ADICHUNCHANAGIRI INSTITUTE OF TECHNOLOGY, CHIKMAGALUR-577102

DEPARTMENT OF MECHANICAL ENGINEERING

DESIGN LABORATORY MANUAL

18MEL77

VII SEMESTER

PREPARED BY:

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ADICHUNCHANAGIRI INSTITUTE OF TECHNOLOGY, CHIKMAGALUR

Department of Mechanical Engineering

Design Laboratory Manual

Semester: 7 **DESIGN LAB SYLLABUSES**

Sub Code: 18MEL77	**IA Marks : 40**	**Hrs/ Week: 04**
Exam Hours: 03	**Total Hrs. 42**	**Exam Marks: 60**

PART – A

1. Determination of natural frequency, logarithmic decrement, damping ratio and damping Coefficient in a single degree of freedom vibrating systems (longitudinal and torsional).
2. Determination of critical speed of a rotating shaft.
3. Balancing of rotating masses.
4. Determination of equilibrium speed, sensitiveness, power and effort of Porter/Proell/Hartnel Governor.

PART - B

1. Determination of Fringe constant of Photo elastic material using.
   i. Circular disc subjected to diametral compression.
   ii. Pure bending specimen (four point bending).
2. Determination of stress concentration using Photo elasticity for simple components like plate with a hole under tension or bending load, circular disk with circular hole under compression, 2D Crane hook.
3. Determination of Pressure distribution in Journal bearing.
4. Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.
5. Determination of stresses in Curved beam using strain gauge.
6. Experiments on Gyroscope (Demonstration only)

Scheme of Examination:

One question from Part A -(10 Write up +30)	40 Marks
One question from Part B -(10 Write up +30)	40 Marks
Viva - Voce -	20 Marks

Total: 100 Marks

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Revision Record

Sl. No.	Experiment No.	Page No.	Revision No.	Date	Remarks	Approved by

Faculty: PRASHANTH N, Asst Prof, Mech Engg, AIT, CKM

Student Name :____________________________________

USN : 4AI ME

Batch : Mechanical Engineering Section : 7th Sec

COURSE OBJECTIVES:

The objectives of Design laboratory is

- ✓ To demonstrate the concepts discussed in Design of Machine Elements, Mechanical Vibrations & Dynamics of Machines courses.
- ✓ To observe, analyze and modify mechanical system components so as to perform safely their intended functions in harmony with other components of the system.
- ✓ To observe and analyze vibration behavior of mechanical systems.
- ✓ To visualize and understand the development of stresses in structural members and experimental determination of stresses in members utilizing the optical method of reflected photo-elasticity.

OUTCOMES: The expected outcome of Design laboratory is that the students will be able

- ✓ To practically relate to concepts discussed in Design of Machine Elements, Mechanical Vibrations & Dynamics of Machines courses.
- ✓ To understand the working principles of machine elements such as Governors, Gyroscopes etc.,
- ✓ To identify forces and moments in mechanical system components.
- ✓ To identify vibrations in machine elements and design appropriate damping methods.
- ✓ To measure strain in various machine elements using strain gauges.
- ✓ To determine strain induced in a structural member using the principle of photo-elasticity.

SAFETY PRECAUTIONS

- ✓ Laboratory uniform, shoes & safety glasses are compulsory in the lab.
- ✓ Do not touch anything with which you are not completely familiar. Carelessness may not only break the valuable equipment in the lab but may also cause serious injury to you and others in the lab.
- ✓ Please follow instructions precisely as instructed by your supervisor. Do not start the experiment unless your setup is verified & approved by your supervisor.
- ✓ Do not leave the experiments unattended while in progress.
- ✓ Do not crowd around the equipment's & run inside the laboratory.
- ✓ During experiments material may fail and disperse, please wear safety glasses and maintain a safe distance from the experiment.
- ✓ If any part of the equipment fails while being used, report it immediately to your supervisor. Never try to fix the problem yourself because you could further damage the equipment and harm yourself and others in the lab.
- ✓ Keep the work area clear of all materials except those needed for your work and cleanup after your work.

CLOS & COS

PART A **18 Hours**

Experiment No.1: Determination of natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems (longitudinal and torsional)

Objectives:

1. The main objective of this experiment is to determine natural frequency, logarithmic decrement, damping ratio and damping coefficient.

Outcomes:

1. After completion of this experiment students will able to understand the concept natural frequency, logarithmic decrement, damping ratio.

Experiment No 2: Balancing of rotating masses

Objectives:

1. The main objective of this experiment is to Balancing of rotating masses

Outcomes:

1. After completion of this experiment students will able to understand how to balance the rotating mass

Experiment No 3: Determination of critical speed of a rotating shaft.

Objectives:

1. The main objective of this experiment is to determine the critical speed of a rotating shaft.

Outcomes:

1. After completion of this experiment students will able to understand the concept of critical speed of a rotating shaft

Experiment No 4: Determination of equilibrium speed, sensitiveness, power and effort of Porter/Prowel /Hartnel Governor

Objectives:

1. The main objective of these experiments is to determine the equilibrium speed, sensitiveness, power and effort of Porter/Prowel /Hartnel Governor

Outcomes:

1. After completion of this experiment students will able to understand the concept of equilibrium speed, sensitiveness, power and effort

PART B **24Hours**

Experiment No 5: Determination of Fringe constant of Photo elastic material using. Circular disk subjected diametric compression

Objectives:

1. The main objective of these experiments is to determine the Fringe constant of Photo elastic material

Outcomes:

After completion of this experiment students will able to understand the concept Fringe constant of Photo elastic material

Experiment No 6: Determination of stress concentration using Photo elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook.

Objectives:

1. The main objective of this experiment is to determine stress concentration using Photo elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression.

Outcomes:

1. After completion of this experiment students will able to understand the concept determine stress concentration using Photo elasticity for simple components

Experiment No 7: Determination of Pressure distribution in Journal bearing. Objectives:

1. The main objective of these experiments is to study the Pressure distribution in Journal bearing

Outcomes:

1. After completion of this experiment students will able to understand the concept of the Pressure distribution in Journal bearing

Experiment No 8: Determination of Principal Stresses and strains in a member subjected to combined loading using Strain rosette

Objectives:

1. The main objective of these experiments is to determine Principal Stresses and strains in a member subjected to combined loading using Strain rosettes.

Outcomes:

1. After completion of this experiment students will able to understand the concept of the Principal Stresses and strains in a member subjected to combined loading using Strain rose

Experiment No 9: Determination of stresses in Curved beam using strain gauge.

Objectives:

1. The main objective of these experiments is to determine the stresses in Curved beam using strain gauge.

Out Comes:

1. After completion of this experiment students will able to understand the concept stresses in Curved beam using strain gauge.

Experiment No 10: Experiments on Gyroscope (Demonstration only)

Objectives:

1. The main objective of these experiments is to study the gyroscopic action

Outcomes:

1. After completion of this Demonstration students will able to understand the concept gyroscopic action

Breadth Options:

This lab potentially taken as a breadth subject component for Bachelor of Engineering specialization in mechanical.

Pre-requisite:

This lab requires the subject knowledge of Dynamics and Machines and Design of Machine Elements

Experiment No: 1

SIMPLE PENDULUM

AIM:-

1) To conducts a test on simple pendulum & to compare experimental time period with theoretical time period.
2) To show that the period of oscillation is independent of mass of the ball.
3) To show that length of pendulum is directly proportional to square of the time period.

DESCRIPTION OF THE EXPERIMENTAL SET UP:-

For conducting the experiment, a beach ball is supported by a nylon thread in to the chuck. It is possible to change the length of pendulum by drawing the thread through chuck. This makes it possible to study the effect of variation of length of pendulum on time period. A small ball may be substituted for larger ball to show that the period of oscillation is independent of the mass of the ball keeping the length of pendulum constant.

PROCEDURE: -

1. Measure the diameter of the balls using vernier calipers.
2. Attach the larger ball to the hook at one end of the nylon thread.
3. Loosen the nut at the top of chuck and draw the thread to adjust the length.
4. Allow the ball to oscillate and note down the time taken for ‘n’ oscillations.
5. Repent the experiment by changing the length of t he pendulum.
6. Repeat the above procedure for smaller ball keeping the length of pendulum same as taken using larger ball.
7. Plot a graph of ${\tau^2}_{exp}$ versus length of pendulum (l).

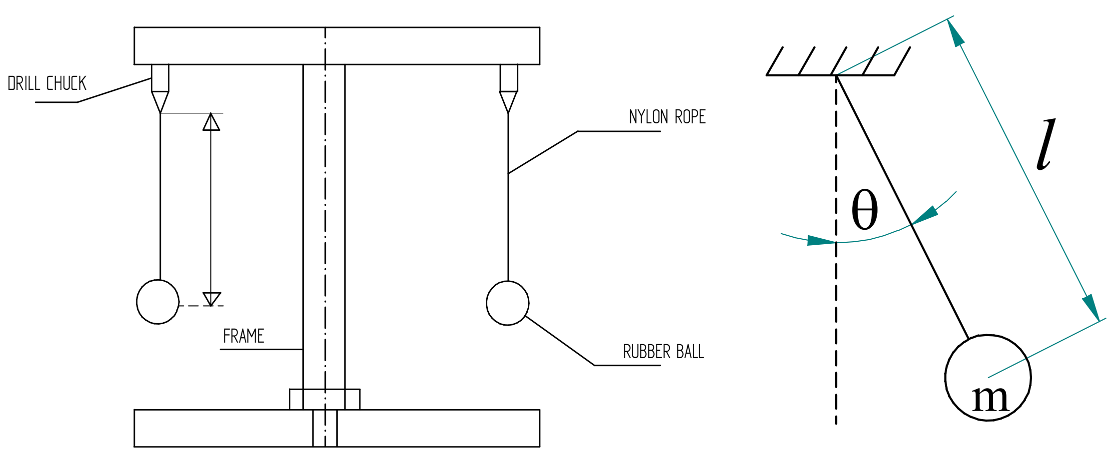


Fig 1: SETUP OF SIMPLE PENDULUM

Tabulation of Readings: **For mass m_1**

Sl. no	Mass M (kg)	Length l (mm)	No. of oscillations (n)	Time for ‘n’ oscillations in sec	Time period τ_{exp} (sec)	Time period τ_{th} (sec)	Natural frequency f_{exp} (Hz)	Natural frequency f_{th} (Hz) ″

For mass m_2

Sl. no	Mass M (kg)	Length l (mm)	No. of oscillations (n)	Time for ‘n’ oscillations in sec	Time period τ_{exp} (sec)	Time period τ_{th} (sec)	Natural frequency f_{exp} (Hz)	Natural frequency f_{th} (Hz) ″

EXPRESSION FOR THEQRITICAL TIME PERIOD

From Newton's second law of motion, $J\,\ddot{\theta} = \Sigma\, T$

$$But\;\; J = m\, l^2$$

$$\therefore\;\; m\, l^2\, \ddot{\theta} = -\mathrm{m\, g}\, l\;\sin\theta$$

$$m\, l^2\, \ddot{\theta} + \mathrm{m\, g}\, l\;\sin\theta = 0$$

$$But\;\;\sin\theta\;\approx\theta\;\; for\; very\; small\; angles$$

$$\therefore\;\; m\, l^2\, \ddot{\theta} + \mathrm{m\, g}\, l\, \theta = 0$$

$$\ddot{\theta} + \frac{m\, g\, l}{m\, l^2}\theta = 0$$

$$\ddot{\theta} + \frac{g}{l}\theta = 0$$

Comparing the above equation with the equation of SHM,

$$\ddot{\theta} + \omega^2\theta = 0$$

$$\therefore\;\; \omega^2 = \frac{g}{l}$$

But for free vibrations $\omega = \omega_n$

$$\omega_n = \sqrt{\frac{g}{l}} \qquad rad/_s$$

Frequency, $f_n = \frac{1}{2\,\pi}\sqrt{\frac{g}{l}} \qquad c/_s\;\; or\;\; Hz$

Time period, $\tau_n = 2\,\pi\sqrt{\frac{l}{g}} \qquad sec$

SPECIMEN CALCULATIONS:

Time period, $\tau_{th} = 2\,\pi\sqrt{\frac{l}{g}} \qquad sec$

$$\tau_{exp} = \frac{Time\; for\; 'n'\; oscillation}{Total\; number\; of oscillation} = \frac{t}{n} \qquad sec$$

$$\tau_{exp} = \frac{t}{n} =$$

$$f_{th} = \frac{1}{\tau_{th}}\; cps\; or\; Hz$$

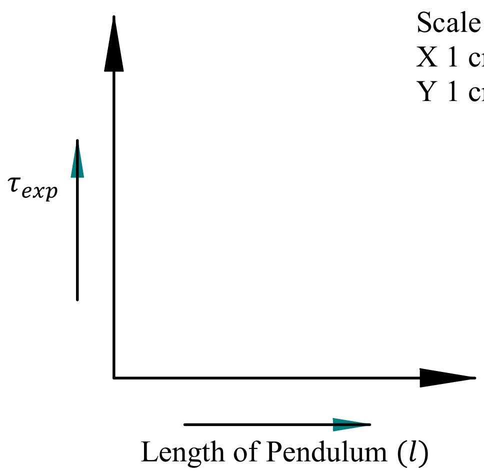
$$f_{exp} = \frac{1}{\tau_{exp}}\;\; cps\; or\;\; Hz$$

TABULATION OF RESULTS:

Sl. No	Time Period		Natural Frequency	
	$\tau_{exp} = \frac{t}{n}$ (sec)	τ_{th} (sec)	$f_{exp} = \frac{1}{\tau_{exp}}$ (Hz)	f_{th} (Hz)

Specimen Graph:

Scale :
X 1 cm =
Y 1 cm =



Note/Comments/Calculations:

Experiment No:2

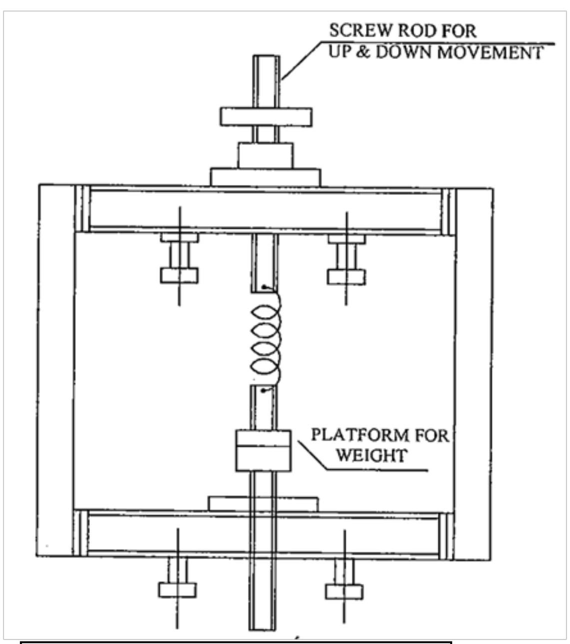
LONGITUDINAL VIBRATIONS OF SPRING MASS SYSTEM

AIM: To conduct a test on spring mass system (undamped single degree freedom system) and to compare theoretical natural frequency & time period with experimental natural frequency & time period.

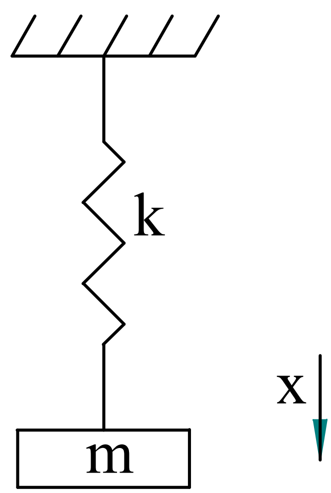
DESCRIPTION: One end of the open helical spring is fixed to the screw. The screw can be adjusted vertically in any convenient position and clamped to the upper beam by means of lock wheel. The lower end of the spring is attached to the platform carrying weight. The weight carrying platform is guided by the lower beam. The whole unit can be clamped at any horizontal position by using clamping nuts.

PROCEDURE:

1. Measure the free length of the given helical spring.
2. Fix one end of the helical spring to the screw rod mounted on the upper beam and the lower end to the platform.
3. Put some weight on the platform and note down the deflection of the spring.
4. Stretch the spring through some distance and release.
5. Count the time required $'t'$ in seconds for $'n'$ oscillations.
6. Determine the experimental time period.
7. Repeat the procedure for different weights.



Fig;
SETUP OF SPRING MASS SYSTEM



Tabulation of Readings:

Sl. no	Mass of the platform m_1 (kg)	Mass added m_2 (kg)	Total Mass $m = m_1 + m_2$ (kg)	unstretched length of spring l_1 (m)	final length of spring l_2 (m)	Static deflection $\Delta = l_2 - l_1$ (m)	Stiffness $k = \frac{m\,g}{\Delta}$ (N\m)	Average stiffness k_{avg} (N\m)	No. of oscillations 'n'	Time for 'n' oscillations 't' (sec)
1										
2										
3										

From Newton's second law of motion, $m\,a = \Sigma\,F$

$$m\ \ddot{x} = -k\,x$$

$$m\ \ddot{x} + k\,x = 0$$

$$\ddot{x} + \frac{k}{m}\,x = 0$$

This is the equation of motion for spring mass system.

Comparing the same with the equation of SHM. $\ddot{x} + \omega^2\,x = 0,\ \ we\ get$

$$\omega^2 = \frac{k}{m}$$

Under free vibrations, frequency of vibration is called natural frequency.

Hence, $\omega^2 = {\omega_n}^2 = \frac{k}{m}$

$$\therefore Natural\ frequency,\ \omega_n = \sqrt{\frac{k}{m}} \qquad rad\backslash s$$

or $f_n = \frac{1}{2\,\pi}\sqrt{\frac{k}{m}}\ \ cycle\backslash s\ \ or\ Hz$

Time period, $\boldsymbol{\tau_n} = 2\,\pi\sqrt{\frac{m}{k}} \qquad s$

Under static equilibrium condition, $mg = k\Delta$

$$\therefore\ \frac{k}{m} = \frac{g}{\Delta}$$

$$\therefore\ f_n = \frac{1}{2\,\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\,\pi}\sqrt{\frac{g}{\Delta}}$$

$$\boldsymbol{\tau_n} = 2\,\pi\sqrt{\frac{m}{k}} = 2\,\pi\sqrt{\frac{\Delta}{g}}$$

<u>SPECIMEN CALCULATIONS:-</u> $Stiffness\ \ k = \frac{mg}{\Delta}\ \ N/m$

Then calculate, $k_{avg} = \frac{N}{m}$

Experimental time period, $\tau_{exp} = \frac{t}{n} = \qquad sec$

Experimental natural frequency, $f_{exp} = \frac{1}{\tau_{exp}} = \qquad Hz$

Theoretical time period, $\tau_{th} = 2\,\pi\sqrt{\frac{m}{k_{avg}}} = \qquad sec$

Theoretical natural frequency, $f_{th} = \frac{1}{\tau_{th}} = \qquad Hz$

TABULATION OF RESULTS:

Sl. No	Total mass 'm' (kg)	Stiffness ' k' (N/m)	Time Period (sec)		Natural Frequency (Hz)	
			$\tau_{exp} = \frac{t}{n}$	τ_{th}	$f_{exp} = \frac{1}{\tau_{exp}}$	f_{th}

Note/Comments/Calculations:

Experiment No:3

UNDAMPED FREE VIBRATIONS OF SPRING MASS SYSTEM (EQUIVALENT SYSTEM)

AIM: - To study the undamped free vibrations of equivalent spring mass system.

DESCRIPTION: - The arrangement is shown in figure: - 3-. The arrangement is designed to study undamped free vibrations .It contains mild Steel rectangular beam supported at one end by pivoted ball bearing. The bearing housing is fixed to the side member of the frame. The other end is supported by the lower end of helical spring. The upper end of the spring is attached to the adjustable screw.

PROCEDURE: -

1. Measure the free length of the given helical spring.
2. Fix one end of the helical spring to the screw rod mounted on the upper beam and the lower end to the platform
3. Put some weight on the platform and note down the deflection of the spring
4. Determine the spring stiffness and hence the average spring stiffness.
5. Support one end of the beam in the slot of the trunnion and clamp by means of screw.
6. Attach the other end of the beam to the lower end of the spring.
7. Adjust the screw to which the spring is attached such that the beam is horizontal in the above position.
8. Weigh the exciter assembly along with discs and bearings and weight platform.
9. Clamp the assembly at any convenient position.
10. Measure the distance $'a'$ of the assembly from the pivot. Allow the system to vibrate freely.
11. Measure the time for $'n'$ oscillations and find the periodic time and the natural frequency of vibrations.
12. Repeat the experiment by varying either varying $'a'$ or by putting different weights on the platform.

OBSERVATIONS:

Length, $l =$ m:

$a =$ m

TO DETERMINE THE SPRING STIFFNESS K:

Sl No	Mass of the Plat for m_1 (kg)	Mass added m_2 (kg)	Total mass $m = m_1 + m_2$ (kg)	Unstretched length of spring l_1 (m)	Final length of Spring l_2 (m)	Static deflection $\Delta = l_1 + l_2$ (m)	Stiffness $k = mg/\Delta$ (N/m)	Average stiffness k_{avg} (N/m)

COMPARISON OF THEORETICAL AND EXPERIMENTAL TIME PERIOD AND NATURAL FREQUENCY

Sl No	Mass of rotor m_1 (kg)	Mass added m_2 (kg)	Total mass $m = m_1 + m_2$ (kg)	Time for $'n'$ oscillations $'t'$ (sec)	Expt. Time period $\tau_{exp} = t/n$ (sec)	Theoretical time period τ_{th}(sec)	Expt. natural frequency $f_{ex} = \frac{1}{\tau_{ex}}$ (Hz)	Theoretical natural frequency f_{th} (Hz)

For the system shown below, from Newton's second law of motion

$$J\,\ddot{\theta} = \Sigma\, T$$

$$But\;\; J = m\, a^2$$

$$m\, a^2\, \ddot{\theta} = -\mathrm{k}\, l^2\, \sin\theta$$

$$m\, a^2\, \ddot{\theta} + \mathrm{k}\, l^2\, \sin\theta = 0$$

$$But\;\; \sin\theta\;\approx \theta\;\; for\ very\ small\ angles$$

$$\therefore\; m\, a^2\, \ddot{\theta} + \mathrm{k}\, l^2\, \theta = 0$$

$$\ddot{\theta} + \left(\frac{\mathrm{k}\, l^2}{m\, a^2}\right)\theta = 0$$

Comparing the above equation with the equation of SHM,

$$\omega^2 = \frac{\mathrm{k}\, l^2}{m\, a^2}$$

Since the vibrations are free, the frequency of vibrations is the natural frequency.

$$\omega^2 = {\omega_n}^2 = \frac{\mathrm{k}\, l^2}{m\, a^2}$$

Frequency, $f_n = \frac{1}{2\,\pi}\sqrt{\frac{\mathrm{k}\, l^2}{m\, a^2}}$ $\quad Hz$

Time period, $\tau_n = \frac{1}{f_n} = 2\,\pi\sqrt{\frac{m\, a^2}{\mathrm{k}\, l^2}}$ $\quad sec$

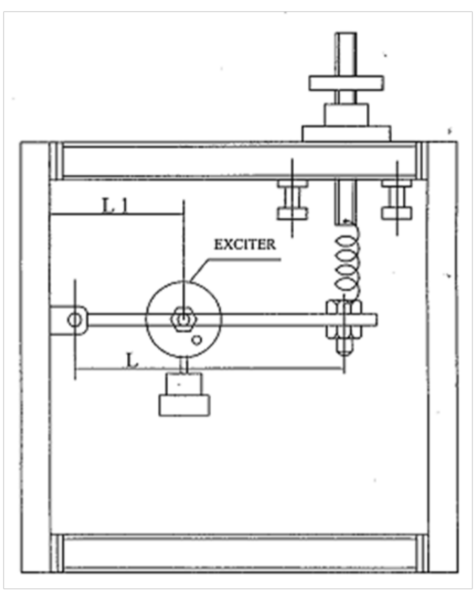
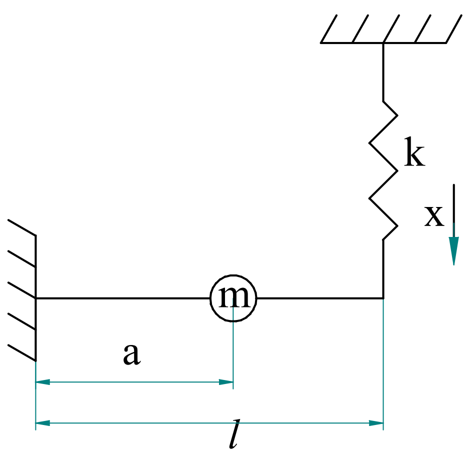


Fig: SETUP OF EQUIVALENT SPRING MASS SYSTEM



Specimen calculations for trial no 1:

Spring stiffness,

$$k_1 = \frac{m\,g}{\Delta} = \quad N\backslash m$$

Average stiffness,

$$k_{avg} = \frac{k_1 + k_2 + \cdots \ldots . + k_n}{n} = \qquad N\backslash m$$

Experimental time period,

$$\tau_{exp} = \frac{t}{n} = \qquad sec$$

Experimental natural frequency,

$$f_{exp} = \frac{1}{\tau_{exp}} = \qquad Hz$$

Theoretical time period,

$$\tau_{th} = 2\,\pi \sqrt{\frac{m\,a^2}{k_{avg}\;l^2}} = \qquad sec$$

Theoretical natural frequency,

$$f_{th} = \frac{1}{\tau_{th}} = \qquad Hz$$

TABULATION OF RESULTS:

Sl. No	Total mass 'm' (kg)	Stiffness ' k' (N/m)	Time Period (sec)		Natural Frequency (Hz)	
			$\tau_{exp} = \frac{t}{n}$	τ_{th}	$f_{exp} = \frac{1}{\tau_{exp}}$	f_{th}

Note/Comments/Calculations:

Experiment No: 4

UNDAMPED TORSIONAL VIBRATIONS OF SINGLE ROTOR SHAFT SYSTEM

AIM: To study the undamped torsion vibration of single rotor shaft system.

APPARATUS: Universal vibration tester, stop watch, measuring tape.

THEORY:

When the shaft or disc moves in a circle about the axis of the shaft, then the vibrations are known as "Torsional vibration"

In torsional vibration the shaft is twisted and untwisted alternately and torsional shear stress are induced in the shaft.

DESCRIPTION OF THE SET UP:

One end of the shaft is gripped in the chuck and heavy flywheel free to rotate in ball bearing is fixed at the other end of the shaft.

The bracket with fixed end of shaft can be clamped at any convenient position along lower beam. Thus length of the shaft can be varied during the experiments. Specially designed chucks are used for damping ends of the shaft. The ball bearing support to the fly wheel provides negligible damping during experiment; the bearing housing is fixed to side member of main frame.

PROCEDURE:

1. Fix the bracket at convenient position along the lower beam.
2. Grip one end of the shaft at the bracket by of chuck.
3. Fix the rotor on the other end of the shaft.
4. Twist the rotor through some angle and release.
5. Note down the time required for 10-20 oscillation.
6. Repeat the procedure for different length of shaft.
7. Make the following observations.

TABULAR COLUMN OF READING:

Sl No	Length of shaft $'L'$ (mm)	Torsional stiffness k_t (N/mm)	No. of oscillation 'n'	Time for $'n'$ oscillations $'t'$ (sec)	Expt. Time period $\tau_{exp} = t/n$ (sec)	Theoretical time period τ_{th}(sec)	Expt. natural frequency $f_{ex} = \frac{1}{\tau_{ex}}$ (Hz)	Theoretical natural frequency f_{th} (Hz)

OBSERVATIONS:

Shaft diameter, $d = 0.0036 \quad m$

Shaft length, $L = \qquad m$

Diameter of the disc, $D = 0.228 \quad m$

Weight of the disc, $W = 3.3 \quad kg$

Modulus of rigidity for shaft, $G = 0.8 \times 10^{11} \quad {}^{N}/_{m^2}$

Polar moment of inertia, $J = \frac{\pi\, d^4}{32} \quad m^4$

SPECIMEN CALCULATION:

Determination of torsional stiffness, $k_t = \frac{G\, J}{L} \quad N - m$

Experimental time period, $\tau_{exp} = \frac{t}{n} = \quad sec$

Experimental natural frequency, $f_{exp} = \frac{1}{\tau_{exp}} \quad Hz$

Theoretical time period, $\tau_{th} = 2\,\pi\sqrt{\frac{I}{k_t}} \quad sec$

Mass moment of inertia $I = \frac{m\, r^2}{2} \quad kg - m^2$; $r = \frac{D}{2} \quad m$

Theoretical natural frequency, $f_{th} = \frac{1}{\tau_{th}} = \quad Hz$

TABULAR OF RESULT:

Sl no	Torsional stiffness $(N\ m)$	Time period (sec)		Frequency (Hz)	
	k_t	τ_{th}	τ_{exp}	f_{th}	f_{exp}
1					
2					
3					

Note/Comments/Calculations:

Experiment No: 5

DAMPED TORSIONAL VIBRATIONS OF SINGLE DEGREE FREEDOM SYSTEM

AIM:-

To conduct a test on single degree freedom damped torsional system and determine logarithmic decrement, damping factor & torsional damping coefficient.

DESCRIPTION OF SETUP: -

The arrangement consists of a long slender elastic shaft gripped at the upper end by the chuck in the bracket. The bracket is clamped to the upper beam of the main frame. The heavy steel disc is clamped at the lower end of the shaft that suspends from the bracket. Damping drum is fixed to the lower face of the disc. This drum is immersed in the oil, which provides damping. Oil container can be taken up and down for varying the depth of immersion of damping drum. Depth of immersion can be read from the scale provided.

Recording drum is mounted to the upper face of the disc. Paper is wrapped around the recording drum. Oscillations are recorded on the paper with the help of specially designed piston of the dashpot. The piston carries the attachment for fixing the sketching pen.

PROCEDURE: -

1. With no oil in the container allow the disc to oscillate and measure the time for $'n'$ oscillations.
2. Put thin mineral oil ($SAE\ 10\ or\ SAE\ 20$) in the drum and note the depth of immersion.
3. Put the sketching pen in its bracket.
4. Allow the disc to oscillate.
5. Allow the pen to descend. Care must be taken to see that the pen always makes contact with the paper.
6. Measure the time for $'n'$ oscillations by means of stopwatch.
7. Determine X_n i.e. amplitude at any cycle (say $'n_{th}'$) and X_{n+r} i.e. amplitude after $'r'$ cycles. .

OBSERVATIONS –

Length of rod, $l =$ m

Diameter of rod, $d =$ m

SPECIMEN CALCULATIONS:

Torsional stiffness, -------- $k_t = \frac{G\,I_p}{l}$ $N\,m\backslash rad$

Where, $G = rigidity\ modulus\ of\ the\ material\ of\ the\ shaft = 0.83 \times 10^{11}\ N\backslash m^2$

$I_p = polar\ moment\ of\ inertia = \frac{\pi\,d^4}{32}\ m^4$ $d = diameter\ of\ the\ shaft\ in\ m.$

$l = length\ of\ shaft\ in\ m$

$$I_p = \frac{\pi\,d^4}{32} \quad m^4$$

$$k_t = \frac{G\,I_p}{l} \quad N\backslash m$$

1. AIR DAMPING

We know that natural frequency, $f_n = \frac{1}{2\,\pi}\sqrt{\frac{k_t}{J}}$

Time period, $\tau_n = 2\,\pi\sqrt{\frac{J}{k_t}}$

Squaring on both sides and rearranging, $J = \frac{\tau^2\,k_t}{4\,\pi^2}$

Critical damping coefficient, $C_c = 2\sqrt{k_t\,J}\ Nm\backslash rad\backslash sec$

Logarithmic decrements, $\delta = \frac{1}{n}\,ln\left(\frac{X_n}{X_{n+r}}\right)$

Damping factor, $\xi = \frac{\delta}{\sqrt{4\,\pi^2+\delta^2}}$

Torsional damping coefficient, $C_t = C_c \times \xi$

2. OIL DAMPING

∴Mass moment of inertia, $J = \frac{\tau^2\,k_t}{4\,\pi^2}$ $kg\,m^2$

Critical damping coefficient, $C_c = 2\sqrt{k_t\,J}$ $Nm\backslash rad\backslash sec$

Logarithmic decrements, $\delta = \frac{1}{n}\,ln\left(\frac{X_n}{X_{n+r}}\right)$

Damping factor, $\xi = \frac{\delta}{\sqrt{4\,\pi^2+\delta^2}}$

Torsional damping coefficient, $C_t = C_c \times \xi$ $Nm/rad/sec$

TABULATION OF READINGS :

SI no	Type of damping	Length of shaft $'l'$ (m))	Torsional stiffness $'k_t'$ in (Nm/rad)	No. of oscillations 'n'	Damped time period $'\tau_n'$ (sec)	Mass moment of inertia 'J' (kgm^2)	Critical damping coefficient $'C_C'$ $(Nm/rad/sec)$	$'X_n'$ (m)	$'X_{n+r}'$ (m)	Logarithmic decrement $'\delta'$	Damping factor $'\xi'$	Torsional damping coefficient $'C_t'$ $(Nm/rad/sec)$
1	Air											
2	Oil											

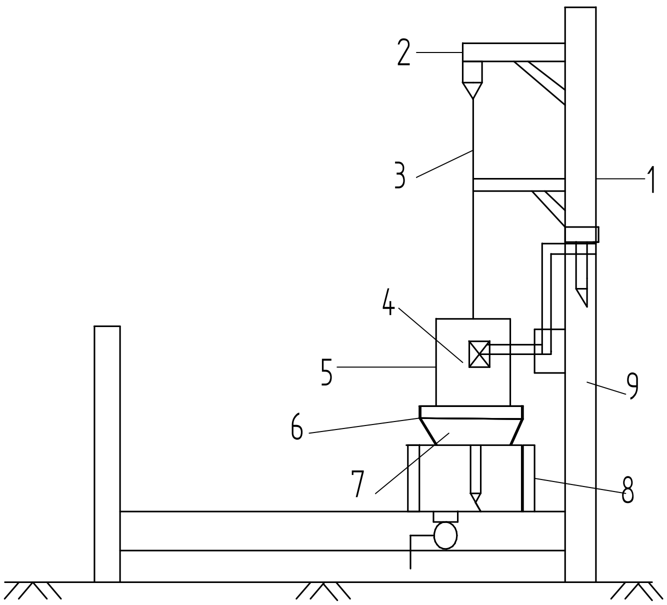


FIG. DAMPED TORIONAL OSCILLATIONS

PART NO	PART NAME
1	FRAME
2	SHAFT HOLDER
3	SHAFT
4	PEN HOLDER
5	RECODING DRUM
6	DISC
7	DAMPING CONE
8	OIL CONTROLLER
9	DESENDER

TABULATION OF RESULTS :

SI No	Type of damping	Torsional stiffness $'k_t'$ (Nm/rad)	Damped time period $'\tau_n'$ (sec)	Critical damping coefficient $'C_C'$ $(Nm/rad/sec)$	Logarithmic decrement $'\delta'$	Damping factor $'\xi'$	Torsional damping coefficient $'C_t'$ $(Nm/rad/sec)$
1	Air						
2	Oil						

Note/Comments/Calculations:

Experiment No: 6

WATT GOVERNOR

AIM: To conduct a test on watt governor and to determine the radius of rotation and centrifugal force at different speeds of rotation. Also to show that for a watt governor the height of governor is inversely proportional to square of speed of rotation.

APPARATUS USED: - Watt governor arranged on universal governor and tachometer.

INTRODUCTION: - The function of a governor is to regulate the mean speed of the engine, when there are variations in the load i.e., when the load on the engine increases, Speed decreases. Therefore it becomes necessary to increase the supply of the fuel on the other hand, when the load on the engine decreases, its speed increases and thus less fuel is required. The governor automatically controls the supply of fuel to the engine with the varying load conditions and keeps the main speed within certain limits.

The governors may, broadly, be classified as:

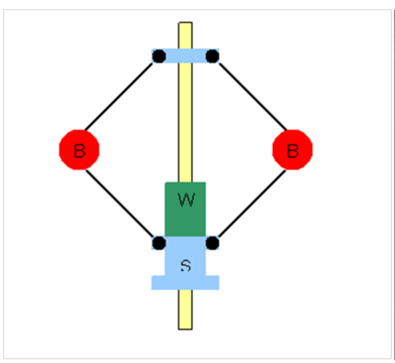
1. Centrifugal governor
2. Inertia governor

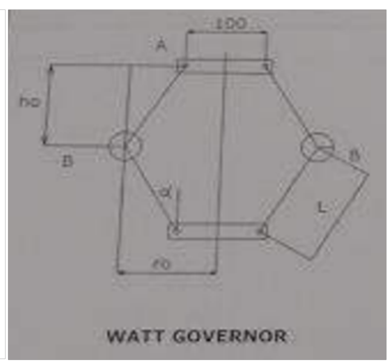
The centrifugal governors may further be classified as follows:

1. Pendulum type (watt governor)
2. Loaded type

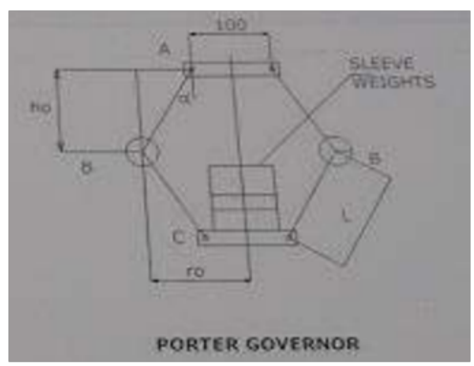
i. Dead weight governor (Porter and Proell governor)

ii. Spring controlled governors (Hartnell governor, Hartung governor, Wilson-Hartnell governor and Pickering governor)

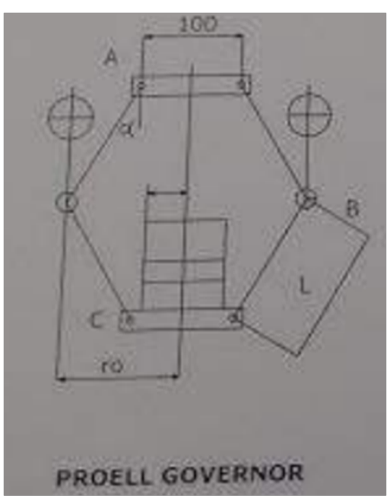




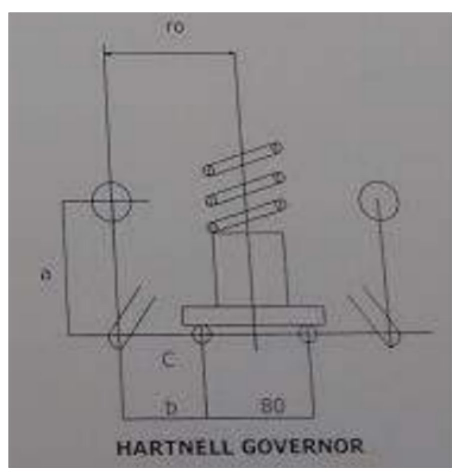
WATT GOVERNOR



PORTER GOVERNOR



PROELL GOVERNOR



HARTNELL GOVERNOR

Watt governor: The simplest form of a centrifugal governor is watt governor. It is basically a conical pendulum with links attached to a sleeve of negligible mass. The arms of the governor may be connected to the spindle in the following three ways:

1. The pivot P may be on the spindle axis.
2. The pivot P may be offset from spindle axis and arms when produced intersect at O.
3. The pivot P may be offset but the arms cross the axis at O.

Porter governor: The porter governor is a modification of a watt governor, with central attached to the sleeve. The load moves up down the central spindle. This additional downward force increases the speed of revolution required to enable the balls to rise to any pre-determined level.

Proell governor: The porter governor is known as a Proell governor if the two balls (masses) are fixed on the upward extensions of the lower links which are in the form of bent links.

<u>THEORY:</u> Fig shows three forms of the simple watt governor. In this pair of balls are attached to the spindle with the help links. In $fig\ (a)$ The upper link are pinned at point O. In $fig\ (b)$ the upper links are connected by a horizontal link and the governor is known as the open-arm type watt governor. On extending the upper link they still meet at O.

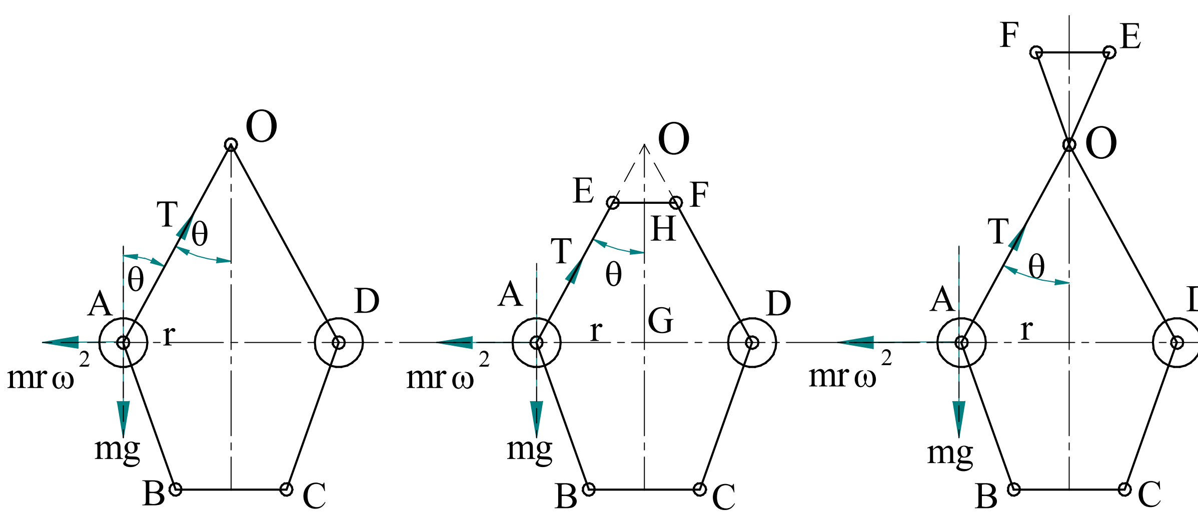


fig. (a) fig. (b) fig. (c)

In $fig.(c)$ the upper links cross the spindle and are connected by a horizontal link and is known as a crossed arm watt governor. In this type the two links still intersect at O. The lower links in every case are fixed to a sleeve free to move on the vertical spindle. As the spindle rotates, the balls take up a position depending upon the speed of the spindle. If it lowers, they move near to the axis due to reduction in the centrifugal force on the balls and the ability of the sleeve to slide on the spindle. The movement of the sleeve is taken to the throttle of the engine by means of suitable linkage (not shown in figure) to decrease or increase the fuel supply.

Assuming the links to be mass less the friction of the sleeve the mass m at A is in static equilibrium under the action of

1. Weight, $w = mg$ 2. Centrifugal force, $m\,r\,\omega^2$ 3. Tension T in the upper links.

If the sleeve is mass less and also friction is neglected, the lower links will be tension free. Then,

$$\Sigma F_x = 0\ ;\quad T\ \sin\theta = m\,r\,\omega^2$$

$$\Sigma F_y = 0\ ;\quad T\ \cos\theta = m\,g$$

$$\frac{T\ \sin\theta}{T\ \cos\theta} = \tan\theta = \frac{m\,r\,\omega^2}{m\,g} = \frac{r\,\omega^2}{g}$$

$$\frac{r}{h} = \frac{r\,\omega^2}{g} \quad \left(Q\ \tan\theta = \frac{r}{h}\right)$$

$$h = \frac{g}{\omega^2}$$

$$h = \frac{g}{\left(\frac{2\,\pi\,n}{60}\right)^2} = \left(\frac{60}{2\,\pi}\right)^2 \times \frac{9.81}{n^2}$$

$$h = \frac{895}{n^2}$$

DESCRIPTION OF THE SET UP:

The watt governor under test is of OPEN-ARM type. All the links of the governor is equal in length, the governor mechanism can be mounted on spindle. Precise speed control is obtained by the speed control unit. The drive unit consists of an electric motor connected through $V -$ belt to drive the shaft motor and main shafts are mounted on a rigid MS base plate in vertical fashion. The spindle is supported in ball bearings. An extension of spindle shaft allows the use of tachometer to determine the speed. A graduated scale is fixed to the sleeve and guided in vertical direction.

PROCEDURE:

1. The watt governor under test (open arm type shown $in\ fig\ (b)$) is fitted with accessories stop and gives a reading on the graduated scale.
2. The control unit is switched on and slowly increase the speed of governor till the sleeve rises off the lower.
3. The sleeve position and speed are then recorded.

The governor speed is increased in steps to give suitable sleeve movements & readings one taken at each throughout the sleeve movement possible the readings thus taken are tabulated

OBSERVATIONS:

Length of each link, $l \;\; m$

Initial Height of governor, $h_o \;\; m \;\; (as\ shown\ below)$

Initial radius of rotation, $r_o \;\; m \;\; (as\ shown\ below)$

Mass of each ball, $m = 0.7\ kg$

TABULATION OF READING:

Sl. No	Speed $\boldsymbol{n}$ (rpm)	Sleeve Displacement $(\boldsymbol{m})$			Height h $(\boldsymbol{m})$	Radius of rotation $\boldsymbol{r}$ $(\boldsymbol{m})$	Force $\boldsymbol{F = m_b r \omega^2}$ $(\boldsymbol{N})$
		Initial	Final	X			

SPECIMEN CALCULATIONS:

Height, $h_1 = h_o - \frac{x}{2} \;\; m$

$$\cos\theta = \frac{h_1}{l}$$

Height of the governor, $h = h_1 + \frac{50 \times 10^{-3}}{\tan\ \theta} \quad m$

Radius of rotation, $r = 50 \times 10^{-3} + l \sin\theta \quad m$

$$\omega = \frac{2\,\pi\,n}{60} \qquad rad/sec$$

Centrifugal force, $F = m_b\, r\, \omega^2 \quad N$

Where, $m_b = mass\ of\ each\ ball\ in\ kg$

$$\omega = angular\ velocity\ in\ rad/s$$

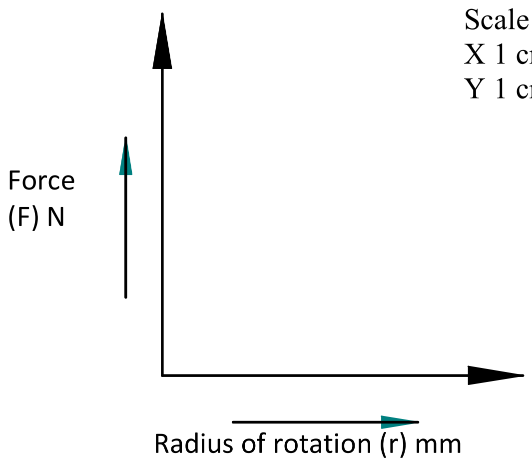
$$r = radius\ of\ rotation\ in\ m$$

Thus height of a watt governor is inversely proportional to the square of the speed. This makes the watt governor unstable for high speeds.

TABULATION OF RESULT:

Sl. No	Speed $\boldsymbol{n}$ (rpm)	Height h $(\boldsymbol{mm})$	Radius of rotation $\boldsymbol{r}\ (\boldsymbol{mm})$	Force $\boldsymbol{F = m_b r \omega^2}\ (\boldsymbol{N})$

Scale :
X 1 cm =
Y 1 cm =



Note/Comments/Calculations:

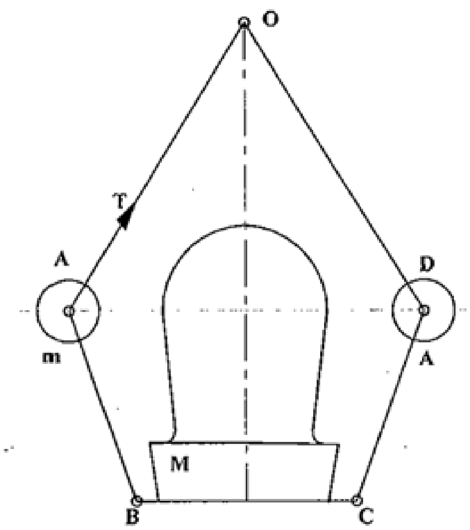
Experiment No:7

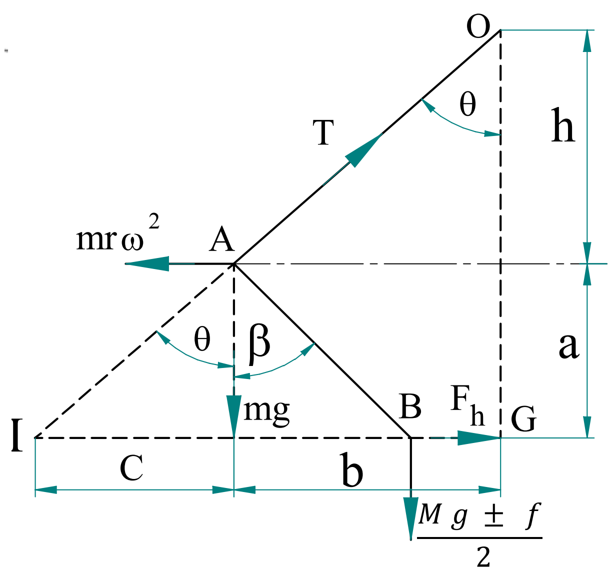
PORTER GOVERNOR

AIM: To conduct a test on porter governor and to determine the radius of rotation and centrifugal force at different speeds of rotation.

APPARATUS used: Porter governor arranged on universal governor and tachometer.

INTRODUCTION: - The function of a governor is to regulate the main speed of the engine, when there is variation in the load i.e., when the load on the engine increases/Speed decreases. Therefore it becomes necessary to increase the supply of the fuel on the other hand when the load on the engine decreases, its speed increases and thus less fuel is required. The governor automatically controls the supply of fuel to the engine with the varying load conditions and keeps the main speed within certain limits.





THEORY: The porter governor is a type of centrifugal governor, if the sleeve of a watt governor is loaded with a heavy mass; it becomes a porter governor as shown in fig (a) and (b)

The force of friction always acts in a direction opposite to that of the motion. Thus when the sleeve moves up, the force of friction acts in the down ward direction and the downward force acting on the sleeve is $(Mg + f)$ similarly when the sleeve moves down, the force on the sleeve will be $(Mg - f)$.

As BAO is kinematically equivalent to a slider crank mechanism with B as slider (vertical motion) the instantaneous centre for the given configuration of the governor.

Considering the equilibrium of the left hand half of the governor and taking moment about I,

$$m \ r \ \ \omega^2 \ a = m \ g \ c \left[\frac{m \ g \pm \ f}{2}(c + b)\right]$$

$$m \ r \ \ \omega^2 \ \ = m \ g \ \ \frac{c}{a} + \left[\frac{m \ g \pm \ f}{2}\left(\frac{c}{a} + \frac{b}{a}\right)\right]$$

$$m \ r \ \ \omega^2 \ \ = m \ \ g \ \ \tan\theta + \frac{m \ g \pm \ f}{2}[\tan\theta + \tan\beta]$$

But for the experimental setup, shown in fig (2)

$$\tan\theta = \tan\beta = \frac{r}{h}$$

$$\therefore \quad m \ r \ \ \omega^2 \ = \tan\theta\left[m\,g + \frac{m\,g \pm\ f}{2}\left(1 + \frac{\tan\beta}{\tan\theta}\right)\right]$$

$$\therefore \quad m \ r \ \ \omega^2 = \frac{r}{h}\left[m\,g + \frac{m\,g \pm\ f}{2} \times 2\right]$$

OBSERVATIONS:-

Length of the link $= l \ m$

Initial height of the governor $= \ h_o \ m$

Initial radius of rotation $= \ r_o \ \ m$

Mass of each ball $= \ m_b = 0.7 \ kg$

Mass of sliding sleeve with pointer $= \ M_1 = 3.5 \ \ kg$

For $\boldsymbol{M_2} \ =$ ***kg***

Sl. no	Speed , N (rpm)	Sleeve displacement, X (m)	Height h (m)	Radius of rotation r (m)	Centrifugal force, F (N)	Frictional force, f (N)

For $\boldsymbol{M_2} \ =$ ***kg***

Sl. no	Speed , N (rpm)	Sleeve displacement, X (m)	Height h (m)	Radius of rotation r (m)	Centrifugal force, F (N)	Frictional force, f (N)

SPECIMEN CALCULATIONS:

Height, $h_1 = h_0 - \frac{X}{2}$ m

$$\cos\theta = \frac{h_1}{l}$$

Height of the governor, $h = h_1 + \frac{50 \times 10^{-3}}{\tan\theta}$ m

Radius of rotation, $r = 50 \times 10^{-3} + l \sin\theta$ m

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

Centrifugal force, $F = m_b\ r\ \omega^2$ N

$m_b = mass\ of\ each\ ball\ in\ kg,$ $\omega =$ angular velocity in rad/s

$r = radius\ of\ rotation\ in\ m$

$$\mathrm{m = M_1 + M_2 \quad in \quad kg}$$

The factional force $\boldsymbol{F_f}$ can be determined from

$$m_b\ r\ \omega^2 = \frac{r}{h}\left[m_b\ g + \frac{m_r\ g \pm \boldsymbol{F_f}}{2} \times 2\right]$$

$$\boldsymbol{F_f} = m\ g + m_b(g - h\ \omega^2) \qquad N$$

DESCRIPTION OF THE SETUP: -

The links of the porter governor is equal in length. The governor mechanism can be mounted on the spindle. Precise speed control is obtained by the speed control unit. The drive unit consists of an electric motor connected through V-belt to drives shaft. Motor and main shaft are mounted on a rigid MS base plate in vertical fashion. The spindle is supported in ball bearings. An extension of the spindle shaft allows the use of a tachometer to determine the speed. A graduated scale is fixed to the sleeve and guided in vertical direction. The center sleeve of porter governor incorporates a weight sleeve to which weights may be added.

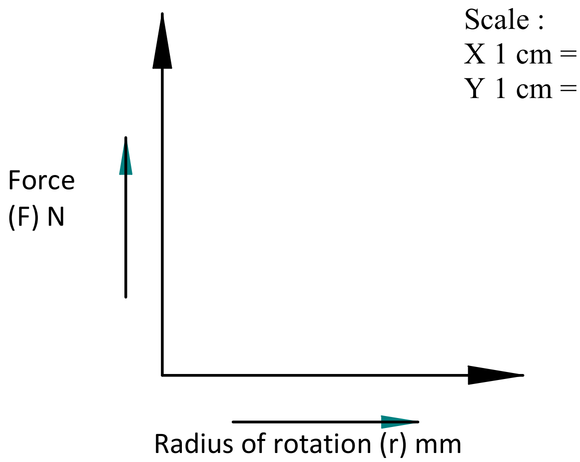
PROCEDURE:-

1. The porter governor under test (shown in fig) is with accessories.
2. The control unit is switched on and slowly increases the speed of governor till the sleeve rises off, the lower stop and gives a reading on graduated scale.
3. The sleeve position and speed are then recorded.
4. The governor speed is then increased in steps to give suitable sleeve movements and readings are taken at each and throughout sleeve movement possible. The readings taken are tabulated.
5. Repeat the above procedure for different mass added on the sleeve.
6. Draw graphs of controlling force (F) v/s radius of rotation (r).

TABULATION OF RESULT:

Sl. No	Speed n (rpm)	Height h (mm)	Radius of rotation r (mm)	Centrifugal Force $F = m_b r \omega^2$ (N)	Frictional force F_f (N)

SPECIMEN GRAPH:



Note/Comments/Calculations:

Experiment No: 8

GYROSCOPE

AIM:- To determine the gyroscopic couple and compare it with the actual applied couple.

APPARATUS:- Motorized gyroscope, dimmer stat set and standard weights, Tachometer, etc.,

THEORY:-

A body rotating about an axis offers a resistance to change in direction of this axis, is known as gyroscopic effect. Important applications of gyroscopic effect are the gyroscopic compass used in aircraft, ships and in internal guidance control system for missiles and space travel.

Force due to gyroscopic effect must be taken into account in the design of machines. These forces are encountered in the bearing of an automobile engine as the automobile takes a turn, in marine turbines as the ship pitches in a heavy sea and in a jet aircraft engine shaft when the aircraft changes direction.

The axis about which the body rotates is called axis of spin. The axis about which the shaft tends to tilt is called the axis of precession. The axis about which the torque is present is called torque axis. The three axes are mutually perpendicular to each other. Gyroscopic couple Gg is given by,

Gyroscopic couple, $Gg = I.\omega.\omega_p$

Where,

$$I = Moment\ of\ inertia = m.K^2$$

$$\omega = Angular\ velocity\ of\ spin = \frac{2\,\pi\,N}{60} \quad rad\backslash sec$$

$$\omega_p = Angular\ velocity\ of\ axis\ of\ spin = \frac{\pi}{4\,t} \quad rad\backslash sec$$

$$K^2 = \frac{r^2}{2}$$

The applied couple Ga is given by,

Applied couple, $Ga = w \times x \quad N-m$

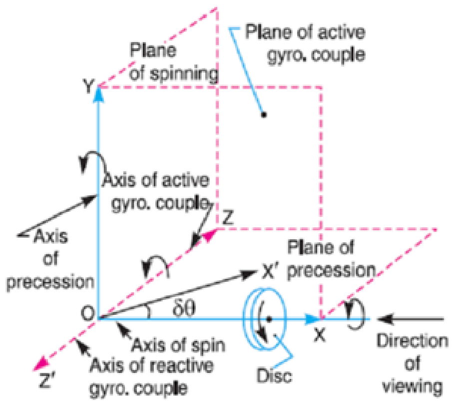
Where,

w = Weight applied.

x = Distance of weight stud form the disc. = $0.260\ m$.

PROCEDURE:-

The electrical connections to the motorized gyroscope apparatus is made and switched on. The dimmer set is adjusted to get a desired speed. The gyroscope is given some time to obtain a constant speed. This speed is noted. The standard weights are now introduced to the gyroscope and the time taken by it to move through an angle of 45^0 is noted. This procedure is repeated at different speeds of the gyroscope.



Gyroscopic couple

TABULAR COLUMN:-

SI. No.	Rotor Speed N (rpm)	Weight attached W (N)	Time (t) for 25^0 precession, ω_p	Angular velocity of Rotor, $\omega = \frac{2\pi N}{60}$ $(rad\backslash sec)$	Gyroscopic couple , Gg $(N-m)$	Applied couple Ga $(N-m)$

OBSERVATION:-

$$W_d = Weight\ of\ disc = 59\ N$$

$$d = diameter\ of\ disc = 0.270\ m$$

$$t = Thickness\ of\ the\ disc = 0.085\ m$$

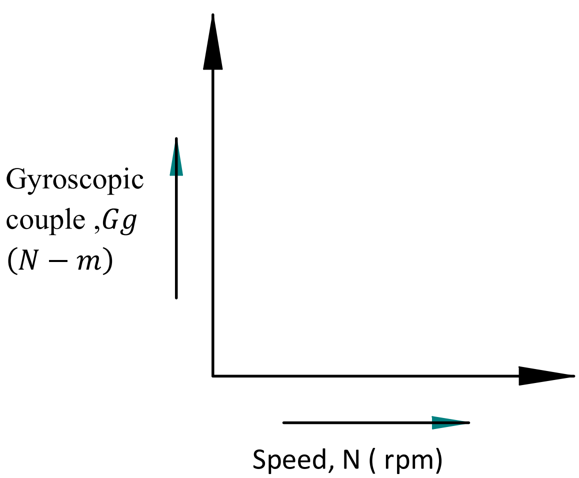
$$x = 0.260\ m$$

$$I = \left(\frac{W_d}{g}\right) \times \left(\frac{d}{2\sqrt{2}}\right)^2 \quad kg\ m^2$$

RESULT

The disparity between the values of the gyroscopic couple and the applied couple is due to varying supply voltage which results in changes in the spin of the motor and also due to friction which is not taken into account.

SI. No.	Rotor Speed N (rpm)	ω_p	Angular velocity of Rotor, ω $(rad \backslash sec)$	Gyroscopic couple ,Gg $(N-m)$	Applied couple, Ga $(N-m)$



Scale :
X 1 cm =
Y 1 cm =

Note/Comments/Calculations:

Experiment No:9

STATIC & DYNAMIC BALANCING

AIM: - To balance the given weights in static and dynamic condition.

DESCRIPTION OF THE APPARATUS: - The apparatus basically consists of a steel shaft mounted on ball bearings in a stiff rectangular frame. A set of four blocks of different weights is provided and may be clamped in any position on the shaft. A disc carrying a circular protractor scale is fitted to one side of the rectangular frame. The rim of this disc is grooved to take a light cord provided with two cylindrical metal containers of exactly the same weight. A scale is fitted to the lower member of the main frame and when used in conjunction with circular protractor scale allows exactly longitudinal and angular position of each adjustable block to be determined. The shaft is driven by $230\,V$ single phase, $50\,Hz$ electric motor mounted under the main frame by a circular sectioned rubber belt.

STATIC BALANCING: - For static balancing of individual weights the main frame is rigidly attached to the support frame by nuts and bolts and in this position the electric motor along with belt is removed.

DYNAMIC BALANCING: - For dynamic balancing of the rotating mass system the main system is suspended from the support frame by two short links. Here electric motor and belt is mounted.

PROCEDURE:

a) **FOR STATIC BALANCING:** The main frame is rigidly fixed at right angles to the support frame and the support frame and the drive belt is removed. The value of w_r for each block is determined by clamping each block in turn on the shaft and with the cord and container system suspended over the protractor disc. The numbers of steel balls which are equal in weights are placed in to one of the container to exactly balance the blocks on the shaft. When the block comes to stationary horizontal position, the number of balls 'n'; will give the value of w_r of the block.

For finding out w_r during static balancing the following procedure is followed.

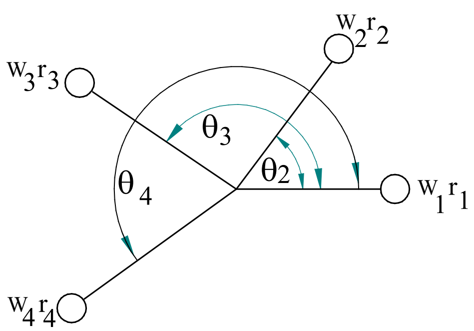
1) Remove the belt and attach the main frame, to support frame rigidly at right angles as shown in figure.
2) Screw the combined hook to the pulley with groove (This pulley is different from the belt pulley)
3) Attach the cord ends of the container (pan) to the above block.
4) Attach the block number '1' to the shaft at any convenient position.
5) Put the steel balls in one of the container to make the blocks horizontal.
6) Number of balls gives the w_r value of block 1 as$w_{r\,1}$.
7) Repeat the procedure for other three blocks and determine $w_{r\,2}, w_{r\,3}, w_{r\,4}$
8) Assume the angular positions of the first two blocks (θ_1 & θ_2) and draw force polygon.
9) From the force polygon measure the remaining angular positions i.e. θ_3 & θ_4.
10) Set the blocks to the corresponding angular positions as obtained from the force polygon and check whether the system of weights is in static balancing.

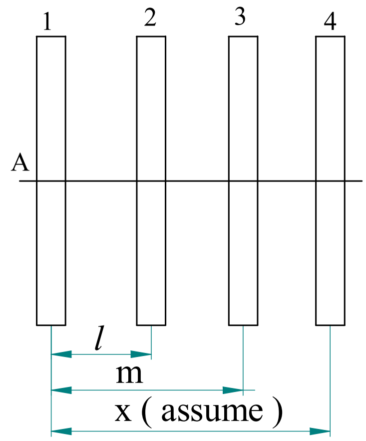
b) FOR DYNAMIC BALANCING: It is necessary to level the machine before the experiment.

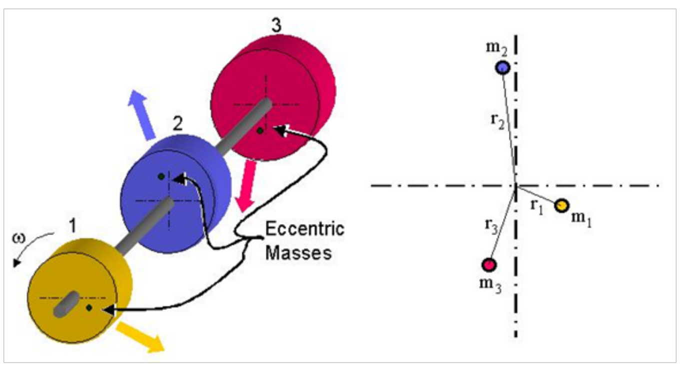
1) Using the values obtained from static balancing the angular position of all the weights are arranged first.

2) Assume the distance between the first two blocks as 'x'(preferably within 100 mm)

3) Then the distance between 1^{st} and 3^{rd} 'l' and 1^{st} and 4^{th} 'm' are calculated by taking moments about the first block in the horizontal and vertical plane respectively.







TABULATION:

$$Mass\ of\ each\ ball\ ,\ \boldsymbol{m}\ =\ \ \ (gms)$$

SI. No.	No. of steel balls (n)	$\boldsymbol{w} = \boldsymbol{m} \times 9.81 \times \boldsymbol{n} \times 10^{-3}$ $(\boldsymbol{N})$	$\boldsymbol{w_r} = \boldsymbol{w} \times \boldsymbol{r}$ $(\boldsymbol{N-m})$
1			
2			
3			
4			

Force polygon Scale:

Dynamic Balancing (Calculations)

Taking moments about A in the vertical plane, $\Sigma\ M_V = 0$

$w_2 r_2\ \sin\theta_2\ x + w_3 r_3\ \sin\theta_3\ l + w_4 r_4\ \sin\theta_4\, m\ = 0$

Taking moments about A in the horizontal, $\Sigma\ M_H = 0$

$$w_2 r_2\ \cos\theta_2\ x + w_3 r_3\ \cos\theta_3\ l + w_4 r_4\ \cos\theta_4\ m = 0$$

Note/Comments/Calculations:

Experiment No: 10

WHIRLING OF SHAFT

AIM:- To determine the whirling speed of the given shaft for the given end conditions and comparing the same with theoretical whirl speed.

DESCRIPTION: -

This apparatus is developed for the study of whirling phenomenon. The shaft can be tested for different end conditions. The apparatus consists of a frame to support its driving motor and fixing and sliding blocks etc. a special design is provided to clear out the effects of bearings of motor spindle from those of testing shafts. Figure illustrates the design feature of this equipment.

A) Kinematic Coupling

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

B) Ball bearing fixing ends

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

End fixing arrangement: -

At motor end as well as at tail end, making use of different fixing blocks can develop different end conditions.

1. Supported end conditions: makes use of end block with single self aligning bearings.
2. Fixed end conditions: make use of end block with double bearing

PROCEDURE:-

1. Measure the length of the shaft between the supports and the diameter.
2. Place the given shaft according to different end conditions separately.
3. For each end conditions gradually increase the speed of the shaft and determine the whirling speed under different modes.
4. Tabulate the obtained whirling speed under different modes.
5. Calculate the theoretical whirling speed using appropriate formula and compare the same with experimental whirling speed.

WHIRLING OF ELASTIC SHAFTS: -

OBSERVATIONS AND CALCULATIONS

Notations used:

$L \;= Length\ of\ the\ shaft\ in\ m$

$E \;= Young's\ modulus\ N/m^2 \quad (\mathbf{2.060 \times 10^{11}})$

$\boldsymbol{I} \;= moment\ of\ inertia\ of\ the\ shaft \;= \dfrac{\pi\, d^4}{64} \quad m^4$

$W \;= 1.03\ kg = Weight\ of\ the\ shaft\ per\ unit\ length\ N\backslash m\ (spring\ steel)$

$g \;= acceleration\ due\ to\ gravity\ 9.81\ \ m\backslash s^2$

$d \;= Diameter\ of\ the\ shaft\ in\ m$

The various values for k are given below:

	Value of k	
End condition	**1^{st} mode**	**2^{nd} mode**
Fixed, Fixed	3.56	14.24
Fixed, Supported	2.45	9.8
Supported, Supported	1.57	6.28

DATA:

Shaft diameter $(\boldsymbol{mm})$	$\boldsymbol{I}$ $(\boldsymbol{m^4})$	$\boldsymbol{W}$ $(\boldsymbol{N/m})$

Then the frequency of vibrations for the various modes is given by the equation:

$$F = k \times \sqrt{\left(\frac{E\ I\ g}{W\ L^4}\right)}$$

CALCULATIONS: End condition:…… Mode: …….

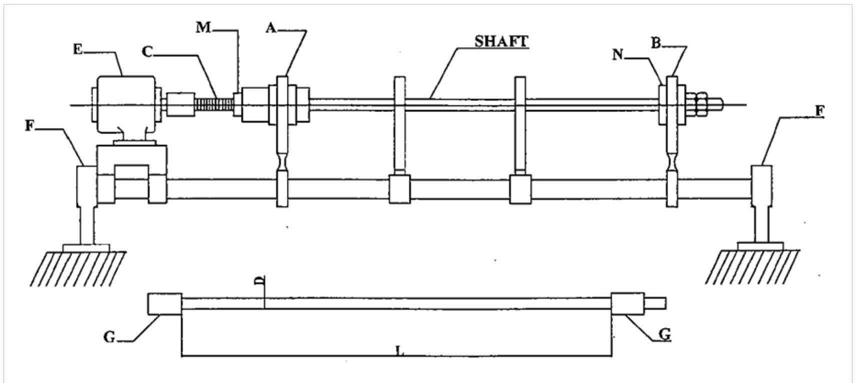
$$F = k \times \sqrt{\left(\frac{E\,I\,g}{W\,L^4}\right)} \quad Hz$$

$$F = \frac{Speed}{60}$$

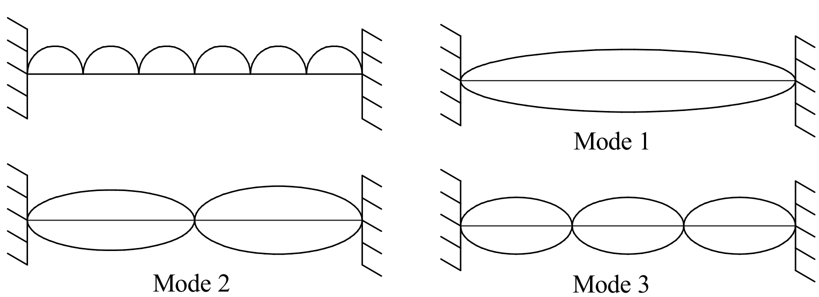
$$Speed, \quad N = F \times 60 \quad rpm$$

TABULAR COLUMN:

End condition	d =	Left: Fixed		Right: Supported
Mode	Theoretical critical whirling speed, N_{th} (rpm)	Theoretical critical natural frequency, f_{th} (Hz)	Experimental critical whirling speed, N_{exp} (rpm)	Experimental critical natural frequency, f_{exp} (Hz)
Mode 1				
Mode 2				



SETUP OF WHIRLING OF SHAFT



Resonannce:
Critical speed/ Whirling/Whipping speed

RESULT: **End Condition**

The critical frequency for first mode = ………… Hz

The critical frequency for second mode = ………… Hz

Note/Comments/Calculations:

POLARISCOPE (PHOTOELASTICITY)

DEFINITIONS:

Photo elasticity: This is an experimental method of determining state of stress magnitude and direction) at any point in a transparent model made of birefringement material using light.

Material fringe value or material fringe constant: Load in Newton required for obtaining one isochromatic fringe in a model of unit thickness.

Isochromatic fringes: Fringes along which principal stress differences are constant.

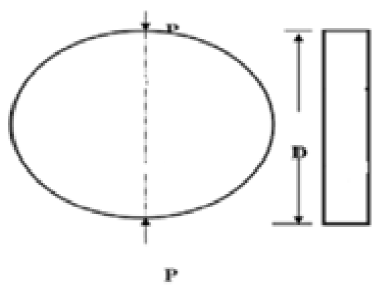
Isoclinic's: Fringes along which principal stress directions are constant.

Polariscope: Equipment used for loading a specimen and for observing isochromatic and isoclinic fringes.

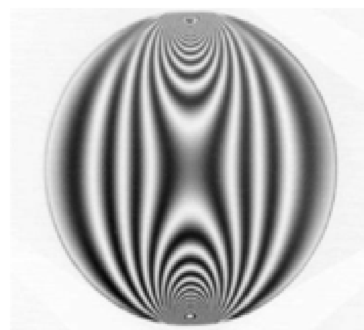
Plane-polariscope: Polariscope employing plane polarized light.

Circular polariscope: Polariscope employing circularly polarized light

Theory:



CIRCULAR RING UNDER COMPRESSION



Circular ring showing fringes

INTRODUCTION:

It is a whole field experimental technique in which the stress distribution in the entire field can be visualized unlike the stress analysis using strain gauges which is a point field technique. This technique is based on stress – optic law applied to photoelastic materials which are temporarily doubly refractive.

OPTICAL INSTRUMENTS: The Polariscope

The Polariscope is an optical instrument that utilizes the properties of polarized light in its operation. For experimental stress analysis work, two types are frequently employed, the plane polariscope and the circular polariscope. The names follow from the type of polarized light used in their operation. In practice, plane polarized light is produced with an optical element known as 'plane or linear polarizer'. Production of circularly polarized light or the more generally elliptically polarized light requires the use of linear polarizer together with an optical element known as a 'wave plate'. Sketch below shows the arrangement of optical elements in plane and circular polariscope respectively.

Arrangement	Quarter wave plates	Polarizer & Analyzer	Field
A	Crossed	Crossed	Dark
B	Crossed	Parallel	Light
C	Parallel	Crossed	Light
D	Parallel	Parallel	Dark

Table: Four arrangements of the optical elements in a circular polariscope

- Arrangements A and B are normally recommended, since a portion of error introduced by imperfect quarter wave plates is cancelled out.

STRESS OPTIC LAW:

For $2-D$ or plane-stress problems, where one of the principal stress is zero, the stress-optic law in terms of the non-zero principal stresses and for light at normal incidence of the model can be written as:

$$\sigma_1 - \sigma_2 = \frac{N\, f_\sigma}{h} \quad N/mm^2$$

where, N is isochromatic fringe order, $f_\sigma =$ is material fringe value, $N/mm/fringe$

h is thickness of the model, mm.

Fringes associated with principal stress direction are called "Isoclinic's" and those associated with stress magnitudes are called "Isochromatic". In plane polariscope both isoclinic's and Isochromatic are obtained and in circular polariscope only Isochromatic are present. Hence, plane polariscope mode is called "direction mode" and circular polariscope mode is called as "magnitude mode". Normally polariscope is used as a dark – field instrument, which means that with no stress in the model all light is extinguished and the model appears uniformly black.

In most of the photoelastic analysis, the stress distribution in a complex model is sought as a function of the load. To determine this stress distribution accurately requires the careful calibration of the material fringe value 'fσ'. This value varies with the supplier, the batch of resin, temperature and age. For this reason it is always necessary to calibrate each sheet of photoelastic material at the time of the test. In any calibration techniques, one must select a body for which the theoretical stress distribution is accurately known. Normally the following type of specimen is used.

- Tensile specimen, Circular disc under diametric compression, Bending specimen

Most elastic stress analyses are conducted by employing one of the following materials.

- Columbia resin, Homalite , Polycarbonate
- Epoxy resin , Urethane rubber

COMPENSATION TECHNIQUES:

Compensation techniques are employed to establish the fringe order N to the fractional values.

The two important methods adopted are,

1. Babinet – Soleil method
2. Tardy's method

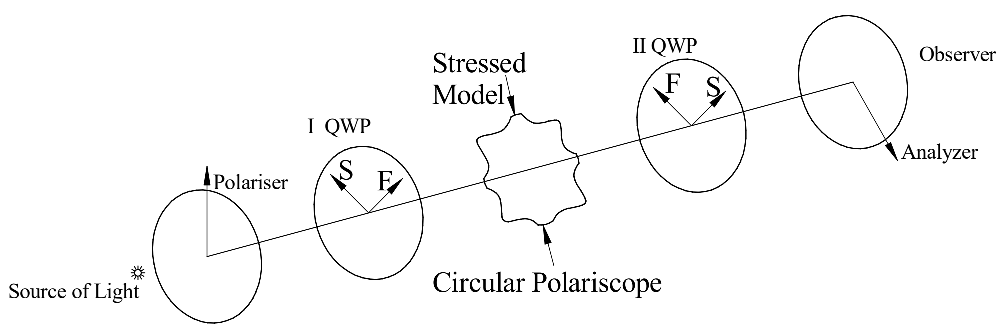
The Tardy's method of compensation is a relatively fast, simple, and accurate technique for measuring fractional fringe orders in photoelastic patterns. To use the Tardy method correctly, however, requires greater operator experience than for null – balance compensation. In particular, it is necessary that the operator be intimately familiar with full – field interpretation of fringe patterns in order to unambiguously recognize and assign orders to all integral – order fringes within the field of view. It is also important that the sign convention for fringe orders be strictly adhered to. When a photoelastic model is viewed in white light, the Tardy's method of compensation is limited in application to fringe orders of 4 or less because higher – order fringes tend to be too pale for accurate measurement by this method.

The basis for Tardy's compensation can be stated as follows:

When the polarizer and analyzer of the polariscope are aligned with the directions of the principal stresses, and the quarter wave plates are at 45^0 to the polarizer axis, independent rotation of the analyzer by α0 will move a fringe to a position where the fractional order is $\alpha/180$.

EXPERIMENTAL SET-UP:

It consists of light source (white light as well as monochromatic), two polarizer plates, two quarter wave plates and a loading frame all arranged on a table. The polarizer plate nearer to the observer is called as analyzer. Photo elastic specimen is held in the loading frame and load applied through dead weights. Fringe pattern is observed through the analyzer or recorded on a photograph.



For determining the principal stress differences at any point in a given model N, f_σ and h should be determined. N can be determined at any point in the model by observing in a circular polariscope, h is the thickness of the model and f_σ is to determined by calibration. For calibration purpose we have to use models for which the state of stress is known theoretically.

Experiment No: 11

CALIBRATION OF PHOTO ELASTIC MODEL MATERIAL BY USING CIRCULAR DISC UNDER DIAMETRICAL COMPRESSION.

AIM:- Calibration of Photo Elastic Model Material by using circular disc under diametrical compression.

OBJECT:- To carry out calibration of Photo elastic model material.

APPARATUS :-

1) Circular disc prepared our of Photo elastic model material.
2) Universal Loading Frame
3) $12''$ Diffused Light Transmission Polariscope.

PROCEDURE:-

1) Ref. $Fig. No. l$ and load the disc in universal loading frame, under diametrical compression by putting pin on '2' hole on right hand side and 7^{th} hole on left hand side.
2) The distances 'X' and $'Y'$ must be measured initially.
3) Apply light load and Plain Polariscope (D) arrangement.
4) Observe the isoclinic fringe pattern and note the isoclinic reading for the point of interest $'P'$ on the model.
5) In this case as the point of interest $'P'$ which is at the center of the disc, the isoclinic reading automatically becomes zero.
6) Now apply known value of load at the end of lever and set to circular polariscope (M) arrangement.
7) Use white light and identify the fringe order at the point $'P'$
8) Use Tardy's Method, if required, to find fractional fringe order at the center point $'P'$.
9) Go on increasing the load in steps and note down fractional fringe order at the center point $'P'$.
10) After measuring the diameter of the disc proceed to calculate material fringe value.

OBSERVATION :-

1) Distance 'X' $=$ mm
2) Distance $'Y' =$ mm
3) Diameter of Disc $'D' =$ mm

TABULATION OF READINGS:-

Load Applied $'W'$ Kg on Load Cell (Kg)	Load on Model $P = \frac{W \times Y \times 9.81}{X}$ (N)	Fractional Fringe Order N at center			Material Fringe Order $f_\sigma = \frac{8\,P}{\pi\,D\,N}$ (N/mm)	Average f_σ (N/mm)
		Lowest Fringe Order	Higher Fringe Order	Average Fringe Order (N)		
5	49.05					
10	98.1					
15	147.15					

SPECIMEN CALCULATIONS:-

For a disc under diametrical compression :

$$f = \frac{8\ \times \text{Load on model in Kg}}{\pi \times \text{Dia. of disc in cm}\ \times \text{fractional fringe order at center}}; \quad f = \frac{8\,P}{\pi\,D\,N} \qquad N/mm$$

Note: - do not exceed load more than 15 Kg

CONCLUSION :-

1. Circular disc model is easy to prepare & load, hence is suitable for calibration of Photo elastic model material.

2. The average value of f_σ calculated is in good arrangement with values specified in the text for epoxy category.

TABULATION OF RESULTS:-

LOAD		Fractional Fringe Order N at center	Material Fringe Order, f_σ (N/mm)	Average f_σ (N/mm)
Kg	N			
5	49.05			
10	98.1			
15	147.15			

Note/Comments/Calculations:

Experiment No: 12

DETERMINATION OF PRINCIPLE STRESSES AND STRAINS USING STRAIN GAUGE ROSETTES

AIM:- To determine principle stress, principal strain, maximum shear stress, maximum shear strain using strain gauge rosettes.

APPARATUS:- Strain gauge rosette, Digital strain indicator, solid shaft.

THEORY: The mathematical analysis of stresses in complex components may not, in some cases, be practical or either not available or cumbersome and uneconomical. It would be essential to have the backing of reliable experimental investigations for confirmation of analytical formulations. Experimental stress analysis or strain measurement techniques have served an increasingly important role in aiding designers to produce not only efficient but economic designs. The accurate measurement of stresses, strains and loads in components under working conditions is an essential requirement of successful engineering design. In particular, location of peak stress values and stress concentration, and subsequently their reduction or removal by suitable design has applications in every field of engineering.

The main techniques of experimental stress analysis which are in use today are:

- Brittle Lacquers, Strain gauges, Photo elasticity, Photo elastic coatings

STRAIN GAUGES:

A Strain gauge is a strain transducer. It is a device for measuring dimensional change on the surface of a structural member under test.

This setup has been designed to study the application of rosette strain gauge and to find out maximum principal stress value and direction. In strain gauge technique a very thin wire of the order of 5 to 10 micron diameter is pasted on a metal part by means of suitable adhesive. The metal part is then subjected to load, which finally results induction of strain in it. By knowing the strain values, stress values are calculated by using standard strength of material relations. Hence the values of stresses at various points of interest can be found out experimentally, resulting into complete stress picture of the metal part under investigation.

For investigating the stresses in metal part the entire cases can be categorized in two groups:

- When direction of stresses is known
- When direction of stresses is unknown

In first case it is easy to analyze because the direction in which the maximum principle stress occurs is known and stain gauges can be oriented in already known direction and single element strain gauges serve the purpose. However in second case single element strain gauge will not serve the purpose, as such, three-element rosette type gauges are used.

Set-up consists of a hollow cylinder pasted with rosette strain gauge. This cylinder can be pressurized by using foot pump. A multichannel strain indicator is provided to measure output of each strain gauge. Students can find out values of maximum stress at various pressures and compare the same with theoretical values.

Rosettes:

Multiple grid or rosettes are a group of gauges bonded in the same supporting material in definite relative positions. Depending on the arrangement of the grids, we have rectangular, delta or T – delta rosettes. The gauges are to be aligned in principal directions. θ is the angle of reference measured positive in counter clockwise direction. The strain gauges can be arranged in combination to get three elemental rectangular rosettes or three element rectangular rosettes or three element delta rosettes or four element rectangular rosettes.

SETUP DETAILS:

The setup consists of L – bracket in which bottom plate is fixed rigidly on the table and vertical plate holds the specimen. One end of the specimen is rigidly fixed by means of screws. Other end of the specimen is fixed with loading arm. Strain gauges are mounted on the specimen in the form of three element rectangular rosettes. Strain gauge outputs are taken out through connectors. These outputs are connected to the corresponding channels of strain indicator. Strain indicator is provided with three independent displays for each gauge. Separate zero and calibration provision is made individually.

DIAGRAM:

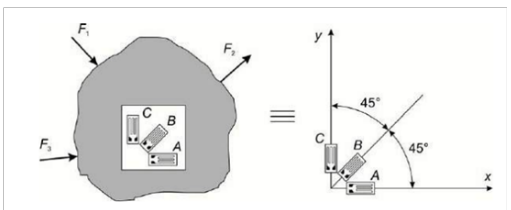


Fig a : Three Element Rectangular rosette

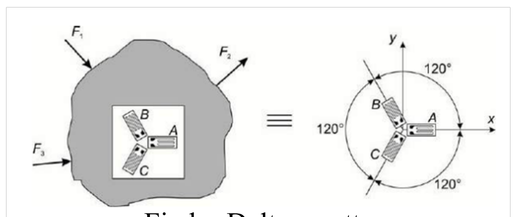


Fig b : Delta rosette

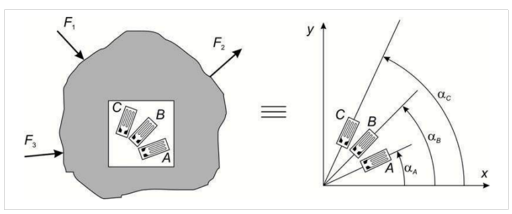


Fig c : Three element rosette

PROCEDURE:

1. Make the necessary connections to the Digital Strain Indicator from sensor. Adjust the indicator knob to zero.
2. Load the specimen with the aid of loading arm in steps.
3. Record the strain in micro – strains by connecting corresponding strain gauges to the indicator with the help of probes.
4. The three readings are recorded which indicates bending and torsional strains. (Torsional -> two readings + ve and − ve)
5. Repeat the above procedure for different load in steps.
6. Compute the required parameters by using appropriate equations.
7. Finally draw the Mohr's circle to compare the obtained results.

OBSERVATIONS:

1. Material of the specimen, Mild steel
2. Diameter of the specimen, $d = .0247 \ \ m$
3. Length of the torque arm, $L \ = 1 \, m$
4. Modulus of elasticity, $E = \ 210 \ \times 10^3 \ MPa$
5. Modulus of rigidity, $G \ = \ 73 \ \times 10^3 \ MPa$
6. Poisson's ratio, $\mu \ = 0.3$
7. Length of the shaft, $l = 0.265 \ m$

CALCULATION:

$$M = \ W \times \ l \quad , \qquad T = \ W \times \ l$$

Experimental stress:

$$\sigma_{1,2} = \frac{E}{2}\left(\left(\frac{\epsilon_A + \epsilon_C}{1-\mu}\right) \pm \frac{\sqrt{2}}{1+\mu}\sqrt{(\ \epsilon_A - \epsilon_B)^2 + (\ \epsilon_B - \epsilon_C)^2}\right)$$

Experimental strain:

$$\epsilon_{1,2} = \frac{\epsilon_A + \epsilon_C}{2} \pm \frac{1}{\sqrt{2}}\sqrt{(\ \epsilon_A - \epsilon_B)^2 + (\ \epsilon_B - \epsilon_C)^2}$$

$$\sigma_x = \frac{M \times \ 32}{\pi \times d^3} \quad MPa; \quad \sigma_y = 0 \ \ MPa; \quad \tau_{xy} = \frac{T \times \ 16}{\pi \times d^3} \quad MPa;$$

Theoretical stress:

$$\sigma_{1,2} = \frac{\sigma_x}{2} \pm \sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau_{xy}{}^2}$$

Theoretical strain:

$\epsilon_1 = \frac{1}{E}(\sigma_1 - \mu \, \sigma_2)$ $\qquad$ $\epsilon_2 = \frac{1}{E}(\sigma_2 - \mu \, \sigma_1)$

Maximum shear stress:

$$\tau_{max} = \pm\sqrt{\left(\frac{\sigma_x}{2}\right)^2 + \tau_{xy}{}^2}$$

TABULAR COLUMN:

Sl no	Load in kg	Strain indicator			Principal stresses (exp) in Pa		Principal strain (exp)		Principal stresses (th) in Pa		Principal strain (th)		Max shear stresses $\tau_{xy}(th)$ in Pa
		$\epsilon_A \times 10^{-6}$	$\epsilon_B \times 10^{-6}$	$\epsilon_C \times 10^{-6}$	$\sigma_1 \times 10^6$	$\sigma_2 \times 10^6$	$\epsilon_1 \times 10^{-6}$	$\epsilon_2 \times 10^{-6}$	$\sigma_1 \times 10^6$	$\sigma_2 \times 10^6$	$\epsilon_1 \times 10^{-6}$	$\epsilon_2 \times 10^{-6}$	$\tau_{xy} \times 10^6$
1													
2													
3													
4													

TABULATIONS OF RESULT:

Sl No	Load in Kg	Experimental		Experimental		Theoretical		Theoretical		Max shear stress
		$\sigma_1 \times 10^6$	$\sigma_2 \times 10^6$	$\epsilon_1 \times 10^{-6}$	$\epsilon_2 \times 10^{-6}$	$\sigma_1 \times 10^6$	$\sigma_2 \times 10^6$	$\epsilon_1 \times 10^{-6}$	$\epsilon_2 \times 10^{-6}$	$\tau_{xy} \times 10^6$
1										
2										
3										
4										

Note/Comments/Calculations:

VIVA VOCE QUESTIONS:

1. What is stress?
The internal resistance by which offers load.

2. What is the difference between stress & pressure?
Stress is defined as force per unit area. Pressure is special variety of stress .However stress is much more complex quantity than pressure because it varies both with direction and with the surface it acts on.

3. What is Strain?
The strain is defined as the amount of deformation obtained due to stress.

4. What is Strain gauge?
A strain gauge is a device is a device used to measure the strain of an object.

5. Name the different type of strain gauges?
Electrical and optical strain gauges.

6. Explain the working principle of electrical strain gauges?
The electrical strain gauges consist of an insulating flexible backing with supports a metallic foil pattern. The gauge is attached to the object by the suitable adhesive. As the object is deformed the foil is also deformed, causing the electrical resistance to change. This electrical resistance change is usually measured using Wheatstone bridge.

7. Define gauge factor?
Gauge factor or Strain factor of a strain gauge is a ratio of relative change in the electrical resistance to the mechanical strain, which is a relative change in length.

8. Name some Strain gauge adhesives or Bonding materials?
Cyanoacrylate, Epoxy, Phenol, Polyamide

9. Define Young's Modulus?
Young's modulus is defined as tensile stress is directly proportional to the tensile strain within the elastic limit.

10. What is the Bulk Modulus?
It is defined as the ratio of Normal stress to the Volumetric strain and is denoted by K

11. Define Rigidity Modulus?
It is defined as the ratio of shear stress & shear strain and is denoted by C.

12. What is Strain Rosette?
The strain rosette is an arrangement of two or more closely positioned gage grids, separately oriented to measure the normal strain along different directions.

13. What is the difference between the Strain Gauge and strain rosettes?
A strain gauge can effectively measure strain in only one direction. In case of strain rosette it is also made up of strain gauges allowing to measure more than one direction.

14. Define stress concentration factor?
A sudden change in the geometric form of a part give raise to additional stress over the calculated stress is known as stress concentration.

15. Name some causes for stress concentration factor?
Geometric discontinues causes an object to experience a local increase in intensity of stress field.

E.g.: Cracks, sharp corners, holes, Changes in the cross sectional area of the object. High local stress can cause objects to fail more quickly.

16. Define the Poison's ratio?
It is the ratio of lateral strain to longitudinal strain.

17. What is Photo elasticity?
Photo elasticity is an experimental method to determine the stress distribution in a material.

18. What is Plain and Circular Polariscope?
It is an instrument for detecting polarized light or for observing objects under polarized light, for detecting strain in transparent materials. First the light is pass through the first polarizes which converts light in to plane polarized light. In circular polariscope, we have to place first quarter wave plate between the polarizer and specimen then the second quarter wave plate is placed between the specimen and the analyzer. So that we can get circular polarized light passing through the sample.

19. Name the Photo elastic material used in our lab?
Araldite

20. How vibrations are classified?
Free, Forced, Self Excited vibrations.

21. Define Frequency, Time period, Simple Harmonic motion
Frequency: It is the number of cycles per unit time. Time period is the time required for one complete cycle Simple Harmonic motion (SHM) is a periodic motion with acceleration always directed towards the equilibrium position.

22. State & Explain the types of free vibrations?
Longitudinal Vibration: The particle of the shaft moves parallel to the axis of the shaft.
Lateral Vibration: The particle of the shaft moves perpendicular to the axis of shaft.
Tensional Vibration: The particle of the shaft moves circular about the axis of shaft.

23. Define Under damping & Critical damping.
Under damping system: Yields an experimentally decreasing sinusoidal output in response to a step input.
Critical damping: The minimum amount of damping that will yield a non oscillatory output in response to step input.

24. Why balancing is necessary?
Balancing is the correction of phenomena by the removal or addition of mass to the component to compensate the center line error.

25. Explain the static and dynamic balancing?
The balancing of rotating masses is important to avoid vibration. Static balancing occurs when there is no resultant centrifugal force and the centre of gravity is on the axis of rotation. In dynamic balancing any resultant centrifugal force and couple does not exist.

26. Balancing of single revolving mass requires minimum two balancing weights, what happen when the different weights are placed?
The net dynamic force acting on the shaft must be equal to zero, i.e. the centre of the masses of the system must lie on the axis of rotation and the net couple due to the dynamic forces acting on the shaft must be equal to zero I.e. the algebraic sum of the movements about any point in the plane must be zero.

27. Explain the terms Primary and Secondary balancing?
Primary balancing: - In the single cylinder engine primary force generated due to the reciprocating mass of piston & connecting. to balance by adding weights to the counter web.

Secondary balancing:- it can be balanced in some multi cylinder engines by appropriate selection of the phase of motion of individual cylinders.

28. Explain the various reasons for the partial balancing of reciprocating masses?
Due to the partial balancing there is an unbalanced primary force along the line of stroke Variation in tractive force of stroke & Sawing couple and unbalanced primary force perpendicular to the line of action to produce variation of rails which results in hammering action on rails.

29. What is line engines & how they are balanced?
The cylinders mounted in a straight line along the crankcase with all the pistons driving a common crankshaft. The primary forces may be completely balanced by suitably arranging the crank angles. The algebraic sum of secondary forces must be equal to zero.

30. What are V Engines? How they are balancing?
V- Engine is an internal combustion engine, the cylinders and pistons are aligned in two separate planes so they are appear in a „V" when view along the axis of the crank shaft. These engines can be balanced by adding counterweight to the crankshaft.

31. Explain the term torsion ally equivalent shaft?
A shaft having diameter for different length can be theoretically replaced by an equivalent shaft of uniform diameter such that they have the same total angle of twist when equal opposing torques re applied at their ends. Such a theoretically replaced shaft is known as torsion ally equivalent shaft.

32. State Dunkerley's rule?
Dunkerley's method is used to determine the critical speed of shaft rotor system.

33. Define the terms Stiffness, Deflection, Critical speed?
Stiffness is the rigidity of an object Deflection is the degree to which a structural element is displaced under load. The speed at which resonance occurs is called critical speed.

34. State the total energy and Rayleigh's method.
The concept of total energy of the system, which is the sum of Kinetic energy (T) and Potential energy (V) remains constant. The Rayleigh's method is equated the maximum kinetic energy of the system to the maximum potential energy of the system.

35. Explain Equivalent mass & Stiffness?
In certain systems more than one spring or mass has to be used and to convert this system in to equivalent mathematical models, it is necessary to find out equivalent stiffness and equivalent mass.

36. Distinguish between the Free, Force & Torsional vibration?
Free or Natural vibrations: When no external force acts on the body, after giving it an initial displacement. then the body is said to be under forced under free vibration.
Forced vibrations:-When the body vibrates under the influence of external force, then the body is said to be under forced under forced vibration.
Torsional vibration:- It may be free or forced vibrations the particles of a shaft or disc move in a circle about the axis of the shaft.

37. Distinguish between Linear & Non linear vibrations?
When the vibrations are represented by linear differential equations and laws of super position are applicable for linear systems.
In case of Non linear vibrations when large amplitudes are encountered and laws of superposition is not applicable.

38. Define Damping ratio & Logarithmic decrement?
The damping ratio is a parameter characterizes the frequency response of a second ordinary differential equation.
The logarithmic decrement is the natural log of the ratio of the amplitudes of any two successive peaks under damping system.

39. Explain the factors affecting the critical speed?
Material properties , Diameter , Length

40. Name the types of Damping?
Viscous damping, Coulomb damping, Solid or Structural damping & slip or interfacial damping.

41. What is gyroscopic effect?
Gyroscopic effect to a body revolving about an axis say OX , if a couple represent by a vector OY perpendicular to OX is applied then the body tries to process about an axis OZ which is perpendicular to both OX & OY. Thus the plane of spin, plane of precession two planes of gyroscopic couple are mutually perpendicular. The above combined effect is known as gyroscopic effect.

42. Explain the Right hand thumb rule?
To determine the direction of spin, Precision and Torque or Vector couple Right hand thumb rule is used. The fingers represent the rotation of the disc And the thumb shows the direction of the spin, precision and torque vector.

43. Define Steering, Pitching and Rolling?
Steering is the turning of a complete ship in a curve towards left or right while it moves forward.
Pitching is the movement of a complete ship up and down in a vertical plane about transverse axis.

Rolling is the movement of ship in a linear fashion.

44. What is the effect gyroscopic couple on rolling ship?
The gyroscopic couple acts only when the axis of precession is perpendicular to the axis of spin for all positions. In case of rolling of ship the axis of precession is parallel to the axis of spin hence there is no effect of the gyroscopic couple on the rolling of ship.

45. Explain the effect of gyroscopic couple in case of Two wheeler when it taking turn?
The gyroscopic couple will act over the vehicle outward. The tendency of this couple is to overturn the vehicle in the outward direction.

46. How the governors are classified?
a. Centrifugal Governors:
i) Pendulum type Ex: - Watt governor
ii) Gravity controlled type Ex:- Porter & proell governors
iii)Spring controlled type :- Hartnell & Hartung governors
b. Inertia governors.

47. Define the terms Sensitiveness, Hunting & Effort with respect to governors?
The sensitiveness is defined as the ratio of the mean speed to the difference between the maximum & minimum speed. The governor is said to be sensitive, when it really responds to the small change in speed.
The phenomenon of the continuous fluctuation in the speed of the engine to the mean speed is known as Hunting.
The mean force acting on the sleeve for a given percentage change of speed for lift of the sleeve is known as the governor effort.

48. Explain the term the stability of the governor?
The governor is said to be stable if there is only one radius of rotation for all equilibrium speeds of the balls with in the working range. If the equilibrium speed increases the radius of governor ball must be increase.

49. What do you mean by isochronous condition in governors?
A governor with zero range of speed, when the equilibrium speed is constant for all the radii of rotation of the balls within the working range, then the governor is said to be isochronous.

50. Name the material used in polarizer, analyzer & quarter wave plate material?
Polaroid

51. Define Principle plane?
Principle plain may be defined as the plane on which normal stress attains its maximum & minimum value.

52. In what condition the Dark & Light fields will obtain in polariscope?
Polarizing axis is crossed to the axis of the polarizer the Dark field of Chromatic pattern is formed. Polarizing axis is parallel to the axis of the polarizer then the light field of chromatic pattern is formed.

53. Define the principle stress & principle strain?
The principle stress is the normal stresses on the orthogonal planes of zero shear stress. The elongation or compression of one of the principle axis of strain relative to its original length is called principal strain.

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Vive questions

1. Explain the significance of experimentation in design
2. List the various experimental techniques

Photo elasticity

1. What are the advantages of Photo elasticity techniques over other experimental techniques?
2. What is by the term “whole field technique “?
3. Explain the principles under laying the use of photo elastic technique for stress analysis?
4. Define the wave front, disturbance?
5. What is nature of light?
6. What is mean by polarized light? What are the important types of polarized light?
7. Write a general expression for the phase difference two plane polarized light (same wave length) vibrating in two mutually perpendicular planes is (1)plane polarized (2)circular polarized

8. What is a polariscope? How many types are there?
9. What is polarizer?
10. What is a difference b/w polarizer and an analyzer?
11. What is a wave plate? How are there classified?
12. What are the elements of a circular polariscope?
13. What do u under stand by the fallowing terms (1)polarized (2)analyses (3)quarter wave plate (4)half wave plate
14. What combination of polarizer – analyses and quarter wave plate give (1) dark field (2) bright field?
15. Name few of the photoelastic material?
16. What is a fringe? Fringe order?
17. How do you understand by briefringent material? Can you name few such materials?
18. Explain temporary bi-refringence?
19. Write a stress optic low for 2-D photoelastisity. Explain how the optical properties are related to the stress?
20. What is calibration of photoelastic material?
21. What is the difference b/w the material fringent value & modal fringent value?
22. What are the different methods of calibrating photoelastic material?
23. What due you understand by pure/constant bending moment (four/two point bending)?
24. Write a bending moment and shear force diagram four point bending specimen?
25. Explain why stress concentration occurs at inner fiber of curved beams?
26. Differentiate b/w isoclinic's and isochromatic
27. Why plane polariscope mode called as direction mode and circular polariscope mode called as magnitude mode?
28. What is difference b/w plane and circular polariscope?
29. Compare diffused light and lens type polariscopes
30. What do you under stand by the figure of merit?
31. Do you know the constituents of the photoelastic models used in design lab?
32. What are the requirements of a photo elastic material?
33. What are the methods of fractional fringe order determination?
34. Explain the principle of (1)tardy's method (2)babinet compensation
35. Write the procedure of trady's compensation technique
36. What are the methods for separation of principle stress
37. Explain oblique incidence methods
38. Explain stress freezing using the concept of spring-ice analogy
39. What is the difference b/w transmission & reflection photo elasticity
40. What is scattered photo elasticity
41. What is fringe multiplication

<u>Strain rosettes</u>

1. Express strain at any point on the free surface of a body using Cartesian co-ordinates
2. How are strain gauges classified
3. What are the main advantages of electric resistance strain gauges
4. What are the applications of strain gauges
5. Define strain sensitivity of a strain gauge
6. What is a gauge factor of strain gauges? what does it indicate
7. What is principle of operation of a strain gauge
8. What do you mean by temperature compensation in strain gauges /how its achieved list the different

9. list the different types of strain gauges are used
10. Explain the bonding techniques used for strain gauges. What are the effects of improper bonding
11. explain what is meant by specific resistance strain gauges
12. What is bridge constant? where it used
13. what do you mean by cross sensitivity in strain gauge
14. discuss factor considered in the selection of strain gauges
15. explain need of rosette
16. what are the different types of rosette gauges
17. how strain gauge rosettes are specified
18. write basic torque equations & give a expression for shear stress
19. write basic bending equations & give a expression for bending stress
20. give expression for principle stress and maximum shear for a circular rod subjected to combined bending and torque
21. give expression for principle strain in terms of Cartesian strains
22. give expression for principle stresses in terms of Cartesian strains
23. given σx,σy,τxy plot Mohr circle and show on it $\sigma 1, \sigma 2 \tau max$

Journal bearing

1. what is journal bearing
2. what parameter are to be considered while designing as bearing
3. explain how lubricating take place in what is journal bearing with sketches(variation with speeds)
4. what is viscous friction
5. what is difference b/w kinematic and absolute viscosity
6. what is viscosity index
7. what is lubrication
8. what is Somerfield number
9. explain hydrodynamics and hydrostatic lubrication
10. what is petroff's equation
11. define the following
    Clearance, eccentricity, attitude, lightly loaded journal bearing
12. compare journal bearing and antifriction bearing
13. classify bearings
14. what is a monoimeter?explain
15. state Reynolds differential equation of fluid flow
16. sketch schematically the pressure distribution around an idealized full journal bearing

vibration

1. explain the fallowing: cycle, time period, SHM, DOF, free vibration, forced vibration, undamped and damped system
2. explain the elements of a vibrating system
3. give classification of vibrating system
4. differentiating b/w continuous and lumped system
5. explain the types of damping
6. write equations for stiffness of shaft (1)longitudinal (2)torsion