of modern manufacturing technologies.

PSO 3: Exhibit the knowledge and skill relevant to HVAC and IC Engines.

CODE OF CONDUCT

1. Students should report to the concerned labs as per the time table schedule.
2. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.
3. After completion of the experiment, certification of the concerned staff in-charge in the observation book is necessary.
4. Staff member in-charge shall award marks based on continuous evaluation for each experiment out of maximum 15 marks and should be entered in the evaluation sheet/attendance register.
5. Students should bring a note book of about 100 pages and should enter the readings/observations into the note book while performing the experiment.
6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate last session should be submitted and certified by the staff member in-charge.
7. Not more than three students in a group are permitted to perform the experiment on a setup for conventional labs and one student in case of computer labs.
8. The components required pertaining to the experiment should be collected from stores in-charge after duly filling in the requisition form.
9. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.
10. Any damage of the equipment or burn-out of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.
11. Students should be present in the labs for the total scheduled duration.
12. Students are required to prepare thoroughly to perform the experiment before coming to Laboratory.

DO'S

1. All the students are instructed to wear protective uniforms, shoes & identity cards before entering into the laboratory.
2. Please follow instructions precisely as instructed by your supervisor. If any part of the equipment fails while being used, report it immediately to your supervisor.
3. Students should come with thorough preparation for the experiment to be conducted.
4. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
5. Practical records should be neatly maintained.
6. Students should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
7. Theory regarding each experiment should be written in the practical record before procedure in your own words.
8. Utmost care must be taken to avert any possible injury while working on Whirling of shafts and Cam apparatus analysis. In case, anything occurs immediately report to the staff members.

DON'TS

1. Don't operate any instrument without getting concerned staff member's prior permission.
2. Using the mobile phone in the laboratory is strictly prohibited.
3. Do not leave the experiments unattended while in progress.
4. Do not crowd around the equipment & run inside the laboratory.
5. Do not wander around the lab and distract other students
6. Do not use any machine that smokes, sparks, or appears defective.

COURSE OBJECTIVES

The objectives of this course are to:

1	Understand the effects and importance of kinematic and dynamic analysis of mechanisms.
2	Understand effects and analysis of Single degree freedom vibration systems
3	Study the gyroscope, governors and cams
4	Carry out the static and dynamic analysis of four bar mechanisms and drives

COURSE OUTCOMES

CO No.	Course Outcomes	PO
CO 1	Analyze the performance and draw the characteristic curves for different types of governors.	1,2,4,8,9,10
CO 2	Evaluate the effect of gyroscopic couple at different speeds.	1,2,4,5,8,9,10
CO 3	Evaluate kinematic and dynamic behaviour of different types of cams.	1,2,4,5,9,10
CO 4	Evaluate static and dynamic balancing of rotating masses.	1,2,4,8,9,10
CO 5	Analyze natural frequencies of various beams with different constraints.	1,2,4,5,8,9,10
CO 6	Determine the critical speed for shafts of various diameter.	1,2,5,9,10

COURSE OUTCOMES VS POs MAPPING

S. NO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PC592ME.1	3.0	3.0	-	3.0	-	-	-	3.0	3.0	3.0	-	-	3.0	-	-
PC592ME.2	3.0	3.0	-	3.0	2.0	-	-	3.0	3.0	3.0	-	-	3.0	-	-
PC592ME.3	3.0	3.0	-	3.0	3.0	-	-	-	3.0	3.0	-	-	3.0	-	-
PC592ME.4	3.0	3.0	-	3.0	-	-	-	3.0	3.0	3.0	-	-	3.0	-	-
PC592ME.5	3.0	3.0	-	2.0	2.0	-	-	2.0	3.0	3.0	-	-	3.0	-	-
PC592ME.6	2.0	2.0	-	-	3.0	-	-	-	3.0	3.0	-	-	3.0	-	-
Avg	2.8	2.8	-	2.8	2.5	-	-	2.8	3.0	3.0	-	-	3.0	-	-

LIST OF EXPERIMENTS

Note: At least ten experiments should be conducted in the Semester

INDEX

Experiment No	Experiment Name	Date	Page No	Marks				Remarks/ Signature
				P	R	V	T	

Experiment No	Experiment Name	Date	Page No	Marks				Remarks/ Signature
				P	R	V	T	

EXPERIMENT - 01
EXPERIMENT ON PERFORMANCE CHARACTERISTIC CURVES OF WATT GOVERNOR

AIM:

To determine the characteristic curves of Watt governor.

APPARATUS REQUIRED:

1. Governor setup
2. Speed regulator
3. Tachometer

THEORY :

The function of a governor is to maintain the mean speed of a machine/prime mover, by regulating the input to the machine/prime mover automatically, when the variation of speed occurs due to fluctuation in the load. The drive unit consists of a small electric motor connected through the belt and pulley arrangement. A DC Variac effects precise speed control and an extension of the spindle shaft allows the use of hand held tachometer to find the speed of the governor spindle. A graduated scale is fixed to the sleeve and guided in vertical direction.

Specifications:

1. Length of each link ‘l‘ = 125 mm
2. Initial height of governor (ho) = 105 mm
3. Initial radius of rotation(ro)= 116mm
4. Mass of each ball (m) = 0.5 kg

PROCEDURE:

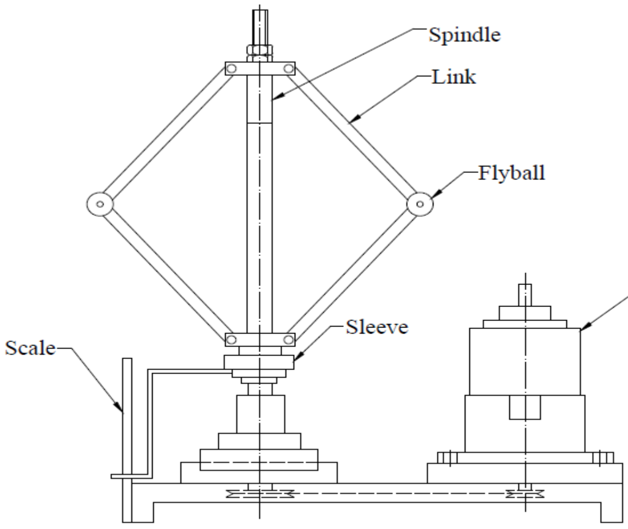
1. Mount the watt governor mechanism on the drive unit of the governor apparatus.
2. Vary the governor spindle speed by adjusting the Variac. The speed can be determined by the hand tachometer.
3. Increase the speed of the governor spindle gradually by adjusting the Variac and note down the speed at which the sleeve just begins to move up.
4. Take four or five sets of readings by increasing the governor speed in steps and note down the corresponding sleeve displacement within the range of the governor and tabulate the observations.

Precautions:

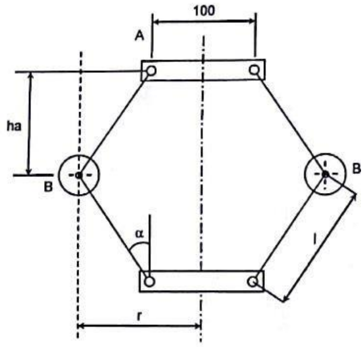
1. Take the sleeve displacement reading when the pointer remains steady.
2. See that at higher speed the load on the sleeve does not hit the upper sleeve of the governor.
3. While closing the test bring the pointer to zero position and then switch off the motor.

Observation Table:

Sl.No	Speed in RPM	Sleeve Displacement "X"



EXPERIMENTAL SETUP OF WATT GOVERNOR



WATT GOVERNOR

Calculations:

1. Height of the governor(h) = [ho - (x/2)]

=

=

2. Find" α "using Cos α = h / l

$\propto = cos^{-1}$(h/l)

$\propto$=

3. Radius of rotation r = 47 +1 sin $\propto$

r =

4. The controlling force F = $m\omega^2 r$

Where,

m = Weight of ball assembly.

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

r= Radius of rotation

F = N

Space For Calculations:

RESULT & CONCLUSION:

Result Tabulation:

Sl .No	Height cos∝ = h / l	Radius of Rotation	Force

Graph: Draw the

i. Force Vs radius of rotation.

ii. Speed Vs sleeve displacement.

Thus the characteristic curves of the WATT Governor are determined.

VIVA QUESTIONS:

1. What is meant by governor?
2. What are types of governors?
3. What is meant by the sensitivity of the governor?
4. What is the classification of governors?
5. What is meant by a centrifugal governor?
6. What is meant by inertia governors?

EXPERIMENT - 02
EXPERIMENT ON PERFORMANCE CHARACTERISTIC CURVES OF PORTER GOVERNOR

AIM:

To determine the characteristic curves of PORTER governor.

APPARATUS REQUIRED:

1. Governor setup
2. Speed regulator
3. Tachometer
4. Dead weights

THEORY :

The function of a governor is to maintain the mean speed of a machine/prime mover, by regulating the input to the machine/prime mover automatically, when the variation of speed occurs due to fluctuation in the load. The drive unit consists of a small electric motor connected through the belt and pulley arrangement. A DC Variac effects precise speed control and an extension of the spindle shaft allows the use of hand held tachometer to find the speed of the governor spindle. A graduated scale is fixed to the sleeve and guided in vertical direction.

specifications:

1. Length of each line L=125 mm
2. Initial height of governor 'ho'=105 mm
3. Initial radius of Rotation 'ro' = 116 mm
4. Weight of each ball assembly 'm'=0.5 Kg

PROCEDURE:

1. The following simple procedure may then be followed.
2. The governor mechanism under test is fitted with the chosen rotating weights and spring, where applicable, and inserted into the drive unit.
3. The control unit is switched on and the speed control knob is slowly turned to increase the governor speed until the centre sleeve rises off the lower stop and aligns with some divisions on the graduated scale. The sleeve position and speed are then

recorded.

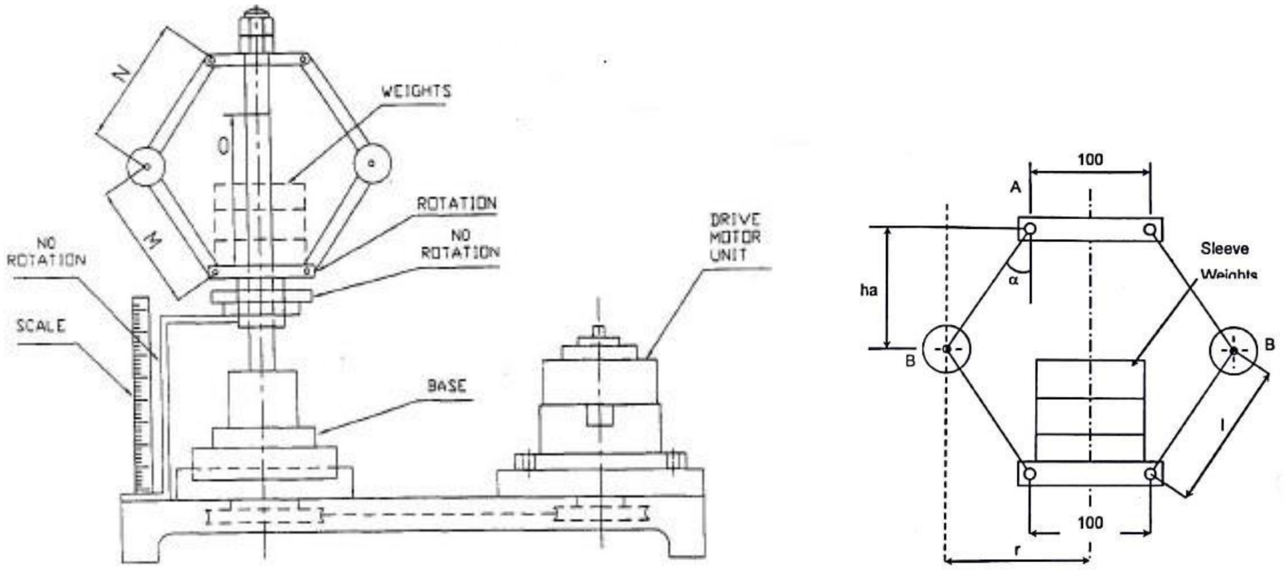
4. The governor speed is then increased in steps to give suitable sleeve movements and readings are recorded at each stage throughout the range of sleeve movement possible.
5. The radius of rotation for corresponding sleeve displacement is measured directly by switching off the electronic control unit.

Precautions:

1. Take the sleeve displacement reading when the pointer remains steady.
2. See that at higher speed the load on the sleeve does not hit the upper sleeve of the governor.
3. While closing the test bring the pointer to zero position and then switch off the motor.

Observation Table:

Sl.No	Speed in RPM	Sleeve Displacement "X"



PORTER GOVERNOR

Calculations:

1. Height of the governor(h) = [ho - (x/2)]

=

=

2. Find" α "using $\cos\alpha = h / l$

$\propto = cos^{-1}$(h/l)

$\propto =$

3. Radius of rotation r = 50 + l sin$\propto$

r =

4. The controlling force F = mω^2r
Where,

m = Weight of ball assembly.

ω = 2 π N/60 rps

r= Radius of rotation

F = N

Space For Calculations:

RESULT & CONCLUSION:

Result Tabulation:

Sl .No	Height cos∝ = h / l	Radius of Rotation	Force

Graph: Draw the

i. Force Vs radius of rotation.

ii. Speed Vs sleeve displacement.

Thus the characteristic curves of the PORTER Governor are determined.

VIVA QUESTIONS:

1. Define height of governor.
2. Define equilibrium speed in case of governor.
3. Define the effort of a governor.
4. Define power of a governor
5. Define hunting for a governor.
6. Define sensitiveness of a governor.

EXPERIMENT - 03
EXPERIMENT ON PERFORMANCE CHARACTERISTIC CURVES OF PROELL GOVERNOR

AIM:

To determine the characteristic curves of PROELL governor.

APPARATUS REQUIRED:

1. Governor setup
2. Speed regulator
3. Tachometer
4. Dead weights

THEORY:

The function of a governor is to maintain the mean speed of a machine/prime mover, by regulating the input to the machine/prime mover automatically, when the variation of speed occurs due to fluctuation in the load. The drive unit consists of a small electric motor connected through the belt and pulley arrangement. A DC Variac effects precise speed control and an extension of the spindle shaft allows the use of hand held tachometer to find the speed of the governor spindle. A graduated scale is fixed to the sleeve and guided in vertical direction.

The centre sleeve of the Porter and Proell governors incorporates a weight sleeve to which weights may be added. The Hartnell governor provides means of varying spring rate and initial compression level and mass of rotating weight. This enables the Hartnell governor to be operated as a stable or unstable governor.

Specifications:

1. Weight of each ball assembly 'm' = 0.5 Kg.
2. Weight of sleeve = 2 Kg. Each
3. Extension of length BG = 75 mm

PROCEDURE:

1. The following simple procedure may then be followed.
2. The governor mechanism under test is fitted with the chosen rotating weights and spring, where applicable, and inserted into the drive unit.
3. The control unit is switched on and the speed control knob is slowly turned to

increase the governor speed until the centre sleeve rises off the lower stop and aligns with some divisions on the graduated scale.

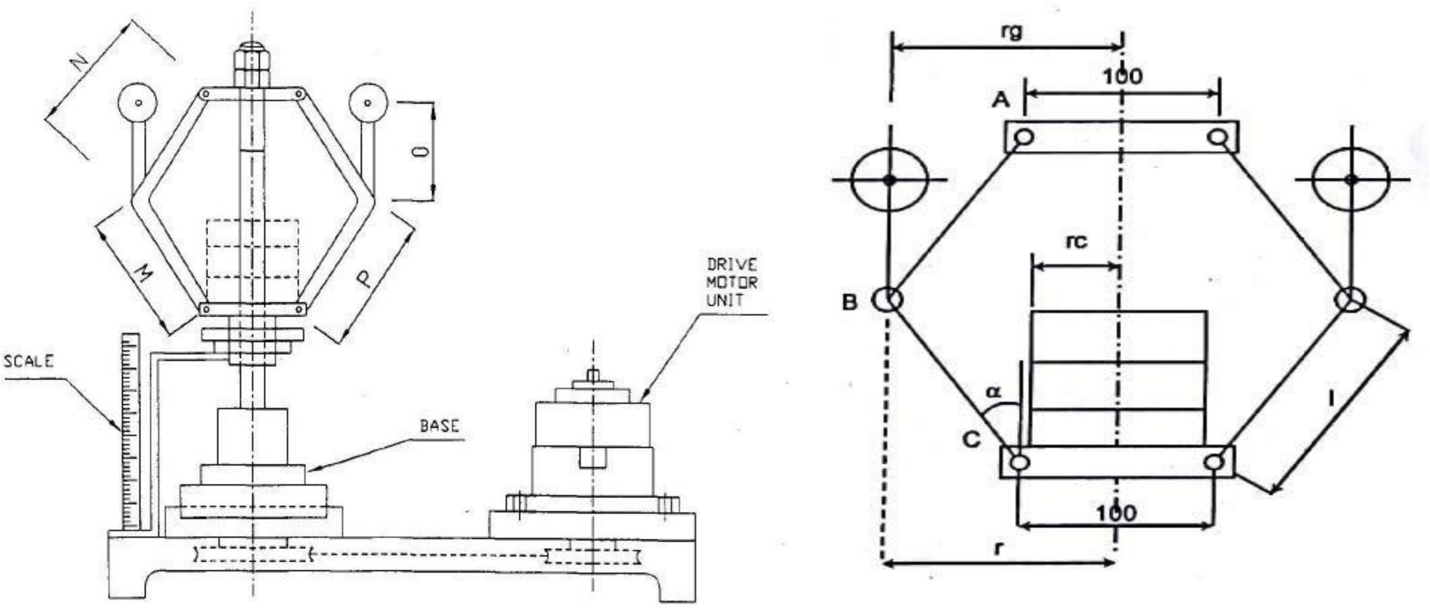
4. The sleeve position and speed are then recorded.
5. The governor speed is then increased in steps to give suitable sleeve movements and readings are recorded at each stage throughout the range of sleeve movement possible.
6. The radius of rotation for corresponding sleeve displacement is measured directly by switching off the electronic control unit.

Precautions:

1. Take the sleeve displacement reading when the pointer remains steady.
2. See that at higher speed the load on the sleeve does not hit the upper sleeve of the governor.
3. While closing the test bring the pointer to zero position and then switch off the motor.

Observation Table:

Sl.No	Speed in RPM	Sleeve Displacement "X"



PROELL GOVERNOR

Calculations:

1. Height of the governor(h) = [ho - (x/2)]

=

=

2. Find" α "using Cos $\alpha = h / l$

$\propto = cos^{-1}(h/l)$

$\propto =$

3. Radius of rotation $r = 50 + 1 \sin \propto$

r =

4. The controlling force $F = m\omega^2 r$
Where,

m = Weight of ball assembly.

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

r= Radius of rotation

F = N

Space For Calculations:

RESULT & CONCLUSIONS:

Result Tabulation:

Sl .No	Height cos∝ = h / l	Radius of Rotation	Force

Graph: Draw the

i. Force Vs radius of rotation.

ii. Speed Vs sleeve displacement.

Thus the characteristic curves of the PROELL Governor are determined.

VIVA QUESTIONS:

1. Define stability of a governor.
2. Define stability of a governor.
3. Define isochronisms of a governor.
4. A governor has_________influence over cyclic speed fluctuation.
5. The ratio of the difference between maximum and minimum speed to the mean equilibrium speed.
6. The balls occupy a definite specified position for each speed within the working range.

EXPERIMENT - 04
EXPERIMENT ON PERFORMANCE CHARACTERISTIC CURVES OF HARTNELL GOVERNOR

AIM:

To determine the characteristic curves of HARTNELL governor.

APPARATUS REQUIRED:

1. Governor setup
2. Speed regulator
3. Tachometer
4. Dead weights

THEORY:

The function of a governor is to maintain the mean speed of a machine/prime mover, by regulating the input to the machine/prime mover automatically, when the variation of speed occurs due to fluctuation in the load. The drive unit of the governor consists of a small electric motor connected through a belt and pulley arrangement. A D.C. Variac effects precise speed control. A photoelectric pick up is used to find speed of the governor spindle. The set up is designed to produce pulses proportional to rpm of shaft using phototransistor as the sensing element. A graduated scale is fixed to the sleeve and guided in vertical direction.

Specifications:

1. Length a = 77 mm
2. Length b = 127mm
3. Weight of each ball assembly = 500 grm
4. Initial radius of rotation = 161 mm
5. Spring stiffness p = 5 Kg /cm
6. Free height of spring 13 cm
7. Weight of sleeve = 3500 grm

PROCEDURE:

1. Mount the Hartnell governor mechanism on the drive unit of the governor apparatus.
2. Vary the governor spindle speed by adjusting the variac.
3. Increase the speed of the governor spindle gradually by adjusting the variac and note down the speed at which the sleeve just begins to move up.

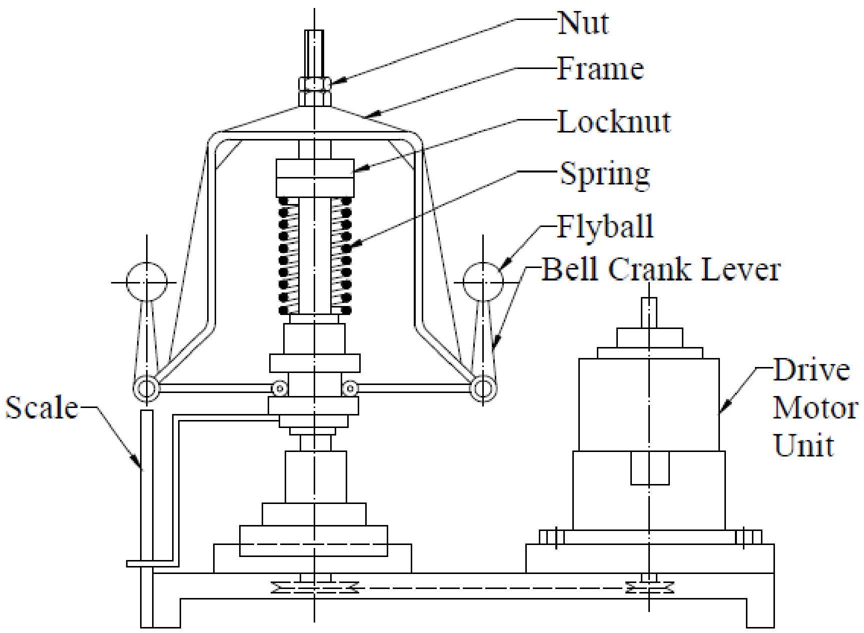
4. Take four or five sets of readings by increasing the governor speed gradually in steps and note down the corresponding sleeve movement within the range of the governor.

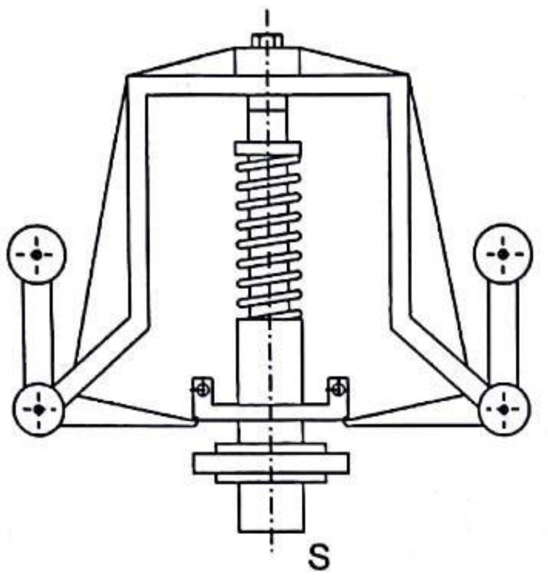
Precautions:

1. Take the sleeve displacement reading when the pointer remains steady.
2. See that at higher speed the load on the sleeve does not hit the upper sleeve of the governor.
3. While closing the test bring the pointer to zero position and then switch off the motor.

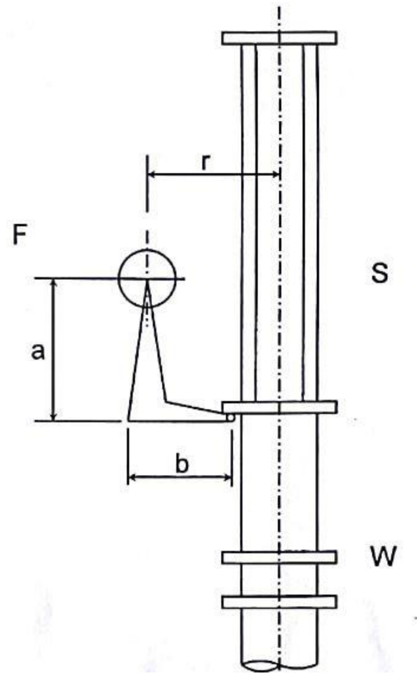
Observation Table:

Sl.No	Speed in RPM	Sleeve Displacement "X"





EXPERIMENTAL SETUP OF HARTNELL GOVERNOR



Calculations:

1. Height of the governor(h) = [ho - (x/2)]

   =

   =

2. Find" α "using Cos α = h / *l*

   $\propto = cos^{-1}$(h/l)

   ∝=

3. Radius of rotation r = ro +(a/b)x
   r =

4. The controlling force F = mω²r
   Where,

   m = Weight of ball assembly.

   ω = 2 π N/60 rps

   r= Radius of rotation

   F = N

Space For Calculations

RESULT & CONCLUSIONS:

Result Tabulation:

Sl .No	Height cos∝ = h / l	Radius of Rotation	Force

Graph: Draw the

i. Force Vs radius of rotation.

ii. Speed Vs sleeve displacement.

Thus the characteristic curves of the HARTNELL Governor are determined.

VIVA QUESTIONS:

1. When the equilibrium speed is constant for all radii of rotation of the balls of governor within the working range.
2. When a governor tends to intensify the speed variations instead of controlling it.
3. Which machine element maintains the speed within prescribed limits for varying output.
4. What type of governor is spring loaded type governor?
5. What type of governor is gravity controlled type governor?

EXPERIMENT - 05

MOTORIZED GYROSCOPE

AIM:

To determine the gyroscopic couple of rotating masses and to verify the gyroscope rules of a plane rotating disc.

APPARATUS REQUIRED:

1. Tachometer (contact type).
2. Rotor Disc.
3. Set of weights.
4. Dimmer set and power supply.
5. Stop watch.

Specifications:

1. Mass of the rotor = 6.3 kg
2. Rotor diameter (D) = 300 mm
3. Rotor thickness (t) = 8 mm
4. Bolt size = MI 08

PROCEDURE:

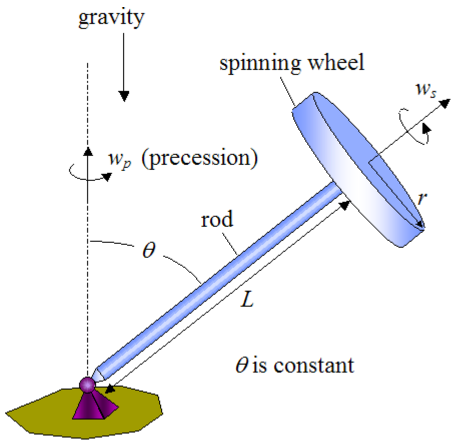
1. Check the rotor for vertical position. Adjust the balance weight slightly, if required.
2. Keep the dimmer at zero position & put 'ON' the supply.
3. Start the motor by applying the voltage of around 170 volts & then reduce.
4. Adjust the rotor speed as required.
5. Note down the rotor speed with the help of tachometer. (Not supplied with the unit) Speed is to be noted when it becomes steady, it takes around 5 minutes to stabilize.
6. Put the required weight in the weight stud & at the same instant, start the stop clock. Note down the time required for 90° precession.
7. Repeat the procedure for different weights and rotor speeds.

Precautions:

1. Check all the fastenings to be tight before start.
2. Check balance of the rotor before start.
3. Lubricate the bearings periodically.
4. Keep the base over a leveled platform.

Observation Table:

S.NO	Speed of Motor (RPM)	Weight (N)	Time taken for Precision(sec)



Calculations:

1. Moment of Inertia of rotor -

$$I = m.k^2$$

where,

I = Moment of inertia, kg. m^2

m= Mass of disc = 6.30 kg.

k= Radius of gyration = $\frac{r}{\sqrt{2}}$

r = Radius of rotor = 0.150 m

k= 0.10

2. Velocity of Spin (or) Angular Velocity

$$\omega = \frac{2\pi N}{60} \text{ rad /sec}$$

Where N = Rotor Speed in RPM

3. Angle of precision

$$\theta = \theta \times \frac{\pi}{180}$$

Where,
θ = Angle of precision (degrees)

4. Angular velocity of precision

$$\omega_p = \frac{d\theta}{dt} = \frac{\theta}{t} \text{ rad/s}$$

Let distance of weight stud from centre of disc be 'x' mtrs.

5. Applied torque:

T_{act} = (welght). (x) (where, x =19.5cm)

6. Now, as derived earlier theoretical torque,

$$T_{th} = I.\omega.\omega_p$$

Space For Calculations

RESULT & CONCLUSIONS:

Result Tabulation:

S.NO	Speed of Motor (RPM)	Weight (N)	Time taken for Precision(sec)	Angle of Precision		Angular velocity of precision (Wp)	Gyroscopic couple (C) (Nm)
				Degrees	Rad		

Thus the value of gyroscopic couple of rotating masses and gyroscopic rules of a plane rotating disc was verified.

VIVA QUESTIONS:

1. What is meant by gyroscope?
2. What is meant by gyroscope couple?
3. What is the use of gyroscope couples?
4. The axis of precession is______________to the plane in which the axis of spin is going to rotate.
5. A disc is a spinning with an angular velocity ω rad/s about the axis of spin. Then what will be the couple applied to the disc causing precession.
6. What is the effect of a gyroscopic couple when the engine of an aeroplane rotates in clockwise direction when seen from the tail end and the aeroplane takes a turn to the left.
7. What is the effect of a reactive gyroscopic couple when aeroplane takes a right turn and the propeller rotates in a clockwise direction?
8. How many degrees of freedom the gyroscope rotor has.

EXPERIMENT - 06
STUDY AND EXPERIMENTS ON STATIC AND DYNAMIC BALANCING OF ROTATING MASSES

AIM:

To check experimentally the method of calculating the position of counter balancing weight in rotating mass system.

APPARATUS REQUIRED:

1. Rotor system
2. Weight
3. Steel rule

THEORY:

If the centre of gravity of the rotating disc does not lie on the axis of rotation but at a distance away from it, we say that the disc is out of balance. When such a disc rotates, a centrifugal force $F_c = m\omega^2 r$ is setup in which, `m' the mass of the disc, `r' the distance of the center of gravity of the disc from the axis of rotation and `ω' the angular velocity. This rotating centrifugal force acts on the bearing in a constantly changing directions and results in a vibrating load. The process of providing or removing the mass to counteract the out of balance is called balancing. Generally all rotating machine elements such as pulleys, flywheels, rotors etc. are designed to rotate about a principal axis of inertia and theoretically require no balancing. However, lack of material homogeneity and inaccuracies in machining and assembly may cause an unintentional shifting of the centre of gravity of the rotor from the axis of rotation. The centrifugal forces resulting from the unbalance increase as the square of the rotational speed and hence it is important that all revolving and reciprocating parts should be completely balanced as far as possible.

Description:

The apparatus basically consists of a steel shaft mounted in ball bearings in a stuff rectangular main frame. A set of six blocks of different weights is provided and may be clamped in any position on the shaft, and also be easily detached from the shaft.

A disc carrying a circular protractor scale is fitted to one side of the rectangular frame. Shaft carries a disc and rim of this disc is grooved to take a light cord provided with two cylindrical metal containers of exactly the same weight.

A scale is fitted to the lower member of the main frame and when used in conjunction with the circular protractor scale, allows the exact longitudinal and angular position of each adjustable block to be determined. The shaft is driven by a 230 volts single phase 50 cycles electric motor, mounted under the main frame, through a belt.

For static balancing of individual weights the main frame is suspended to the support frame by chains and in this position the motor driving belt is removed.

For dynamic balancing of the rotating mass system the main frame is suspended from the support frame by two short links such that the main frame and the supporting frame are in the same plane.

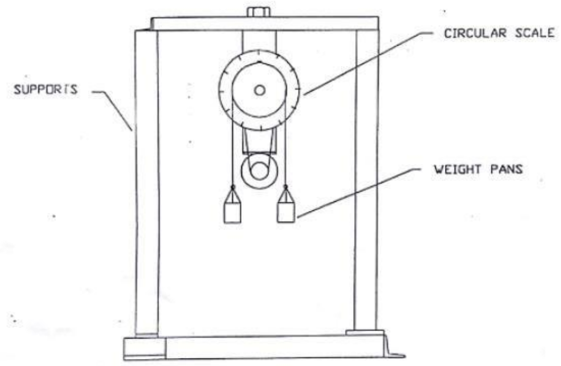
Formula:

1. Centrifugal force = $m \times r$ (N)

2. Couple = $m \times r \times l$ (Nm)

STATIC BALANCING:

The main frame is rigidly fixed at right angles to the support frame and the drive belt is removed. The value of 'mr'. for each block is determined by clamping each block in turn on the shaft and with the cord and container system suspended over the protractor disc, the number of steel balls, which are of equal weight, are placed into one of the containers to exactly balance the blocks on the shaft. When the block comes to stationery horizontal position, the number of balls "N' will give the value of mr' for the block.



Set-up For Statically Balancing Of Rotary Masses

PROCEDURE:

For finding out "mr" during static balancing proceed as follows:

1. Remove the belt.

2. Screw the combined hook to the pulley with groove. (This pulley is different than the belt pulley.).

3. Attach the cord - ends of the pans to the above combined hook.

4. Attach the block No. 1 to the shaft at any convenient position and in vertical downward direction.

5. Put steel balls in one of the pans till the block starts moving up. (Up to horizontal position)

6. Number of balls give the "mr" value of block I. Repeat this for 2-3 times and find the average no. of balls.

7. Repeat the procedure for other blocks.

Sl.No	'mr' Weight
1	56
2	62
3	67
4	72
5	76
6	78

DYNAMIC BALANCING:

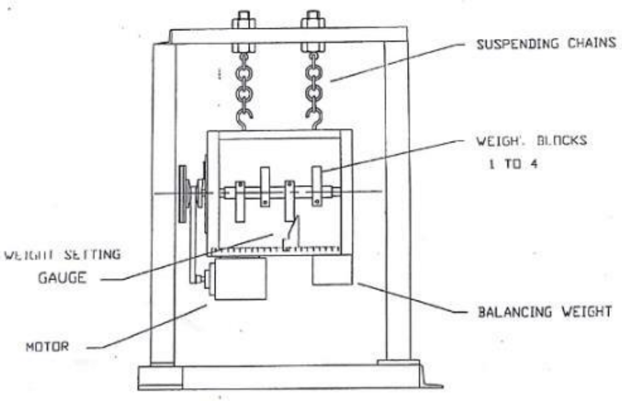
After obtaining the values of `mr' for all the four blocks draw a force polygon by assuming suitable values of angular displacement between any two masses (say block 1 and 2 is 40o). Using the force polygon the angular displacement of other two masses can be obtained. If all the four blocks are arranged on the shaft as per the values of the angular displacement obtained from the force polygon, the system will be statically balanced i.e. sum of all the forces acting on the system will be zero. But there will be unbalanced couple. For complete balance i.e. for dynamic balancing, the blocks should be arranged on the shaft in such a manner, that the sum of all the couple acting on the system is zero. For this, without altering the angular displacement of all the four blocks, the relative axial displacement should be calculated as follows.

To determine the axial distances frame the table as follows:

Mass No.	mr	Axial distance of the masses form m_1 in m (L)	mrl	θ	mrl sin(θ)	mrl cos (θ)
m_1	m_1r_1	$L_1 = 0$	0	θ_1	$m_1r_1l_1 \sin\theta_1$	$m_1r_1l_1 \cos\theta_1$
m_2	m_2r_2	L_2	$m_2r_2l_2$	θ_2	$m_2r_2l_2 \sin\theta_2$	$m_2r_2l_2 \cos\theta_2$
m_3	m_3r_3	L_3	$m_3r_3l_3$	θ_3	$m_3r_3l_3 \sin\theta_3$	$m_3r_3l_3 \cos\theta_3$
m_4	m_4r_4	L_4	$m_4r_4l_4$	θ_4	$m_4r_4l_4 \sin\theta_4$	$m_4r_4l_4 \cos\theta_4$
				SUM		

For complete dynamic balance (Sum) mrl Sinθ = 0
& (Sum) mrl Cosθ = 0

l_1 & l_2 values are assumed. The above two equations will contain the unknowns namely l_3& l_4. The value of l_3 & l_4 can be determined by solving the two simultaneous equations. Having known the axial and angular displacement of the masses, all the blocks can be clamped on the shaft in their appropriate positions. Connect the shaft pulley with the motor using the belt and transfer the frame to its hanging position. Run the motor to verify the complete balance of the system.



Set-up For Dnamically Balancing Of Rotary Masses

Observation Table:

Mass No.	mr	Axial distance of the masses form $m_1$in m (L)	mrl	θ	mrl sin(θ)	mrl cos (θ)

let us assume l_1=0, l_2= 0.12m, θ_1= 0º, θ_2 = 40º

DIAGRAMs:

1.Length Diagram:

2.Space for force Polygon:

-Obtain the values of θ_3 & θ_4 from force polygon.

3.Space for Couple Polygon:

Specimen Calculation:

For complete dynamic balancing

Net couple = 0 i.e., Σ mrl sin $\theta = 0$ & Σ mrl Cos $\theta = 0$

Step – 1

$m_1r_1l_1 \sin\theta_1 + m_2r_2l_2 \sin\theta_2 + m_3r_3l_3 \sin\theta_3 + m_4r_4l_4 \sin\theta_4 = 0$------------------ Eqn. 1

Step – 2

$m_1r_1l_1 \cos\theta_1 + m_2r_2l_2 \cos\theta_2 + m_3r_3l_3 \cos\theta_3 + m_4 r_4 l_4 \cos\theta_4 = 0$ -----Eqn. 2

Solving the eqn. 1 & 2 find the values of l_3 & l_4

Space For Calculations

RESULT & CONCLUSIONS:

The given rotor system has been dynamically balanced with the aid of force polygon and couple polygon.

VIVA QUESTIONS:

1. Why balancing is necessary for high speed engine
2. What is the difference between Static & Dynamic Balancing?
3. What are the effects of partial balancing in locomotives?
4. What are the practical applications of balancing?
5. Secondary balancing force is given by relation ……
6. Write the importance of balancing?
7. Why are rotating masses dynamically balanced? (or) Why balancing of dynamic forces necessary?
8. Differentiate: static and dynamic balancing.
9. Why is only a part of the unbalanced force due to reciprocating masses balanced by revolving mass? (Or) Why is complete balancing not possible in reciprocating engines?
10. Can a single cylinder engine be fully balanced? Why?
11. What are the effects of hammer blow and swaying a couple?
12. List the effects of partial balancing of locomotives?
13. Define tractive force. And what is a swaying couple?

EXPERIMENT - 07
UNDAMPED FREE VIBRATION OF SPRING MASS SYSTEM

AIM:

To study the longitudinal vibration of helical spring and to determine the frequency or period of vibration. (oscillation) theoretically and actually by experiment.

APPARATUS REQUIRED :

1. Helical spring.
2. Platform.
3. Weights.
4. Measuring tape.
5. Stop watch.

THEORY:

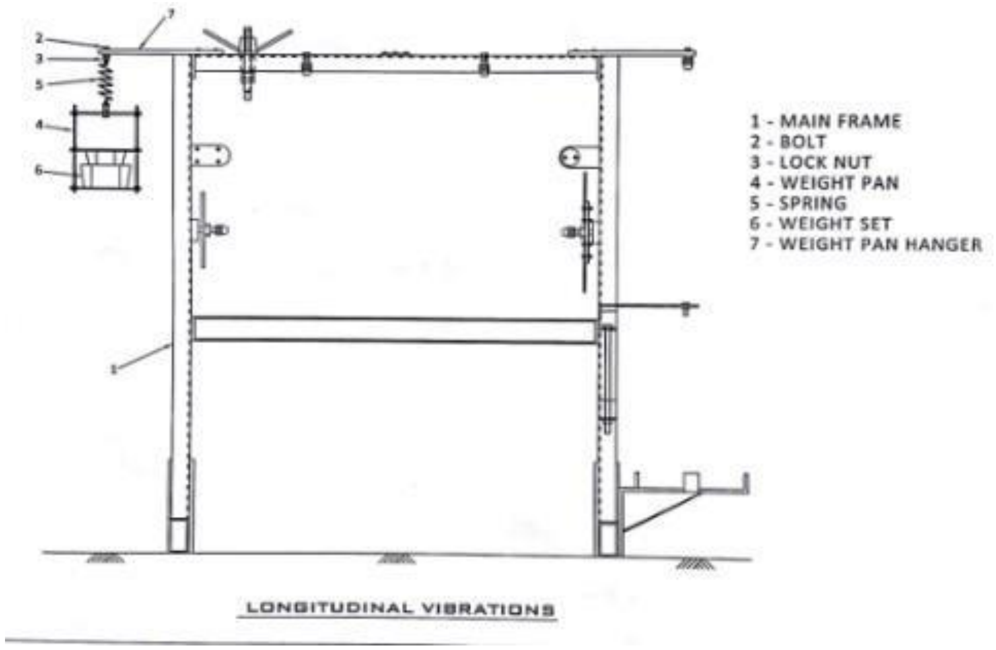
One end of open coil spring is fixed to the screw which engages with screwed hand wheel. The screw can be adjusted vertically in any convenient position and then clamped to upper beam by means of lock nuts. Lower end of the spring is attached to the platform carrying the weights. The platform is guided in the lower beam. The whole unit can be clamped at any horizontal position by using the upper and lower clamping nuts. Thus the design of the system incorporates vertical and lateral positioning of the unit to suit the convenience.

PROCEDURE:

1. Fix one end of helical spring to the upper screw.
2. Determine free length.
3. Put some weight to platform and note down the deflection.
4. Stretch the spring through some distance and release.
5. Count the time required (in sec) for some say 10, 25, 50 oscillation.
6. Determine the actual period.
7. Repeat the procedure for different weights.

Observation:

1. Length of spring =
2. Mean diameter of spring =
3. Wire diameter =



Observation Table:

S.No	Weight (m) in Kg's	No.Of OSC (n)	Deflection of spring in cm(δ)	Stiffness (K) i.e $\frac{w}{\delta}$	Time for "n" OSC in sec "t"	T[Expt] t/n

<u>CALCULATIONS:</u>

1. Find T_{theo} by using relation:

$$T_{theo} = 2\pi\sqrt{\frac{m}{k\,.g}}$$

Where; m = mass in Kg
k=Stiffness in N/cm
g= Gravitational acceleration

2. Check the experimental value T_{expt} =

Hence (Frequency) f Theoretical = $\frac{1}{T(theo)}$ cps(cycles per sec or Hz)

Hence (Frequency) f Experimental = $\frac{1}{T(Expt)}$ cps(cycles per sec or Hz)

Space For Calculations

Graph: Deflection vs Load added

RESULT & CONCLUSIONS:

The period and frequency of undamped free vibration (longitudinal vibration) of spring mass system are determined experimentally and verified with the theoretical values.

VIVA QUESTIONS:

1. Name different types of vibrations
2. Define free vibrations.
3. Define damped vibrations.
4. What Is Meant By Logarithmic Decrement?
5. Define Transmissibility?

EXPERIMENT - 08
DAMPED FORCED VIBRATION OF SPRING MASS SYSTEM

AIM:

To study the forced vibration(Damped) of equivalent spring mass system.

APPARATUS REQUIRED:

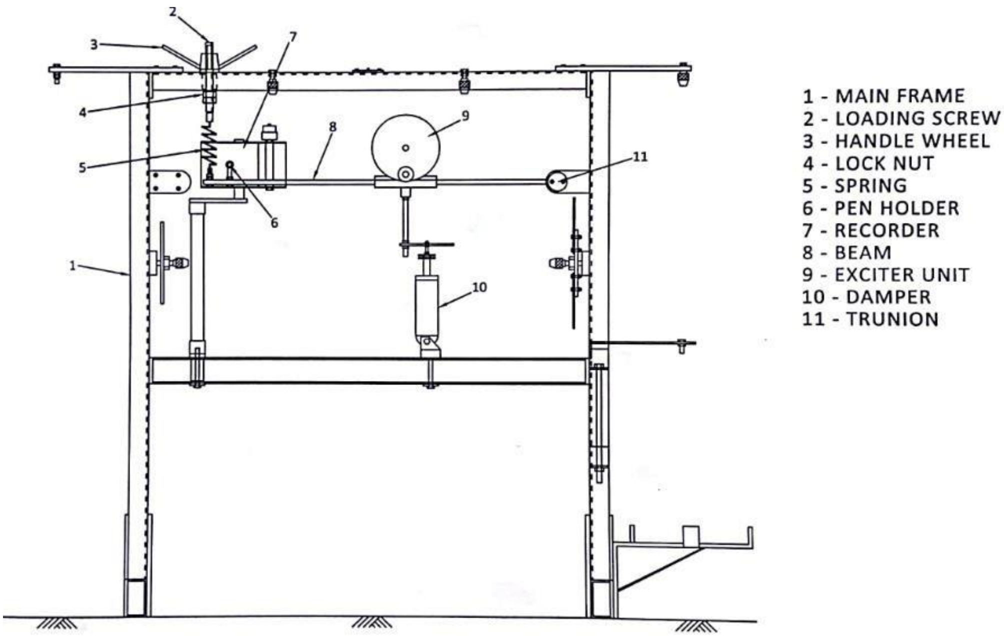
1. Vibrating table setup
2. Dimmer set with speedometer
3. Stopwatch
4. Recorder

THEORY:

The arrangement shown in Fig. The exciter unit is coupled to D.C. variable speed motor through the flexible shaft. Speed of the motor can be varied with the Dimmerstat provided on the control panel Speed of rotation can be known from the speed indicator on control panel. It is necessary to connect the damper unit to the exciter. Amplitude record of vibration is to be obtained on the strip chat recorder is 33mm/sec.

PROCEDURE:

1. Arrange the setup as described in fig.
2. Connect the exciter to D.C. motor through flexible shaft.
3. Start the motor and allow the system to vibrate.
4. Wait for 3 to 5 minutes for the amplitude to built the particular forcing frequency.
5. Adjust the position of strip chart recorder. Take the record of amplitude vs time on strip chart by starting recording motor. Press the recorder platform on the pen gently. Pen should be wet with ink. Avoid excessive pressure to get good record.
6. Take record by changing forcing frequencies.
7. Repeat the experiment for different damping. Damping can be changed by adjusting the holes on the piston of the exciter.
8. Plot the graph of amplitude Vs frequency for each damping conditions.



FORCED VIBRATION OF EQUIVALENT SPRING MASS SYSTEM

Obsevation Table:

Speed in Rpm	Frequency in Cps i.e speed/60	Amplitude in Mm

Space For Calculations

Graph: of amplitude Vs frequency for each settings.

RESULT & CONCLUSIONS:

The forced vibrations of equivalent spring mass system are calculated.

VIVA QUESTIONS:

1. What Is Dry Friction Damper?
2. What Is Rayleigh's Method, Write Its Applications?
3. What Is Meant By Viscous Damping?
4. Define Vibration Isolation?
5. What Is An Accelerometer And What Is Its Use?

EXPERIMENT - 09
TORSIONAL VIBRATION OF SINGLE ROTOR SYSTEM

AIM:

To study the Torsional vibration (Undamped) of single rotor shaft system.

APPARATUS REQUIRED:

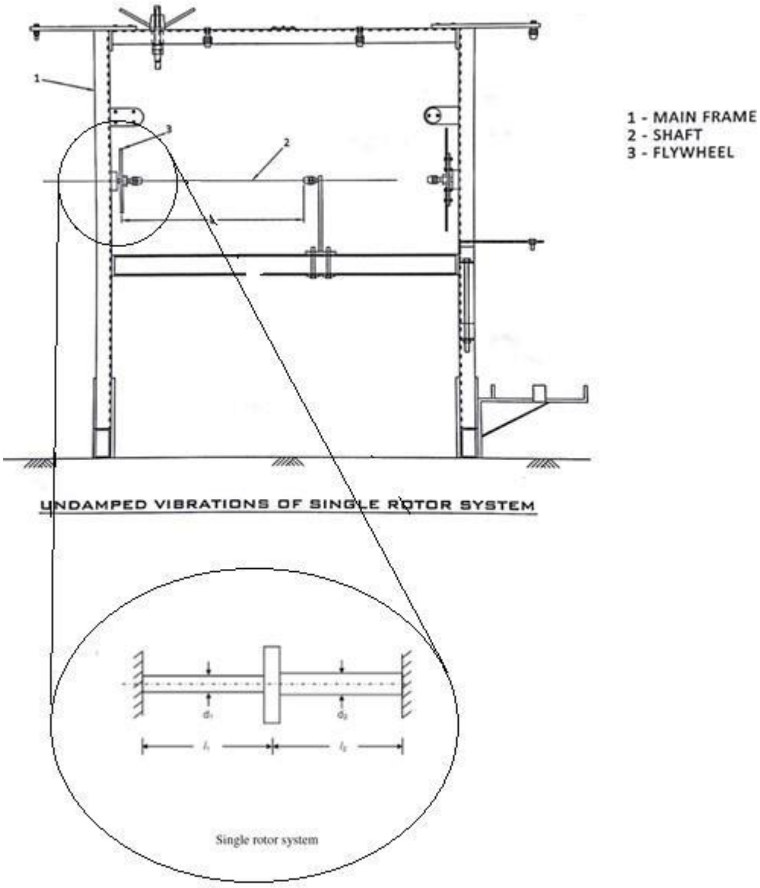
1. Shaft
2. Rotor
3. Stop watch

THEORY:

Fig. shows the general arrangement for carrying out the experiment.
One end of the shaft is gripped in the chuck and heavy flywheel free to rotate in ball bearing is fixed at the other end of the shaft.
The bracket of fixed end of shaft can be clamped at any convenient position along lower beam. Thus length of the shaft can be varied during the experiment. Specially designed chucks are used for clamping ends of the shaft. The ball bearing support to the flywheel provides negligible damping during experiment. The bearing housing is fixed to side member of main frame.

PROCEDURE:

1. Fixed the bracket at convenient position along the lower beam.
2. Grip one end of the shaft at the bracket of the chuck.
3. Fix the rotor on the other end of the 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 different lengths of shaft.
7. Make the following observations:
   a. Shaft dia d = 3mm
   b. Dia of Disc D = 225 mm
   c. Wt of the Disc W = 3.120 Kg
   d. Modulus of rigidity for shaft G =0.8 x 10^6 Kg/cm^2



Observation:

S.No	Length of shaft "L" in cm	No.Of OSC. "n"	Time for "n"OSC sec "t"	Periodic time $T_{expt} = t/n$

Calculation:

1. "I_p" is polar moment of inertia of the shaft $= \frac{\pi\, d^4}{32}$

2. "I" is moment of inertia of the disc $= \frac{Wd^2}{8g}$

3. Determine the Torsonal stiffness $K_t = \frac{G\,Ip}{L}$

   Where , K_t = Torsonal stiffness of shaft,

   G =Modulus of rigidity for shaft 0.8 x 10^6 Kg/cm^2,

   L =length of shaft.

Now

$$T_{theo} = 2\,\pi \sqrt{\frac{I}{Kt}}$$

Determine

$$T_{expt} = \frac{\text{Time for n sec}}{\text{No.Of osc in "n"}}$$

1. Theoretical Frequency (f_{theo}) $= \frac{1}{T\ theo}$

2. Experimental Frequency (f_{expt}) $= \frac{1}{T\ expt}$

Space For Calculations

RESULT & CONCLUSIONS:

Thus the natural frequency of a shaft in a single rotor system is determined.

VIVA QUESTIONS:

1. What Is An Accelerometer And What Is Its Use?
2. Define The Term Magnification Factor?
3. What Is Basic Assumption Is Deriving Dunker Lay's Formula?
4. What Happens To The Response Of An Undamped System At Resonance?
5. What Is The Difference Between A Vibration Absorber And A Vibration Isolator?

EXPERIMENT - 10
TORSIONAL VIBRATION OF TWO ROTOR SYSTEM

AIM:

To study the free vibrations(Undamped) of two rotor system and to determine the natural frequency of vibration theoretically and experimentally.

APPARATUS REQUIRED :

1. Shaft
2. Spanner
3. Chuck key
4. Measuring tape
5. Stop watch
6. Weights and
7. Cross arms

THEORY:

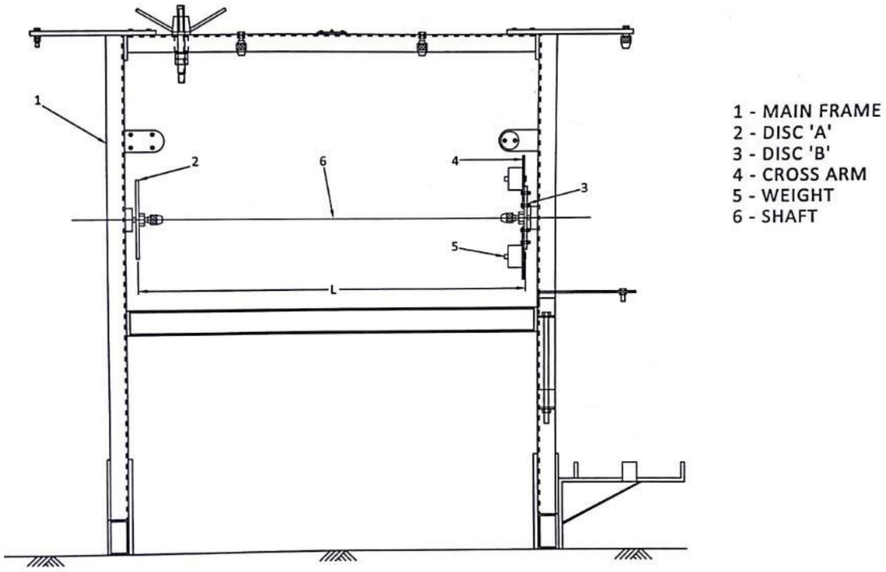
Fig. shows the general arrangement for carrying out the experiment.
Two disks having different mass moment of Inertia are clamped one at each end of shaft by means of collet and chucks.
Mass moment of inertia of any disc can be changed by attaching the cross leaver weights. Both disks are free to oscillate in the ball bearings. This provides negligible damping during experiment.

PROCEDURE:

1. Fix two disks to the shaft and fit the shaft in bearings.
2. Deflect the disks in opposite direction by hand and release.
3. Note down time required for particular number of oscillation.
4. Fit the crosses arm to one of the disks and again note down time.
5. Repeat the procedure with different equal masses attached to the ends of cross arm and note down the time.

Observation:

1. Dia. of Disk A = D_A = 225 mm
2. Dia. of Disk B = D_B = 190 mm
3. Wt of Disk A = W_A = 3.12 Kg
4. Wt of Disk B = W_B = 2.22 Kg
5. Length of the cross arm 110 & 160 mm respectively.
6. Dia. of shaft = 3 mm
7. Length of shaft between rotors = L =



FREE VIBRATIONS OF TWO ROTOR SYSTEM

OSEVATION TABLE:

S.No	No.Of osc	ime required for "n" osc	T $_{expt}$ = t/n

Calculation:

1. "I_p" is polar moment of inertia of the shaft = $\frac{\pi d^4}{32}$

2. "I_A" is moment of inertia of the disc = $\frac{WAda^2}{8g}$

   "I_B" is moment of inertia of the disc = $\frac{WBdb^2}{8g}$

3. Determine the Torsonal stiffness $K_t = \frac{G\ Ip}{L}$

   Where , K_t = Torsonal stiffness of shaft,
   G =Modulus of rigidity for shaft 0.8 x 10^6 Kg/cm^2,
   L =length of shaft.

NOW

$$T_{theo} = 2\pi\sqrt{\frac{IA*IB}{Kt\ (IA*IB)}}$$

Determine

$$T_{expt} = \frac{\text{Time for n sec}}{\text{No.Of osc in "n"}}$$

1. Theoretical Frequency (f_{theo}) = $\frac{1}{T\ theo}$ in cps

2. Experimental Frequency (f_{expt}) = $\frac{1}{T\ expt}$ in cps

Space For Calculations

RESULT & CONCLUSIONS:

The period and frequency of torsional vibration of the two rotor system are determined experimentally and verified with the theoretical values.

VIVA QUESTIONS:

1. Define free vibrations.
2. Define damped vibrations.
3. What Is Meant By Logarithmic Decrement?
4. Define Transmissibility?
5. What Is Dry Friction Damper?

EXPERIMENT - 11
DAMPED TORSIONAL VIBRATION

AIM:

To study the damped torsional oscillations and determine the damping coefficient Ct.

APPARATUS REQUIRED :

1. Shaft
2. Spanner
3. Recording drum
4. Measuring tape
5. Stop watch
6. Descender and
7. Oil container

THEORY:

Fig. shows the general arrangement for the experiment. It consist of a long elastic shaft gripped at the upper end by the chuck in the bracket. The bracket is clamped to the upper beam of the main frame. heavy steel flywheel clamped at the lower end of the shaft suspended from the bracket.

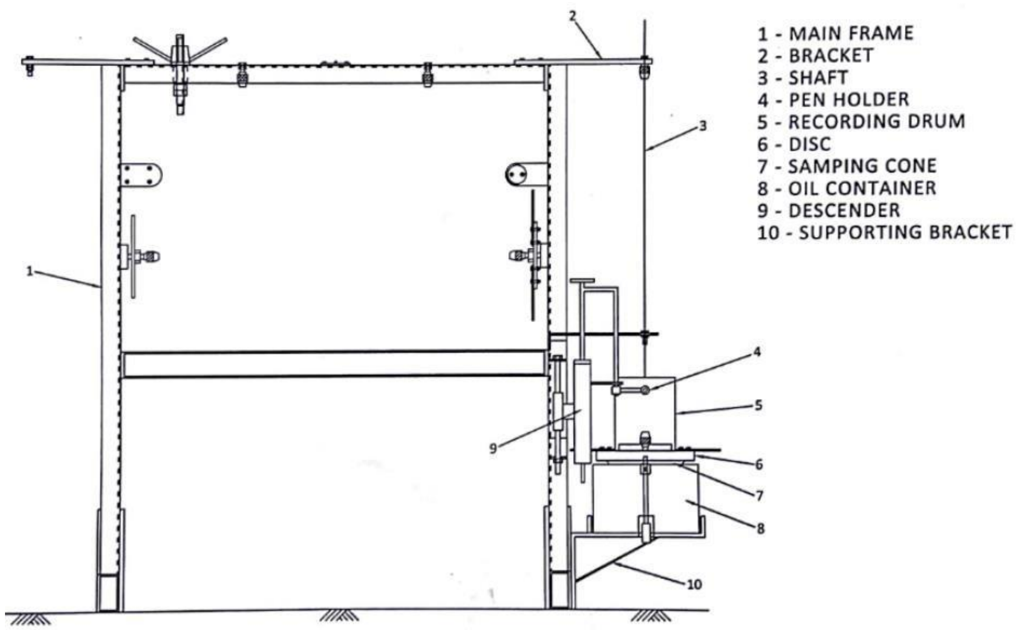
A Damping drum is fixed to the lower face of the flywheel. this drum is immersed in the oil/water which provides damping. Oil container can be taken up and down for varying the depth of immersion of damping drum. Depth of immersion can be read from the scale.

Observation:

1. Dia. of shaft, d = 3 mm
2. Mass of the flywheel, M = 8 kg
3. Diameter of the flywheel = 25cm
4. Length of the shaft, L =

PROCEDURE:

1. With no oil in the container allow the flywheel to oscillate and measure logarithmic decrement.
2. Put water/oil in the drum and note the depth of immersion. (Note - Even you can calculate air damping factor without putting any fluid in the container.)
3. Put the sketching pen in the bracket.
4. Allow the flywheel to bracket.
5. Allow the pen to descend. See that the pen always makes contact with the paper.
6. Measure the time for some oscillations by means of stop watch.
7. Determine Xn i.e. amplitude at any position and X ntr amplitude after 'r cycles.



Observation Table:

S.No	Depth. of immersion in cm	X_n in cm	X_{ntr} in cm

CALCULATION:

1."I_p" is polar moment of inertia of the shaft = $\frac{\pi d^4}{32}$

2. "I" is moment of inertia of the disc = $\frac{Wd^2}{8g}$

3. Determine the Torsonal stiffness $K_t = \frac{G\,Ip}{L}$

Where , K_t = Torsonal stiffness of shaft,

G =Modulus of rigidity for shaft 0.8 x 10^6 Kg/cm^2,

L =length of shaft.

Now

$$_{theo} = 2\pi\sqrt{\frac{I}{Kt}}$$

1. Calculate critical damping factor $C_{tc} = \sqrt{4 \cdot I \cdot Kt}$

2. Determine the logarithmic decrement (□)

$$\square = \frac{1}{r} \log \frac{Xn}{Xntr}$$

Where , Xn = Amplitude of vibrations at the beginning of measurement to be found from record.

X ntr = Amplitude of vibrations after "r" no.of cycles from record.

3. Find damping coefficient "C_t"

$$C_t = \frac{\square \cdot Ctc}{(\sqrt{4 \cdot \pi^2 + \square^2})}$$

Space For Calculations

RESULT & CONCLUSIONS:

The damping coefficient Ct is

VIVA QUESTIONS:

1. Define Vibration Isolation?
2. What Is An Accelerometer And What Is Its Use?
3. Define The Term Magnification Factor?
4. What Is Basic Assumption Is Deriving Dunker Lay’s Formula?
5. What Happens To The Response Of An Undamped System At Resonance?

EXPERIMENT - 12

DUNKERLEY'S RULE

AIM:

To verify the Dunkerley's Rule Viz.

$$\frac{1}{F^2} = \frac{1}{Fl^2} + \frac{1}{Fb^2}$$

THEORY:

Fig. shows general arrangement for carrying out the experiment. A rectangular section bar is supported in turning fittings at each end. Each turnnion is pivoted in a ball bearing carried in housing. Each bearing housing is fixed to the vertical frame member. The beam carries at its centre a weight platform.

PROCEDURE:

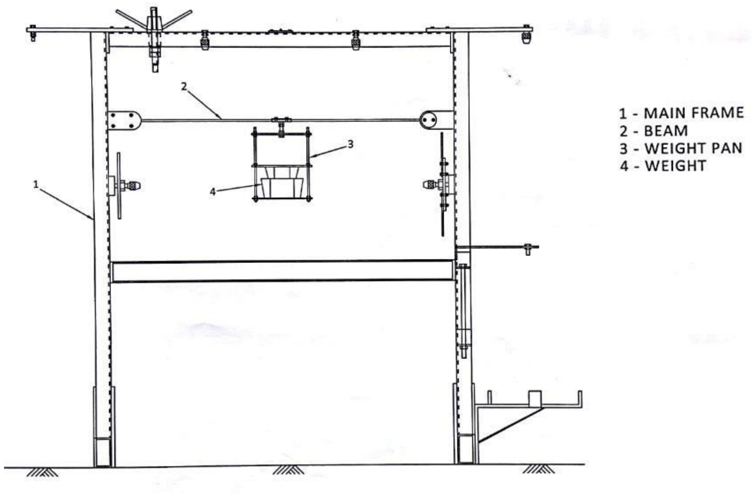
1. Arrange the setup as shown in Fig. with some weight 'W' clamped to Wt platform.
2. Pull the platform and release it to set the system into natural vibrations.
3. Find periodic time T and frequency of vibrations F by measuring time for some oscillations.
4. Repeat expt. by putting additional masses on weight platform.
5. Play the graph of $1/f^2$ Vs W.

Observation:

1. Length of beam = L = 1045 mm = 1.045 m.
2. Wt per cm of the beam = w = 1Kg/m.
3. Section of the beam = 25 x 6 mm.

Observation Table:

S.No	Weight Attached "W" In Kg	No.Of Osc "N"	Time For "N" Osc In Sec "T"	Periodic Time T_{expt} =T/N	Frequency F = 1/ T_{expt}



DUNKERLEY'S RULE

CALCULATIONS:

1. Find natural frequency of vibration of the beam given by equation.

$$F_b = \frac{\pi}{2L^2}\sqrt{\frac{2EIg}{W^2}}$$

Where, W = Wt of beam per unit length i.e 1 kg/m

I = M.I of beam section $bh^3/12$.

E = Modulus of elasticity of a beam material(To be taken as $2*10^6$ Kg/cm^2.) L= 1045 m

2. F= Natural frequency of given beam (Considering the weight of the beam) with central load W. Fl = Natural frequency of given beam (Neglecting the weight of the beam) with central load to be calculated from formula.

$$F_I = \sqrt{\frac{48EIg}{4\pi^2 L^3 W}}$$

Where , W = Central load of the beam.

L = Length of the beam

3.Plot the graph of $1/F^2$ Vs 'W'' Intercept of the graph with w = 0 gives the value frequency of the beam.

4.Compare the values of natural frequency of beam obtained by using theoretical expression and that obtained from graph.

5.To verify Dunkerley's Rule proceed as follows.

a. Find 'Fb' from expression given above.

b. Fine 'F by using formula given above.

c. Find 'F by using Dunkerley's equation.

d. Compare this with experimental value of 'F

Space For Calculations

RESULT & CONCLUSIONS:

Dunkerley's Rule IS verified.

VIVA QUESTIONS:

1. What Is Basic Assumption Is Deriving Dunker Lay's Formula?
2. Name different types of vibrations
3. Define free vibrations.
4. Define damped vibrations.
5. What Is Meant By Logarithmic Decrement?

EXPERIMENT - 13
LATERAL VIBRATION OF THE BEAM

AIM:

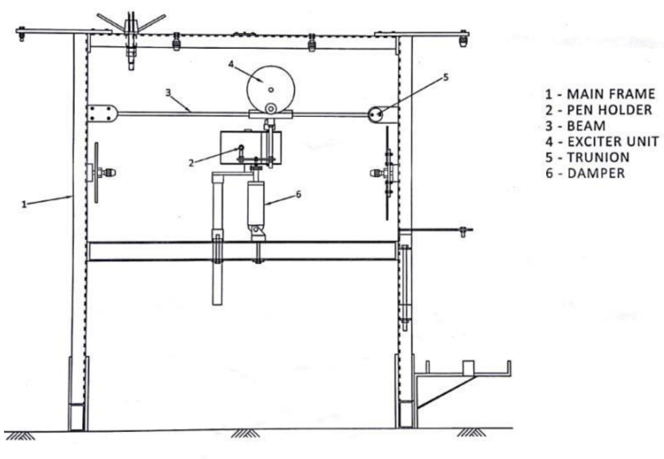
To study the force lateral vibration of the beam for different damping.

THEORY:

Fig. shows the general setup. Slightly heavy rectangular section bar is supported at both ends in turning fittings. Exciter unit can be clamped at any convenient position along the beam. Exciter unit is connected to the damper which provides the necessary damping.

PROCEDURE:

1. Arrange the setup as shown in Fig.
2. Connect the exciter to D.C. motor to flexible shaft.
3. Start the motor and allow the system to vibrate.
4. Wait for some time for amplitude to build up for particular forcing frequency.
5. Adjust the position of strip chart recorder. Take the record ofamplitude Vs time on strip. chart recorder by starting recorder motor.
6. Take record by changing forcing frequency.
7. Repeat the experiment for different damping.
8. 8lot graph of amplitude Vs frequency for each damping.



FORCED LATERAL VIBRATIONS OF BEAM

Observation Table:

Speed in RPM	Frequency in cps = Speed/60	Amplitude in mm

Space For Calculations

RESULT & CONCLUSIONS:

VIVA QUESTIONS:

1. What Is Dry Friction Damper?
2. What Is Rayleigh’s Method, Write Its Applications?
3. What Is Meant By Viscous Damping?
4. Define Vibration Isolation?
5. What Is An Accelerometer And What Is Its Use?

EXPERIMENT -14
STUDY AND EXPERIMENTS ON CIRCULAR ARC CAM APPARATUS

AIM:

To draw the profile of the circular arc cam with Mushroom follower using the given apparatus, and testing cam performance for jump phenomenon during under operation.

THEORY:

The machine is a motorized unit consisting of a cam shaft driven by a AC/DC motor. The shaft runs in a ball bearing. At the free end of the cam shaft a cam can be easily mounted. The follower is properly guided in gun metal bushes. A graduated circular protractor is fitted co-axial with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the follower system. Weights on the follower rod can be adjusted as per the requirements. The arrangement of speed regulation is provided.

The machine is particularly very useful for testing the cam performance for jump phenomenon during operation. This machine clearly shows the effect of change of inertia forces on jump action of cam follower during the operation. It is used for testing various cam and follower pairs, i.e. 1) Circular arc cam with mushroom follower, 2) Tangent cam with roller follower, and 3) An eccentric cam with knife edge follower.

Jump Phenomenon:

The jump phenomenon occurs in case of cam operating under the action of compression spring load. This is a transient coefficient that occurs only with high speed, highly flexible cam follower systems. With jump, cam and the follower separate owing to excessively unbalanced forces exceeding the spring force during the period of negative acceleration. This is undesirable since the fundamental function of the cam follower system, the constraint and control of follower motion are not maintained. Also related are the short life of the cam flank surface, high noise, vibrations and poor action.

Jump And Crossover Shock:

A cam follower retained against the cam with a compression retaining spring will under certain conditions, jump or bounce out of contact with the cam. This condition is most likely to occur with low values of damping and with high speed cams of quite flexible follower trains.

Crossover shock occurs in a positive drive cam mechanism when contact moves from one side of the cam to the other. Clearance and backlash are taken up.

Experiments -

1. To plot n - (follower displacement vs. angle of cam rotation). Curve for different cam follower pairs. The n-6 plot can be used to find out the velocity and acceleration of the follower system.
2. For this experiment, arrange the set up as shown in fig. 1. The exact profile of the cam be obtained by taking observations n vs. θ. Where n = displacement of the follower from

rotation initial position and θ = angle of cam rotation with reference from axis of symmetry chosen. By differentiating the n - θ curve once and twice, the velocity and acceleration curves can be plotted for the follower and cam under study.

3. To observe the phenomenon of jump. For this, use of a stroboscope (not included in scope of supply) is necessary. The speed of cam rotation and stroboscope frequency on neon lamp are gradually and simultaneously increased and at the time jump to occur the follower is seen to loose contact with the cam. When jump occurs the follower pounds on the cam surface giving a good thumping sound.

Observation :

Base circle radius or minimum radius of the cam, r1 = mm

Observation Table:

	Forward Stroke	Dwell	Return Stroke	Dwell
Angle In Degree				
Follower Lift In mm				

<u>Displacement, velocity and acceleration diagrams of the Mushroom follower :</u>

Profile Of The Circular Arc Cam :

Observation Table For Jump Speed:

S.No	Wt. added on follower assembly in kg	Jump Speed in RPM

RESULT & CONCLUSIONS:

Thus the profile of the circular arc cam with mushroom follower has been drawn, and jump speed is

VIVA QUESTIONS:

1. What is the use of cam?
2. What is meant by camp jump phenomenon?
3. A cam and follower constitute___________pair.
4. Define circular arc cam?
5. Define trace point in the study of cams.

EXPERIMENT - 15
STUDY AND EXPERIMENTS ON ECCENTRIC CAM APPARATUS

AIM:

To draw the profile of the Eccentric cam with Knife edge follower using the given apparatus, and testing cam performance for jump phenomenon during under operation.

THEORY:

The machine is a motorized unit consisting of a cam shaft driven by a AC/DC motor. The shaft runs in a ball bearing. At the free end of the cam shaft a cam can be easily mounted. The follower is properly guided in gun metal bushes. A graduated circular protractor is fitted co-axial with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the follower system. Weights on the follower rod can be adjusted as per the requirements. The arrangement of speed regulation is provided.

The machine is particularly very useful for testing the cam performance for jump phenomenon during operation. This machine clearly shows the effect of change of inertia forces on jump action of cam follower during the operation. It is used for testing various cam and follower pairs, i.e. 1) Circular arc cam with mushroom follower, 2) Tangent cam with roller follower, and 3) An eccentric cam with knife edge follower.

Jump Phenomenon:

The jump phenomenon occurs in case of cam operating under the action of compression spring load. This is a transient coefficient that occurs only with high speed, highly flexible cam follower systems. With jump, cam and the follower separate owing to excessively unbalanced forces exceeding the spring force during the period of negative acceleration. This is undesirable since the fundamental function of the cam follower system, the constraint and control of follower motion are not maintained. Also related are the short life of the cam flank surface, high noise, vibrations and poor action.

Jump And Crossover Shock:

A cam follower retained against the cam with a compression retaining spring will under certain conditions, jump or bounce out of contact with the cam. This condition is most likely to occur with low values of damping and with high speed cams of quite flexible follower trains.

Crossover shock occurs in a positive drive cam mechanism when contact moves from one side of the cam to the other. Clearance and backlash are taken up.

<u>Experiments -</u>

1. To plot n - (follower displacement vs. angle of cam rotation). Curve for different cam follower pairs. The n-6 plot can be used to find out the velocity and acceleration of the follower system.
2. For this experiment, arrange the set up as shown in fig. 1. The exact profile of the cam be obtained by taking observations n vs. θ. Where n = displacement of the follower from rotation initial position and θ = angle of cam rotation with reference from axis of symmetry

chosen. By differentiating the n - θ curve once and twice, the velocity and acceleration curves can be plotted for the follower and cam under study.

3. To observe the phenomenon of jump. For this, use of a stroboscope (not included in scope of supply) is necessary. The speed of cam rotation and stroboscope frequency on neon lamp are gradually and simultaneously increased and at the time jump to occur the follower is seen to loose contact with the cam. When jump occurs the follower pounds on the cam surface giving a good thumping sound.

Observation :

Base circle radius or minimum radius of the cam, r1 = mm

Observation Table:

	Forward Stroke	Dwell	Return Stroke	Dwell
Angle In Degree				
Follower Lift In mm				

<u>Displacement, velocity and acceleration diagrams of the Knife edge follower :</u>

Profile Of The an Eccentric Cam :

OBSERVATION TABLE FOR JUMP SPEED:

S.No	Wt. added on follower assembly in kg	Jump Speed in RPM

RESULT & CONCLUSIONS:

Thus the profile of the Eccentric cam with knife edge follower has been drawn, and jump speed is

VIVA QUESTIONS:

1. What are the different motions of the follower?
2. Define pressure angle with respect to cams.
3. Define Eccentric cam?
4. Define Lift (or) Stroke in cam.
5. Define base circle in cam profile.

EXPERIMENT - 16
STUDY AND EXPERIMENTS ON TANGENT CAM APPARATUS

AIM:

To draw the profile of the Tangent cam with roller follower using the given apparatus, and testing cam performance for jump phenomenon during under operation.

THEORY:

The machine is a motorized unit consisting of a cam shaft driven by a AC/DC motor. The shaft runs in a ball bearing. At the free end of the cam shaft a cam can be easily mounted. The follower is properly guided in gun metal bushes. A graduated circular protractor is fitted co-axial with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the follower system. Weights on the follower rod can be adjusted as per the requirements. The arrangement of speed regulation is provided.

The machine is particularly very useful for testing the cam performance for jump phenomenon during operation. This machine clearly shows the effect of change of inertia forces on jump action of cam follower during the operation. It is used for testing various cam and follower pairs, i.e. 1) Circular arc cam with mushroom follower, 2) Tangent cam with roller follower, and 3) An eccentric cam with knife edge follower.

Jump Phenomenon:

The jump phenomenon occurs in case of cam operating under the action of compression spring load. This is a transient coefficient that occurs only with high speed, highly flexible cam follower systems. With jump, cam and the follower separate owing to excessively unbalanced forces exceeding the spring force during the period of negative acceleration. This is undesirable since the fundamental function of the cam follower system, the constraint and control of follower motion are not maintained. Also related are the short life of the cam flank surface, high noise, vibrations and poor action.

Jump And Crossover Shock:

A cam follower retained against the cam with a compression retaining spring will under certain conditions, jump or bounce out of contact with the cam. This condition is most likely to occur with low values of damping and with high speed cams of quite flexible follower trains.

Crossover shock occurs in a positive drive cam mechanism when contact moves from one side of the cam to the other. Clearance and backlash are taken up.

<u>Experiments -</u>

1. To plot n - (follower displacement vs. angle of cam rotation). Curve for different cam follower pairs. The n-6 plot can be used to find out the velocity and acceleration of the follower system.
2. For this experiment, arrange the set up as shown in fig. 1. The exact profile of the cam be obtained by taking observations n vs. θ. Where n = displacement of the follower from

rotation initial position and θ = angle of cam rotation with reference from axis of symmetry chosen. By differentiating the n - θ curve once and twice, the velocity and acceleration curves can be plotted for the follower and cam under study.

3. To observe the phenomenon of jump. For this, use of a stroboscope (not included in scope of supply) is necessary. The speed of cam rotation and stroboscope frequency on neon lamp are gradually and simultaneously increased and at the time jump to occur the follower is seen to loose contact with the cam. When jump occurs the follower pounds on the cam surface giving a good thumping sound.

Observation :

Base circle radius or minimum radius of the cam, r1 = mm

Observation Table:

	Forward Stroke	Dwell	Return Stroke	Dwell
Angle In Degree				
Follower Lift In mm				

<u>Displacement, velocity and acceleration diagrams of the Roller follower :</u>

Profile Of The Tangent Cam :

OBSERVATION TABLE FOR JUMP SPEED:

S.No	Wt. added on follower assembly in kg	Jump Speed in RPM

RESULT & CONCLUSIONS:

Thus the profile of the Tangent cam with roller follower has been drawn, and jump speed is

VIVA QUESTIONS:

1. Define tangent cam?
2. Describe different types of followers?
3. Define pitch point with reference to cam profile.
4. Explain cycloidal motion for follower.
5. What is prime circle?

EXPERIMENT - 17
CRITICAL SPEED OF SHAFT

AIM:

To determine the critical speed of shaft of various sizes and to compare it with the theoretical values.

APPARATUS REQUIRED:

1. Power source
2. Tachometer (Noncontact type)
3. Vernier caliper
4. Scale
5. Shaft

THEORY:

Critical Speed : The Phenomena is that the "The additional deflection of the shaft from the axis of rotation becomes infinite is known as critical speed".In normal running conditions the centre of gravity of a loaded shaft will always displace from the axis of rotation, although this amount of displacement may be very less. As a result of this displacement, the centre of gravity is subjected to a centripetal acceleration as soon as the shaft begins to rotate. The inertia force acts radially outwards and bends the shaft. The bending of shaft not only depends upon the value of eccentricity, but also depends upon the speed at which it rotates.

DESCRIPTION OF THE APPARATUS:

This apparatus is specially developed for the study of Whirling Phenomenon. The shaft can be tested for different end conditions.

The Apparatus consists of a frame to support its driving motor, end fixing and sliding blocks, etc. A special design is provided to clear out the effects of bearings of motor spindle from those of testing shafts. The special design features of this equipment are as follows:

A. KINEMATIC COUPLING: : (C)

This coupling is specifically designed to eliminate the effect of motor spindle bearings on those of the rotating shafts.

B. BALL BEARING FIXING ENDS: (M&N)

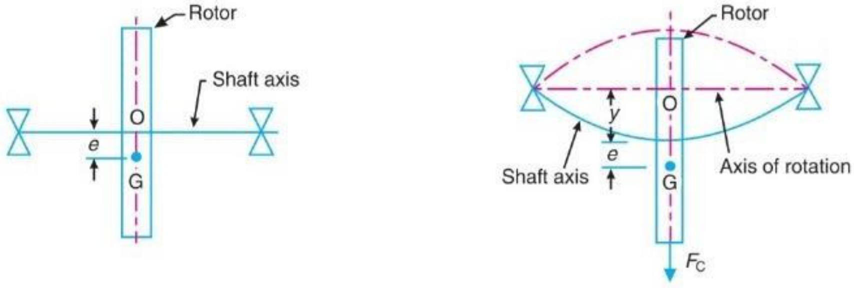
These ends fix the shafts while it rotates. The shaft can be replaced within a short time with the help of this unit. The fixing ends provide change of end fixing condition of the rotating shaft as per the requirement.

Specifications:

1. Shaft diameter (d) = 5 mm, 6 mm, 8 mm
2. Length of shaft between ends (l) = 900 mm
3. Density of material of shaft (&) = 8000 kg/m^3
4. Young's modulus(E) = 2.18 x 10^{10} N/mm^2

PROCEDURE:

1. Take the shaft of difference diameter as 4, 6 and 8 mm
2. To fix the shaft at both ends
3. Switch on the motor and increase the speed
4. Note down the speed at which the vibration is maximum using tachometer
5. This speed is known as critical speed (or) wire ling speed
6. Repeat the same procedure for all shaft
7. Tabulate the readings and calculate the theoretical value
8. Compare the experimental value with theoretical value



(*a*) When shaft is stationary. (*b*) When shaft is rotating.

Critical or whirling speed of a shaft.

Calculations

1. Moment of inertia of shaft

$$I = \frac{\pi\, d^4}{64}$$ in mm^4 Where ,d =diameter of shaft.

2. Mass of shaft per meter length

$$M_s = A \times L \times \rho$$

Where,

A= area of shaft (m^2)

L = length of shaft (m)

ρ = density of shaft material (kg/m^3)

3. Static deflection due to mass of shaft

$$\square_s = \frac{W\ l^4}{382EI}$$

Where,

W – Weight of the shaft (N)

4. Frequency

$$F_n = \frac{0.498}{\sqrt{\frac{\square s}{1.27}}} \text{Hz}$$

5. Whirling speed of shaft

N_{cr} = frequency of shaft in rps

6. Efficiency of whirling shaft

$$\eta = \frac{\text{Actual critical speed}}{\text{Theoritical speed}} \times 100$$

Space For Calculations

RESULT & CONCLUSIONS:

The whirling speed for the shafts of various diameter are determined experimentally and verified with the theoretical values.

VIVA QUESTIONS:

1. What Is The Critical Speed Of Shaft?
2. The speed at which the shaft runs so that the additional deflection from the axis of rotation of the shaft becomes infinite, is known as __________
3. The critical speed of a shaft depends upon its
4. What are the factors which affects the critical speed of a shaft?
5. Define node in critical speed of shaft?

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METHODIST

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