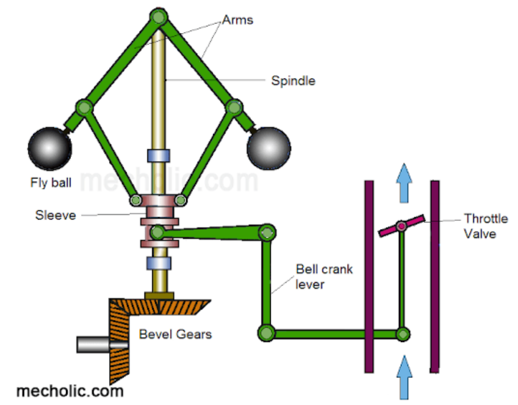
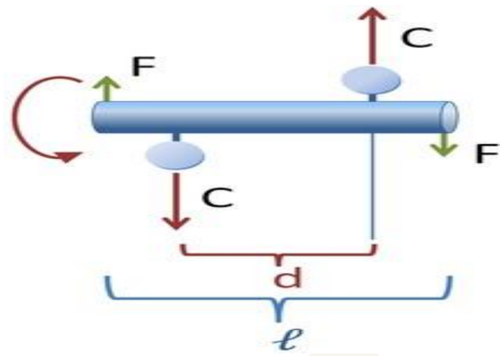
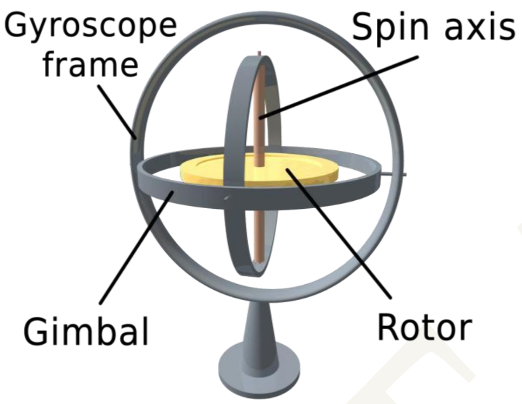
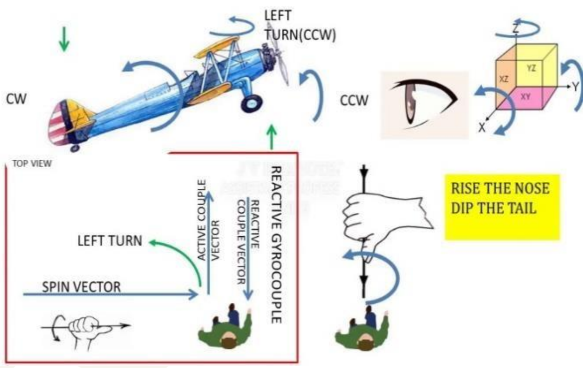
SREENIVASA INSTITUTE OF TECHNOLOGY AND MANAGEMENT STUDIES (AUTONOMOUS)
DEPARTMENT OF MECHANICAL ENGINEERING









DYNAMICS OF MACHINERY LABORATORY

(23MEC35)

NAME OF THE STUDENT : ______________________

ROLL NO : ______________________

CLASS : ______________________

BRANCH : ______________________

FACULTY INCHARGE: D r .N.Sathish Kumar

Department of Mechanical Engineering

SREENIVASA INSTITUTE of TECHNOLOGY and MANAGEMENT STUDIES

(AUTONOMOUS)

INSTITUTE VISION AND MISSION

VISION

- To emerge as a Center of Excellence for Learning and Research in the domains of engineering, computing and management.

MISSION

- Provide congenial academic ambience with state-art of resources for learning and research.
- Ignite the students to acquire self-reliance in the latest technologies.
- Unleash and encourage the innate potential and creativity of students.
- Inculcate confidence to face and experience new challenges.
- Foster enterprising spirit among students.
- Work collaboratively with technical Institutes / Universities / Industries of National and International repute.

SREENIVASA INSTITUTE of TECHNOLOGY and MANAGEMENT STUDIES

(Autonomous)

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

- To become a center of excellence in mechanical engineering studies and research.

MISSION

- Provide congenial academic ambience with necessary infrastructure and learning resources.
- Inculcate the confidence to face and experience new challenges from industry and society.
- Ignite the students to acquire self-reliance in the latest technologies.
- Foster Enterprising spirit among students.

SREENIVASA INSTITUTE of TECHNOLOGY and MANAGEMENT STUDIES

(Autonomous)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Have Professional competency through the application of knowledge gained from subjects like Mathematics, Physics, Chemistry, Inter-Disciplinary and core subjects like Manufacturing Engineering, Thermal Sciences, CAD/CAM and Design & Development. **(Professional Competency).**

PEO2: Excel in one's career by critical thinking towards successful services and growth of the organization or as an entrepreneur or through higher studies. **(Successful Career Goals).**

PEO3: Enhance knowledge by updating advanced technological concepts for facing the rapidly changing world and contribute to society through innovation and creativity. **(Continuing Education and Contribution to Society).**

PROGRAM SPECIFIC OUTCOMES (PSO's)

PSO1: Apply the knowledge obtained in core areas for the design, analysis and manufacturing of mechanical systems and processes.

PSO2: Exhibit novel concepts on product development with the help of modern CAD/CAM integration, while ensuring best manufacturing practices.

PROGRAM OUTCOMES (PO"s)

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 multi disciplinary 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.

III B.Tech V Semester

L	T	P	C
0	**0**	**2**	**1**

20MEC316 DYNAMICS OF MACHINERY LAB

Course Educational Objectives:

PRE-REQUISITES:	
COURSE EDUCATIONAL OBJECTIVES	
1	To supplement the principles learnt in kinematics and Dynamics of Machinery.
2	To understand how certain measuring devices are used for dynamic testing.

DYNAMICS LAB:

List of Experiments:

1. Kinematics of Four Bar, Slider Crank, Crank Rocker, Double crank, Double rocker, Oscillating cylinder Mechanisms.
2. Determination of Mass moment of inertia of Flywheel and Axle system.
3. Determination of range sensitivity, effort etc., for Watts, Porter, Proell, and Hartnell Governors.
4. Cams–Cam profile drawing, Motion curves and study of jump phenomenon.
5. DeterminationoftorsionalnaturalfrequencyofsingleRotorsystems.Undampedand Damped Natural frequencies.
6. DeterminationoftorsionalnaturalfrequencyofDoubleRotorsystems.Undampedand Damped Natural frequencies.
7. Multi degree freedom suspension system–Determination of influence coefficient.
8. Determination of torsional natural frequency of single and Double Rotor systems.- Un damped and Damped Natural frequencies.
9. Balancing of rotating masses.
10. Balancing of reciprocating masses.
11. Determination of natural Frequency and verification of Laws of springs
12. Forced Vibration of Cantilever beam–Mode shapes and natural frequencies.

Course Outcomes:

On successful completion of the course, Students will be able to		POs related to COs
CO1	Ability to demonstrate the principles of kinematics and dynamics of machinery	**PO1**
CO2	Determine the Mass moment of inertia, Range sensivity.	**PO2**
CO3	Drawing of Cam profile, determination of torsional, undamped and damped natural frequencies.	**PO3**
CO4	Determining of influence of coefficient and balancing of rotating, reciprocating masses.	**PO4**
CO5	Verify the laws of springs and forced vibration of cantilever beam.	**PO5**

Text Books:

1. Lab manual provided by the department.

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO.1	3	-	-	-	-	-	-	-	-	-	-	-
CO.2	-	3	-	-	-	-	-	-	-	-	-	-
CO.3	-	-	3	-	-	-	-	-	-	-	-	-
CO.4	-	-	-	3		-	-	-	-	-	-	-
CO.5	-	-	-	-	3	-	-	-	-	-	-	-
CO.6	-	-	-	-	-	-	-	3	-	-	-	-
CO.7	-	-	-	-	-	-	-	-	3	-	-	-
CO.8	-	-	-	-	-	-	-	-	-	3	-	-
CO.9	-	-	-	-	-	-	-	-	-	-	-	3
CO*	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**3**	**3**	**3**	**-**	**3**

Course	Course Outcomes		POs related to Cos
DYNAMICS LAB	C219.1	Demonstrate knowledge on governors, cam analysis, vibration of shafts, gyroscopic couple and turning table.	PO1
	C219.2	Analyze the results from the varying load of governors, cam profile and amplitude of whirling shafts, the effect of gyroscopic couple and rotating of different masses at different angles.	PO2
	C219.3	Design and develop the radial and offset of cam profile and also design different loads at different angles for balancing of rotating shafts.	PO3
	C219.4	Identification of maximum and minimum displacement of cam profile and also maximum amplitude of whirling shafts at different rpm.	PO4
	C219.5	Follow ethical principles and safety procedure inside the laboratory.	PO8
	C219.6	Do experiments effectively as a team for the experiments.	PO9
	C219.7	Communicate verbally and in written form, the understandings about the experiments.	PO10
	C219.8	Utilize the knowledge of the theory and principles for their future research and projects.	PO12

Details of experiments conducted

Ex. No.	Name of the experiment	Date	Signature	Remarks

Signature of the Faculty In-charge with date

INTERNAL MARKS - INDEX SHEET

S.No	Experiment Name	Knowledge Gained	Analysis, Design and Use of Modern Tool / Technique	Ability of do experiment and following of ethical principles	Result & Conclusion	VIVA VOCE (Communication, Life Long learning	TOTAL	Signature of the Faculty
		5	5	5	5	10	30M	
1	Kinematics of Four Bar, Slider Crank, Crank Rocker, Double crank, Double rocker, Oscillating cylinder Mechanisms							
2	Determination of Mass moment of inertia of Flywheel and Axle system.							
3	Determination of range sensitivity, effort etc., for Watts, Porter, Proell, and Hartnell Governors.							
4	Cams–Cam profile drawing, Motion curves and study of jump phenomenon.							
5	DeterminationoftorsionalnaturalfrequencyofsingleRotorsystems.Undampedand Damped Natural frequencies.							
6	DeterminationoftorsionalnaturalfrequencyofDoubleRotorsystems.Undampedand Damped Natural frequencies.							
7	Multi degree freedom suspension system–Determination of influence coefficient.							
8	Determination of torsional natural frequency of single and Double Rotor systems.- Un damped and Damped Natural frequencies.							
9	Balancing of rotating masses.							
10	Balancing of reciprocating masses.							
11	Determination of natural Frequency and verification of Laws of springs.							
12	Forced Vibration of Cantilever beam–Mode shapes and natural frequencies.							

Signature of the Faculty In-charge with date

ATTAINMENT LEVEL - INDEX SHEET

S. No	Experiment Name	CO1 Knowledge	CO2 Analysis	CO3 Design	CO4 Complex Analysis& Conclusion	CO5 Use of modern tools	CO6 Communication ability	CO7 Ethics	CO8 Individual / Team work	CO9 Life Long Learning
1	Kinematics of Four Bar, Slider Crank, Crank Rocker, Double crank, Double rocker, Oscillating cylinder Mechanisms									
2	Determination of Mass moment of inertia of Flywheel and Axle system.									
3	Determination of range sensitivity, effort etc., for Watts, Porter, Proell, and Hartnell Governors.									
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7	Multi degree freedom suspension system–Determination of influence coefficient.									
8	Determination of torsional natural frequency of single and Double Rotor systems.- Un damped and Damped Natural frequencies.									
9	Balancing of rotating masses.									
10	Balancing of reciprocating masses.									
11	Determination of natural Frequency and verification of Laws of springs.									
12	Forced Vibration of Cantilever beam–Mode shapes and natural frequencies.									
Total Attainment (B1)										

****Excellent (3) Good (2) Fair (1)**

Signature of the Faculty In-charge with date

BALANCING OF ROTATING MASSES

AIM:

To verify the balancing using the rotating machine element

APPARATUS REQUIRED:

1. Balancing rotary system
2. Masses

PROCEDURE:

1.To order of the basic operation involved with respect to static balancing as following

2.Then the mass should be fixed in one side of the stud and its angle to be adjusted with the help of angular scale and its radial can be corrected with the help of vernier caliper.

3.Angular displacement between the masses is calculated by force diagram through known value of mass and radial.

4.Fix the masses to the calculated angular displacement using angular scale.

5.Now switch on the motor.

6.By changing the sped of the motor, check it out for vibration for running

7.Add by changing the mass with different radial and find out the angular displacement among the mass for balancing the system

FORMULAE REQUIRED:

Centrifugal force = mass * radius

Couple = mass*radius*length

Mass in kilogram (kg)

Radius in meter (m)

Length in meter (l)

TABULATION

Plane	**Mass**	**Radius**	**Centrifugal force**	**Couple**
A plane				
B plane				
C plane				
D plane				

RESULT:

Thus the Balancing Of Reciprocating Machine Was Verified.

CAM ANALYSIS

AIM:

1. To obtain displacement diagram and cam profile for various type of cam follower.
2. To determine "jumping speed" for different type of cam follower and speed.

APPARATUS REQUIRED:

1) Experimental setup

2) Flat, Roller, Knife edge follower

3) Cams

SPECIFICATION:

Diameter of base circle =50mm, Lift = 8mm, Diameter of cam shaft = 20mm

Diameter of follower shaft = 20 mm, Diameter of roller = 30mm,

Type of follower motion = SHM (during ascent & descent)

- Types of followers:

(i) Based on surface in contact.

(a) Knife edge follower

(b) Roller follower

(c) Flat faced follower

PROCEDURE:

Cam analysis system consists of cam roller follower, pull rod and guide of pull rod.

1. Set the cam at 0° and note down the projected length of the pull rod
2. Rotate the can through 10° and note down the projected length of the pull rod above the guide
3. Calculate the lift by subtracting each reading with the initial reading.

JUMP-SPEED:

1. The cam is run at gradually increasing speeds, and the speed at which the follower jumps off is observed.
2. This jump-speed is observed for different loads on the follower.

GRAPH:

Displacement diagram and also the cam profile is drawn using a polar graph chart.

The Force Vs Jump-speed curve is drawn.

TABULATION:

1. Cam profile

Sl. No.	Angle of rotation (degrees)	Lift in mm	Lift + base circle radius (mm)

RESULT:

The jumping speed of follower is given in observation table.

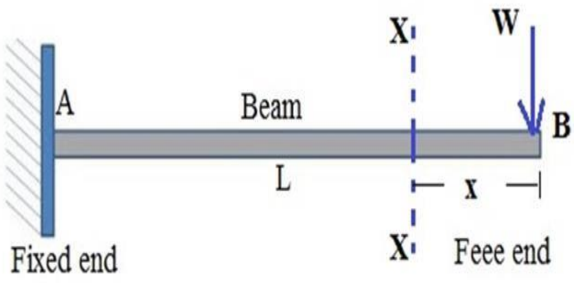
TRANSVERSE VIBRATION – CANTILEVER BEAM

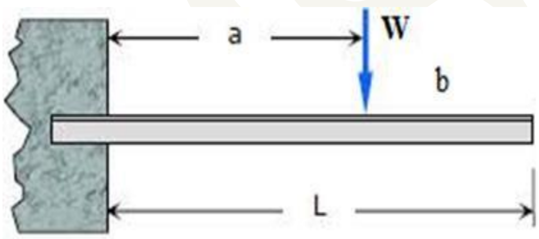
Aim:

To study the transverse vibrations of a cantilever beam

Apparatus Required:

- Trunnion bearings
- beams
- weights





Concentric Load

Formulae used:

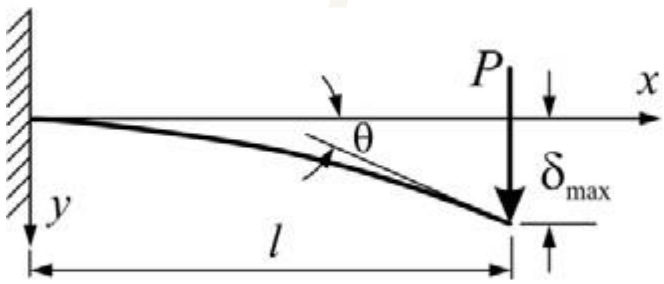
1. Natural frequency = $1/2\pi\sqrt{(g/\delta)}$ Hz = **0 .4985**
------------ Hz
$\sqrt{\delta}$

Where, g= Acceleration due to gravity in m/s^2=9.81

δ = Deflection in m.

2. Theoretical deflection

a. Concentrated load P at the free end



$\delta_T = Wl^3/3EI$

W=m*g

Where, W= applied load in Newton,

L= length of the beam in mm

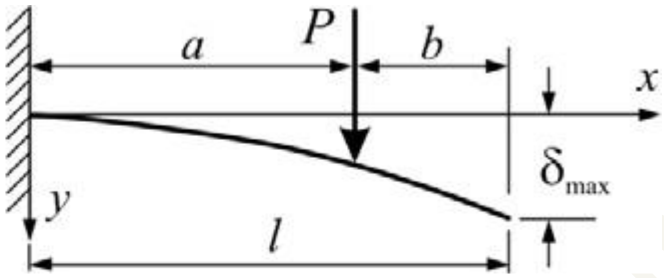
E= young's modules of material in N/mm^2,=(2.01X10^6)

I= moment of inertia in mm^4 =bd^3/12

Mild steel

b. Concentrated load P at any point

δ_T = [Wa^2/ 6EI] (3l - a)



3. Experimental stiffness = W/δ N-mm

Theoretical stiffness = W/δ =3EI/l^3 N/mm

Procedure:

1. Fix the beam into the slots of trunnion bearings and tighten.
2. Add the concentrated uniformly distributed.
3. Determine the deflection of the beam for various weights added.

Observation:

Cantilever beam dimensions**:**

Length=**750mm**

Breadth=**25mm**

Height=4mm

Tabulation:

Sl. No	Applied mass m (kg)	Deflection δ (mm)	Theoretical deflection δ_T (mm)	Experimental Stiffness k_e (N/mm)	Theoretical Stiffness k_t (N/mm)	Expt. Natural frequency fn (Hz)	Theoretical Natural frequency fn (Hz)
1							
2							
3							

Graphs:

1. Deflection Vs. load (N) from this get stiffness (graph)
2. Deflection Vs. Natural frequency
3. Load in N Vs. natural frequency

Result:

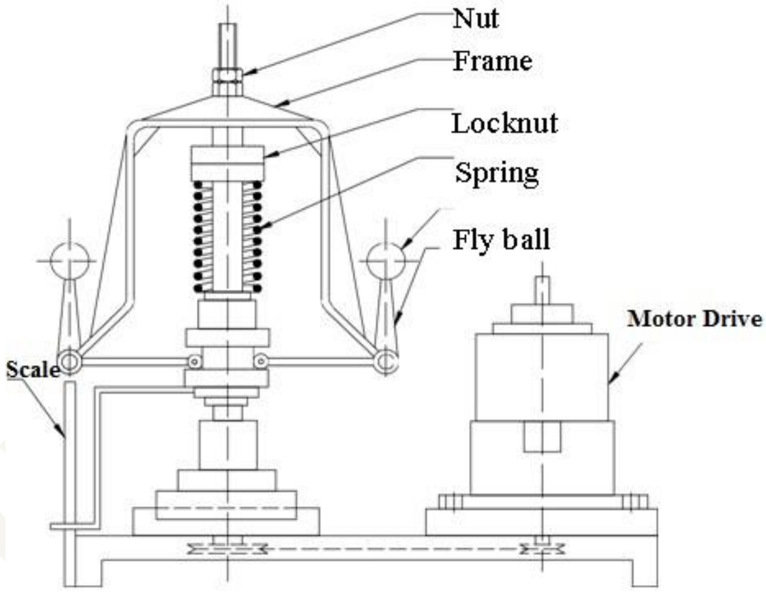
DETERMINATION OF EFFORT AND SENSITIVITY FOR HARTNELL GOVERNOR

AIM:

To determine the Effort and Sensitivity of the HART NELL GOVERNOR.

APPARATUS REQUIRED:

1. Hart Nell governor
2. Tachometer.
3. Dimmer.



FORMULA USED:

Mass of the fly ball (m) = 0.225kg

Mass of the sleeve assembly (M) = 2.25 kg

Length of sleeve arm(a) = 155mm.

Length of sleeve arm(b) = 190 mm

Minimum speed of the governor(N_1) = rpm

Maximum speed of the governor(N_2) = rpm

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

Centrifugal force @ minimum speed $F_{c1} = m\omega_1^2 r_1$

Centrifugal force @ maximum speed $F_{c2} = m\omega_2^2 r_2$

r_1 and r_2 are the radius of rotation on minimum, Max. Speed

$$\frac{M.g+S1}{2} X\ b = F_{c1} X\ a$$

$S_1 = \ldots\ldots\ldots$ Similarly

$S_2 = \ldots\ldots\ldots$

Stiffness S= (S1~S2)/h where h=($r_2 \sim r_1$) X (b/a)

PROCEDURE:

1. The porter governor assembly is mounted over the spindle.

2. The motor is started and speed is adjusted. Speed is measured with the help of tachometer.

3. Due to this centrifugal force the sleeve will be rise, the speed and the sleeve height are noted.

4. By using the formula the speed of the governor is calculated.

5. The experiment is repeated at different speed and force.

TABULATION:

Sl. No	**Speed inrpm N**	**Radius of rotation**	**Centrifugal force**	**S_0**	**Stiffness (S)**
1	Mini Speed N_1=	r_1=	$F_{c1}=m\omega_1^2 r_1$	S_1=	(S1~S2)/h =
2	Max Speed N_2=	r_2=	$F_{c2}=m\omega_2^2 r_2$	S_2=	

GRAPH:

1. Mean speed Vs. Sensitivity
2. Mean speed Vs. Effort

RESULT:

At different motor speed the sleeve lift are noted and corresponding governor Effort and sensitivity are calculated.

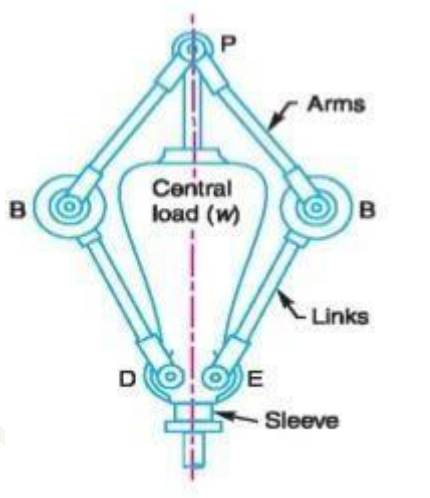
DETERMINATION OF EFFORT AND SENSITIVITY FOR PORTER GOVERNOR

AIM:

To determine the Effort and sensitivity of the PORTER Governor

APPARATUS REQUIRED:

1. Porter governor.
2. Tachometer.
3. Dimmer.



FORMULA USED:

Mean eq .speed = (Max .eq .speed + Min .eq .speed) / 2

Range of speed = N2 – N1

Sensitivity (S) = $2(N_2-N_1)/(N_2+N_1)$

Increase in speed (c) = $(N_2-N_1)/N_1$

Effort (e) $=\sqrt{\left(\frac{m+M}{m}\right)}.\sqrt{(895/h)}$ rpm;

M- Mass of the sleeve assembly =2.25 kg

m- Mass of the each ball=0.225 kg

N-Mean speed

N2-Maximum speed

N1-Minimum speed

PROCEDURE:

1. The porter governor assembly is mounted over the spindle.

2. The motor is started and speed is adjusted. Speed is measured with the help of tachometer.

3. Due to this centrifugal force the sleeve will be rise, the speed and the sleeve height are noted.

4. By using the formula the speed of the governor is calculated.

5. The experiment is repeated at different speed and force.

TABULATION:

Sl. No.	Speed, N (rpm)			Sleeve lift (h) (mm)	Sensitivity	Effort (N)
	Min	max	mean			

GRAPH:

1. Mean speed Vs. Sensitivity
2. Mean speed Vs. Effort

RESULT:
At different motor speed the sleeve lift are noted and corresponding governor Effort and Sensitivity are calculated.

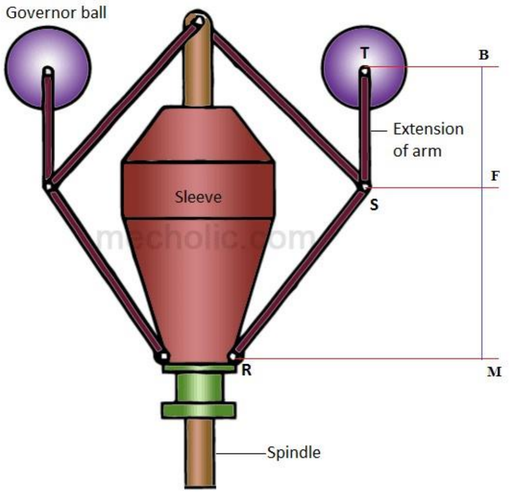
DETERMINATION OF EFFORT AND SENSITIVITY FOR PROELL GOVERNOR

AIM:

To determine the Effort and Sensitivity of the PROELL Governor.

APPARATUS REQUIRED:

1. Proell governor
2. Tachometer.
3. Dimmer



FORMULA USED:

Mean eq .speed = (Max .eq .speed + Min .eq .speed) / 2

Range of speed = N2 – N1

Sensitivity (S) = $2(N_2-N_1)/(N_2+N_1)$

Effort (e) = $\sqrt{(FM/BM)}\sqrt{\left(\frac{m+M}{m}\right)} . \sqrt{(8957h)}$ rpm

(FM/BM)-Proell link ratio =0.57.

M- Mass of the sleeve assembly=2.25kg

m- Mass of the ball = 0.092 kg.

h-sleeve lift

N2-Maximum speed

N1-Minimum speed

N-Mean speed

PROCEDURE:

1. The proell governor assembly is mounted over the spindle.

2. The motor is started and speed is adjusted. Speed is measured with the help of tachometer.

3. Due to this centrifugal force the sleeve will be rise, the speed and the sleeve height are noted.

4. By using the formula the speed of the governor is calculated.

5. The experiment is repeated at different speed and force.

TABULATION:

Sl. No.	Speed, N (rpm)			Sleeve lift (h) (mm)	Sensitivity	Effort (N)
	Min	Max	Mean			

CALCULATION:

GRAPH:

1. Mean speed Vs. Sensitivity
2. Mean speed Vs. Effort

RESULT:

At different motor speed the sleeve lift are noted and corresponding governor Effort and Sensitivity are calculated.

DETERMINATION OF EFFORT AND SENSITIVITY FOR WATT GOVERNOR

AIM:

To determine the Effort and sensitivity of the Watt Governor

APPARATUS REQUIRED:

1. Watt governor setup
2. Tachometer
3. Dimmer

FORMULA USED:

Mean eq .speed = (Max .eq .speed + Min .eq .speed) / 2

Range of speed = N2 – N1

Sensitivity (S) = $2(N_2-N_1)/(N_2+N_1)$

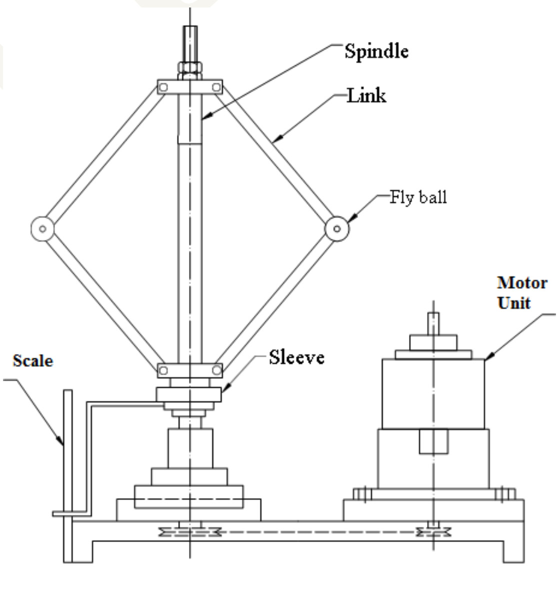
Effort (e) $=\sqrt{\left(\frac{895}{h}\right)}$ rpm;

Where, h- height of sleeve lift

M- Mass of the sleeve assembly =2.25 kg

m- Mass of the each ball=0.225 kg

Where, N_2, N_1 are maximum and minimum speed respectively



EXPERIMENTAL SETUP OF WATT GOVERNOR

PROCEDURE:

1. The watt governor assembly is mounted over the spindle.

2. Keep the speed regulation in 0 position before starting the motor
   - Increase the regulated output gradually till the motor takes the critical speed and immediately control the speed of the governor

3. The motor is started and speed is adjusted. Speed is measured with the help of tachometer.

4. Due to this centrifugal force the sleeve will be rise, the speed and the sleeve height are noted.

   - Maintain the speed for each and every graduation as required to take the direct reading

5. By using the formula the speed of the governor is calculated.

6. The experiment is repeated at different speed and force.

TABULATION:

Sl. No.	Speed, N (rpm)			Sleeve lift (h) (mm)	Sensitivity	Effort (N)
	Min	max	mean			

GRAPH:

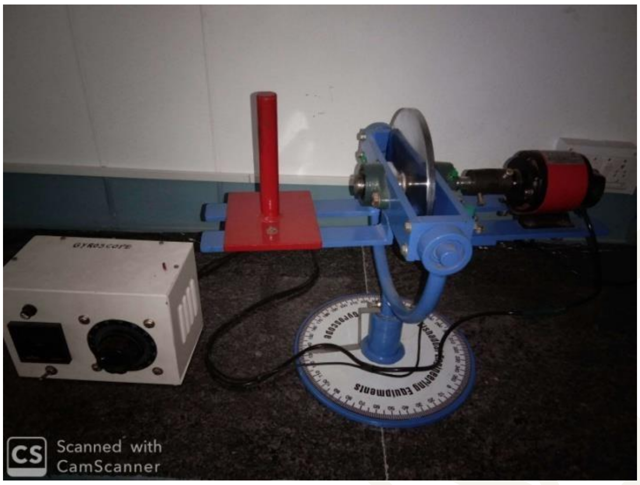
1. Mean speed Vs. Sensitivity
2. Mean speed Vs. Effort

RESULT:

At different motor speed the sleeve lift are noted and corresponding governor Effort and sensitivity are calculated.

MOTORIZED GYROSCOPE

AIM:
To study the gyroscopic principle and verify the relation between the applied torque, Spin velocity and Precessional velocity in case of free precession and forced precession.



FORMULA USED:

1. Gyroscopic couple C = I x w x wp
2. Applied Torque (T) = W X r'

PROCEDURE:

PART I:
The spinning body exerts a torque or a couple in such a direction which tends to make the axis of spin coincides with that of the precession. To study the phenomenon of forced precession following procedure is adopted.

1. Balance initial horizontal position of rotor.
2. Start the motor and adjust the voltage to get the constant speed.
3. Press the yoke frame about the vertical axis by applying the necessary force by hand in the clockwise direction viewed from the top.
4. It will be observed that rotor frame swing about the horizontal axis so that the motorside moves upwards.
5. Rotating the yoke axis in the opposite direction causes the rotor frame to move in the opposite direction.

Part II:

The spinning body processes in such a way that to make the axis of spin to coincide with that ofthe applied couple. The direction is verified by following the procedure given below and usingthe apparatus as well as the relation for the magnitude of the couple.

1) Balance the rotor in the horizontal plane.

2) Start the motor and adjust the speed with the help of voltage regulator. The speed is measured using a tachometer.

3) Put weights on the side opposite to the motor.

4) The yoke start processing.

5) Note down the direction of precession.

6) Verify this direction

7) Measure the velocity of precession using the pointer provided the yoke and stop watch.

8) Verify the relation C = I X W X wp

Observations:

Part I:

1. Direction of spin axis: CLOCKWISE/ANTICLOCKWISE
2. Direction of forced precession: DOWNWARD
3. Direction of couple acting on the frame: Clockwise/Anticlockwise

Part II:

1. Mass of rotor (m): 4kg
2. Thickness of rotor: 10mm
3. Rotor diameter (d): 250mm
4. Moment arm (r’): 230mm
5. Motor power: 120w
6. Speed of motor: 0 – 500 rpm

Observation Table:

Sl. No.	Weight kg. (W)	Spin speed Rpm(N)	Angle turned Degrees (θ)	Time in sec (t)	Direction of rotation

CALCULATIONS:

1. Moment of Inertia (I) = $mr^2/2$ Kg.m^2

2. w = 2πN / 60 = rad/s

3. wp = θ / t X π / 180 = rad/s

4. Gyroscopic Couple © = I X W X wp = N – m.

5. Applied Torque (T) = Wr' = N – m.

W = Weight of the disc

r = Distance of weight pan bolt center to disc center

I= Moment of inertia of the rotating disc

w =Angular velocity(**Spin Velocity)**

RESULT TABLE:

Sl. No.	Spin Velocity w (rad / s)	Precessional velocity wp (rad / s)	Gyroscopic Couple C (N-m)	Applied torque T (N-m)

CONCLUSIONS:

a) Comments are to be written based on the observations of direction observed during Part Iand Part II of the experiment.

b) The values tabulated in the result table are to be compared (i.e. the values of C & T are compared) and comments on the variation are to be written.

c) Different case where the gyroscopic couple is observed is to be mentioned.

SINGLE AND MULTI DEGREE OF FREEDOM

AIM:

To determine **single and multi degree of freedom using** spring – mass system

APPARATUS REQUIRED:

- Spring
- Trunnion
- Beam
- Extra Mass
- Steel Rule.

FORMULAE USED:

Spring stiffness, K = load/deflection

= W/ δ

= mg/ δN/m in (part I)

m- Mass added to spring in kg

Equivalent mass, $M_{eq} = M (L_2/L_1)$ kg,

M- mass of the exciter assembly in kg

Time period, (Theoretical) $T_{the} = 2\Pi\ M_{eq}/K$ sec.

Experimental time period, $T_{exp} = t/N$ sec.

L_1- Distance between pivot and spring, m

L_2- Distance between pivot and exciter assembly, m

- Theoretical natural frequency, $f_{n(the)} = 1/T_{the}$ Hz ,
- Experimental natural frequency, $f_{n(exp)} = 1/T_{exp}$
- Experimental time period, $T_{exp} = t/N$ sec.
- (N)Number of oscillations = 10

PROCEDURE:

Determination of spring stiffness

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
5. With this determine spring stiffness

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

Graph:

Load vs Deflection

Load vs Theoretical natural frequency

Load vs Experimental natural frequency

Tabulation:

Sl. no	Weight added m (kg)	Deflection δ (mm)	Stiffness k (N/m)	Time for 10 oscillation t (sec)	Time period T (sec) T= t/N	Experimental natural frequency, $f_{n(exp)}$, Hz	Theoretical natural frequency $f_{n(the)}$, Hz

Result:

Thus the natural frequency of spring mass system by damping factor and damping co-efficient.

DETERMINE THE MASS MOMENT OF INERTIA OF SOLID BODY USING TURNING TABLE APPARATUS

AIM:

To determine the mass moment of inertia of a solid body using turn table apparatus.

APPARATUS REQUIRED:

1. Given load
2. Specimen
3. Stop watch

FORMULA USED:

To Find By Moment Of Inertia (I)

FORMULA USED:

ENERGY PASSED BY TURN TABLE:

I = Moment of Inertia turn table

$$\frac{1}{2} I w^2 = m g h$$

$$I = 2 m g h / w^2$$

Where,

m – Mass attached to cord

g - Acceleration due to gravity = 9.81

h - Height of fall

w - Angular velocity = $2\pi N$

SPEED (N) = n/t = No.of.revolution /Time taken

PROCEDURE:

1. Attach a cord to the drum and over pulley. It can allow a long path for the descending weight. I is the time of descent of the weight over a specified vertical path. Clamp the base of the turn table. The angular acceleration of the system and its moment of inertia can be found out.

2. Attach a load of mass ‘m’ of sufficient size to cause the system to accelerate with a smooth motion and measure the time to descent of particular length from initial rest position. Repeat the experiment to obtain the mean value.

TABULATION:

S.No	Time Taken (t)	No.of Revolution (n)	Speed (N)	Height of Fall (h)	Hanging mass (m)	Angular Velocity (w)	Moment of Inertia (I)

RESULT:

Thus the moment of inertia of solid body using the turntable is

WHIRLING OF SHAFT- DETERMINATION OF CRITICAL SPEED

AIM:
To determine theoretically the critical speed of the given shaft with the given end conditions

APPARATUS REQUIRED:

Whirling of shaft apparatus (rigid frame with motor, supporting ends)

FORMULA USED:

Theoretical whirling speed, $N_{ctheo} = \{0.4985 / [\text{sqrt}(\delta s / 1.27)]\} \times 60$, rpm

Static deflection due to mass of the shaft (UDL), $\delta s = (5wL^4) / (384\ EI)$

Where,

w = weight of the shaft per meter, N/m

L = Length of the shaft, m

E = Young's modulus for the shaft material, N/m^2

I = Mass moment of inertia of the shaft

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

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

OBSERVATION TABLE:

a) Young's modulus, (For Steel) = $2.06*10^{11} N / m^2$

b) Diameter of shaft (d) = ______mm

c) Effective length of shaft (L) =________mm

d) End conditions:

i) Motor end – simply supported / fixed

ii) Far end – simply supported / fixed

TABULATION:

S.NO	Mass moment of inertia of shaft I (m^4)	Weight of the shaft per meter W (N/m)	Whirling Speed (rpm)	
			N_{cexp}	N_{ctheo}
1.				
2.				
3.				

RESULT:

Thus the whirling speed for the given shaft is determined experimentally and verified with the theoretical values.

RUBRICS FOR DYNAMICS LAB

	Excellent(3)	Good(2)	Fair(1)
Conduct Experiments (CO1)	Student successfully completes the experiment, records the data, analyzes the experiment's main topics, and explains the experiment concisely and well.	Student successfully completes the experiment, records the data, and analyzes the experiment's main topics	Student successfully completes the experiment, records the data, and unable to analyzes.
Analysis and Synthesis (CO2)	Thorough analysis of cam profile and balancing of rotating masses	Reasonable analysis of cam profile and balancing of rotating masses	Improper analysis of cam profile and balancing of rotating masses
Design (CO3)	Student understands what needs to be tested and designs an appropriate experiment, and explains the experiment concisely and well	Student understands what needs to be tested and designs an appropriate experiment.	Student understands what needs to be tested and does not design an appropriate experiment.
Complex Analysis & Conclusion (CO4)	Thorough comprehension through analysis/ synthesis	Reasonable comprehension through analysis/ synthesis	Improper comprehension through analysis/ synthesis
Report Writing (CO6)	Status report with clear and logical sequence of parameter using excellent language	Status report with logical sequence of parameter using understandable language	Status report not properly organized
Lab safety (CO7)	Student will demonstrate good understanding and follow lab safety	Student will demonstrate good understanding of lab safety	Students demonstrate a little knowledge of lab safety.
Ability to work in teams (CO8)	Performance on teams is excellent with clear evidence of equal distribution of tasks and Effort	Performance on teams is good with equal distribution of tasks and effort	Performance on teams is acceptable with one or more members carrying a larger amount of the effort
Continuous learning (CO9)	Highly enthusiastic towards continuous learning	Interested in continuous learning	Inadequate interest in continuous learning