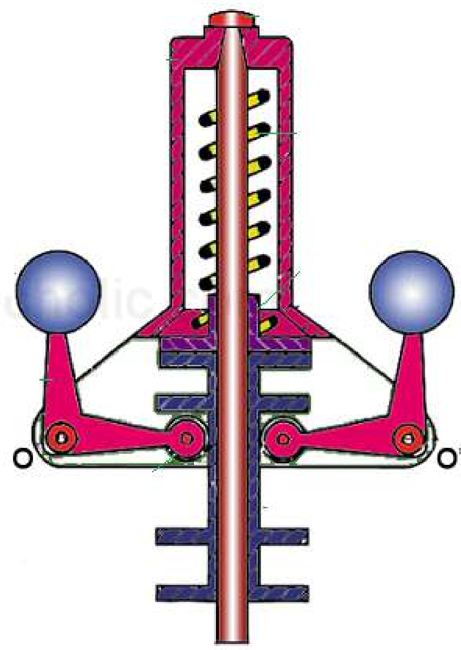
DEPARTMENT OF MECHANICAL ENGINEERING

NAME OF THE LAB	**: MECHANICS OF MACHINES**
REGULATION	**: 2021**



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PREPARED BY

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INSTRUCTIONS FOR STUDENTS

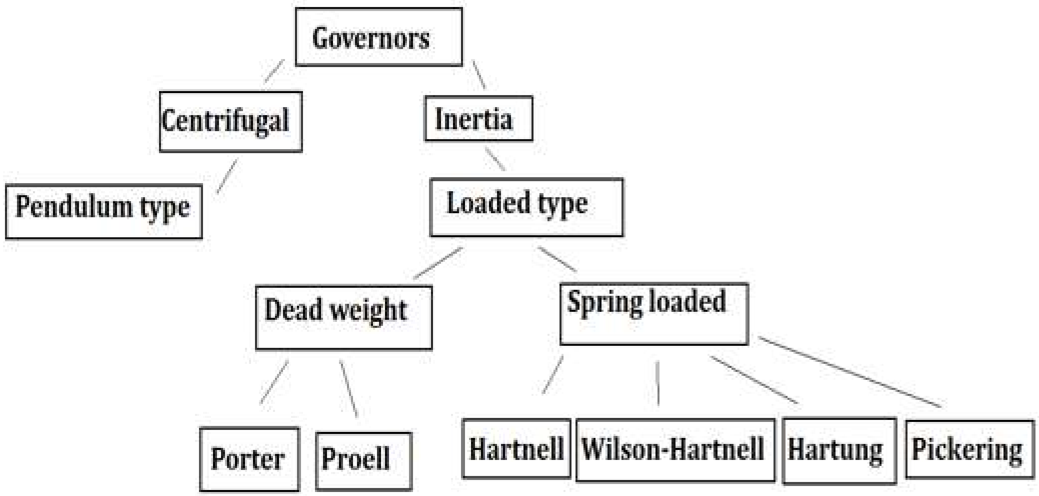
- Students shall read the points given below for understanding the theoretical concepts and practical applications.
- Listen carefully to the lecture given by teachers about the importance of the subject, information about equipment, instruments, procedure, method of continuous assessment, a tentative plan of work in the laboratory and total amount of work to be done in a semester.
- Students should undergo study visit of the laboratory for types of equipment, instruments, material to be used, before performing experiments.
- Read the write up of each experiment to be performed, a day in advance.
- Organize the work in the group and make a record of all observations.
- Understand the purpose of experimentation and its practical implications.
- The student should not hesitate to ask any difficulty faced during the conduct of practical/exercise.
- The student should develop maintenance skills as expected by the industries.
- The student should develop the habit of group discussion related to the experiments/exercises so that exchanges of knowledge/skills could take place.
- The student should attempt to develop related hands on skills and gain confidence.
- The student should develop the habit of evolving more ideas, innovations, skills, etc. Then included in the scope of the manual.
- The student should refer technical magazines, proceedings of the seminars, refer websites related to the scope of the subjects and update their knowledge and skills.
- The student should develop the habit of not to depend totally on Teachers, but to develop self learning techniques.
- The student should develop the habit to submit the practical/ exercise continuously and progressively on the scheduled dates an should get the assessment done.
- The student should be well prepared while submitting the write up of the exercise, this will develop the continuity of the studies and he will not be overloaded at the end of the term

INTRODUCTION

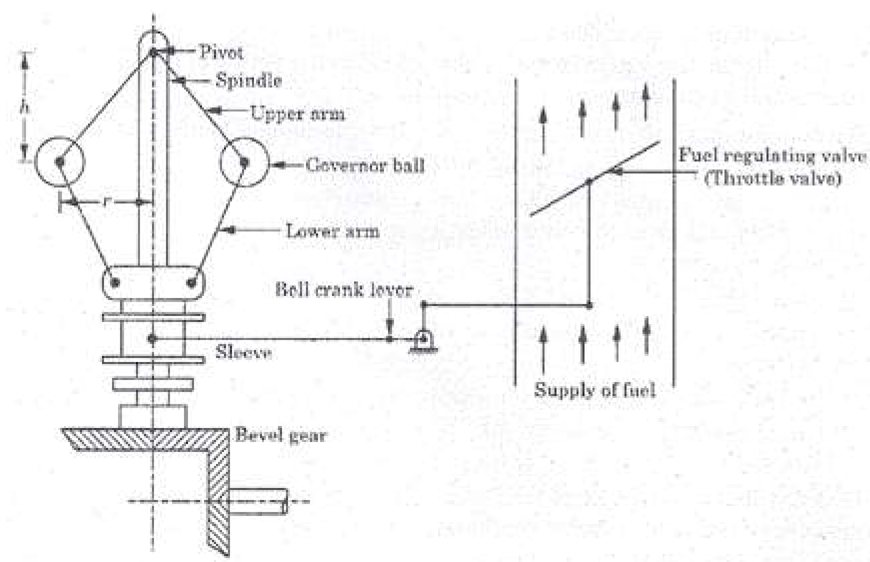
GOVERNORS:

The function of Governors is to control the speed of an engine. Governors are to keep the variation in mean speed of the engine within prescribed limits due to the fluctuations in load over a period of time. Governors are taking care of quantity of working fluid.

TYPES OF GOVERNORS



CENTRIFUGAL GOVERNOR:

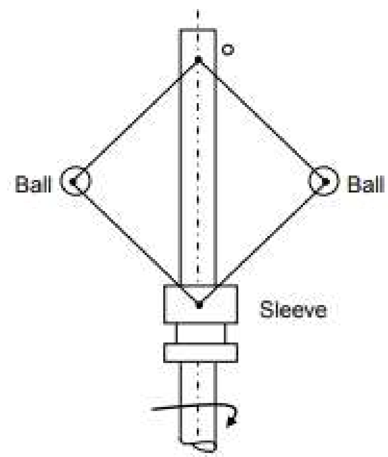


- Centrifugal governor's work on the principle of balancing the centrifugal force on the rotating balls by an equal and opposite radial force called as controlling force. The spindle of the governor is driven by the crank shaft of the engine through bevel gears. When the output of the engine and the governor will rotate at a uniform mean speed.
- The radius of rotation of balls will be such that the outward centrifugal force ($m.\omega^2 \cdot r$) is just balanced by the inward controlling force provided by the weight of sleeve. Incase the load on the engine decreases, the speed of the engine and that off the governor would increased.
- Due to this, the centrifugal force on governor balls increases and it will outbalance the controlling force. Consequently, the balls fly outwards and sleeve will move upwards. The upwards movement of sleeve is transmitted to a throttle valve through bell-crank lever which closes the supply of working fluid.

- Due to the reduced supply of working fluid , the engine output reduces and balances the load on the engine and the speed of engine reduces it comes to new equilibrium speed. Conversely, if the load on the engine increases, speed decreases, sleeve will move downwards and the fuel supply valve operating increases.
- This increases the charge supply to the engine corresponding to the load on the engine, hence the speed increases. The variation of speed obtained with different loads has to be within the prescribed limits for which the governor is designed. The total travel of the sleeve is restricted by the lower and upper stops which correspond to no load and maximum load positions.

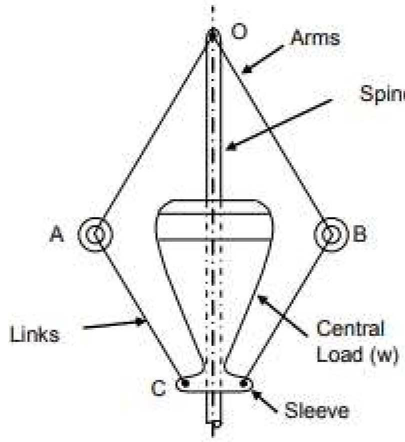
WATT GOVERNOR:

- Watt governor is the simplest form of centrifugal governor.
- Watt governor consists of a pair of balls which are attached to the spindle with the help of links or arms.
- The upper links are connected by a horizontal link and governor is known as open-arm type Watt governor.
- The upper links cross the spindle and are connected by horizontal link are known as a crossed-arm Watt governor.
- The lower links in all above cases are fixed to a sleeve which is free to move on the vertical spindle.



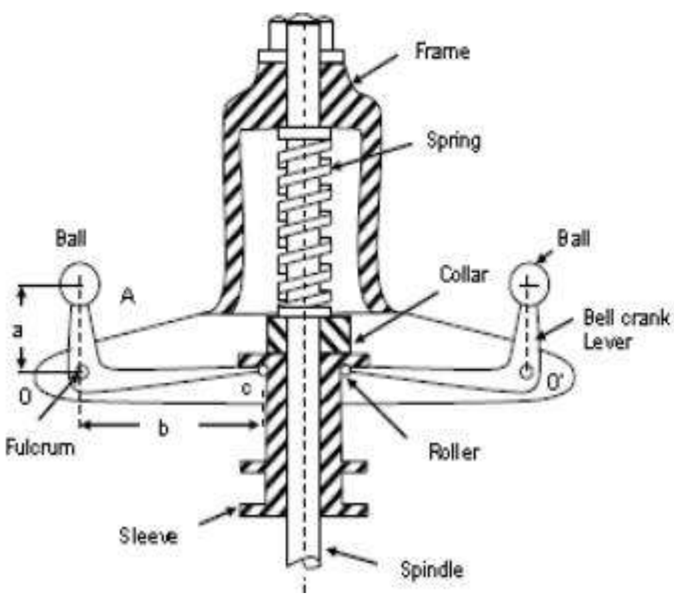
PORTER GOVERNOR

- The porter governor has two sets of arms.
- The top arms OA and OB connect balls to the hinge O.
- The hinge may be on the spindle or slightly away.
- The lower arms support dead weight and connect balls also.
- All of them rotate with the spindle. We can consider one-half of governor for equilibrium.



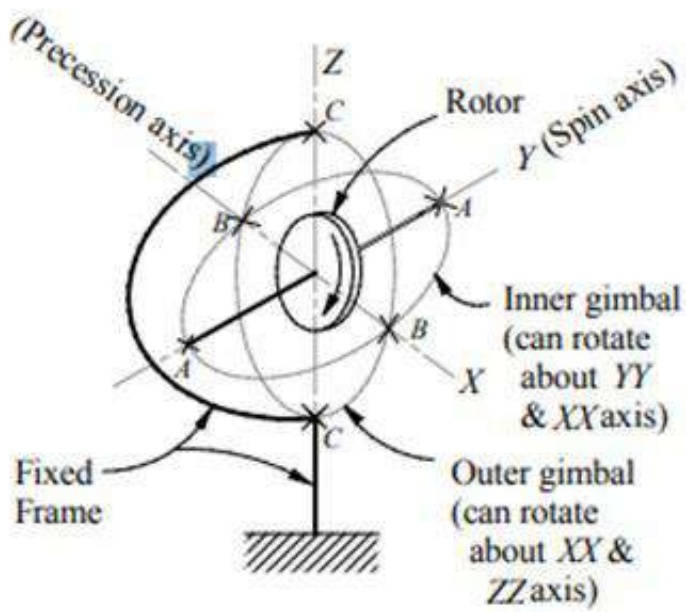
HARTNELL GOVERNOR

- A Hartnell governor consists of two bell crank levers pivoted at the points O, O to the frame.
- The frame is attached to the governor spindle and therefore rotates with it.
- Each lever carries a ball at the end of the vertical arm OB and a roller at the end of the horizontal arm OR.
- A helical spring in compression provides equal downward forces on the two rollers through a collar on the sleeve.
- The spring force may be adjusted by screwing a nut up or down on the sleeve.



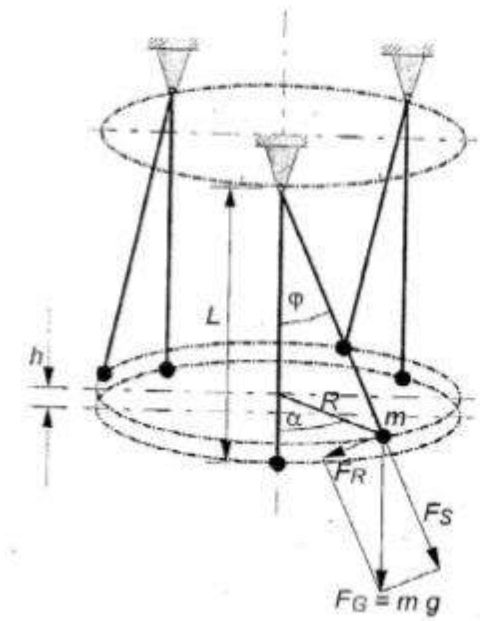
GYROSCOPIC COUPLE

- A Gyroscope is a device used for measuring or maintaining orientation and angular velocity. It is having a spinning wheel or disc in which the axis of rotation (spin axis) is free to assume any orientation by itself. When rotating, the orientation of this axis is unaffected by tilting or rotation of the mounting, according to the conservation of angular momentum.
- A Gyroscope is a wheel mounted in two or three gimbals, which are pivoted supports that allow the rotation of the wheel about a single axis. A set of three gimbals, one mounted on the other with orthogonal pivot axes, may be used to allow a wheel mounted on the innermost gimbal to have an orientation remaining independent of the orientation, in space, of its support. In the case of a gyroscope with two gimbals, the outer gimbal, which is the gyroscope frame, is mounted so as to pivot about an axis in its own plane determined by the support. This outer gimbal possesses one degree of rotational freedom and its axis possesses none. The inner gimbal is mounted in the gyroscope frame (outer gimbal) so as to pivot about an axis in its own plane that is always perpendicular to the pivotal axis of the gyroscope frame (outer gimbal). This inner gimbal has two degrees of rotational freedom.
- The axle of the spinning wheel defines the spin axis. The rotor is constrained to spin about an axis, which is always perpendicular to the axis of the inner gimbal. So the rotor possesses three degrees of rotational freedom and its axis possesses two. The wheel responds to a force applied to the input axis by a reaction force to the output axis.
- The behavior of a gyroscope can be most easily appreciated by consideration of the front wheel of a bicycle. If the wheel is leaned away from the vertical so that the top of the wheel moves to the left, the forward rim of the wheel also turns to the left. In other words, rotation on one axis of the turning wheel produces rotation of the third axis.



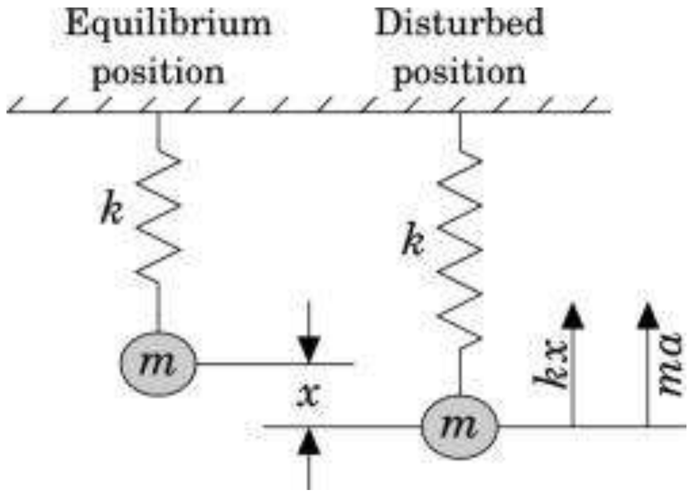
SUSPENSION SYSTEM

- The mass moment of inertia of a rigid body can also be determined experimentally by an apparatus called trifillar suspension or torsional pendulum.
- In a bifilar suspension, the pendulum body is suspended over two threads. The pendulum body oscillates in a plane purely translational without rotation. This kind of pendulum can be considered as a mathematical pendulum.
- In a trifilar suspension with three threads, the pendulum body is set in a torsional vibration. The torsional vibration can be used to determine the moment of inertia by experiment.



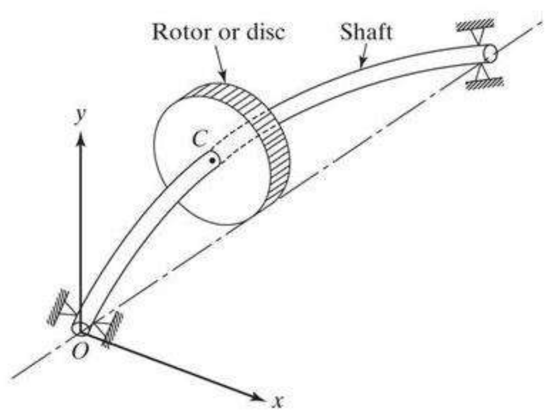
SPRING-MASS SYSTEM

- In a real spring–mass system, the spring has a non-negligible mass ‘m’. Since not all of the spring's length moves at the same velocity ‘v’ as the suspended mass M, its kinetic energy is not equal to $\frac{1}{2}mv^2$.
- As such, ‘m’ cannot be simply added to M to determine the frequency of oscillation, and the effective mass of the spring is defined as the mass that needs to be added to M to correctly predict the behavior of the system.
- The effective mass of the spring in a spring-mass system when using an ideal spring of uniform linear density is 1/3 of the mass of the spring and is independent of the direction of the spring-mass system (i.e., horizontal, vertical, and oblique systems all have the same effective mass). This is because external acceleration does not affect the period of motion around the equilibrium point.



WHIRLING OF SHAFT

- Whirling speed is also called as Critical speed of a shaft. It is defined as the speed at which a rotating shaft will tend to vibrate violently in the transverse direction if the shaft rotates in horizontal direction.
- In other words, the whirling or critical speed is the speed at which resonance occurs.
- In the field of rotor dynamics, the critical speed is the theoretical angular velocity which excites the natural frequency of a rotating object, such as a shaft, propeller or gear.
- As the speed of rotation approaches the objects natural frequency, the object begins to resonate which dramatically increases system vibration.
- The resulting resonance occurs regardless of orientation.
- Whirling Speed is due to the unbalanced forces acting on a rotating shaft.



LIST OF EXPERIMENTS

To perform an experiment on Watt and Porter Governor to prepare performance characteristic curves and to find stability and sensitivity

To determine the position of sleeve against controlling force and speed of a Hartnell governor and to plot the characteristic curve of radius of rotation

To analyse the motion of a motorized gyroscope when the couple is applied along its spin axis and determine gyroscopic couple

Determine the Moment of Inertia by compound pendulum and tri-filar suspension.

To determine the frequency of undamped free vibration and damped forced vibration of an equivalent spring mass system.

To determine whirling speed of shaft theoretically and experimentally.

AVIT AARUPADAI VEEDU INSTITUTE OF TECHNOLOGY
VINAYAKA MISSION'S RESEARCH FOUNDATION
(Deemed to be University under section 3 of the UGC Act 1956)

LIST OF EQUIPMENTS

1.CENTRIFUGAL GOVERNOR

2.GYROSCOPIC COUPLE

3.TRI-FILAR SUSPENSION.

4.BI-FILAR SUSPENSION.

5.COMPOUND PENDULUM

6.SPRING MASS SYSTEM

7.WHIRLING OF SHAFT

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

AIM

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

DESCRIPTION:

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

FORMULA:

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

Where,

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

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

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

PROCEDURE:

1. The control unit is switched on.

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

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

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

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

6. Tabulate all these values.

7. Calculate the range of speed and sensitivity.

8. Verify with theoretical calculations.

9 Draw graphs for experimental values

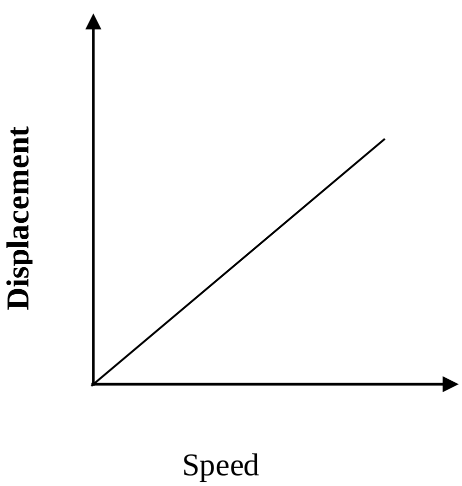
a. Speed vs. displacement

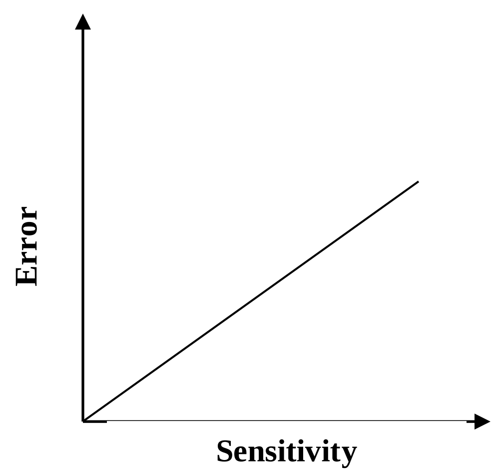
b.Sensitivity and error

TABULATION:

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

MODEL GRAPH:





RESULT:

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

2.TO DETERMINE THE POSITION OF SLEEVE AGAINST CONTROLLING FORCE AND SPEED OF A HARTNELL GOVERNOR AND TO PLOT THE CHARECTERISTIC CURVES OF RADIUS OF ROTATION

AIM

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

DESCRIPTION:

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

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PROCEDURE:

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8. Verify with theoretical calculations.

9 Draw graphs for experimental values

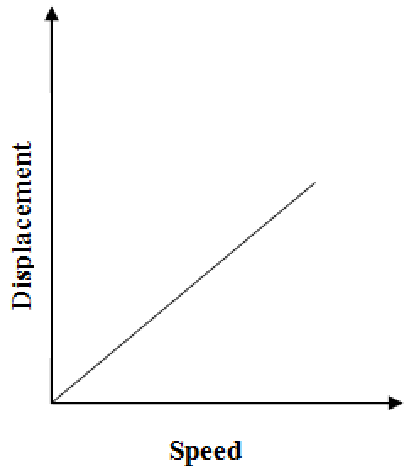
a. Speed vs. displacement

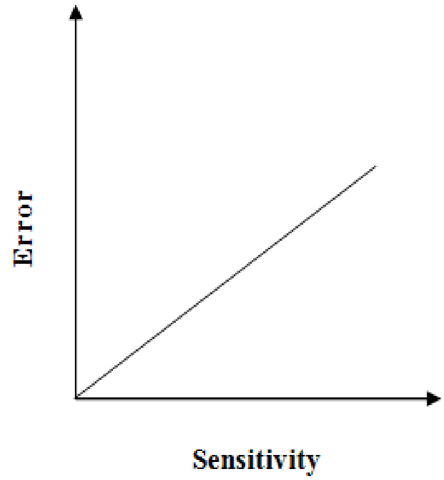
b. Sensitivity and error

TABULATION:

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

MODEL GRAPH:





RESULT:

The characteristic curves for the Hartnell governor were plotted.

3. TO ANALYZE THE MOTION OF A MOTORIZED GYROSCOPE WHEN THE COUPLE IS APPLIED ALONG ITS SPIN AXIS AND DETERMINE GYROSCOPIC

AIM:

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

APPARATUS REQUIRED:

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

DESCRIPTION:

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

$C = I \omega \omega_P$

Where

C=the gyroscopic couple
ω =spinning velocity
I= mass moment of inertia of the rotor about the spin axis
ω_P = velocity of precession

The following gyroscopic behaviors could be observed.

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

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

DESCRIPTION OF THE APPARATUS:

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

FORMULA USED:

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

PROCDURE:

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

1. Balance the initial horizontal position of the rotor frames No .1
2. Start the motor by increasing the voltage with the autotransformer and wait until it attains constant speed.

3. Press the yoke frame No.2 about vertical axis by applying necessary force by hand to the same. {In the clockwise sense seen from above}.
4. It will be observed that the rotor frame swings about the horizontal axis yy.Motor side is seen coming upward and the weight pan side going downwards.
5. Rotate the vertical yoke in the anti clockwise sense seen from above and observe that the rotor frame swings in the opposite sense {as compared to that in previous case, following the above role}.

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

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

TABULATION

CONSTANT SPEED:

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

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

CONSTANT LOAD:

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

RESULT:

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

4. DETERMINE THE MOMENT OF INERTIA BY COMPOUND PENDULUM & TRIFILAR SUSPENSION

AIM:

To find the moment of inertia by compound pendulum and tri-filar suspension system.

APPARATUS REQUIRED:

Stop watch
Circular Disc
Wire or Rope
Scale

COMPOUND PENDULUM

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

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

Where, K=radius of gyration about centre of gravity in "cm"
OG=distance of centre of gravity rod from support in"cm"
G=acceleration due to gravity=9.81 m/s^2

FORMULA REQUIRED:

Theoretical radius of gyration, $K_{th} = L/2*\sqrt{3}$ cm
Where, L=total length of rod in 'cm'

PROCEDURE:

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

TABULATION:

S.N	Length of Compound Pendulum(L) Cm	OG Cm	Time for 10 oscillations 't' Sec	Time period T EXP =t/10 Sec	K EXP m

1					
2					
3					

Mean=

TRIFILAR SUSPENSION SYSTEM

THEORY:

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

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

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

OBSERVATIONS:

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

CALCULATION:

TRIFILAR SUSPENSION:

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

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

TABULATION:

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

RESULT:

Thus the moment of inertia of compound pendulum and tri-filar suspension system was determined.

5. TO DETERMINE OF FREQUENCY OF UNDAMPED FREE VIBRATION AND DAMPED FORCED VIBRATION OF AN EQUIVALENT SPRING MASS SYSTEM

AIM:

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

APPARATUS REQUIRED:

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

FORMULA:

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

$$f_n = \frac{1}{2\pi}\sqrt{\frac{g}{\delta}}\ \text{Hz}$$

Where g = Acceleration due to gravity (9.81 m/s^2)

δ= Deflection of the spring in m.

DESCRIPTION:

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

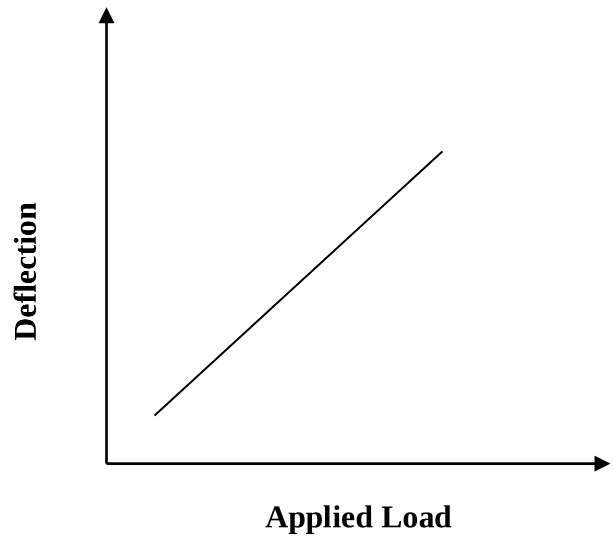
PROCEDURE:

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

GRAPH:

APPLIED LOAD Vs DEFLECTION

MODEL GRAPH:



TABULATION

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

RESULT:

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

6.**TO DETERMINE WHIRLING OF SHAFTSPEED OF SHAFT THEORETICALLY AND EXPERIMENTALLY**

AIM

To determine the Whirling speed of shaft theoretically and experimentally.

APPARATUS REQUIRED:

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

DESCRIPTION:

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

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

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

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

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

PROCEDURE:

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

FORMULA USED :

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

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

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

$\rho = m/v$

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

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

$C = 2.45$

$N_c = \frac{1}{2\pi}\sqrt{\frac{g}{\delta}} = 0.4985/\sqrt{\delta}$

Where,

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

d – Diameter of the shaft in meters

E- Young's modulus

TABULATION

Sl.No	Diameter of the shaft (d) in mm	Distance between chuck and free end (L) in mm	Theoretical Critical speed (fn) in rpm	Deflection in mm	Node
1					
2					
3					

RESULT:

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

VIVA-VOCE QUESTIONS

GOVERNOR

1. What is controlling force?
2. What is Inertia force?
3. What is Centrifugal force?
4. Define height of Governor
5. What is the speed range suitable for Watt's governor?
6. What is Stability?
7. How Centrifugal governor classified
8. Define sensitiveness of governor.
9. Define sleeve lift.
10. What is the use of Governor
11. Name the two types of governors
12. What is spring loaded governor?
13. What do you mean by Proell governor?
14. What are the advantages of a Hartnell governor?
15. What is centripetal force

GYROSCOPIC COUPLES

1. What is Gyroscopic couple?
2. What is the principle of gyroscope?
3. What are the applications of gyroscope?
4. What is angular momentum?
5. Define bow
6. Define stern.
7. What is port
8. Define pitching of the ship
9. What is starboard
10. Define propeller shaft

COMPOUND PENDULUM AND TRIFILIAR SUSPENSION

1. What is bifilar suspension?
2. What is radius of gyration?
3. Define compound pendulum?
4. What is Trifilar suspension?
5. What is static force?
6. What is dynamic force?
7. What is Inertia force?
8. What is rigid body?
9. What is mass moment of inertia?
10. Define centre of the axis.

VIBRATION

1. Define free vibration?
2. Define undamped free vibration
3. Give the types of vibrations
4. Define D'Alembert's principle
5. Define damping
6. What are the different types of damping?
7. What is longitudinal vibration?
8. What is logarithmic decrement?
9. Define Transverse vibration
10. What is Tensional vibration?

WHIRLING OF SHAFT

1. What is forced vibration?
2. Define vibration isolation
3. What are isolating materials for vibrations?
4. Define critical speed
5. Define single node in whirling of shaft
6. What is damping ratio?
7. Define Dry friction
8. **Define Resonance**
9. What causes Whirling of shaft?
10. What is Whirling speed?