K.L.N. College of Engineering

(An Autonomous Institution)

Accredited by National Assessment and Accreditation Council (NAAC)

Pottapalayam – 630612.(11 km From Madurai City) TamilNadu, India.

Department of Mechanical Engineering

Accredited by NBA, New Delhi
Approved Research Center by Anna University, Chennai
Approved Nodal Center for e – YANTRA Lab

Regulations – 2020

20ME5L1
Dynamics Laboratory

Lab In charge

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Prepared by

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Approved by

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HOD / Mech. Engg

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To become a Centre of excellence for Education and Research in Mechanical Engineering.

MISSION

- **Attaining academic excellence through effective teaching learning process and state of the art infrastructure.**
- **Providing research culture through academic and applied research.**
- **Inculcating social consciousness and ethical values through co-curricular and extra-curricular activities.**

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO I	**Graduates will have successful career in Mechanical Engineering and service industries.**
PEO II	**Graduates will contribute towards technological development through academic research and industrial practices.**
PEO III	**Graduates will practice their profession with good communication, leadership, ethics and social responsibility.**
PEO IV	**Graduates will adapt to evolving technologies through lifelong learning.**

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1	**Derive technical knowledge and skills in the design, develop, analyze and manufacture of mechanical systems with sustainable energy, by the use of modern tools and techniques and applying research based knowledge.**
PSO 2	**Acquire technical competency to face continuous technological changes in the field of mechanical engineering and provide creative, innovative and sustainable solutions to complex engineering problems.**
PSO 3	**Attain academic and professional skills for successful career and to serve the society needs in local and global environment.**

Program Outcomes(PO's)
Mechanical Engineering Graduates will be able to:

PO1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**The engineer and society:** Apply reasoning informed by 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 and norms of the engineering 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 with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and 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.

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. CO

20ME5L1 - DYNAMICS LABORATORY

OBJECTIVES:

- To understand simple mechanisms like gears, cam, four bar and slider crank mechanism.
- To understand dynamic testing of machines.
- To understand the concept of torsional vibration of rotors.
- To know about the mass moment of inertia of axi symmetric bodies.
- To understand machine dynamics with various equipments like governors, gyroscopes and balancing machines

LIST OF EXPERIMENTS

1. Study of Kinematics of four bar, slider crank, crank rocker, double crank, double rocker, oscillating cylinder mechanisms, single and double universal joints.
2. Study of gyroscopic effect and couple.
3. Determine the velocity ratio of simple and compound gear train.
4. Determine the mass moment of inertia of fly wheel and axle system.
5. Determine the mass moment of Inertia of axisymmetric bodies using Turn Table apparatus.
6. Determine the mass moment of Inertia using bifilar suspension and compound pendulum.
7. Draw the controlling force diagram for Watts, Porter, Proell, and Hartnell Governors.
8. Draw the Cam profile and study about jump phenomenon.
9. Determine the natural frequency, damping coefficient for single and multi-degree spring mass system.
10. Determine the natural frequency of single rotor system.
11. Determine the natural frequency of double rotor system.
12. Determine the critical speeds of shafts with concentrated loads.
13. Determine the deflection in Cantilever beam under different loading conditions.
14. Determine the unbalanced mass and relative angular setting for balancing the rotating body.

TOTAL : 45 PERIODS

OUTCOMES:

AT THE END OF THE COURSE, LEARNERS WILL BE ABLE TO:

Course Name : DYNAMICS LABORATORY		**Course Code : 20ME5L1**			
CO	**Course Outcomes**	**EXP**	**K-CO**	**POs**	**PSOs**
C308.1	Calculate the deflection of the cantilever beam and Determine the critical speed of the shaft.	1,2	K3	1,2,3,4,9	1,2,3
C308.2	Determine the unbalanced mass and relative angular setting for balancing the rotating body and cam analysis	3,4	K3	1,2,3,4,9	1,2,3
C308.3	Calculate the natural frequency of the longitudinal, transverse and torsional vibratory systems.	5,6	K3	1,2,3,4,9	1,2,3
C308.4	Calculate the Effect of Actual Spindle Speed on Sleeve Displacement, Effect of Radius of Rotation on Centrifugal Force and draw the characteristics curve for different types of governors.	7	K3	1,2,3,4,9	1,2,3
C308.5	Determination of Mass moment of inertia of Fly wheel and Axle system and calculate the speed ratio and train value of simple and compound gear train	8,9	K3	1,2,3,4,9	1,2,3
C308.6	Determine the Mass Moment of Inertia of axisymmetric bodies using Turn Table apparatus, compound pendulum and bifilar suspension	10,11, 12	K3	1,2,3,4,9	1,2,3

CO-PO Mapping

CO	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
C308.1	3	2	1	1	-	-	-	-	2	-	-	-	2	1	1
C308.2	3	2	1	1	-	-	-	-	2	-	-	-	2	1	1
C308.3	3	2	1	1	-	-	-	-	2	-	-	-	2	1	1
C308.4	3	2	1	1	-	-	-	-	2	-	-	-	2	1	1
C308.5	3	2	1	1	-	-	-	-	2	-	-	-	2	1	1
C308.6	3	2	1	1	-	-	-	-	2	-	-	-	2	1	1

CYCLE I

1. Study of Kinematics of four bar, slider crank, crank rocker, double crank, double rocker, oscillating cylinder mechanisms, single and double universal joints.
2. Determine the velocity ratio of simple and compound gear train.
3. Determine the mass moment of Inertia of axisymmetric bodies using Turn Table apparatus.
4. Determine the natural frequency of single rotor system.
5. Determine the critical speeds of shafts with concentrated loads.
6. Determine the unbalanced mass and relative angular setting for balancing the rotating body.
7. Determine the deflection in Cantilever beam under different loading conditions.

CYCLE II

1. Study of gyroscopic effect and couple.
2. Determine the mass moment of inertia of fly wheel and axle system.
3. Determine the mass moment of Inertia using bifilar suspension and compound pendulum.
4. Draw the controlling force diagram for Watts, Porter, Proell, and Hartnell Governors.
5. Draw the Cam profile and study about jump phenomenon.
6. Determine the natural frequency, damping coefficient for single and multi-degree spring mass system.
7. Determine the natural frequency of double rotor system.

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4.	Determine the mass moment of inertia of fly wheel and axle system.	16
5.	Determine the mass moment of Inertia of axisymmetric bodies using Turn Table apparatus.	18
6.	Determine the mass moment of Inertia using bifilar suspension and compound pendulum.	24
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Name : ……………………………………….……… *Batch…………………………..………….*

Roll No.:…………… *Year ……..…* *Semester……..…* *Section : ………..…*

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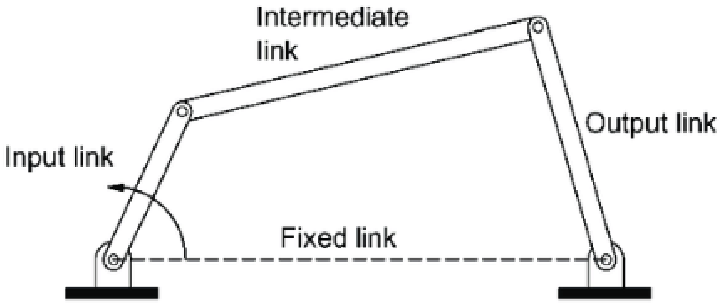
Staff - in – charge

Ex No: 1 ***Date:***

Study of Kinematics of four bar, slider crank, crank rocker, double crank, double rocker, oscillating cylinder mechanisms, single and double universal joints

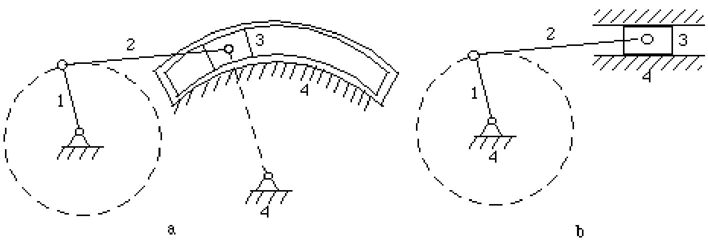
Four bar mechanism:

It is composed of four rigid bars attached to each other to produce the desired output. Before understanding the four-bar mechanism, it is crucial to understand the mechanism. A mechanism is a device that turns the required input and motion set into the necessary output forces and motion.



Single Slider Crank Mechanism

The single slider crank mechanism is a four-bar linkage with a rotating crank attached to a slider that moves in a straight line. This mechanism is made up of three major components: the crank, which is the revolving disc, the slider, which slides inside the tube; and the connecting rod, which connects the pieces.



Crank Rocker Mechanism :

It is a four bar linkage. In this linkage, the shortest link rotates fully while the other link pivoted to the fixed link oscillates.

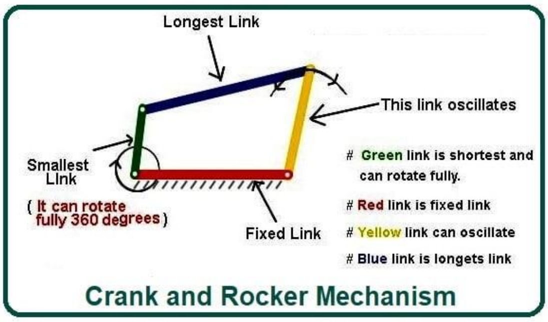
It is a Grashof linkage for which the sum of the lengths of the shortest link and the largest link is less than the sum of the lengths of the other two links.

$$s + l < p + q$$

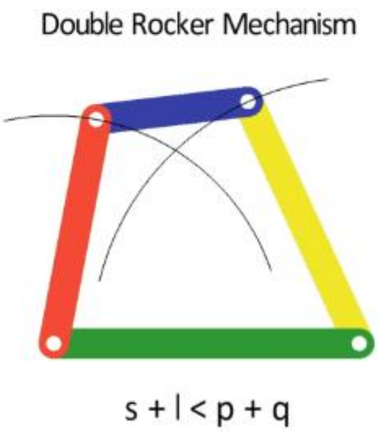
s = length of the shortest link

l = length of the largest link

p and q = lengths of the other two links



double rocker



Double Rocker Mechanism is a four-bar mechanism. In this linkage, both the links pivoted to the fixed link oscillate.

It is a Grashof linkage for which the sum of the lengths of the shortest link and the largest link is less than the sum of the lengths of the other two links.

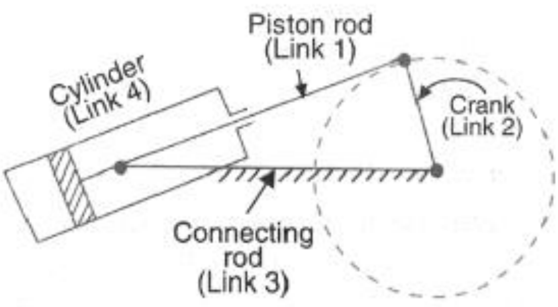
$$s + l < p + q$$

s = length of the shortest link

l = length of the largest link

p and q = lengths of the other two links

oscillating cylinder mechanisms:



Construction :

This mechanism is an inversion of Single slider crank chain , which is obtained by fixing connecting rod. It has three turning pairs & one Sliding pair. As shown in figure. both rod & piston form one link . There is no relative motion between rod & Piston . The cylinder is pivoted to frame, due to which whole cylinder is free to oscillate about the frame.

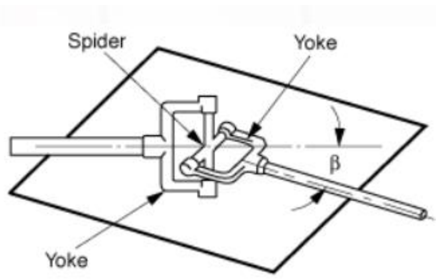
Working :

When crank starts rotating, it causes the piston to reciprocate inside the cylinder. A piston while reciprocating causes the cylinder oscillate about pt.'O' ,because there is no relative motion between connecting rod and piston.

Application :

The mechanism is used where rotary transmitted into oscillating motion. It is used in printing press m/c.

Universal Joints

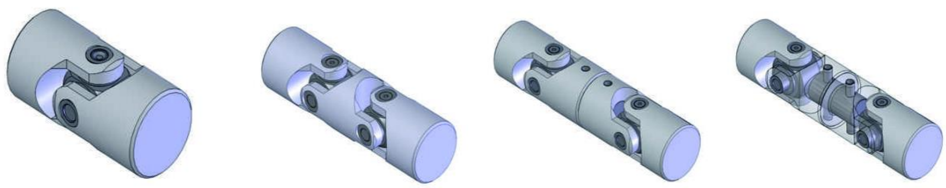


APPLICATIONS:

Typical application of universal joints include aircraft, appliances, control mechanisms, electronics, instrumentation, medical and optical devices, ordnance, radio, sewing machines, textile machinery, and tool drives.

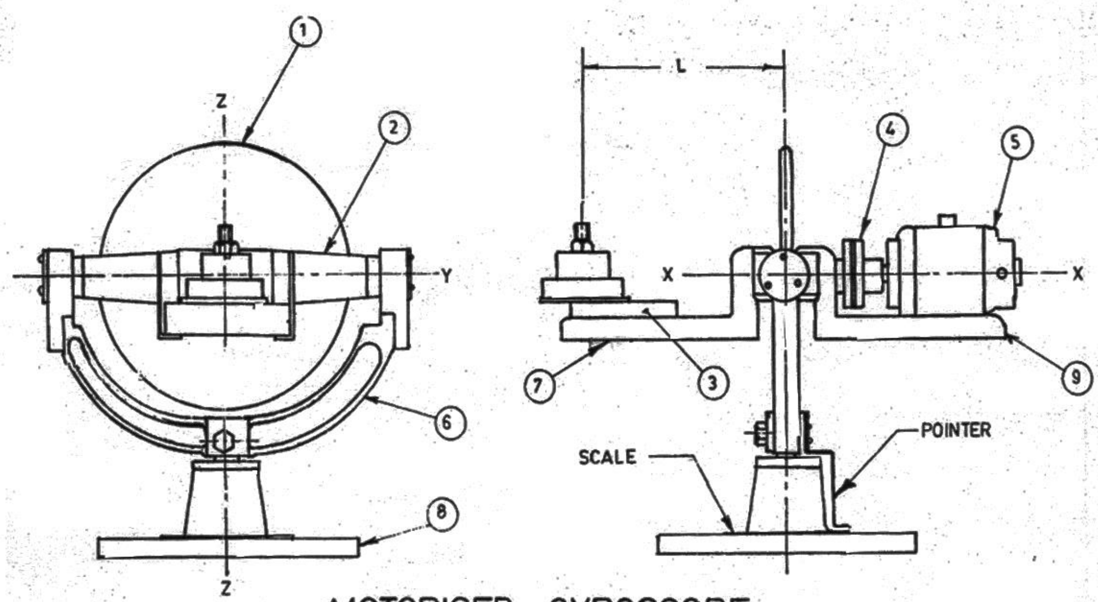
Universal joints are available in steel or in thermoplastic body members. Universal joints made of steel have maximum load-carrying capacity for a given size. Universal joints with thermoplastic body members are used in light industrial applications in which their self-lubricating feature, light weight, negligible backlash, corrosion resistance, and capability for high-speed operation are significant advantages.

Universal joints of special construction, such as ball-jointed universals are also available. These are used for high-speed operation and for carrying large torques. They are available both in miniature and standard sizes.



Single Universal Joint

Double Universal Joints



MOTORISED GYROSCOPE

(1) DISC	(2) DISC HOLDER	(3) BALANCING WEIGHT
(4) COUPLING	(5) MOTOR	(6) FORK
(7) PLATFORM FOR 3	(8) BASE	(9) PLAT FORM FOR 5

XX AXIS OF SPIN YY AXIS OF COUPLE ZZ AXIS OF PRECESSION

Ex No :2. ***Date :***

Gyroscopic Couple

Aim:

To determine gyroscopic couple produced in motorized gyroscope for different masses &compare with theoretical values and to draw graph (i) couple vs ω_p (ii) ω vs ω_p

Apparatus required:

1. Gyroscope
2. Non-contact tachometer or Stroboscope,
3. Variable voltage transformer,
4. Stop watch & weight – 3 nos.

Description:

The angular velocity is a vector quantity and change in its magnitude can be caused by acceleration. To create this angular acceleration a torque or couple is required. To keep this angular velocity constant in magnitude due to the angular acceleration caused by the couple the spinning mass of the gyroscope undergoes a change called the angle of precession. This causes the gyroscopic couple to incline to a certain degree so that it can retain its angular velocity. This angle of precession for different torques and couple can be analysed by this experiment.

When a body moves along a curved path with a uniform linear velocity, a force in the direction of centripetal acceleration (known as centripetal force) has to be applied externally over the body so that it moves along required curved path. This external force applied is known as active force. When a body itself is moving with uniform linear velocity along a circular path it is subjected to the centrifugal force radially outwards. This centrifugal force is called as reactive force.

The change in angular momentum is known as active gyroscopic couple($I .\omega. \omega_p$) when the axis of the spin itself moves with angular velocity ω_p the disc is subjected to reactive couple whose magnitude is same (i.e $I .\omega. \omega_p$) but opposite in direction to that of active couple.

Observation:

Mass of the disc (m) = 7.4 kg.

Rotor diameter (d) = 0.300m

distance (L) = 0.172m

Tabulation:

S.No	Speed of disc N (rpm)	Angular velocity ω (rad/sec)	Weight in Pan W (N)	$\partial\theta$ in (deg.)	∂t in (sec.)	$\omega p = \frac{\partial\theta}{\partial t}$ (rad/sec)	Active couple (W× l) (Nm)	Reactive or Gyroscopic couple $= I\times\omega\times\omega_p$ (Nm)
1.								
2.								
3.								
4.								
5.								

Procedure:

1. The disc as made to rotate at a constant speed at a specific time using variable voltage transformer.
2. The speed of the (N) disc is measured using a tachometer or a stroboscope.
3. A weight /mass is added on the extending platform attached to the disc.
4. This causes an active gyroscopic couple and the whole assembly (rotating disc, rotor and weight platform with weight) is standing to move in a perpendicular plane to that of plane of rotating of disc. This is called gyroscopic motion.
5. The time taken (t) to traverse a specific angular displacement (θ =60°) is noted.

Formula used:

1. Mass moment of inertia of the disc, $I = md^2/8$, kg-m^2,
2. m-mass of the disc and d-dia of the disc.
3. Angular velocity of the disc, $\omega = 2\pi N/60$, rad/s, N-speed of disc in rpm
4. Angular velocity of precession, $\omega_p = (\partial\theta / \partial t) \times (\pi/180)$ rad/s
5. Reactive gyroscopic couple, $C_r = I.\omega.\omega_p$ Nm and Active couple, $C_a = W \times L$

Model Calculation:

Result:

The Active couple and gyroscopic couple are verified.

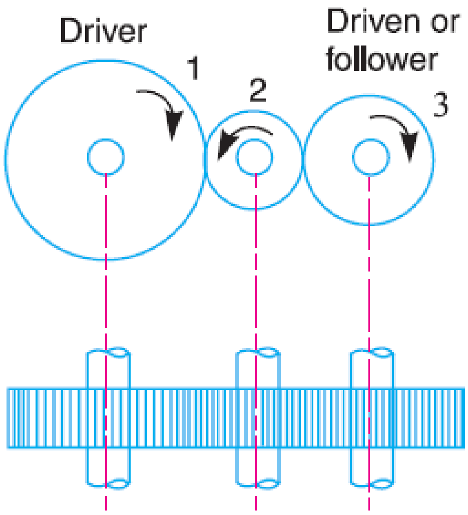
1. Active couple =
2. Reactive or Gyroscopic couple =

Inference:

By conducting this experiment, I understood thatif the axis of a rotating body is given an angular motion about an axis perpendicular to the axis of spin, an angular acceleration acts on the body about the third perpendicular axis.

Application:

The gyroscopic effect can be experienced in aero planes, ships and automobiles including Two wheelers.



Simple gear train

Gear	*No of teeth on the gear*	*Speed ratio*	*Train value*
Gear no 1			
Gear no 2			
Gear no 3			

$$\text{Speed ratio} = \frac{\text{Speed of driver}}{\text{Speed of driven}} = \frac{\text{No. of teeth on driven}}{\text{No. of teeth on driver}}$$

$$\text{Train value} = \frac{\text{Speed of driven}}{\text{Speed of driver}} = \frac{\text{No. of teeth on driver}}{\text{No. of teeth on driven}}$$

$$\frac{N_1}{N_2} \times \frac{N_2}{N_3} = \frac{T_2}{T_1} \times \frac{T_3}{T_2} \quad \text{or} \quad \frac{N_1}{N_3} = \frac{T_3}{T_1}$$

Ex No: 3A ***Date:***

Simple gear train

Aim:

To find the speed ratio and train value of the given gear train

Formula:

$$\frac{N_1}{N_2} \times \frac{N_2}{N_3} = \frac{T_2}{T_1} \times \frac{T_3}{T_2} \quad \text{or} \quad \frac{N_1}{N_3} = \frac{T_3}{T_1}$$

$$\text{Speed ratio} = \frac{\text{Speed of driver}}{\text{Speed of driven}} = \frac{\text{No. of teeth on driven}}{\text{No. of teeth on driver}}$$

$$\text{Train value} = \frac{\text{Speed of driven}}{\text{Speed of driver}} = \frac{\text{No. of teeth on driver}}{\text{No. of teeth on driven}}$$

N_1 = Speed of driver in r.p.m.,
N_2 = Speed of intermediate gear in r.p.m.,

N_3 = Speed of driven or follower in r.p.m.,
T_1 = Number of teeth on driver,
T_2 = Number of teeth on intermediate gear, and
T_3 = Number of teeth on driven or follower.

Procedure:

Check the given gear train is simple gear train or compound gear train. It may be checked by following method.

When there is only one gear on each shaft is known as simple gear train. When there are more than one gear one shaft is called compound gear train.

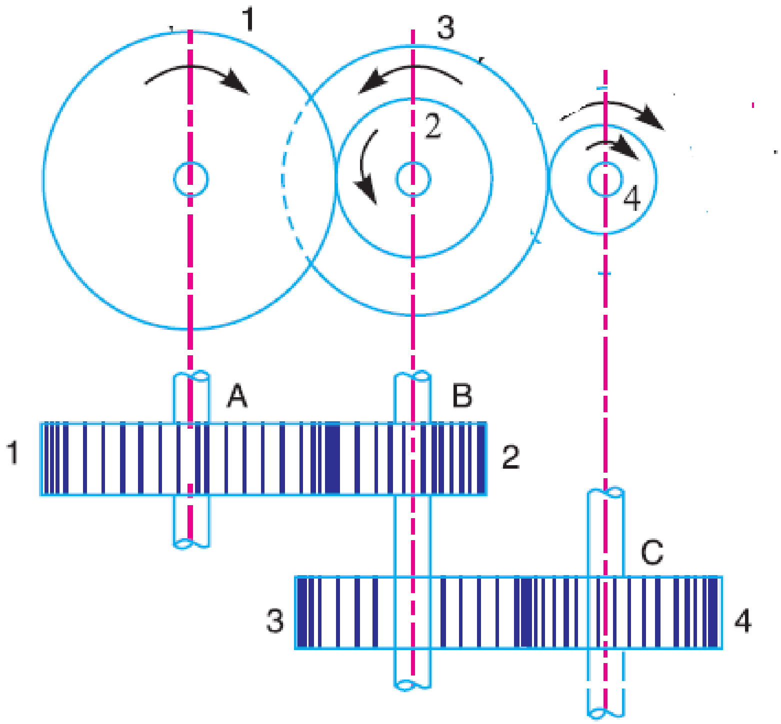
Count the number of teeeth on each gear

Apply the speed ratio and train value formula

Result:

Speed ratio of the simple gear train =

Train value of the simple gear train =



Compound gear train.

Gear	No of teeth on the gear	Speed ratio	Train value
Gear no 1			
Gear no 2			
Gear no 3			
Gear no 4			

Speed ratio of the compound gear train

$$\frac{N_1}{N_2} \times \frac{N_3}{N_4} = \frac{T_2}{T_1} \times \frac{T_4}{T_3} \quad \text{or} \quad \frac{N_1}{N_4} = \frac{T_2 \times T_4}{T_1 \times T_3}$$

Ex No: 3B. ***Date:***

Compound gear train

Aim:

To find the speed ratio and train value of the given gear train

Formula:

$$\text{Speed ratio} = \frac{\text{Speed of the first driver}}{\text{Speed of the last driven or follower}} = \frac{\text{Product of the number of teeth on the drivens}}{\text{Product of the number of teeth on the drivers}}$$

$$\text{Train value} = \frac{\text{Speed of the last driven or follower}}{\text{Speed of the first driver}} = \frac{\text{Product of the number of teeth on the drivers}}{\text{Product of the number of teeth on the drivens}}$$

$$\frac{N_1}{N_2} \times \frac{N_3}{N_4} = \frac{T_2}{T_1} \times \frac{T_4}{T_3} \quad \text{or} \quad \frac{N_1}{N_4} = \frac{T_2 \times T_4}{T_1 \times T_3}$$

Procedure:

Check the given gear train is simple gear train or compound gear train. It may be checked by following method.

When there is only one gear on each shaft is known as simple gear train. When there are more than one gear one shaft is called compound gear train.

In a compound train of gears, as shown in Fig. the gear 1 is the driving gear mounted on shaft *A*, gears 2 and 3 are compound gears which are mounted on shaft *B*. The gears 4 which are mounted on shaft *C* and the gear 4 is the driven gear mounted on shaft *C*.

Count the number of teeeth on each gear

Apply the speed ratio and train value formula

Result:

Speed ratio of the Compound gear train =

Train value of the Compound gear train =

Table

Mass suspended Kg	Height m.	Number of revolutions		Time for N revolutions t in seconds	Mean Angular Velocity Rad/s^2	Mass Moment of Inertia Kg/m^2
		n.	N			
Mean value of I						

Ex No : 4 ***Date:***

Flywheel and Axle System

Aim:

To determine the moment of inertia of a flywheel using flywheel-axle system.

Apparatus required:

Weight & scale, Hanger, Slotted Weight, stop watch

Formula:

$$I = \frac{Nm}{N+n}\left(\frac{2gh}{\omega^2} - r^2\right)$$

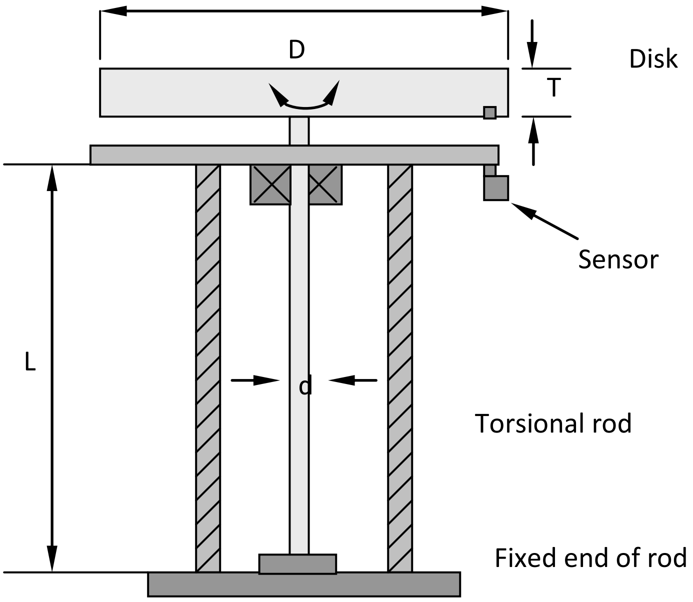
ω	=	2πN/t
I	=	Mass moment of inertia in kgm^2
m	=	suspended mass in kg
n	=	number of revolutions the cord is wound
N	=	Number of rotations made by flywheel during particular interval of time
g	=	acceleration due to gravity in m/s^2
h	=	The height of weight hanger from the ground in m
t	=	Time taken for the flywheel to come standstill in s
ω	=	Average angular velocity of flywheel in rad/s

Procedure:

The length of the cord is carefully adjusted, so that when the weight-hanger just touches the ground. A suitable weight is placed in the weight hanger. A chalk mark is made on the rim so that the number of revolutions it makes to come to standstill can be measured. The other end of the cord is loosely looped around the axle keeping the weight hanger just touching the ground. The flywheel is given a suitable number (n) of rotation so that the cord is wound round the axle without overlapping. The height (h) of the weight hanger from the ground is measured. The flywheel is released. The weight hanger descends and the flywheel rotates. The cord slips off from the axle when the weight hanger just touches the ground. By this time the flywheel would have made n rotations. A stop clock is started just when the hanger touches the ground. The time taken by the flywheel to come to a stop is determined as (t) seconds. The number of rotations(N) made by the flywheel during this interval is counted. The experiment is repeated by changing the value of m.

Result:

Moment of Inertia of flywheel I = kgm^2


D
T
Disk
Sensor
L
d
Torsional rod
Fixed end of rod

Ex No: 5 ***Date:***

Turn Table

Aim:

Determination of Mass moment of inertia of connecting rod using Turn Table Apparatus.

Description of Equipment:

Mass moment of inertia of machine member such as connecting rod, flywheel plays an important role for the evaluation of inertia force and consequent stress in various members of the machine. Moment of inertia of flywheel or other rotating member, contributes for kinetic energy stored and consequent fluctuation of speed due to variable input or loading condition. Certain machine members have complicated shape and theoretical determination of mass moment of inertia is tedious time consuming and less accurate

The principle of working of equipment is determination of moment of inertia by torsional vibration.This consists of a solid steel disc 300 mm diameter and 27 mm thick mounted on a 6.1 mm round rod 660 m.m in length fixed at bottom. A bearing is provided below the disc to avoid buckling of the rod.

Apparatus Required:

1. Experimental setup
2. Connecting rod
3. Spanner
4. Stop watch

***Observation*:**

Disk: diameter – 300 mm: thickness – 27 mm, mass 15 kgI_1 = 0.16875 kg. mm^2

Tabulation

Time taken for one revolution in seconds

Parameter	**Time taken 10 oscillations in (sec)**			**Time taken one oscillations in (sec)**			**Mass moment of Inertia of object average**
	t_1	**t_2**	**t_3**	**t_1**	**t_2**	**t_3**	
without member							
with member							

Formula used:

$$I_1 = \frac{qt_1^2}{4\pi^2}$$

$$I_2 = \frac{qt_2^2}{4\pi^2} - I_1$$

Where

I_1 is mass moment of inertia of Disc

I_2 is mass moment of inertia of object (flywheel, connecting rod)

T_1 is time taken for one oscillation of disc

T_1 is time taken for one oscillation of disc with object

q is torsional stiffness of the rod.

Torsional stiffness of the rod **q**= $\frac{GJ}{L}$

G –modulus of rigidity

J –polar moment of inertia = $\frac{\pi}{32} d^4$

L –length of the polish rod = 660 mm

Where d is wire dia = 6.1 mm

Model Calculation:

Procedure:

1. Give angular twist to the disc and measure period (t_1) for one oscillation.
2. Find out the mass moment of inertia of the disc using formula $I_1 = \frac{qt_1^2}{4\pi^2}$.
3. Compare with theoretical value of the disc using the formula
4. Mass moment of inertia of disc, $= \frac{mr^2}{2}$
5. Take an object Place it on centre of marking and find out time taken for one oscillation (t_2).
6. Find out the mass moment of inertia of the disc and test object using formula given

$$I_2 = \frac{qt_2^2}{4\pi^2} - I_1$$

Result:

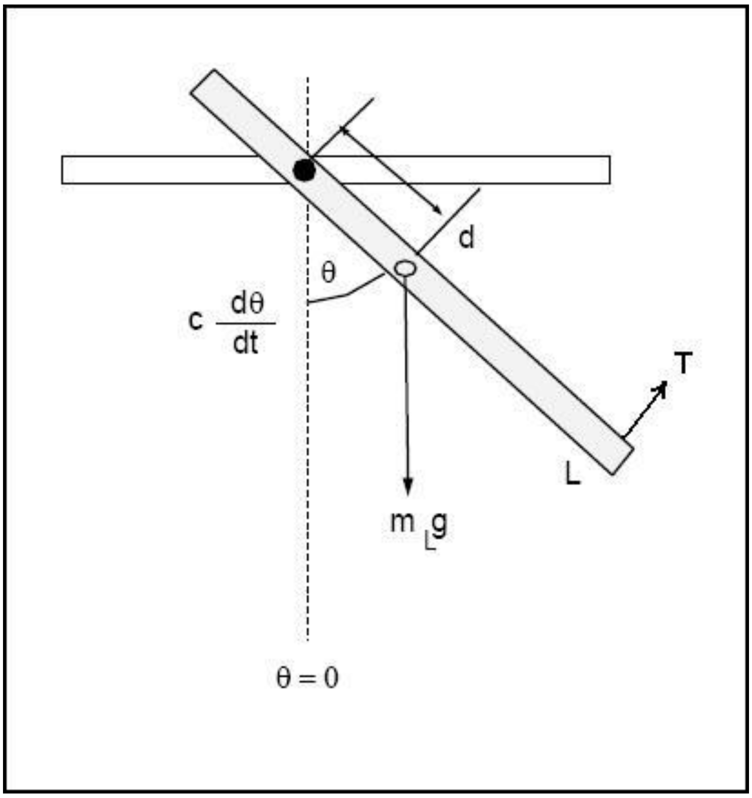
Thus the Mass moment of inertia of connecting rod using Turn Table Apparatus found.

Inference:

We can determine the moment of inertia of body if it is subjected to swing as pendulum about a fixed knife edge.

Application:

We can determine the moment of inertia of the flywheel about its geometric axis by conducting experiments. Also this concept can be extended to find out the mass moment of inertia of the body which is not in exactly geometric shape.



Compound Pendulum

Ex No: 6A ***Date:***

Compound Pendulum

Aim:

To find the mass moment of inertia of a compound pendulum.

Apparatus Required:

1. Stop watch.
2. Steel rule.

Formula Used:

$$k = \sqrt{\left(\frac{t}{2\pi}\right)^2 gh - h^2}$$

Where,

k = radius of gyration (m)

t = time taken for 1 oscillation in sec. t_1 / 10, t_1 = time for 10 oscillation in sec.

g = acceleration due to gravity from axis of suspension in m/sec^2.

h = distance between axis of suspension and centre of gravity of compound pendulum in m.

I = mk^2 kg/m^2

Procedure:

1. The compound pendulum is placed by one of its hole on the test rig.
2. The distance of centre of gravity from axis of suspension is noted.
3. From the formula, radius of gyration is found.
4. The experiment is repeated for different portions and average is found.

Observation:

mass of the pendulum = 1.610kg.

Tabulation:

S.No.	height (m)	Time taken for 5 oscillations t_1 (sec)	Time taken for 1 oscillation t (sec)	radius of gyration k(m)	k^2	Mass moment of inertia I (kgm^2)
1.						
2.						
3.						
4.						
5.						

Model Calculation:

Result:

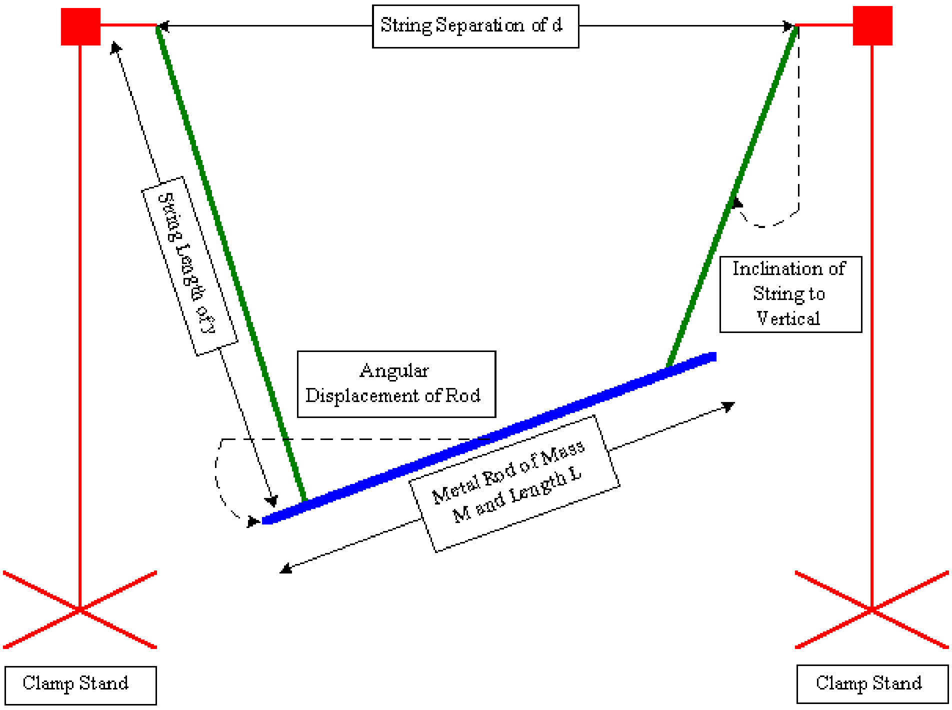
Thus the mass moment of inertia using compound pendulum was found.

Inference:

We can determine the moment of inertia of body if it is subjected to swing as pendulum about a fixed knife edge.

Application:

We can determine the moment of inertia of the flywheel about its geometric axis by conducting experiments. Also this concept can be extended to find out the mass moment of inertia of the body which is not in exactly geometric shape.


String Separation of d
String Length of y
Inclination of String to Vertical
Angular Displacement of Rod
Metal Rod of Mass M and Length L
Clamp Stand
Clamp Stand

Ex No:6B ***Date :***

Bi - Filar Suspension

Aim:

Determination of the mass moment of inertia using Bi-fillar system.

Apparatus required:

Bi-filar suspension weights, stop watch and steel rule.

Formula Used:

$$k = \frac{b}{2\pi f_n} \times \sqrt{\frac{g}{l}}$$

$$t = \frac{time\ for\ 10\ oscilation}{10}$$

Where f_n = frequency of oscillations in sec.

b = distance of string from centre of gravity =

l = length of strings in m,

Mass moment of inertia $I = mk^2$ kgm^2

***Procedure*:**

Attach the bi-filar suspension strings to the chucks mounted at top of the frame. Adjust the strings to equal lengths. Fix the weights required over the beam of bi-filar. Oscillate the system about vertical axis passing through the centre of beam. Measure the time required for 10 oscillations.

Tabulation:

S.No.	Length (m)	weight fitted (kg)	time for 10 oscillations (sec)	time for one oscillation (sec)	radius of gyration (k)	k^2	mass moment of inertia (kgm^2)
1.							
2.							
3.							
4.							
5.							

Model Calculation:

***Result*:**

Thus the mass moment of inertia using Bi-filar system found.

Inference:

We can determine the moment of inertia of body if it is subjected to swing as pendulum about a fixed knife edge.

Application:

We can determine the moment of inertia of the flywheel about its geometric axis by conducting experiments. Also this concept can be extended to find out the mass moment of inertia of the body which is not in exactly geometric shape.

Ex No: 7 **Date:**

Universal Governor

Aim:

To study the characteristics of Watt governor.

Apparatus Required:

1. Digital Tachometer
2. Watt governor setup
3. Spanner 16-17

Description of the setup:

The drive unit consists of a DC electric motor connected through belt and pulley arrangement. Motor and test setup are mounted on a M.S. fabricated frame. The governor spindle is driven by motor through V belt and is supported in a ball bearing. The optional governor mechanisms can be mounted on spindle. Digital speed is controlled by the electronic control unit.

A rpm indicator with sensor to determine the speed. A graduated scale is fixed to the sleeve and guided in vertical direction. Sleeve displacement is to be noted on the scale provided.

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.

Watt Governor

Observation:

1. Length of each link (L) = 125 mm = 0.125m
2. Initial height of Governor (h_o) = 94 mm = 0.094m
3. Initial radius of rotation (r_o) = 136 mm = 0.136m
4. Mass of each ball (m) = 700 gms (0.7 kg)

Tabulation:

S. No.	Speed N rpm	sleeve displacement (x)	height (h) m	Radius of rotation (R)m	Angular velocity (ω)rad/s	Force, (N)
1.						
2.						
3.						
4.						
5.						

Procedure:

The governor mechanism under test is fitted with the chosen rotating weights and spring, where applicable, and inserted into the drive unit. The following simple procedure may then be followed.

- 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.
- 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.
- The radius of rotation for corresponding sleeve displacement is measured directly by switching off the electronic control unit.
- This Procedure is adopted for all the other three Governor mechanisms by properly fitting the assembly to the spindle shaft.

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.

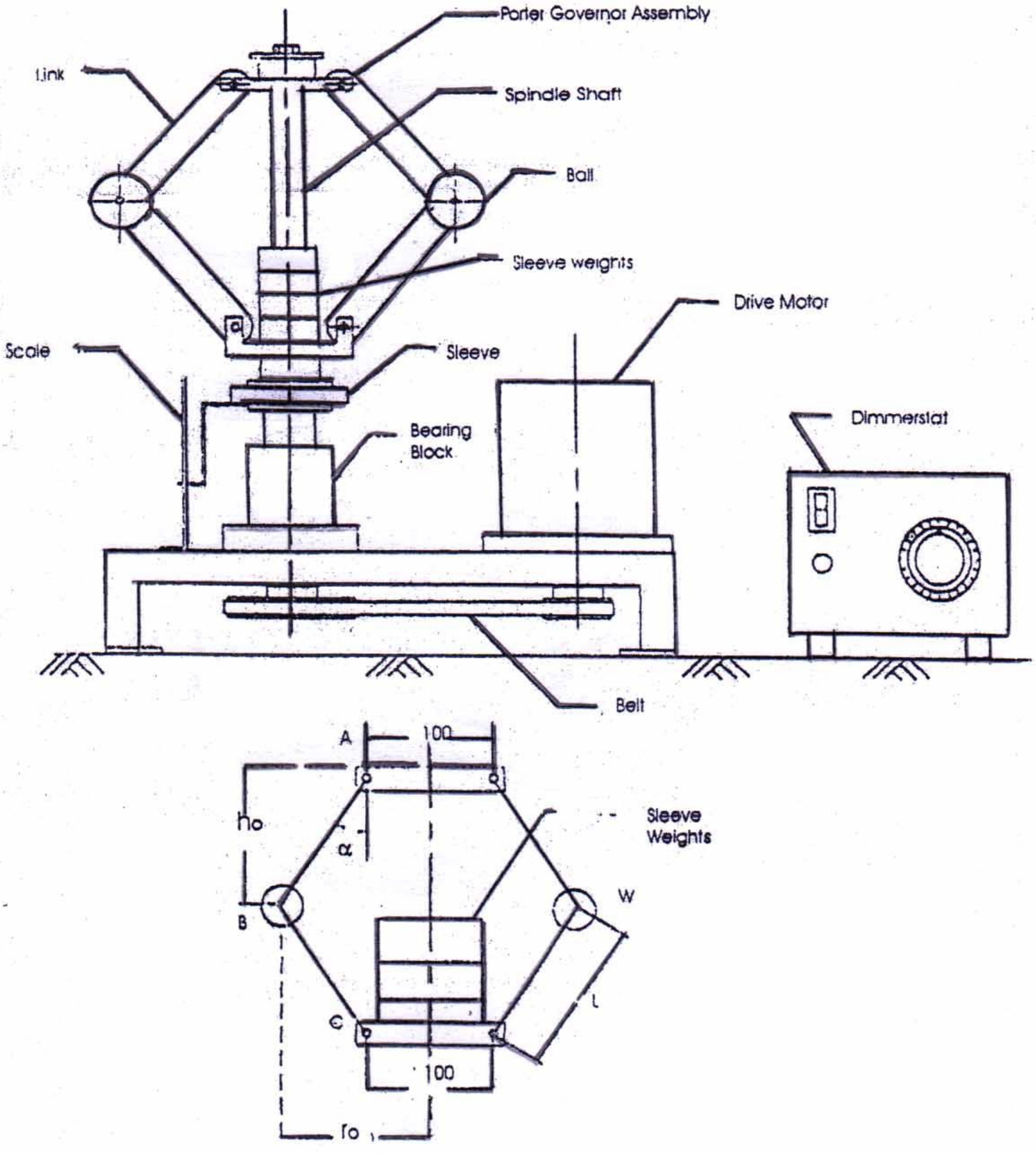
Formulae:

1. Height $h = h_o - x/2$ (m)
2. $\alpha = \cos^{-1}(h/L)$
3. $r = 0.05 + L \sin \alpha$
4. Force, $F = m\omega^2 r$ (N)
5. Angular velocity $(\omega) = (2\pi N)/60$ (rad/sec)

Model Calculation:

Graph:

1. Displacement vs Speed
2. Radius of rotation vs Controlling force



Schematic Layout of Governor Apparatus

Setup - Porter Governor Arrangement

Porter Governor

Aim:

To study the characteristics of Portergovernor

Apparatus Required:

1. Digital Tachometer
2. Sleeve weights
3. Governor setup for Porter
4. Spanner 16-17

Formulae:

1. Height $h = h_o - x/2$ (m)
2. $\alpha = Cos^{-1}(h/L)$
3. $r = 0.05 + L \sin \alpha$ (m)
4. Force, $F = m\omega^2 r$, (N)
5. Angular velocity (ω) $= (2\pi N) / 60$ rad/sec

Observation:

1. Length of each link (L) = 125 mm = 0.125m
2. Initial height of Governor (h_o) = 94 mm = 0.094m
3. Initial radius of rotation (r_o) = 136 mm = 0.136m
4. Mass of each ball (m) = 700 gms = 0.7kg
5. Sleeve weight= 500 gms each

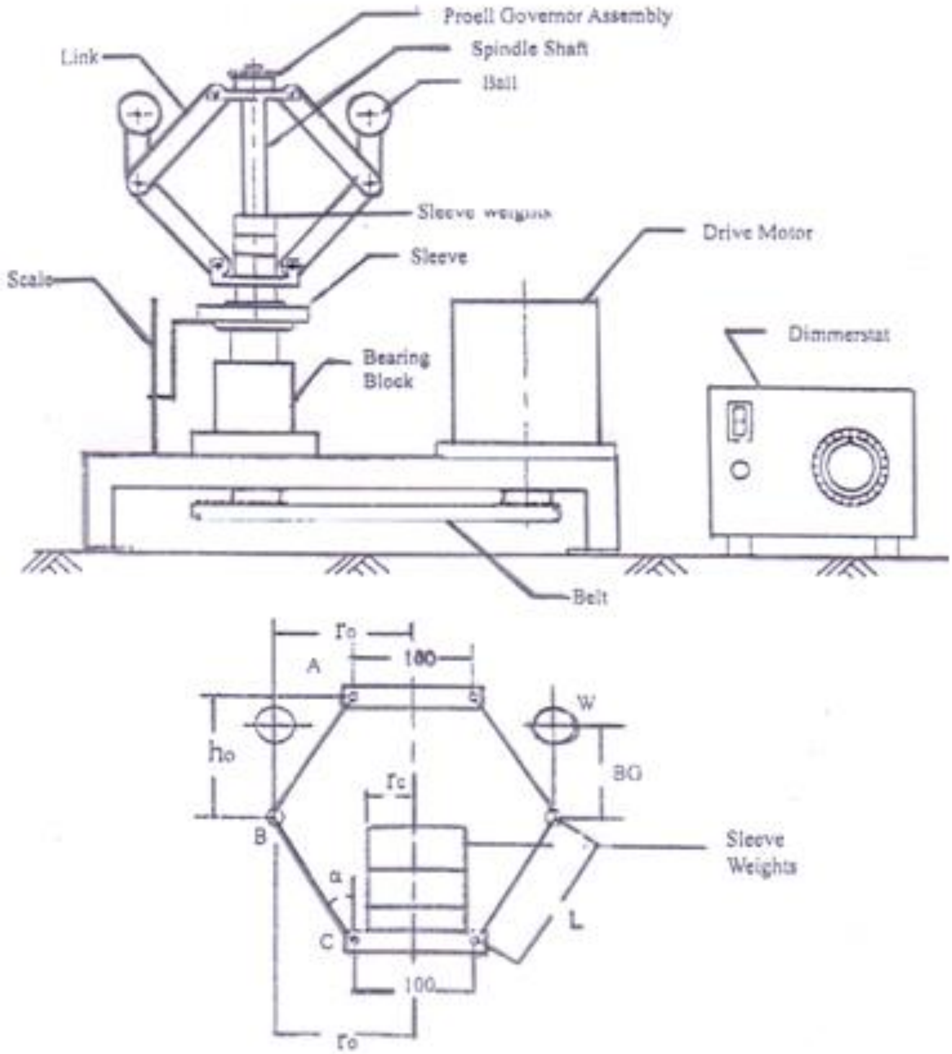
Tabulation:

S. No	Speed , N rpm	Sleeve displacement (x in m)	Height (h in m)	Radius of rotation (r in m)	Angular velocity (ω in rad/sec)	Force (F in N)
1.						
2.						
3.						
4.						
5.						

Model Calculation:

Graphs: (i) Displacement Vs Speed

(ii) Radius of rotation Vs Force



Governor Apparatus

Setup – Proell Governor Arrangement

Proell Governor

Aim:

To study the characteristics of Proell governor.

Apparatus Required:

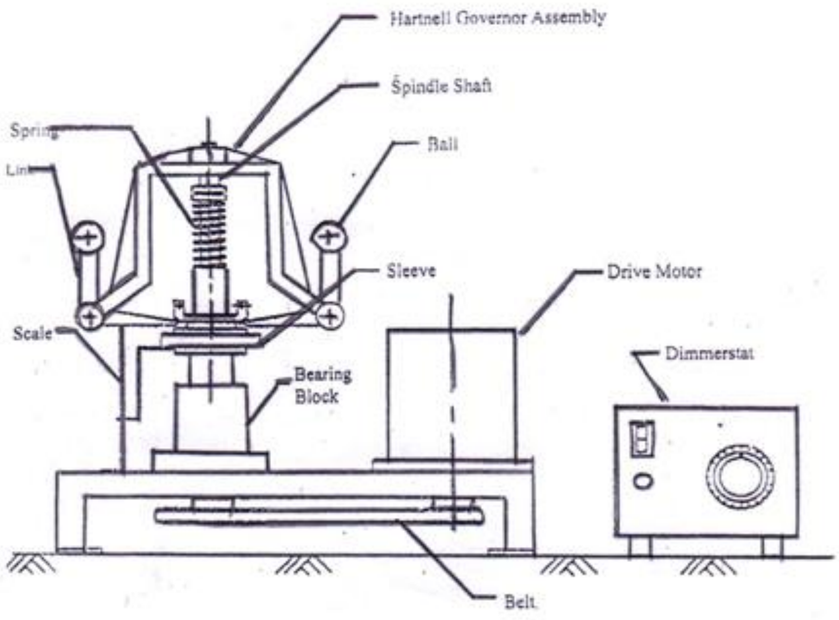
1. Digital Tachometer
2. Sleeve weights
3. Governor setup for Porter
4. Spanner 16-17

Description:

Arrange the set up as shown in fig.In the Proell Governor with the use of fly weights the governor becomes highly sensitive. Under these conditions large sleeve displacement is observed for very small change in speed. Hence it is suggested that increase the speed of motor very slowly and carefully get the lift.

Formulae:

1. Height h = ho-x/2 (m)
2. $\alpha = \cos^{-1}(h/L)$
3. $r = 0.05 + L \sin \alpha$
4. Force, $F = m\omega^2 r$,N
5. Angular velocity (ω) = ($2\pi N$) / 60 rad/sec



Schematic Layout of Governor Apparatus

Setup – Spring controlled Hartnell Governor Arrangement

Observation:

1. Length of each link (L)= 125 mm = 0.125m
2. Initial height of Governor (h_o)= 94 mm = 0.094m
3. Initial radius of rotation (r_o) = 141.5 mm = 0.1415m
4. Mass of each ball (m)= 700 gms = 0.7kg
5. Sleeve weight= 500 gms
6. Extension of length BG = 75 mm

Tabulation:

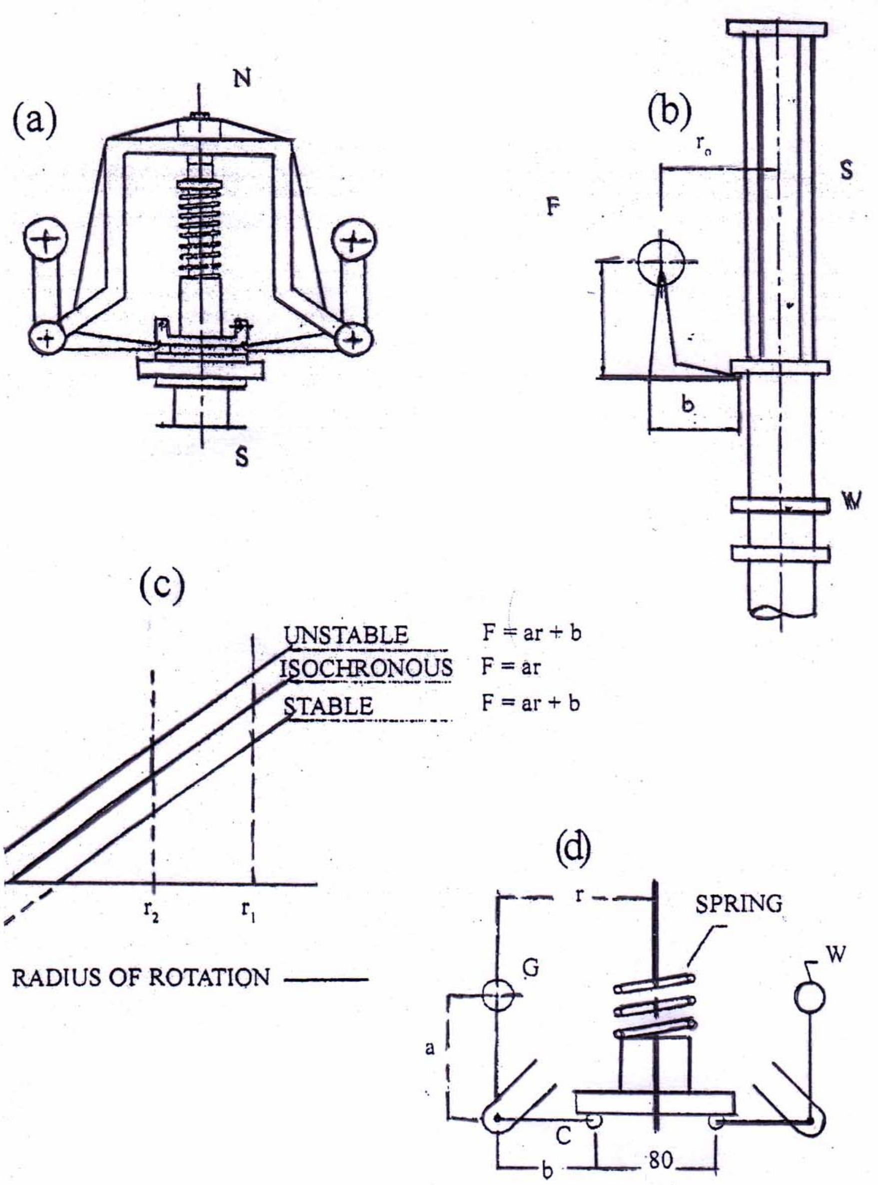
S. No	Speed N rpm	Sleeve displacement (x in m)	Height (h in m)	Radius of rotation (r in m)	Angular velocity (ω in rad/sec)	Force(N)
1.						
2.						
3.						
4.						
5.						

Model Calculation:

Graphs:

(i) Displacement vs Speed

(ii) Radius of rotation vs Controlling force


(a)
N
S
(b)
r_0
F
S
b
W
(c)
UNSTABLE F = ar + b
ISOCHRONOUS F = ar
STABLE F = ar + b
r_2
r_1
RADIUS OF ROTATION
(d)
r
SPRING
G
W
a
C
b
80

Hartnell Governor

Aim:

To study the characteristics of Hartnell governor.

Apparatus Required:

1. Digital Tachometer
2. Sleeve weights & Spring
3. Governor setup for Hartnell
4. Spanner 16-17

Formulae:

1. $r = r_o + x(a/b)$ m
2. Force, $F = m\omega^2 r$, N
3. Angular velocity (ω) $= (2\pi N) / 60$ rad/sec
4. Spring force = (free length of spring- Compressed length of spring) × spring stiffness

Observation:

1. Length a = 77 mm = 0.077m
2. Length b = 122 mm = 0.122m
3. Mass of ball (m)= 700 gms = 0.7kg
4. Initial radius of rotation (r_o) = 177.5 mm = 0.1775m
5. Spring Stiffness = 1962N/m
6. Free length of Spring = 0.1 m

Tabulation:

S. No	Speed , N rpm	Sleeve displacement (x in m)	Radius of rotation (r in m)	Angular velocity (ω in rad/sec)	Force (F in N)
1.					
2.					
3.					
4.					
5.					

Model Calculation:

Graphs:

1. Displacement vs Speed
2. Radius of rotation vs Controlling force

Result:

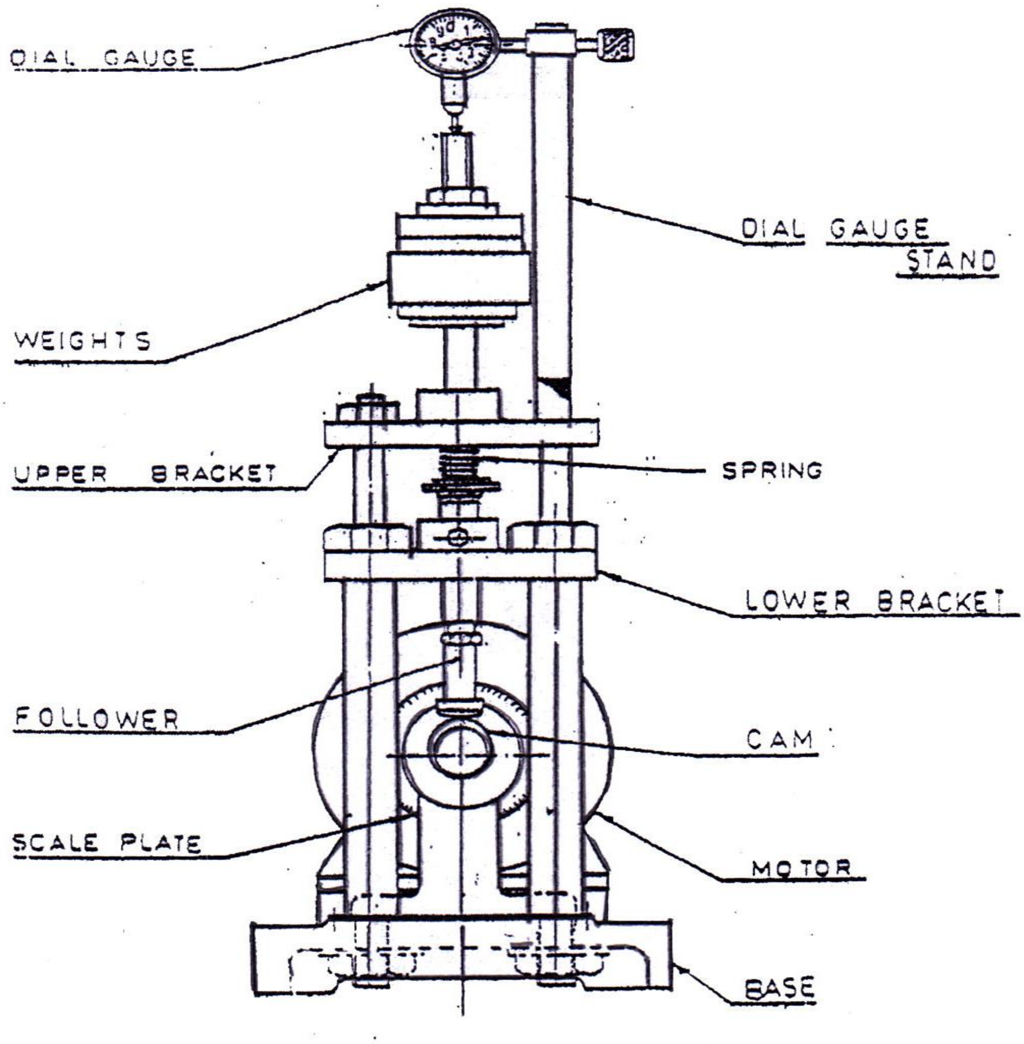
The characteristic curves are drawn for Watt, Porter, Proell and Hartnell governors.

Inference:

From the above experiment, I understood that the change of speed of the rotating mass produces the centrifugal force for change of position of sleeve.

Application:

The motion of the sleeve can be used for controlling the throttle valve in steam engine etc., which is rotating at low speeds.



ARRANGEMENT FOR n-θ DIAGRAM

Ex No :8 ***Date :***

CAM Analysis

Aim:

To draw n-θ curve for different cam follower pairs and to determine the jump speed of cam and draw the profile of the cam.

Apparatus Required:

1. Digital tachometer
2. Dial gauge and dial gauge spanner
3. Weights – 3 Nos.

Description of the set up:

- 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 forces on jump action of cam follower during operation.
- It is used for testing various cam follower pairs, i.e., (a) Circular arc cam with flat follower, (b) An eccentric cam with flat follower and (c) Sharp edged cam with flat follower.

Tabulation:1

S.No	Angular Position (degree)	Displacement (mm)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		
16.		
17.		
18.		

Tabulation: 2

S.No	Added weights on push rod (N)	Jump Speed (rpm)
1.		
2.		
3.		

- The unit is provided with the push rod in the two bush bearings. Should the unit be disassembled, for any, reason while assembling following precautions should be taken:

  (a) The horizontality of the upper and lower glands should be checked by a spirit level.

  (b) The supporting pillars should be properly tightened with the lock nuts provided.

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.

Procedure :

1. Select any one pair of cam and follower.
2. Follower is fixed to push rod and cam is fixed to camshaft.
3. Keeping the cam at the lower most position (Nose of the cam in downward position) follower is tightened in such a way that the follower and cam are in just contact.
4. Dial gauge is fixed to the stand and cam shaft is rotated with the help of the hand through some angle and note down the angle of cam rotation indicated on the protractor and the corresponding follower displacement indicated in the dial gauge.

Model Calculation:

To observe the Jump speed

- The speed of cam rotation and stroboscope frequency of neon lamp are gradually and simultaneously increased and at the time of jump to occur the follower is seen to loose contact with cam.
- The jump speed thus can be obtained from the stroboscope. When jump occurs the follower pounds on the cam surface giving a good thumping sound.

Precautions:

Before starting the motorized experiment see that the dial gauge is removed from the stand after taking the n-θ readings and then only one should carry on the motorized experiment.

CAM and Follower: ______________________________

Graph:

1. Displacement vs Angular position of cam
2. Follower weight vs Jump speed

Result:

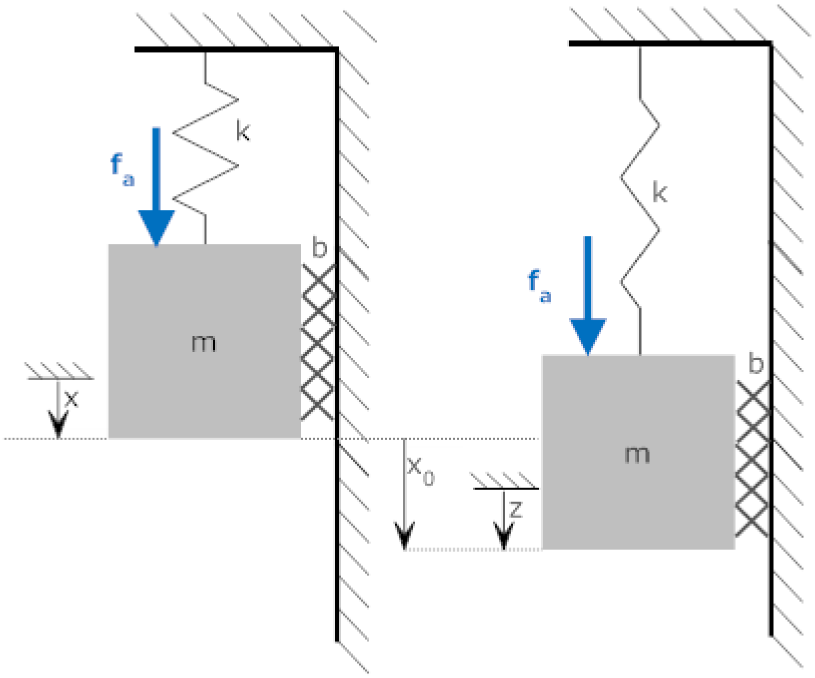
Thus the displacement diagram is drawn, profile of the cam and jump speed is determined.

Inference:

By conducting this experiment, I understood that the Cam makes the Follower to displace. With respect to the required displacement of the follower the Cam profile can be designed. Also the increase speed of the Cam will cause Jump phenomena.

Application:

Cam and Follower concept is utilized in many mechanical devices like Power Press, Power Braking etc.



(a) spring relaxed

(b) at equilibrium with gravity

Ex No:9 ***Date:***

Free Vibration of Spring – Mass System

Aim:

To calculate the undamped natural frequency of a spring mass system.

Apparatus required:

Weight, Scale &Stopwatch

Description:

The setup is designed to study the free or forced vibration of a spring mass system either damped or undamped condition. It consists of a mild steel flat firmly fixed at one end through a trunnion and in the other end suspended by a helical spring, the trunnion has got its bearings fixed to a side member of the frame and allows the pivotal motion of the flat and hence the vertical motion of a mass which can be mounted at any position along the longitudinal axes of the flat. The mass unit is also called the exciter, and its unbalanced mass can create an excitation force during the study of forced vibration experiment. The experiment consists of two freely rotating unbalanced discs. The magnitude of the mass of the exciter can be varied by adding extra weight, which can be screwed at the end of the exciter.

Formula used

$$Stiffness\ of\ spring\ K = \frac{Gd^4}{8D^3n}$$

$$Natural\ frequency \omega_n = \sqrt{\frac{K}{m}}$$

$$Damping\ frequency \omega_d = \sqrt{\frac{2\pi}{t^d}}$$

$$Damping\ factor\ \ \varepsilon = \sqrt{1 - \left[\frac{\omega_d}{\omega_n}\right]}$$

$$Damping\ co-efficient\ \ C = 2 \times \varepsilon \times m \times \omega_n$$

Tabulation:

Single Degree Freedom system

S.No	Weight added m (N)	time for 10 oscillation Hz	time for one oscillation Hz	Natural frequency Hz	Damping frequency Hz	Damping factor ε	Damping co-efficient C
1.							
2.							
3.							

Multi Degree Freedom system

S.No	Weight added m (N)	time for 10 oscillation Hz	time for one oscillation Hz	Natural frequency Hz	Damping frequency Hz	Damping factor ε	Damping co-efficient C
1.							
2.							
3.							

Multi Degree Freedom system

Model Calculation:

Procedure

1. Fix the top bracket at the side of the scale and Insert one end of the spring on the hook.
2. At the bottom of the spring fix the other plat form
3. Note down the reading corresponding to the plat form
4. Add the weight and observe the change in deflection

Determination of natural frequency

1. Add the weight and make the spring to oscillate for 10 times
2. Note the corresponding time taken for 10 oscillations and calculate time period
3. From the time period calculate experimental natural frequency

Result:

1. Thus calculate the undamped natural frequency of a spring mass system.

Inference:

The Longitudinal vibration of a system is understood. We can calculate the Longitudinal Undamped vibration theoretically and compare with the actual experiment.

Application:

Many components to subject to Longitudinal vibration and we can findout the respective vibration frequency, so that we can maintain the system within the safer limit.


SINGLE AND TWO ROTOR SYSTEM

Ex No :10 ***Date :***

Single Rotor System

Aim:

To study the free vibrations of single rotor system and to determine the natural frequency of vibration theoretically and experimentally.

Apparatus required:

1. Steel scale
2. Stop watch
3. Spanner – 2 Nos.

Procedure:

1. The mass is fixed at the one end of the rotor.
2. The mass is given an angular displacement with respect to the axis of rotor.
3. Because of the initial change of position the disc as a torsional vibration.
4. The time taken for the five oscillation is measured and tabulated.
5. Using the formula we can determine the actual and theoretical torsional frequency.
6. The results are tabulated.

Observation:

K_t = Torsional Stiffness = $\frac{G.I_P}{L}$ where G – modulus of rigidity=0.8 × 10^6 N/mm^2

I_P = Polar moment of Inertia = $\frac{\Pi \times d^4}{32}$

T_{TH} = $2\Pi\sqrt{\frac{I}{K_t}}$

where

I = Moment of inertia of disc. = $\frac{W \times D^2}{8 \times g}$

Where

d = dia of the shaft 3 mm

T_{EXP} = t/n Hz.

Tabulation:

S.No.	Length of shaft (m)	Time for 5 oscill. (sec)	Time for one oscill. (sec)	torsional stiffness K_t (N/mm)	T_{TH} (sec.)	F_{TH} (Hz)	$F_{EXP.}$ (Hz)
1.							
2.							
3.							
4.							
5.							

Model Calculation:

Result:

Thus the torsional vibration of single rotor system is studied and theoretical frequency was compared with experimental frequency.

Inference:

The torsional vibration of the single and Two Rotor system is calculated theoretically and compared with the experimental frequency. This concept gives us the knowledge of Torsional vibration effect.

Application:

Basing on the above knowledge, we can determine Torsional stiffness for stepped pulleys by considering anTorsionally Equivalent Shaft. This concept can be extended in designing Gear Power Transmission.


SINGLE AND TWO ROTOR SYSTEM

Ex No :11 ***Date:***

Double Rotor System

Aim:

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

Apparatus required:

1. Steel scale
2. Stop watch
3. Spanner – 2 Nos.

Formula

K_t = Torsional Stiffness = $\frac{G.I_P}{L}$ where G – modulus of rigidity=0.8 × 10^6 N/mm^2

I_P= Polar moment of Inertia = $\frac{\Pi \times d^4}{32}$

T_{TH} = $2\Pi\sqrt{\frac{I_A \times I_B}{K_t(I_A + I_B)}}$ where "I" = Moment of inertia of disc A. = I_A = $\frac{W_A \times {D_A}^2}{8 \times g}$

Where

d = dia of the shaft 3 mm

I_B = Moment of Inertia of Disc B. = $\frac{W_B \times {D_B}^2}{8 \times g} + \frac{2W_1R^2}{8g}$

***Observations*:**

Dia of Disc A D_A = 22.5 cm,

Dia of Disc B D_B = 19 cm

Weight of Disc A W_A = 2.8 kg

Weight of Disc B W_B = 2 kg

W_I = Weight attached to cross arm = 0.85 kg

R = Radius of fixation of wt on the arm = 13 cm

L = Length of shaft between rotors = 96 cm

Tabulation:

S.No.	Length of shaft (m)	time for 5 oscill. (sec.)	time for 1 oscill. (sec.)	K_t (sec.)	T_{TH} (sec.)	F_{TH} (Hz)	F_{EXP} (sec.)
1.							
2.							
3.							
4.							
5.							

Procedure:

1. Two masses are fixed at both end of the rotor.Weight is fixed at the one end of the rotor in the cross arm.
2. Any of the mass is given an angular displacement with respect to that another disc which is kept idle.
3. Because of the initial change of position the disc actas a torsional vibration.
4. The time taken for the five oscillations is measured and tabulated.
5. Using the formula we can determine the actual and theoretical torsional frequency.
6. The results are tabulated.

Model Calculation:

***Result*:**

Thus the torsional vibrtation of double rotor system is studied and theoretical frequency was compared with experimental frequency.

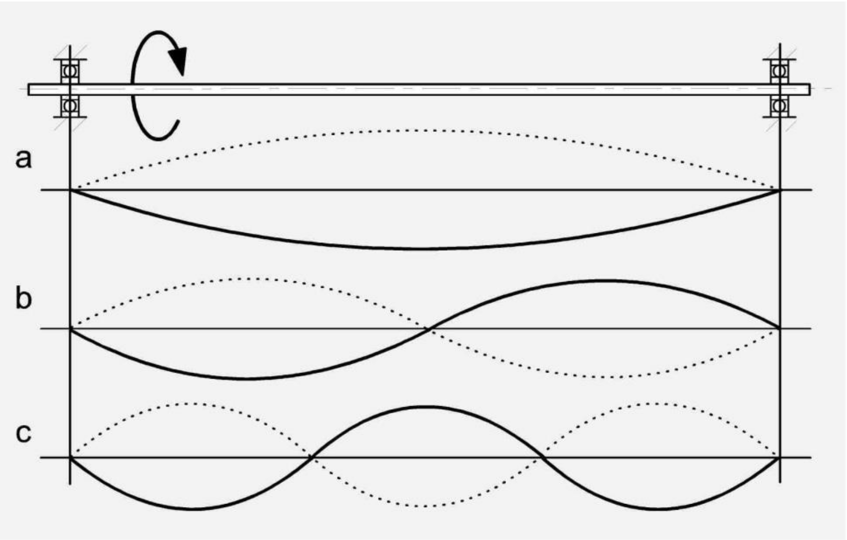
Inference:

The torsional vibration of the single and Two Rotor system is calculated theoretically and compared with the experimental frequency. This concept gives us the knowledge of Torsional vibration effect.

Application:

Basing on the above knowledge, we can determine Torsional stiffness for stepped pulleys by considering Torsionally Equivalent Shaft. This concept can be extended in designing Gear Power Transmission.

Whirling Phenomenon of Shaft



Ex No :12 ***Date :***

Whirling Phenomenon of Shaft

Aim:

To study whirling phenomenon of shaft **v**ibration.

1. Compare the critical speed of shaft for fixed support condition with theoretical values.
2. Plot graph of diavsCri.$_{theo.}$

Apparatus required:

1. Scale
2. Micrometer

Description:

The speed at which the shaft runs so that additional deflection of the shaft from the axis of rotation becomes infinite is known as critical speed.

At certain speed, a rotating shaft or rotor has been found to exhibit excessive lateral vibrations (transverse vibrations). The angular velocity of the shaft at which this occurs is called a critical speed or whirling speed or whipping speed. At a critical speed, the shaft deflection becomes excessive and may cause permanent deformation or structural damage. Therefore it is important to note that the machine should never be operated for any length of time at a speed close to a critical speed.

Observation:

1. Diameter of shaft (d) = ______m
2. Effective length of shaft (L) =_______m
3. End conditions:
4. Motor end – simply supported / fixed
5. Far end – simply supported / fixed

Tabulation:

S. No.	Diameter of shaft between center (m)	Length of shaft (m)	Theoretical Critical Speed (rpm)	Actual Critical Speed (rpm)
1.				

Formula Used:

$$Lateral\ Stiffness\ q = 192\frac{EI}{l^3}$$

$$Moment\ of\ inertia\ I = \frac{\pi}{64}d^4$$

$$natural\ frequency\ \omega n = \sqrt{\frac{q}{m}}$$

$$critical\ speed N_c = \omega n \times \frac{60}{2\pi}$$

E – Young's Modulus of shaft N/m^2 (2.1× 10^{11} N/m^2)

I – Moment of Inertia of shaft m^4

L – Length of shaft in m

(t)n – natural frequency of lateral vibration

Procedure:

1. Choose the required size of the shaft.
2. Mount the two fixing ends on the frame to obtain the desired condition.
3. The shaft is fixed between two ends.
4. The motor is started.
5. Motor speed is increased slowly.
6. The amplitude of vibrations in lateral direction starts and mode shape is observed.
7. The speed is noted down so also the mode shape and mode point.
8. To observe second mode shape the speed is increased further.
9. The speed and the mode shape is noted down.
10. The procedure is followed for different shafts and different end conditions.

Model Calculation:

***Result*:**

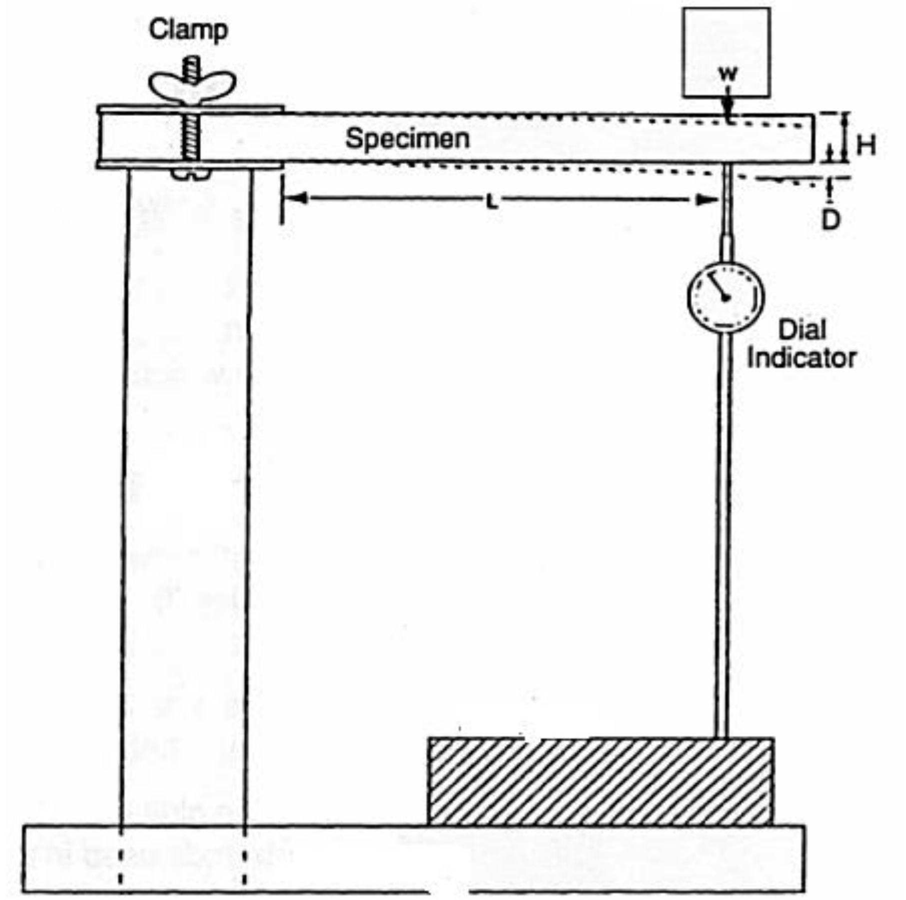
1. Moment of inertia =
2. Natural frequency =
3. Critical speed =

Inference:

Due to static deflection of the rotating shaft, it results in Transverse loading and produces Transverse vibration. This will further increase the deflection and damage the system at critical speed.

Application:

Transverse vibration can be expected for Cantilever type loading and also simply supported beams which are in rotation. In practical many components in Automobile subjected to Transverse loading resulting in Transverse vibrations. The speed can be controlled within the critical speed to avoid system damage.



Cantilever Beam

Ex No:13 ***Date:***

Cantilever Beam

Aim:

To determine the deflection of cantilever beam with concentrated mass under transverse vibration.

Apparatus required:

1. Meter scale
2. Weight Set.
3. Magnetic base dial gauge

Procedure:

1. Place the weight hanger on the cantilever beam to its extreme end (i.e.) 50 cm length. (approx.) and clamp it to the beam.

2. Measure the initial deflection by the scale from the top of the base frame to the weight hanger plate and enter it in the observation table.

3. Put weight in the hanger in steps of 0.5 kg up to 3skgs. One by one. Measure the deflection as measured earlier from same point for every weight put in the hanger. Fill the observation table accordingly.

4. After removing all the weights, loosen the clamping bolt of the hanger and move it to some desired length from the fixed end and clamp it (Say 50cm or 30cm)

Observation:

Dimension of Beam – breadth – ‘b’ =

Thickness –‘h’ =

Tabulation:

S. No.	Distance from pillar end L	Weight put in hanger (N)	Deflection Expr. (mm)		Deflection Theore. (mm)		Bending Moment Nmm
1.	50 cm	0.1					
2.		0.2					
3.		0.3					
4.		0.4					
5.		0.5					
6.		0.6					
			a	b	a	b	
7.	30 cm	0.1					
8.		0.2					
9.		0.3					
10.		0.4					
11.		0.5					
12		0.6					

Note:

“a” deflection at the loading point and “b” free end point of the cantilever, which are to be measured and filled in the above table.

5. Measure the length where the hanger is clamped from the fixed end and enter it in the observation table.

6. Repeat the same procedure as said in clause No.6&7. Fill in the observation table accordingly for different lengths on the beam, where the weight is hanged.

7. Carry out the calculations to find out the deflection theoretically and experimentally. Fill the theoretical & experimental values the observation table. Also, calculate Bending Moment of the cantilever for the same lengths.

Formula

1. E = Modulus of Elasticity of Mild steel $= 2.1\times 10^{11}$ N/m^2

2. I = Moment of inertia of the beam; I $= \dfrac{b\times h^3}{12}$

3. Maximum deflection at loading point $\delta_{th} = \dfrac{P\times L^3}{3EI}$

   Where L = length of full beam

5. Maximum Bending Moment at fixed endB.M.= P × lN.m

6. Maximum deflection at point 'C' $\delta_{th} = \dfrac{P\times a^3}{3EI}$ m

7. Maximum Deflection at free end $\delta_{th} = \dfrac{P\times(L-b)^3}{3EI} + \dfrac{P\times(L-b)^2}{3EI}b$ m

Model Calculation:

Result:

Thus the maximum deflection and maximum bending moment of cantilever beam was determined.

Inference:

The maximum deflection and maximum bending moment for any type of Cantilever beam can be theoretically calculated and compared with the experimental results.

Application:

While designing Cantilever beams, If the beam is subjected to Cantilever type loading we can find out the maximum deflection, bending moment. Based on this, we can design the beam to avoid damage.

Ex No : 14 ***Date:***

Dynamic Balancing Machine

Aim:

To determine the unbalance mass of rotating bodies and balancing them.

***Description*:**

Dynamic Balancing Machine of HD series works on electric measuring system. The pressure transducer used in this system is for high accuracy. The machine are sensible and of sturdy design. The basic design on the machine enables quick balancing of rotors with various configurations without any trial run.

The mechanical part of the machine consists of the drilling shaft. The electrical part includes pressure transducer phase generator and the unbalance measuring unit for measuring with precession. All controls required for the operation of the machine arearranged on the panel keyboard of the measuring unit.

***Application*:**

The Dynamic Balancing Machine of "HDM" series is used for of rotating bodies. This dynamic balancing machine is designed for convenient handling of rotors. The machine can also be balance irregular shaped bodies like crank shaft cams and spinning parts etc.,

For balancing, the rotor is placed directly on the roller bearings of the Dynamic Balancing Machine.

***Tabulation*:**

S.No.	Left		Right	
	Weight (gms)	(Angle) (θ)	Weight (gms)	Angle (θ)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

***Procedure*:**

1. The rotor is placed on a work support, which is rigidly fixed by side plates.
2. A pressure transducer senses the centrifugal force transmitted by the work supportand produces an electrical signal, which is proportional to the rotor balance.
3. The electrical signal is amplified and processed through the analog computers to read the angle of balance and amount of unbalance on the meters.
4. The place sector switch unbalance reading of both sides of the place are measured during a single run of rotor.

Result:

Thus the unbalanced rotating mass was determined and balanced.

Inference:

I have understood the concept of balancing rotating parts.

Application:

Many rotating masses are balanced by counter masses, so that the system is in dynamically equilibrium in engines, machines etc.,

PROGRAM OUTCOMES (POs)

Mechanical Engineering Graduates will be able to

1	**Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to solution of complex engineering problems.
2	**Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	**Design / development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	**Modern tool usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6	**The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7	**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.
8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9	**Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10	**Communication:** Communicate effectively on complex engineering activities withthe engineering community andwith society atlarge, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11	**Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects in multidisciplinary environments.
12	**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.

K.L.N. COLLEGE OF ENGINEERING

VISION

To become a Centre of Excellence in Technical Education and Research in producing Competent and Ethical professionals to the Society.

MISSION

To impart Value and Need based curriculum to the students with enriched skill development in the field of Engineering, Technology, Management and Entrepreneurship and to nurture their character with social concern and to pursue their career in the areas of Research and Industry.

Principal **Secretary &Correspondent** **President**