|| Jai Sri Gurudev ||

Sri Adichunchanagiri Shikshana Trust (R.)

BGS INSTITUTE OF TECHNOLOGY

[Affiliated to VTU, Belgaum; Approved by AICTE, New Delhi and Recognized by Govt. of Karnataka]

BG Nagara – 571 448 (Bellur Cross)
Nagamangala Taluk, Mandya District

Certificate

This is to certify that Mr/Ms. yashavanth Jain D. G

USN: 4BW.16.ME050.... *has satisfactorily completed the course of experiments*

in ....Design............ *Laboratory (Course Code:*.15MEL76........*)*

prescribed by the Visvesvaraya Technological University, Belagavi for ....7th.........

Semester, BE..........Mechanical............................ *Engineering,*

of this College in the year 2019- 2020

Record Marks : 12 *Test Marks :* 08

IA Marks : 20

Date :....29/4/19.........

21/11/19

Staff Incharge

Head of the Department

Rubrics for CIE of Practical Subject

1. For 20 Marks

Sl.No.	Description	Marks
1	a) Observation write up & punctuality	02
	b) Conduction of experiment and output	04
	c) Viva voce	02
	d) Record write up	04
2.	Internal Test	08
	Total	20

2. For 40 Marks

Sl.No.	Description	Marks
1	a) Observation write up & punctuality	05
	b) Conduction of experiment and output	10
	c) Viva voce	05
	d) Record write up	10
2.	Internal Test	10
	Total	40

INDEX

Name of the Student: yashavanth Jain D.G Class: 7 Sem. 7th

Expt. No.	Date	Tittle of the Experiment	Page No.	Marks obtained a	b	c	d	Total	Sign. of the Staff
		Introduction	1-9						
01	21/08/19	Free vibration of helical Coil Spring	10-13	01	04	02	04	11	[signature]
02	4/09/19	Simple pendulum	14-16	02	04	01	04	11	[signature]
03	11/09/19	Torsional vibration of Single rotor System.	17-19	02	04	02	04	12	[signature]
04	11/09/19	Torsional vibration of double rotor System	20-22	02	04	02	04	12	[signature]
05	18/09/19	Damped torsional Vibration	23-26	02	04	02	04	12	[signature]
06	09/10/19	watt Governor	27-31	02	04	02	04	12	[signature]
07	16/10/19	Porter Governor	32-36	02	04	02	04	12	[signature]

INDEX

Name of the Student yashavanth Jain D.G. Class .... Sem. 7th

Expt. No.	Date	Tittle of the Experiment	Page No.	Marks obtained a	b	c	d	Total	Sign of the Staff
08	23/10/19	whirling of Shaft	34-39	02	04	02	04	12	
09	6/11/19	Strain gauge apparatus	40-44	02	04	02	04	12	
10	13/11/19	Balancing of Several masses in same plane	45-47	02	04	02	04	12	
11	13/11/19	Balancing of Several masses in different plane	48-49	02	04	02	04	12	
12.	14/11/19	Calibration of photo elastic mat under diametric Compression.	50-51	02	04	02	04	12	
13.	19/11/19	Journal bearing Stress Concentration	52-53	02	04	02	04	12	
14.	19/11/19	Stress Concentration factor	54-56	01	04	02	04	11	
								11.78	

Name of Experiment: Introduction   Date :

Experiment No.   Page No. 01

Vibration:

Vibration is defined as the measurement of a periodic process of oscillation with respect to an equilibrium point.

Concept of vibration:

All bodies having mass and elasticity are capable of vibration. When external force is applied on the body the internal force are set up in the body which tends to bring the body in the original position. The internal force which are set up are the elastic force which tend to bring the body into equilibrium position.

* Periodic motion: A motion that repeat itself after equal interval of time.
* Time period: Time taken for one complete cycle.
* Amplitude: The maximum displacement of vibrating body from its mean position.
* Frequency: It is the number of cycles per unit time. Frequency & time period are inversely proportional to each other.
* Simple harmonic motion: Motion of particles with time that moves around a circle with uniform angular velocity.
* Free vibration: Vibration of a system because of its own elastic property. No external force is required for this vibration & only initiation.

of vibration may be necessary.

* Forced vibration: A System that vibration under an external force at the Same frequency as that of external force.

* Natural frequency: It is the frequency of free vibration of a System. It is Constant for a System. In fact it is all innerent property of System.

* Resonance: Vibration of a system where the frequency of external force is equal to the natural frequency of System.

* Damping: It is the resistance to motion. It is also the a lugging. Hence it is the delay in response to any action. Damping is observed only under fast loading and not during Static loading.

* Degree of freedom: The number of independent Co ordinate Systems required to Specify a motion.

* Phase difference: The angle between two rotating Section representing Simple harmonic motion.

* wave: It is the vibrating motion of a body or a particle represented in terms domain or Space domain.

Free vibration: In free vibration, the object is not under the influence of any kind of outside force.

The free vibration of an elastic body can further for 3 types.

a) Longitudinal vibration: when the particles of the body move parallel to the axis of the body the vibration is known as longitudinal vibration.

b) Transverse vibration: when the particles is the body moves nearly perpendicular to the axis of the body, the vibration is known as transverse vibration.

c) Torsional vibration: when the particles is the body move in a circle about the axis of the body the vibration is known as torsional vibration.

Forced vibration: In forced vibration the object under the influence of an outside force.

Damped vibration: Refers to the gradual & exponential reduction of vibration through resistance of the vibration force & by damping as the indication as against free vibration.

Undamped vibration: Is the response of a vibration system modeled without a damping & dissipative component.
i.e, with only mass and springs elements

Design Considerations:

1) Defination of problem.
2) Synthesis.
3) Analysis of force.
4) Selection of material.
5) Determination of mode of facture.
6) Selection of factor of Safety.
7) Determination of dimensions.
8) Modification of dimensions.
9) Preparation of drawings.
10) Preparation of design report.

Maximum shear stress:

The maximum shear stress is the maximum Concentrated shear force in a small area.

Like the normal stress, the shear stress will also have a maximum at a given angle $\theta_{\tau-max}$. This angle can be determined by taking a derivative of the shear stress rotation equation with respect to the angle and set equal to zero.

$$\tau_{x'y'} = -\frac{\sigma_x - \sigma_y}{2} \sin 2\theta + \tau_{xy} \cos 2\theta.$$

$$\frac{d\tau_{x'y'}}{d\theta} = -[\sigma_x - \sigma_y] \cos 2\theta + 2\tau_{xy} \sin 2\theta = 0.$$

$$\tan 2\theta_{\tau-max} = -\left[\frac{\sigma_x - \sigma_y}{2\tau_{xy}}\right]$$ where the angle is subs back into the shear

Stress transformation etc, the maximum shear stress is

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

Minimum shear stress: will be the absolute value as the maximum but in the opposite direction. The maximum shear stress can also found from the principal stresses σ_1 & σ_2 as

$$\tau_{max} = \frac{(\sigma_x - \sigma_y)}{2}$$

Strain gauges: A strain gauge is a sensor where resistance varies with applied force. It converts force, pressure, weight etc into a change in electrical resistance which can be measured.

Types of Strain gauges:

Various means like mechanical, optical, acoustical, electric can be used to measure deformation of an object.

Extensometer: were used to measure strain by measuring the change in length & comparing it to the original length of object. However mechanical strain gauge offer certain limitation like low resolution they are bulky and difficult to use.

Photoelectric gauges: These gauges use a light beam, two few gratings and a photo cell detector to generate an electrical Current proportional to Strain. A photo electric gauge Can be as short as 8inch but its usage proves to be extermely.

Metallic wire - type Strain gauge was introd-uced the metallic foil type - Strain gauge is Constructed of a grid of wire approximately 0.001 in thickness banded directly to the strained Surface by a thin layer of epoxy resin, where i load in applied to the Surface. it gets strawed and expreances a change in length this resulting change length Conveyed to resistor Corresponding Strain. is measured in terms of electrical resistance of the foil Curve which various linearly with Strain.

Semiconductor Strain gauges:

Semiconductor Strain gauges exhibit following key features.

* Unlike other Strain gauges, Semiconductor Strain gauges are based upon the Piezo resistance effect is Silicon & germinium and measured the change in resistance with stress as opposed to Strain.
* The Semiconductor bounded Strain gauges is a water with the resistance element difficult

into a Substrate of Silicon.
* No backing is provided for to water element and banding it to the Strained Surface inside extra care Since only a thin layer of epoxy is used to attach it.
* Size of a Semiconductor Strain gauge is much smaller and the Cost much lower than for a metallic foil Sensor.

Thin film Strain gauges:
Thin film Strain gauge is more advanced form of Strain gauge as it doesnot necessitial adhesions banding. A thin film Strain gauge is Constructed by first depositing an electrical insulation. Usually a Ceramic on to the Stressed Surface and there depositing the Strain gauge onto this insulation layer.

Advantages of Strain gauge:
* There is no moving parts.
* It is Small and inexpensive.

Application of Strain gauge:
Strain gauges are used to determine verify Components & Structure Stresses an by manufactures of load Cells, Pressure and torque transducers etc.
where they utilize the physical parameters being measured to Strain a part of the

transducer in a linear way.

Selection of a proper gauge:

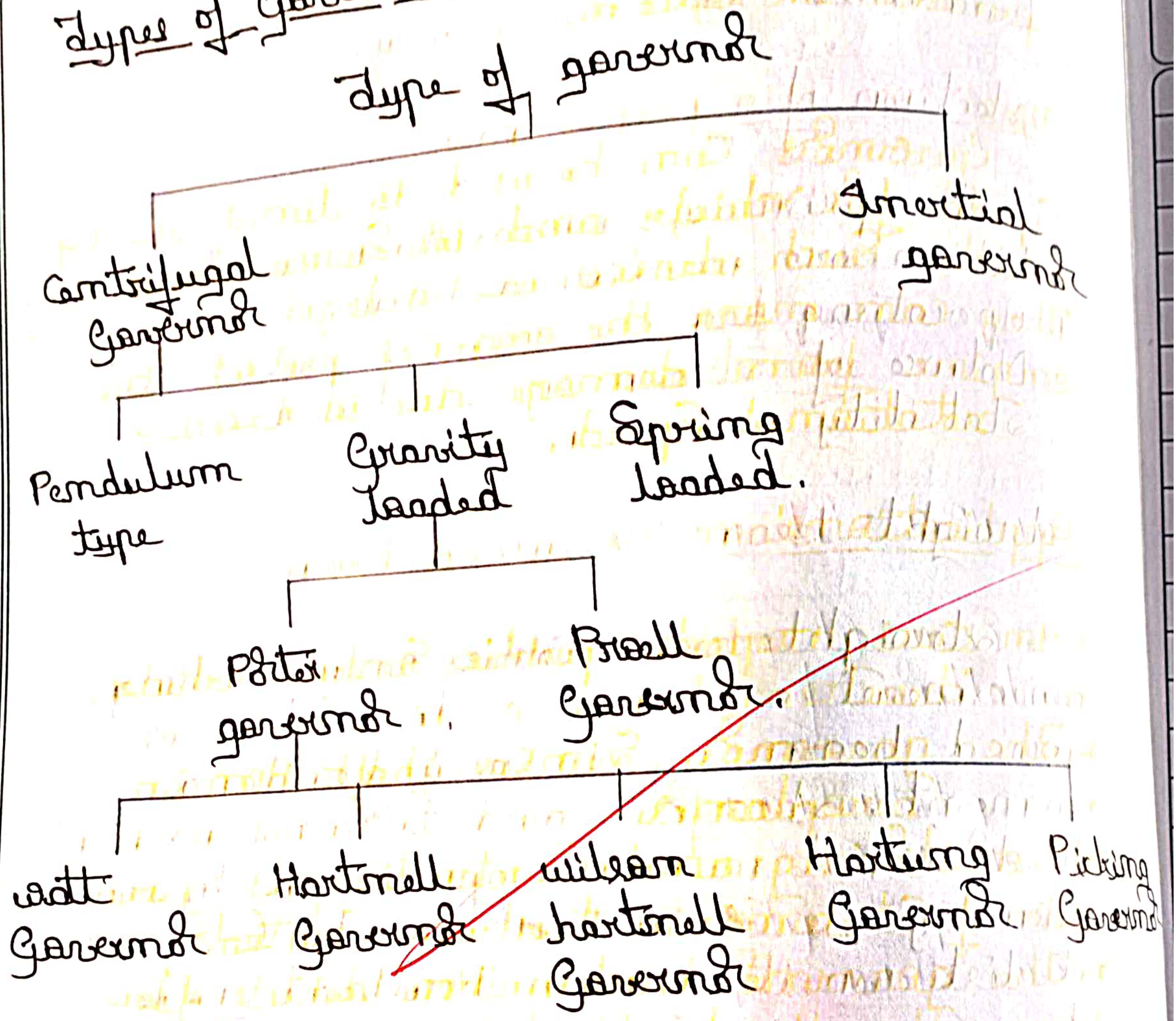
The primary Consideration in Strain gauge Selection are mentioned below.
1. Operating temperature.
2. Nature of Strain to be detected
3. Stability requirement.

Straight beam v/s Curved beam:

Straight beam Carries only bending movement and nuclear force where as Curved beam use to Carry bending moment, Shearforce and Torsional moment the torsional moment appears due to Brown geometry its Centroid of geometry (C.G) does not list on its length Resultant force acting on C.G Creates this torsional moment at beam Supports. Torsional moment will be product of resultant force and liner area between Centroid of Geometry and Supports.

Governor: It is a mechanical device which is generally used to determined & Regulate the Speed of Engine to the desired Cust, it is a particular as feedback System used where in the used to Control variation of load

Types of Governor:



present in system.

Uses:

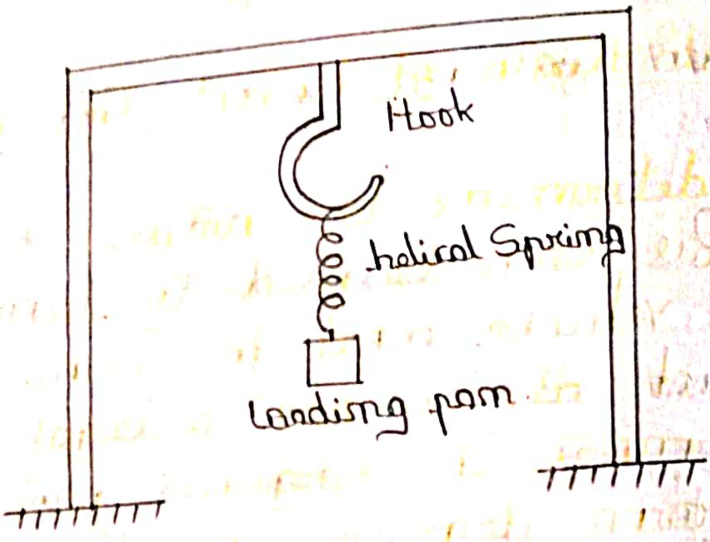
Governors can be used to limit the top speed for vehicles and for some classes of vehicles such devices are a legal requirements. They can more the engines protect the engine from damage due to excessive rotational speed.

Applications:

* In cars, mopeds, public services vehicles, trucks.
* The governor senses shaft RPM in aeroplanes.
* Monitoring and controlling the flow rate of steam in turbine controls.
* The governor mechanism detects flow from the flywheel blower used to cool an air cooled engine.

20/10/19

Figure:



Observation:

1. Initial length of the Spring (L_i) = 0.24 m
2. Number of oscillation, n = 10
3. Final length of the Spring (L_f) = 0.32 & 0.48 m
4. Time taken for n number of oscillations,
   N = 8 & 9 sec
5. Mass of weight applied m = 0.1 & 0.2 kg
6. Stiffness of the spring, k = 12.26 & 10.9 N/m
7. Time period Experimentally, T_{exp} = 0.8 & 0.9 sec
8. Time period theoritical, T_{the} = 0.568 & 0.854 sec
9. Frequency Experimentally, f_{exp} = 1.25 & 1.11 Cycle/sec
10. Frequency theoritically, f_{the} = 1.76 & 1.17 Cycle/sec

Free vibration of helical Coil Spring.

Aim: To determine the natural frequency and time period of helical Coil Spring.

Apparatus: Vibration tester, closed Coil helical Spring, Stopwatch, weight etc.

Theory:

when the particle of the Shaft (disc) moves parallel to the axis of the Shaft the vibration is known as longitudinal vibration we Study this experiment to the longitudinal vibration of this experiment to the helical Coil Spring and determine the frequency.

Theoritical time period

$$T_{the} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

where, m = mass in kg
k = Spring Stiffness in N/m.

Procedure:

* Hang the helical Coil Spring having loading pan at the bottom of Spring inside the hook on a universal vibration tester.
* Note down the initial length of the

Tabular Column:

SL NO:	Mass & weight in kg	Deflection in m	Time taken for 10 oscillation t in Sec	T_{exp} Sec	T_{the} Sec	Natural frequency f_{exp} cycle/sec	Natural frequency f_{the} Cycle/sec
1	0.1	0.08	8	0.8	0.568	1.25	1.76
2	0.2	0.18	9	0.9	0.854	1.11	1.17

Calculation:

* For mass $m = 0.1$ kg

1. Deflection $\delta = l_f - l_i$

$$\delta = 0.32 - 0.24 = 0.08 \text{ m.}$$

2. Stiffness $k = \frac{w}{\delta} = \frac{9.81 \times 0.1}{0.08} = 12.26$ N/m.

3. $T_{exp} = \frac{t}{n} = \frac{8}{10} = 0.8$ sec.

4. $T_{the} = \frac{1}{f_{n\,the}} = \frac{1}{1.76} = 0.568$ sec

5. $f_{n\,the} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$$f_{n\,the} = \frac{1}{2\pi}\sqrt{\frac{12.26}{0.1}} = 1.76 \text{ Cycle/sec}$$

6. $f_{n\,exp} = \frac{1}{T_{exp}} = \frac{1}{0.8} = 1.25$ Cycle/sec

Spring without weight.

* Now put the weight on loading pan and then note down the final length.
* Sketch the spring along with weight and ~~loosen~~ it.
* Note down the time taken for 10 oscillations using stopwatch.
* Repeat the procedure for different values of weight.
* Calculate the time period and natural frequency and tabulate it.

<u>Formula used:</u>

1. Deflection $\delta = L_f - L_i$ in m

   where L_f = final length of spring in m.

   L_i = initial length of spring in m.

2. Stiffness, $k = \frac{W}{\delta}$ in N/m

   where, W = weight in N

   δ = Deflection in m.

3. Time period ; $T_{exp} = \frac{t}{n}$

4. For mass $m = 0.2$ kg

1. Deflection, $\delta = l_f - l_i = 0.42 - 0.24$

$\delta = 0.18$ m

2. Stiffness $= k = \frac{W}{\delta} = \frac{0.2 \times 9.81}{0.18}$

$k = 10.9$ N/m.

3. $T_{exp} = \frac{t}{n} = \frac{9}{10} = 0.9$ Sec.

4. $T_{the} = \frac{1}{f_{nthe}} = \frac{1}{1.17} = 0.854$ Sec.

5. $f_{nthe} = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$= \frac{1}{2\pi}\sqrt{\frac{10.9}{0.2}}$

$f_{nthe} = 1.17$ Cycle/Sec.

6. $f_{nexp} = \frac{1}{T_{exp}} = \frac{1}{0.9} = 1.11$ Cycle/Sec.

where, T_{exp} = Experimental time period in Sec.
t = time taken for 10 oscillations.
n = number of oscillation.

4. Time period, $T_{the} = \frac{1}{f_{n the}}$

5. Theoritical time period, $T_{the} = \frac{1}{f_{n the}}$

where, $f_{n the}$ = Natural frequency in Sec.
$= \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$f_{n exp} = \frac{1}{T_{exp}}$

where, k = Stiffness in N/m
m = mass in kg.

Result:

* For mass m in kg = 0.1 kg
1. The experimental natural frequency
$f_{n exp}$ = 1.228 Cycle/Sec
2. The theoritical natural frequency
$f_{n the}$ = 1.769 Cycle/Sec
3. The experimental time period
T_{exp} = 0.8 Sec
4. The theoritical time period,
T_{the} = 0.568 Sec.

* For mass m in kg → 0.2 kg.

1. The experimental natural frequency,

$f_{nexp} = 1.11$ Cycle/Sec

2. The theoritical natural frequency,

$f_{nthe} = 1.171$ Cycle/Sec

3. The experimental time period,

$T_{exp} = 0.9$ Sec

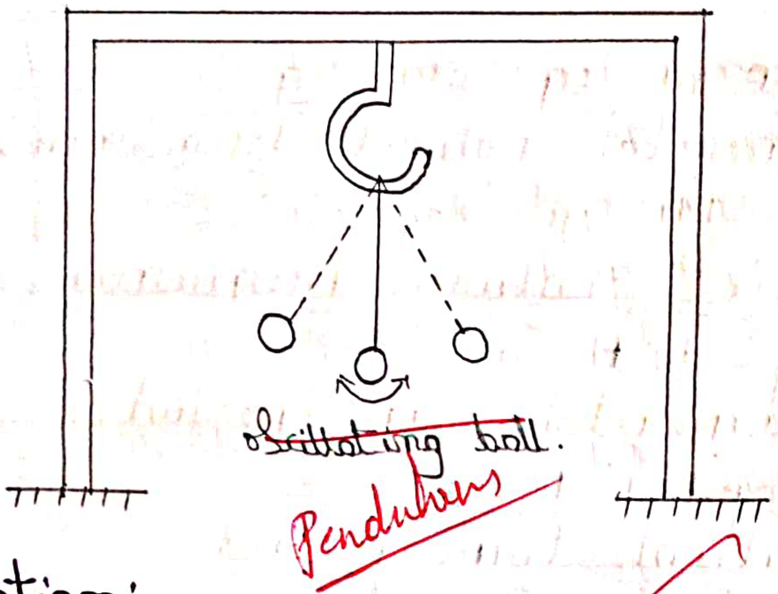
4. The theoritical time period,

$T_{the} = 0.854$ Sec

06/11/19

11/12

Figure:



Observation:

1. Dia of the ball, d = 0.035 m
2. Radius of the ball, r = 0.0175 m.
3. No of oscillation, n = 10
4. Time for 10 oscillation, t = 9 sec
5. weight of the ball, w = 0.18 kg
6. Length of the wire, L = 0.21 m.

Name of Experiment: Simple pendulum Date: 4/09/19
Experiment No. 02

Simple pendulum

Aim: To determine the natural frequency & time period of Simple pendulum.

Apparatus: Vibration tester, Pendulum, measurment tape & Stopwatch.

Theory:

when a ball Connected to the tip moves horizontally parallel to the axis of the shaft then the vibration is said to be Simple pendulum.

we study this experiment to find the longitudinal vibration of the ball Connected with tag and the phenomenon is said to be Simple pendulum.

we also determine the angular natural frequency and time period Theoritically and experimentally.

Theoritical time period, $T_{the} = \frac{2\pi}{\omega_{n\,the}}$

where,

$\omega_{n\,the}$ = Angular frequency in rad/Sec

Procedure:

1. Tie a tag to the Steel bar at one end and the ball standard weight at the other end

Tabular Column:

Sl No.	Mass of ball in kg	Length of wire (L) m	Time taken in Sec	Experimental time period T_{exp} in Sec	Theoritical time period T_{the} in Sec	Angu[illegible] frequ[illegible] ω_{n} rad
1	0.18	0.21	9	0.9	0.919	5.1[illegible]
2	0.18	0.36	11	1.1	1.20	5.3[illegible]

Angular frequency ω_{nthe} in rad/Sec	Experimental natural frequency f_{nexp} in Cycle/Sec	Theoritical natural frequency f_{nthe} in Cycle/Sec
6.83	1.11	1.088
5.22	0.909	0.833

Calculation:

1. $T_{exp} = \frac{t}{n} = \frac{9}{10} = 0.9$ Sec

$T_{exp} = \frac{11}{10} = 1.1$ Sec.

2. $T_{the} = \frac{2\pi}{\omega_{nthe}} = \frac{2\pi}{6.83} = 0.919$ Sec

$T_{the} = \frac{2\pi}{5.22} = 1.20$ Sec.

the universal vibration tester.

2. Note down the diameter of ball and radius of the ball.
3. Note down the length of the wire.
4. Measure the weight of the ball and note down the readings.
5. Drag the ball perpendicular to the upper steel bar and leave it for oscillating.
6. Note down the time taken by the ball to move from one side to other side known as oscillation.
7. Note down the time taken for No. of oscillations.
8. Repeat the experiment for different values of weight.
9. Calculate the natural frequency and time period.

Formula used:

1. $T_{exp} = \frac{t}{n}$ sec.

2. $T_{the} = \frac{2\pi}{\omega_{n the}}$ ~~rad~~/sec

$\omega_{n the}$ = Angular natural frequency.

3. $\omega_{n exp} = 2\pi \cdot f_{n exp}$ rad/sec.
4. $\omega_{n the} = \sqrt{\frac{g}{l}}$ rad/sec.

3. $\omega_{n\,the} = \sqrt{\frac{g}{l}} = \sqrt{\frac{9.81}{0.21}} = 6.83$ rad/Sec.

$\omega_{n\,the} = \sqrt{\frac{9.81}{0.36}} = 5.22$ rad/Sec.

4. $\omega_{n\,exp} = 2\pi - f_{n\,exp} = 2\pi - 1.11 = 5.173$ rad/Sec

$\omega_{n\,exp} = 2\pi - 0.909 = 5.374$ rad/Sec.

5. $f_{n\,exp} = \frac{1}{T_{exp}} = \frac{1}{0.9} = 1.11$ Cycle/Sec

$f_{n\,exp} = \frac{1}{1.1} = 0.909$ Cycle/Sec.

6. $f_{n\,the} = \frac{1}{T_{the}} = \frac{1}{0.919} = 1.088$ Cycle/Sec.

$f_{n\,the} = \frac{1}{1.2} = 0.833$ Cycle/Sec.

5. $f_{nthe} = \frac{1}{T_{the}}$ Cycle/Sec.

6. $f_{nexp} = \frac{1}{T_{exp}}$ Cycle/Sec.

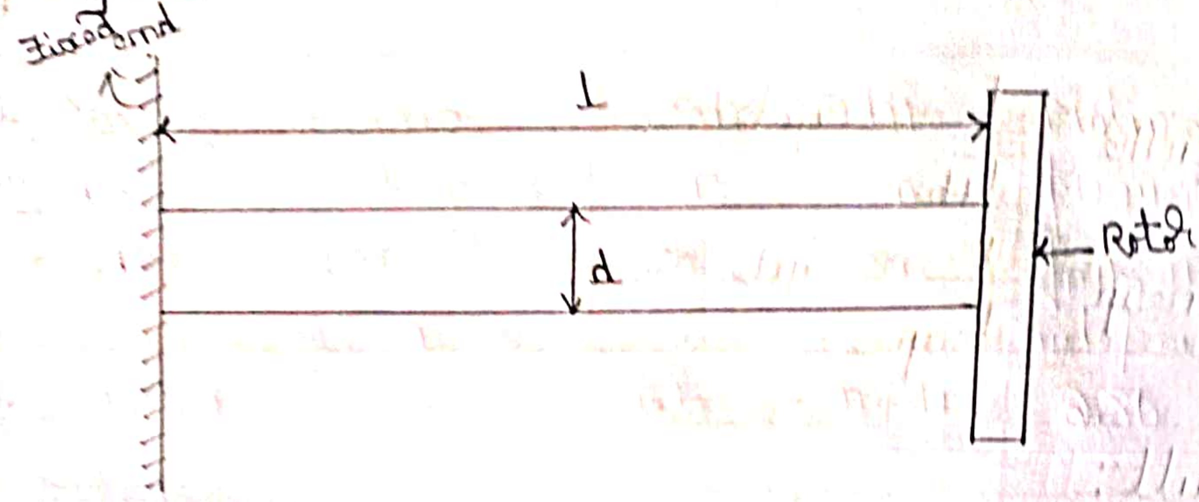
Result:

1. The experimental angular frequency
   $\omega_{nexp} = 5.173$ rad/Sec.
2. The theoritical angular frequency
   $\omega_{nthe} = 6.83$ rad/Sec.
3. The experimental time period
   $T_{exp} = 0.9$ Sec.
4. The theoritical time period
   $T_{the} = 0.919$ Sec.
5. The experimental natural frequency,
   $f_{nexp} = 1.11$ Cycle/Sec.
6. The theoritical natural frequency,
   $f_{nthe} = 1.088$ Cycle/Sec.

06/11/19

11/12

Figure:



Observation:

1. Dia of the shaft, $d = 4 \times 10^{-3}$ m.
2. Mass of rotor, $m = 3.8$ kg
3. Dia of the rotor & disc, $D = 0.2$ m.
4. Modulus of Rigidity, $G = 80 \times 10^{9}$ N/m²
5. Length of the shaft, $L = 0.35$ m.

Torsional Vibration of Single Rotor System.

Aim: To determine natural frequency & time period of a shaft subjected to torsional vibration.

Apparatus: Vibration tester, Pendulum, measurement tape & stop watch.

Theory:

when a particle of the shaft disc moves in a circle about the axis of the shaft i.e if the shaft get alternatively twisted and untwisted on account of vibrating motion then the vibration motion then the vibration are known as torsional vibration.

~~Consider a shaft of negligable weight is fixed at one end and carrying a rotor on the free end the amplitude of the free end that is called single rotor system.~~

The natural frequency of torsional vibration is $f_n = \frac{1}{2\pi}\sqrt{\frac{GJ}{Il}}$

Procedure:

1) Fix the shaft one end by the chuck key and fix the other end of the shaft in rotor side by chuck key.

Tabular Column:

SL No.	Dia of Shaft in m	Time taken for 10 oscillation (t) in sec	Texp in Sec	Tthe in Sec	Natural frequency fnthe in Cycle/Sec	Natural frequency fnexp in Cycle/Sec
1.	0.004	5	0.5	0.34	2.86	2

Calculation:

1. Polar moment of inertia, $I = \frac{\pi d^4}{32}$

$$= \frac{\pi \times (0.004)^4}{32}$$

$$I = 2.512 \times 10^{-11}\ m^4$$

2. Mass of moment of inertia

$$I = \frac{mD^2}{8} = \frac{3.8 \times (0.2)^2}{8} = 0.019\ kg-m^2.$$

3. Experimental time period

$$T_{exp} = \frac{t}{n} = \frac{5}{10} = 0.5\ sec.$$

4. Theoritical time period

$$T_{the} = \frac{1}{f_{nthe}} = \frac{1}{2.86} = 0.34\ Sec.$$

5. $f_{nthe} = \frac{1}{2\pi}\sqrt{\frac{GJ}{IL}}$

$$= \frac{1}{2\pi}\sqrt{\frac{86 \times 10^9 \times 2.513 \times 10^{-11}}{0.019 \times 0.35}}$$

$$f_{nthe} = 2.86\ Cycle/Sec$$

2> Twist the rotor/disc through some angle and release it.

3> Note down the length of the shaft.

4> Note down the time required for 10 oscillation.

5> Calculate the time period and frequency and compared the experimental values with theoritical values.

Formula used:

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

2. Mass moment of inertia, $I = \frac{MD^2}{8}$ $kg-m^2$.

where, d = Dia of shaft in m.
D = Dia of disc in m

3. Natural frequency

$$f_n = \frac{1}{2\pi}\sqrt{\frac{GJ}{IL}}$$

where, G - Modulus of Rigidity in N/m^2.
J - Polar moment of inertia in m^4.
I - Mass moment of inertia in $kg-m^2$.
l - length of shaft in m.

4. Experimental time period

$$T_{exp} = t/n$$

where, t = time taken for 10 oscillation.
n = 10 oscillation.

5. Theoritical time period

$$T_{the} = 1/f_{nthe}$$

b. $f_{resp} = \frac{1}{T_{resp}} = \frac{1}{0.5} = 2$ Cycle/Sec.

Result:

In natural frequency, time period and torsional Stiffness for Simple in different and in tabulated below.

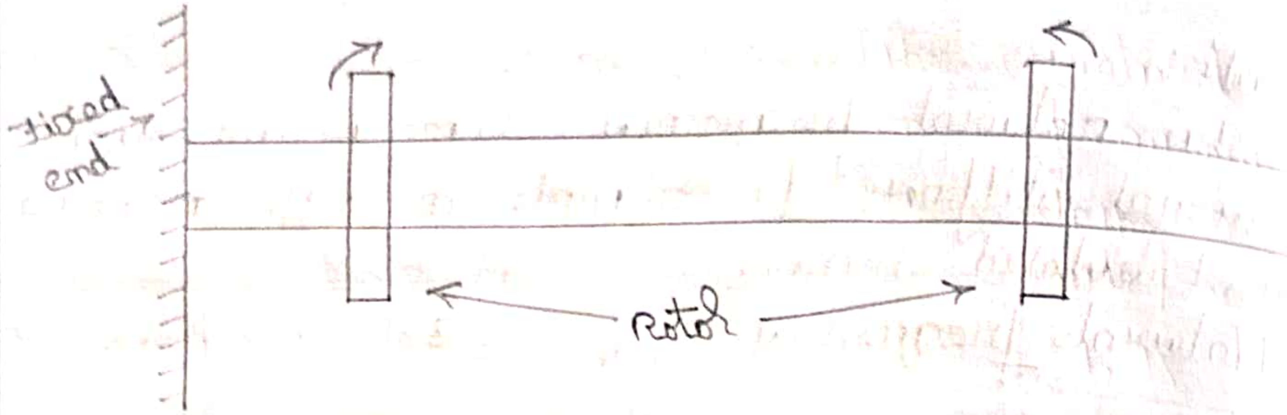
1. Natural frequency $f_{n\,the}$ = 2.886 Cycle/Sec.

2. Experimental time period T_{exp} = 0.5 Sec.

3. Theoritical time period T_{the} = 0.348 Sec.

4. Natural frequency $f_{n\,exp}$ = 2 Cycle/Sec.

Figure:



Observation:

1. Dia of the Shaft, $d = 4 \times 10^{-3}$ m
2. Mass of bigger rotor $m_A = 4.2$ kg.
3. Mass of Smaller rotor $m_B = 2.8$ kg.
4. Dia of bigger rotor $D_A = 0.25$ m.
5. Dia of Smaller rotor $D_B = 0.2$ m.
6. Length of the Shaft, $L = 1.1$ m.
7. Modulus of rigidity of Shaft, $G = 86 \times 10^{9}$ N/m^2.

Torsional vibration of double rotor System

Aim: To determine the natural frequency & time period of Shaft Subjected to torsional vibration.

Apparatus: Vibration tester, pendulum, measurement tape & Stopwatch.

Theory:

when the particle of Shaft move in a Circle about the axis of Shaft the vibration are known as torsional vibration.

The double rotor System Consists of a Shaft mounted with two rotor A and B at its two ends Both Shaft are freely rotates in the bore bearing. In this system the torsional vibration occurs only when two rotor A & B are rotating in opposite direction. it must be noted that the natural frequency of the two rotor must be same. the profit 'N' in the node and Can be assumed as fixed end the Shaft therefore Can be Considered at two Seperate Shaft fixed at one end and having at the other end.

Natural frequency of torsional vibration

$$f_n = \frac{1}{2\pi}\sqrt{\frac{GJ}{I_A L_A}}$$

Tabular Column:

Sl. No	Dia of Shaft in m	Time taken for 10 oscillation t in sec	Texp in Sec	Tthe in Sec	Natural frequency fnthe in Cycle/Sec	Natural frequency fnexp in Cycle/Sec
1	0.004	6	0.6	0.505	1.98	1.66

Calculation:

1. $I_A = \frac{m_A \times D_A^2}{8} = \frac{3.8 \times (200 \times 10^{-3})^2}{8} = 0.019 \text{ kg-m}^2$

2. $I_B = \frac{M_B \times D_B^2}{8} = \frac{4.9 \times (0.25)^2}{8} = 0.0382 \text{ kg-m}^2$

3. $L_A = \frac{L \times I_B}{I_A + I_B} = \frac{110 \times 10^{-2} \times 0.0382}{0.019 + 0.0382}$

   $L_A = 0.7346 \text{ m.}$

4. $L_B = L - L_A = 110 \times 10^{-2} - 0.7346 = 0.365 \text{ m.}$

5. $T_{exp} = \frac{t}{n} = \frac{6}{10} = 0.6 \text{ Sec.}$

6. $f_{nexp} = \frac{1}{T_{exp}} = \frac{1}{0.6} = 1.66 \text{ Cycle/Sec}$

7. $f_{nthe} = \frac{1}{2\pi}\sqrt{\frac{GI}{I_A \times L_A}} = \frac{1}{2\pi}\sqrt{\frac{86 \times 10^9 \times 2.513 \times 10^{-7}}{0.019 \times 0.7346}}$

   $f_{nthe} = 1.98 \text{ Cycle/Sec.}$

8. $T_{the} = \frac{1}{f_{nthe}} = \frac{1}{1.98} = 0.505 \text{ Sec.}$

where,

L_A - Distance of node from rotor A.

L_B - Distance of node from rotor B.

J - Polar moment of inertia.

I_A - Mass moment of inertia of rotor A.

I_B - Mass moment of inertia of rotor B.

G - Modulus of rigidity.

Procedure:

1. The shaft whose diameter is known as mounted b/w the two disc or rotor.
2. The length of the shaft is measured.
3. Rotates the disc A and B in opposite direction by hand and release it.
4. Note down the time taken for 10 oscillation using stopwatch.
5. Calculate the time period and Natural frequency for disc A and tabulate it.

Formula used:

1. Length of small rotor A from node point

$$L_A = \frac{L \times I_A}{I_A + I_B} \text{ m}$$

where, $L_B = L - L_A$ in m

L = Length of shaft in m

I_A = Mass moment of inertia of small rotor A = $M_A \times D_A^2 / 8$ kg-m^2.

Name of Experiment .... Date : ....

Experiment No. .... Page No. 22

I_B = Mass moment of inertia of big rotor B

$= \frac{M_B \times D_B^2}{8}$ kg-m².

where, M_A = Mass of Small rotor (A) = 2.8 kg

D_A = Dia of Small rotor (A) = 0.2 m.

2. Time period

$T_{exp} = \frac{t}{n}$ in Sec.

3. Theoritical time period, $T_{the} = \frac{1}{f_{nthe}}$ in Sec.

4. $f_{nthe} = \frac{1}{2\pi}\sqrt{\frac{GJ}{I_A L_A}}$ in Cycle/Sec.

5. $f_{nexp} = \frac{1}{T_{exp}}$ in Cycle/Sec.

Result:

The time period and natural frequency for given double rotor tabulation in Column as follows.

06/11/14

1. f_{nexp} = 1.66 Cycle/Sec

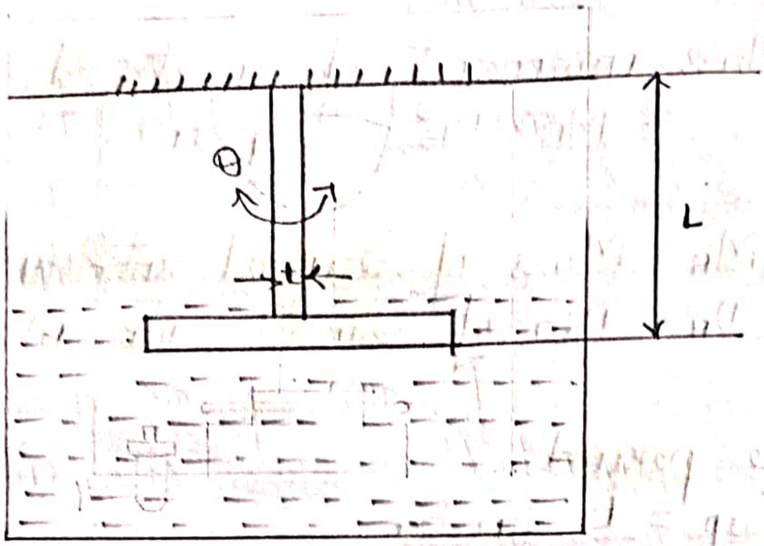
2. f_{nthe} = 1.98 Cycle/Sec.

3. T_{exp} = 0.6 Sec.

4. T_{the} = 0.505 Sec.

12/12

Figure:



Observation:

1. Dia of the Shaft, (d) = 6×10^{-3} m
2. Length of Shaft, (L) = 650×10^{-3} m
3. Modulus of rigidity of Shaft = 89×10^{9} Pa
4. Mass of the rotor m = 6 kg.

Formula used:

* Time period $T_p = \frac{t}{n}$ in Sec.
* Torsional Stiffness of Shaft, $k_t = \frac{GJ}{l}$ N-m.
* Polar moment of inertia $J = \frac{\pi d^4}{32}$ mm^4.
* Mass moment of inertia, $I = \left(\frac{T_p}{2\pi}\right) k_t$ $N\text{-}m^4$.
* Logarithmic decrement.

$$\delta = \frac{1}{n} \ln\left(\frac{x_1}{x_2}\right).$$

Damped torsional vibration

Aim: To determine the logarithmic decrement, damping ratio, the critical & experimentally.

Apparatus: Stopwatch, torsional vibration tester, Shaft.

Theory:

Damped Vibration:

If the vibration System has to dampe them there is a reduction in amplitude over every cycle of vibration. Since the Energy of System dissipated due to friction this type of vibration is damped vibration.

Torsional vibration:

when the particles of Shaft or disc moves in wire about the axis of Shaft i.e if the shaft gets alternatively twisted & untwisted on account of vibratory motion, Such is torsional vibration.

Damping ratio:

Damping ratio is defined as ratio of actual damping present in System to Critical damping Co-efficient. It is denoted by ξ.

$$\xi = \frac{C}{C_c}$$

* Damping ratio $\varepsilon = \frac{C}{C_c} = \frac{\delta}{\sqrt{4\pi^2 + \delta^2}}$.

* Actual damping ratio, $\varepsilon_a = \frac{\delta}{m}$.

<u>Tabular Column:</u>

SL NO	Time for n No of oscillation in Sec	No of oscillation	Time period T_p in Sec.
1.	3	10	0.3

<u>Calculation:</u>

$x_1 = 2.5\,mm$, $x_2 = 1.5\,mm$

* $T_p = \frac{t}{n}$

$= \frac{3}{10}$

$T_p = 0.3\,sec$

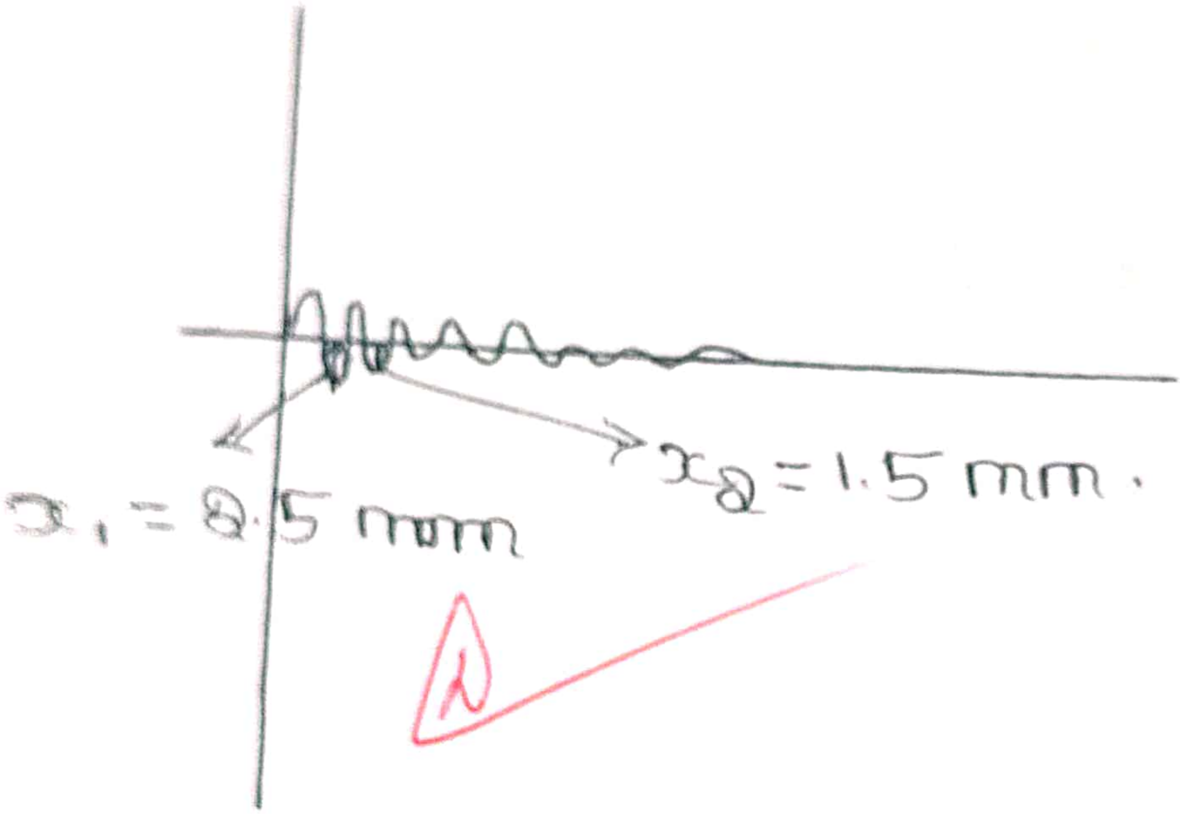
* $k_t = \frac{GJ}{l}$

$J = \frac{\pi d^4}{32} = \frac{\pi \times (6\times10^{-3})^4}{32}$

$J = 1.272 \times 10^{-10}\,m^4$.

$k_t = \frac{89\times10^{9} \times 1.272\times10^{-10}}{650\times10^{-3}}$.

$k_t = 17.41\ N\text{-}m$.

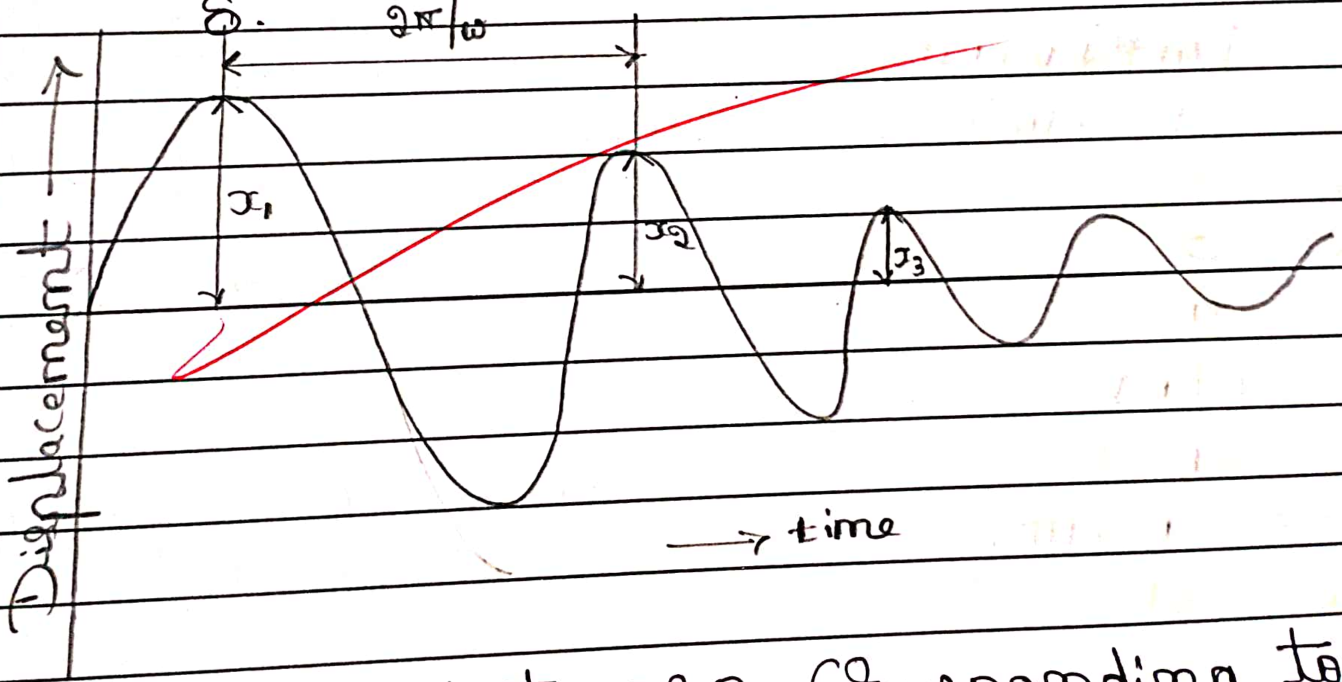

$x_1 = 2.5$ mm
$x_2 = 1.5$ mm.

Damping Coefficient:
It is the value of c which makes the quantity under the square root in the characteristic equation equal to zero.

$$\xi = 2m\omega_n.$$

$$c = 2\xi\omega_n.$$

Logarithmic decrement:
It is defined as the natural logarithmic of the ratio of any 2 successive amplitudes on the same side of the mean position in an under damped system. It is denoted by δ.



Consider points A & B Corresponding to time $t_B - t_A = \frac{2\pi}{\omega_n\phi}$.

$$= \frac{2\pi}{\omega_n\sqrt{1-\xi^2}}.$$

$$* \ I = \left(\frac{T_p}{2\pi}\right) k_t$$

$$= \left(\frac{0.3}{2\times\pi}\right) \times 17.41$$

$$I = 0.831 \text{ N-m.}$$

$$* \ \delta = \frac{1}{n} \ln\left(\frac{x_1}{x_2}\right)$$

$$= \frac{1}{10} \ln\left(\frac{2.5\times10^{-3}}{1.5\times10^{-3}}\right)$$

$$\delta = 0.051$$

$$* \ \xi = \frac{\delta}{\sqrt{4\pi^2+\delta^2}} = \frac{c}{c_c}$$

$$= \frac{0.051}{\sqrt{4\pi^2+0.051^2}}$$

$$\xi = 3.183\times10^{-3}.$$

$$* \ \xi_0 = \frac{\delta}{m}$$

$$= \frac{0.051}{6}$$

$$\xi_0 = 8.5\times10^{-3}.$$

The amplitude of undamped system with initial condition

$x = x_0$ when $t = 0$.

$\dot{x} = 0$ when $t = 0$.

$$x = \frac{x_0}{\sqrt{1-\xi^2}} e^{-\xi\omega_n t}.$$

at time $t = t_A$

$$x_A = \frac{x_0}{\sqrt{1-\xi^2}} e^{-\xi\omega_n t_A}$$

at time $t = t_B$

$$x_B = \frac{x_1}{\sqrt{1-\xi^2}} e^{-\xi\omega_n t_B}.$$

divide x_A / x_B

$$\frac{x_A}{x_B} = e^{-\xi\omega_n (t_A - t_B)}$$

$$\frac{x_A}{x_B} = e^{2\pi\xi / \sqrt{1-\xi^2}}$$

$$\delta = \ln \frac{x_A}{x_B} = \frac{2\pi\xi}{\sqrt{1-\xi^2}}.$$

For every small value of ξ, the logarithmic equation reduces to $\delta = 2\pi\xi$.

The logarithmic decrement also given by

$$\delta = \frac{1}{n} \ln\left(\frac{x_1}{x_2}\right).$$

Procedure:

1. For the shaft at bucket and attach the rotor damping drum.

* Set the pen holder at suitable position and fix the paper over rotating drum.
* Lift descend and gradually descend the pen over the paper.
* Note down the time taken for 10 oscillations.
* Repeat the experiment for different time and calculate time required and also note down reading.

Result:

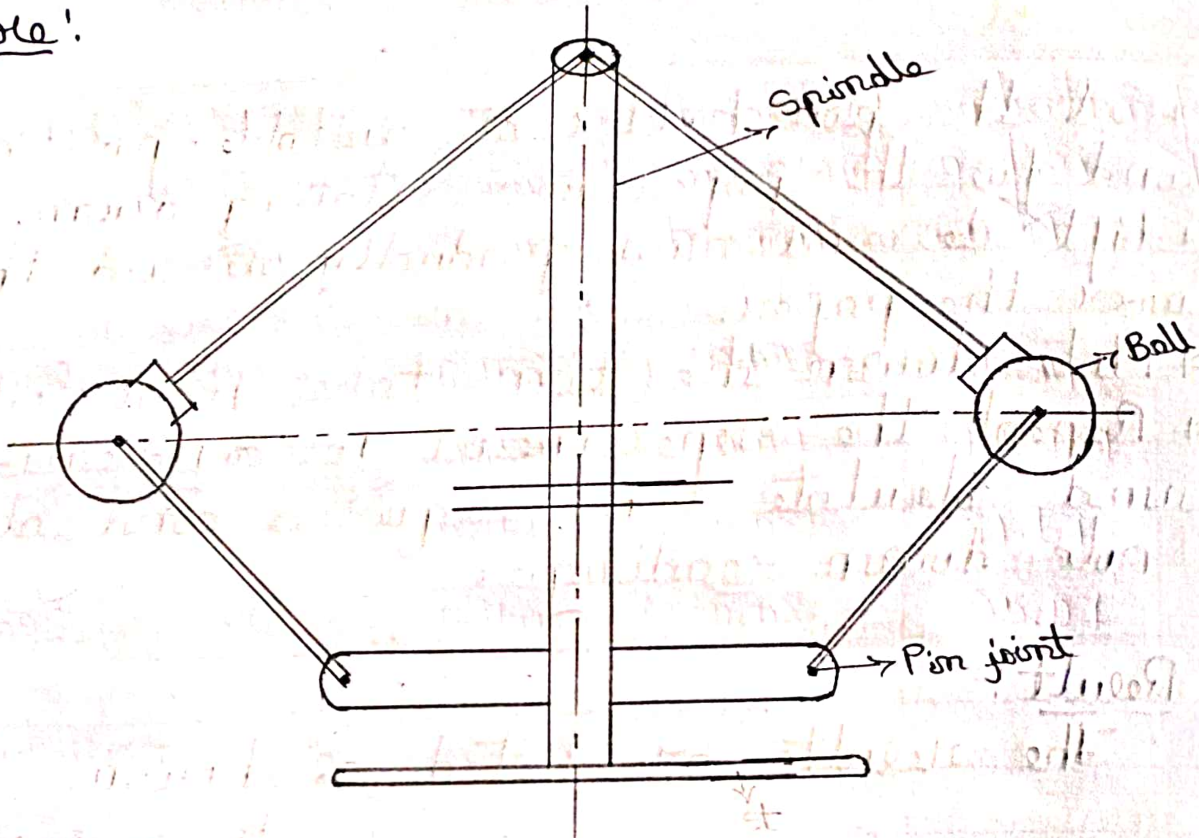
The results are listed as shown

1. Mass moment of inertia, $I = 0.831$ N-m
2. Logarithmic decrement, $\delta = 0.051$
3. Damping ratio $= C/C_c = 8.111 \times 10^{-3}$
4. Actual damping ratio $= 8.5 \times 10^{-3}$

06/11/19

12/12

Figure:



Observation:

1. Length of each link arm $L = \underline{140}$ mm.
2. Mass of sleeve assembly, $M = \underline{3}$ kg
3. Mass of governor ball, $m = \underline{0.146}$ kg
4. Initial radius of rotation, $r_1 = \underline{0.1}$ m
5. Initial height of governor, $h_i = \underline{0.1}$ m

watt Governor

Aim: To Conduct the experiment on watt governor to plot the characteristics Curves
1. Force v/s radius of rotation.
2. Speed v/s Sleeve displacement.

Apparatus:
Measurement tape, Governor apparatus etc.

Theory:
The function of the governor is to regulate the mean Speed of an engine's when there are variation in the load.
watt governor is a Centrifugal Governor is which is changes Centrifugal force of the rotating masses due to the change in Speed of the Engine is used for the movement of the governor sleeve the Centrifugal force is balanced by Controlling force acting radially inward. The Centrifugal governor is often used in the example of a dynamic System in which the representation of information Cannot be clearly Seperated from the operation being applied to the representation.

Tabular column:

Sl No:	Governor Speed in rpm	Sleeve lift x in m	radius of rotation in m	height of governor (h) in m	Controlling force in N	friction force in N.
1	264	0.01	0.152	0.095	16.94	-20.266
2	280	0.02	0.157	0.09	19.707	-19.57
3	290	0.03	0.161	0.085	21.67	-19.48
4	309	0.04	0.164	0.08	25.07	-18.63

Calculation:

* Height, $h_i = h_0 - x/2$

$h_1 = 0.1 - \frac{0.01}{2} = 0.095$

$h_2 = 0.1 - \frac{0.02}{2} = 0.09$

$h_3 = 0.1 - \frac{0.03}{2} = 0.085$

$h_4 = 0.1 - \frac{0.04}{2} = 0.08$

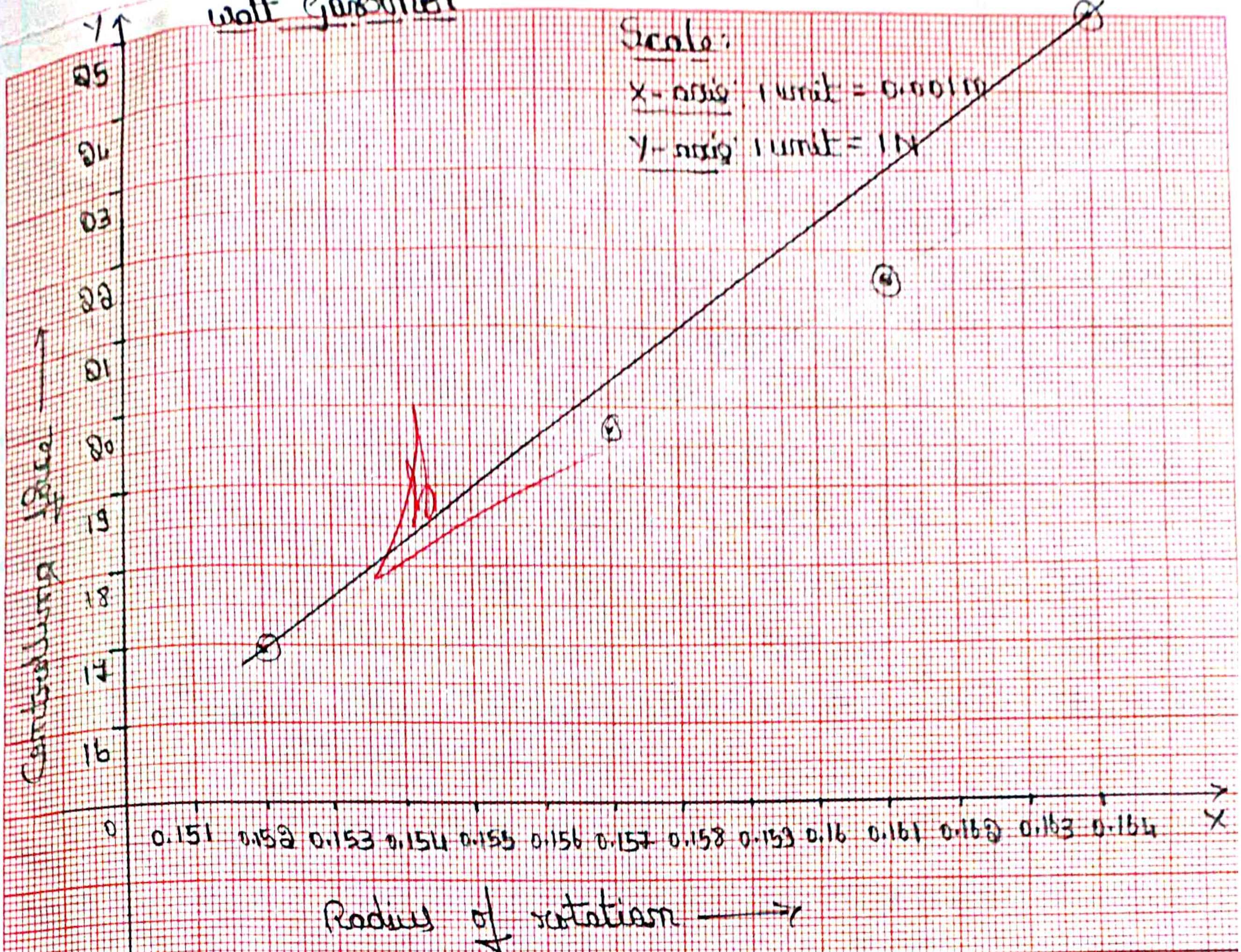
* $\alpha = \cos^{-1}(h/l)$

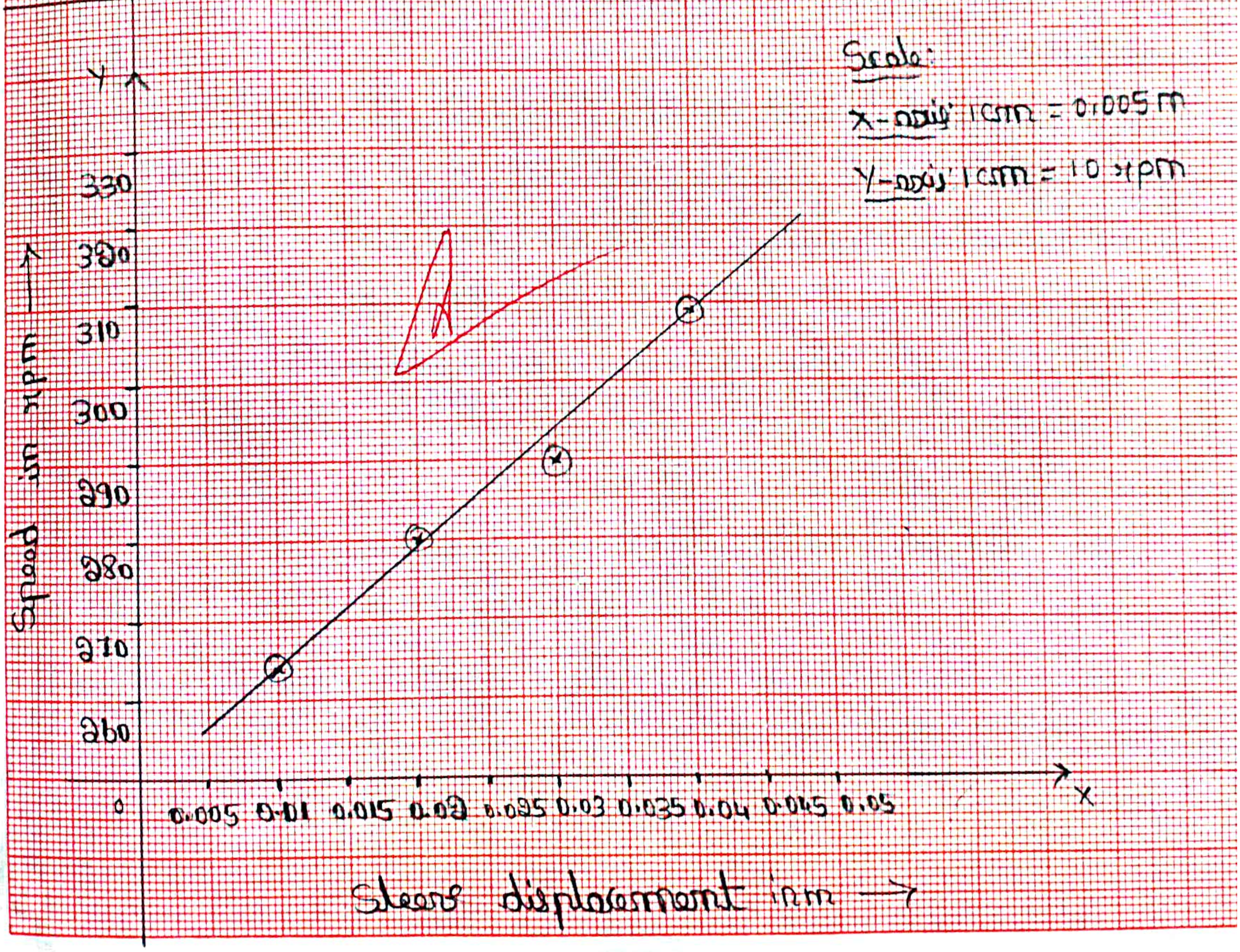
$\alpha_1 = \cos^{-1}\left(\frac{0.095}{0.14}\right) = 47.26^\circ$

$\alpha_2 = \cos^{-1}\left(\frac{0.09}{0.14}\right) = 49.99^\circ$

$\alpha_3 = \cos^{-1}\left(\frac{0.085}{0.14}\right) = 52.61^\circ$.

Watt Governor





ω = Rotation of spindle in rad/sec.

$$d_4 = \cos^{-1}\left(\frac{0.08}{0.14}\right) = 55.15^\circ.$$

* $r = 0.05 + l \sin \alpha$

$r_1 = 0.05 + 0.14 \sin(47.26) = 0.152\,m$

$r_2 = 0.05 + 0.14 \sin(49.99) = 0.157\,m$

$r_3 = 0.05 + 0.14 \sin(52.61) = 0.161\,m$

$r_4 = 0.05 + 0.14 \sin(55.15) = 0.1648\,m.$

* Controlling force.

$F = m\omega^2 r$

$$F_1 = 0.146 \times \left[\frac{2\pi N}{60}\right]^2 \times r_1$$

$$= 0.146 \times \left[\frac{2\pi \times 264}{60}\right]^2 \times 0.152$$

$F_1 = 16.94\,N,$

$$F_2 = 0.146 \times \left[\frac{2\pi \times 280}{60}\right]^2 \times 0.157$$

$F_2 = 19.707\,N$

$$F_3 = 0.146 \times \left[\frac{2\pi \times 290}{60}\right]^2 \times 0.161$$

$F_3 = 21.67\,N.$

$$F_4 = 0.146 \times \left[\frac{2\pi \times 309}{60}\right]^2 \times 0.1648$$

$F_4 = 25.07\,N.$

* Frictional force.

$$f = \frac{N^2 mgh}{895} - (m+M)g$$

$$f_1 = \frac{264^2 \times 0.146 \times 9.81 \times 0.095}{895} - (0.146 + 3)\,9.81 = -20.266\,N$$

r = radius of rotation in m.

4. Frictional force.

$$f = \frac{N^2 m g h}{895} - (m+M)g$$

where,

N = Speed of governor in rpm.
m = mass of governor in kg.
g = acceleration due to gravity in m/sec².
h = height of the governor in m.
m = mass of Sleeve assembly in kg.

$$f_2 = \frac{280^2 \times 0.146 \times 9.81 \times 0.09}{895} - (0.146+3)\,9.81 = -19.57.$$

$$f_3 = \frac{290^2 \times 0.146 \times 9.81 \times 0.085}{895} - (0.146+3)\,9.81 = -19.42$$

$$f_4 = \frac{309^2 \times 0.146 \times 9.81 \times 0.08}{895} - (0.146+3)\,9.81 = -18.63$$

1. Governor effort

$$Q = \left[\frac{2w}{1+k} + W\right] c$$

$W = 3 \times 9.81 = 29.43\,N$

$w = 0.146 \times 9.81 = 1.432\,N.$

$$c = \frac{280 - 264}{280} = 0.0571$$

$$= \left[\frac{2 \times 1.432}{1+1} + 29.43\right] \times 0.0571$$

$Q = 1.762\,N.$

2. Power $= \dfrac{4c^2}{1+2c} \times h\left(w + \dfrac{W}{2}(1+k)\right)$

$$= \frac{4 \times 0.0571^2}{1+2\times 0.0571} \times 0.095\left(1.432 + \frac{29.43}{2}(1+1)\right)$$

$P = 0.03438$ N-m/sec

3. Equilibrium, $N^2 = \dfrac{\left(w + \dfrac{W}{2}(1+k)\right)}{m} \times \dfrac{1}{h} \times \left(\dfrac{60}{2\pi}\right)^2$

$$= \frac{\left(1.432 + \frac{29.43}{2}(1+1)\right)}{0.143} \times \frac{1}{0.095} \times \left(\frac{60}{2\pi}\right)^2$$

$N = 455$ rpm.

4. Sensitiveness $= \dfrac{N_2 - N_1}{\left(\dfrac{N_2 + N_1}{2}\right)} = \dfrac{280 - 264}{\left(\dfrac{280 + 264}{2}\right)} = 5.82\%$

5. Coefficient of insensitiveness $= \dfrac{1}{\dfrac{2w}{1+k} + w}$

$= \dfrac{20.266}{\dfrac{2 \times 1.432}{1+1} + 29.43}$

$= 0.65\%$

Result:

The characteristics Curve of
1. Force v/s radius of rotation plotted and Speed v/s Sleeve displacement is shown in fig and found that.

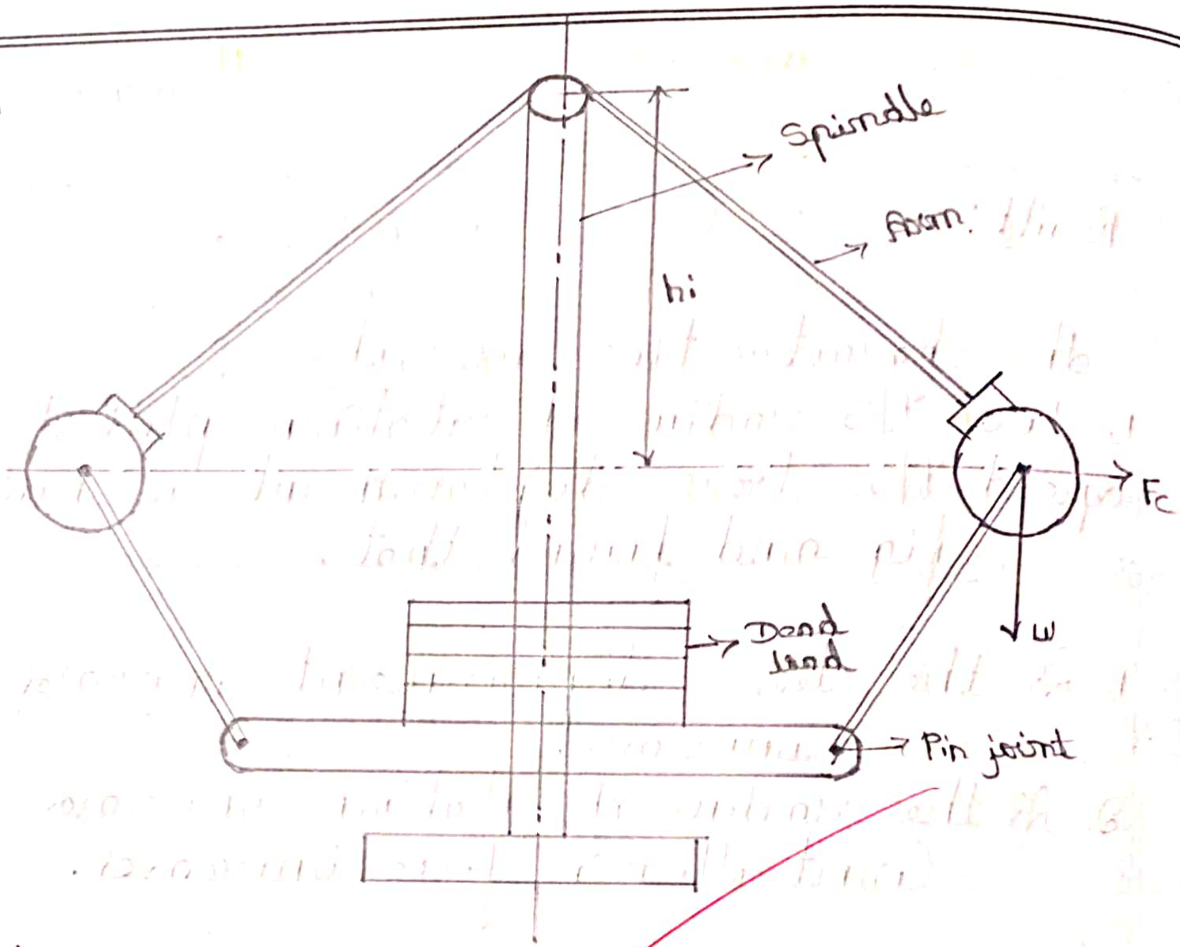
1. As the sleeve displacement increases speed increases.
2. As the radius of rotation increases Controlling force increases.

Governor effort Q = 1.762 N
Power P = 0.03438 N-m
Equilibrium N = 455 rpm
Sensitiveness = 5.82 %
Co-efficient of insensitiveness = 0.65 %

06/11/19

12/12

Figure:



Observation:

1. Length of each link/arm; l = 0.14 m
2. Mass of Sleeve assembly, M = 3 kg + 0.82 × 2 = 4.6 kg
3. Mass of governor ball, m = 0.146 kg
4. Initial radius of rotation r_i = 0.145 m
5. Initial length of governor, h_i = 0.1 m

Porter Governor

Aim: To Conduct the experiment on porter governor to plot the characteristics Curve of
a) Force v/s radius of rotation.
b) Speed v/s Sleeve displacement.

Apparatus:
Measurement tape, Governor apparatus etc.

Theory:

Difference between flywheel and Governor.

Flywheel	Governor
1. The function of a flywheel is to reduces the function of Speed during a Cycle above and below the mean value for Constant output load from the prime mover	1. The function of governor is to Control the mean Speed over a period for output load variation by manipulating input energy to the prime mover automatically.
2. Mathematically it Controls δN/δt	2. It Controls δN.

Tabular Column:

SL NO	Governor Speed in rpm	sleeve lift x in m	Radius of rotation in m	height of governor h	Controlling force in N	friction force in N.
1	310	0.01	0.152	0.095	23.36	-31.94
2	315	0.02	0.157	0.09	24.94	-32.26
3	334	0.03	0.161	0.085	28.09	-31.38
4	346	0.04	0.164	0.08	30.09	-31.2[illegible]

Calculation:

1. $h = h_i - x/2$

$$h_1 = 0.1 - \frac{0.01}{2} = 0.095\ m$$

$$h_2 = 0.1 - \frac{0.02}{2} = 0.09\ m$$

$$h_3 = 0.1 - \frac{0.03}{2} = 0.085\ m$$

$$h_4 = 0.1 - \frac{0.04}{2} = 0.08\ m.$$

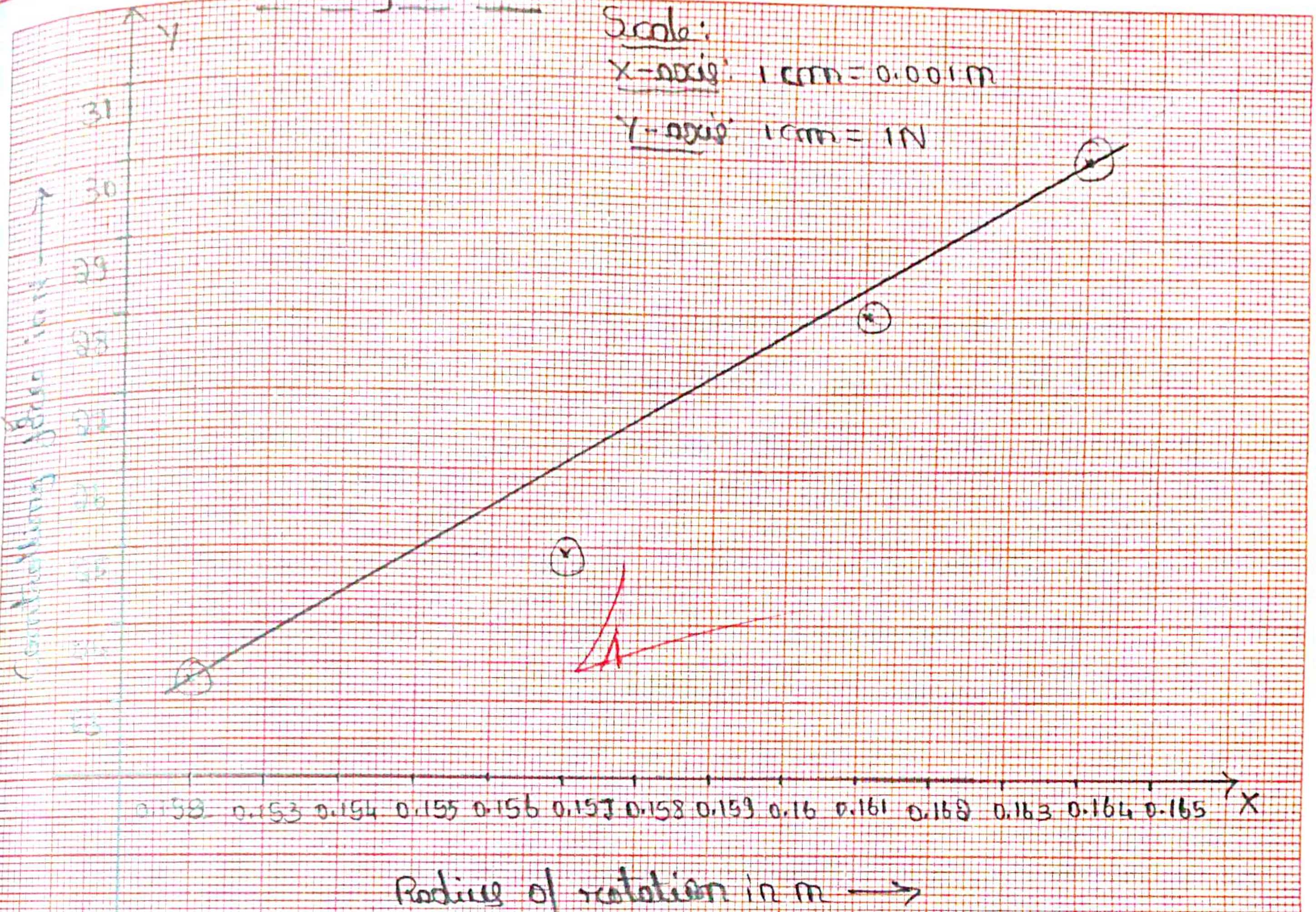
2. $\alpha = \cos^{-1}(h/l)$

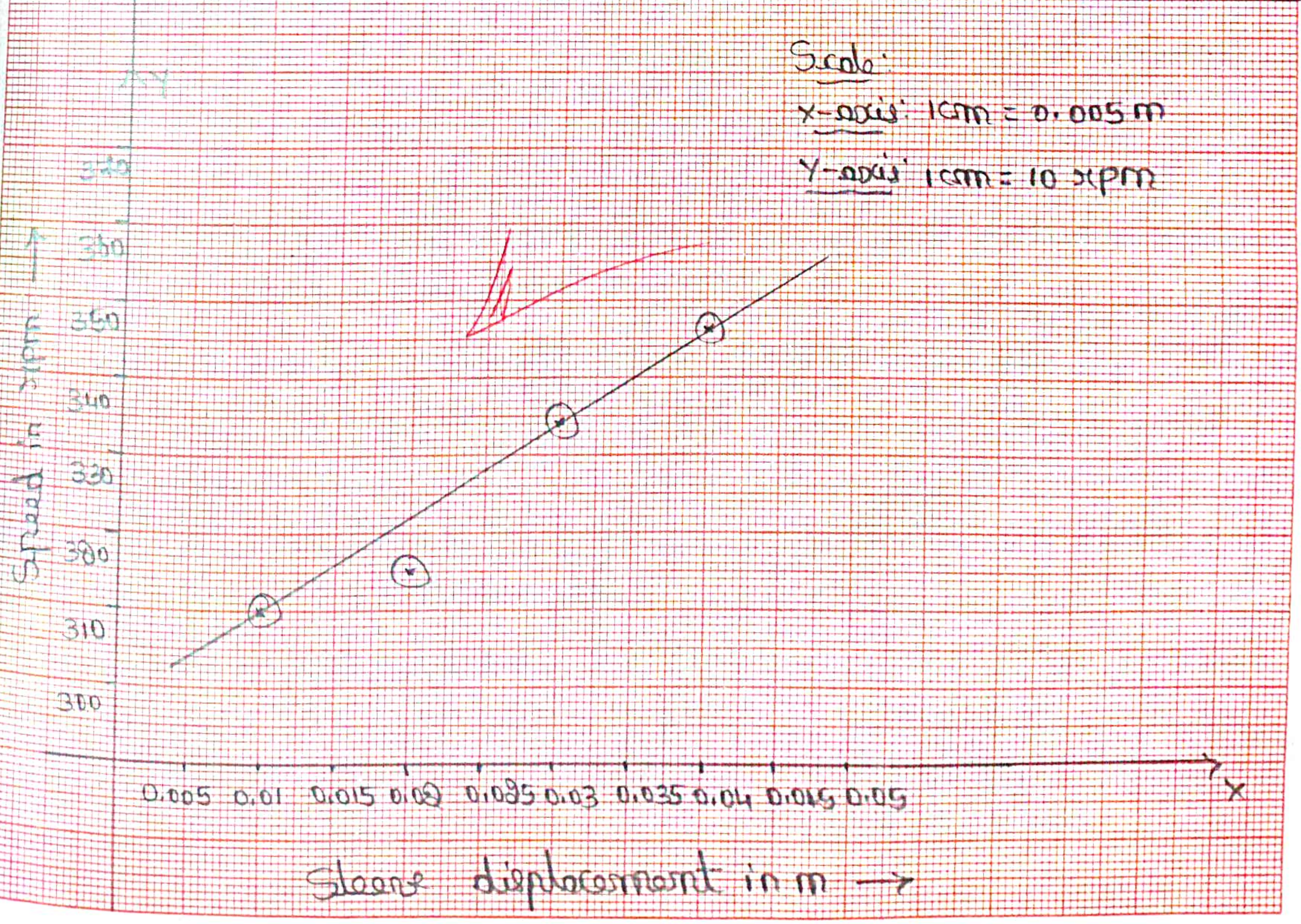
$$\alpha_1 = \cos^{-1}\left(\frac{0.095}{0.14}\right) = 47.20^\circ$$

$$\alpha_2 = \cos^{-1}\left(\frac{0.09}{0.14}\right) = 49.9^\circ.$$

$$\alpha_3 = \cos^{-1}\left(\frac{0.085}{0.14}\right) = 52.61^\circ.$$

Porter Governor





3. A flywheel stores energy & given up whenever required during a cycle the energy is stored in a flywheel by stepping it up and delivered by slowing it down it is a analogous to a Capacitor in an electric Circuit.	3. A governor regulate the Speed by regulating the quantity of working agent of the prime mover. Thus a governor is a device for automatic Control.
4. The flywheel has no influence on mean Speed of the prime mover.	4. Governor has no influence over Cyclic Speed fluctuation
5. A flywheel has no Control over the quant-ity & quality of the working agent.	5. Governor takes Care of change of quality & quantity of working agent.
6. A flywheel has no influence over the varying load demand on the prime mover.	6. A Governor adjusts Supply Energy of the prime mover to demand energy from the prime mover when output is varying.

$$\alpha_4 = \cos^{-1}\left(\frac{0.08}{0.14}\right) = 55.15^\circ.$$

3. $r = 0.05 + l \sin\alpha.$

$r_1 = 0.05 + 0.14 \sin(47.20) = 0.1528$ m.

$r_2 = 0.05 + 0.14 \sin(49.99) = 0.1572$ m.

$r_3 = 0.05 + 0.14 \sin(50.61) = 0.161$ m.

$r_4 = 0.05 + 0.14 \sin(55.15^\circ) = 0.1648$ m.

4. Controlling force,

$$F = m\omega^2 r = m \times \left(\frac{2\pi N}{60}\right)^2 r.$$

$$F_1 = 0.146 \times \left(\frac{2\pi \times 310}{60}\right)^2 \times 0.152 = 23.36 \text{ N}.$$

$$F_2 = 0.146 \times \left(\frac{2\pi \times 315}{60}\right)^2 \times 0.157 = 24.94 \text{ N}.$$

$$F_3 = 0.146 \times \left(\frac{2\pi \times 334}{60}\right)^2 \times 0.161 = 28.04 \text{ N}.$$

$$F_4 = 0.146 \times \left(\frac{2\pi \times 346}{60}\right)^2 \times 0.166 = 30.09 \text{ N}.$$

5. Frictional force.

$$f = \frac{N^2 mgh}{895} - (m+M)g.$$

$$f_1 = \frac{310^2 \times 0.146 \times 9.81 \times 0.095}{895} - (0.146 + 4.6)\,9.81 = -31.94 \text{N}$$

$$f_2 = \frac{315^2 \times 0.146 \times 9.81 \times 0.09}{895} - (0.146 + 4.6)\,9.81 = -32.26 \text{N}$$

$$f_3 = \frac{334^2 \times 0.146 \times 9.81 \times 0.085}{895} - (0.146 + 4.6)\,9.81 = -31.38 \text{N}$$

$$f_4 = \frac{346^2 \times 0.146 \times 9.81 \times 0.08}{895} - (0.146 + 4.6)\,9.81 = -31.83 \text{N}.$$

Name of Experiment .... Date : ....

Experiment No. .... Page No. 34

The porter governor is loaded type governor in centrifugal governor this governor controls the mean speed over a period for output load vibration by manipulating input energy to the prime mover automatically.

The governor rodius at uniform speed the ball weight tends to fly radically outward due to centrifugal force in followed by equal and opposite force caused centripetal force acting radially inward.

Procedure:

1. Arrange the set of governor.
2. Measure the length of each link.
3. A unknown weight is put on a sleeve.
4. Increase the speed gradually and lift the sleeve.
5. Corresponding to the speed displacement note down the speed.
6. Repeat same procedure for 3 to 4 sleeve displacement.
7. Calculate the results and plot the graph.

1. Governor effort, $Q = \left(\frac{2w}{1+k} + W\right)c$

$$c = \frac{315 - 310}{315} = 0.0158$$

$$= \left(\frac{2 \times 9.81 \times 0.146}{1+1} + 45.12\right) \times 0.0158$$

$$Q = 0.74N$$

2. Power $= \frac{4c^2}{1+2c} \times h\left(w + \frac{W}{2}(1+k)\right)$

$$= \frac{4 \times 0.0158^2}{1 + 2 \times 0.0158} \times 0.095\left(1.432 + \frac{45.12}{2}(1+1)\right)$$

$$P = 0.00428 \text{ N-m/sec.}$$

3. Sensitivity $= \frac{N_2 - N_1}{\left(\frac{N_2 + N_1}{2}\right)} = \frac{315 - 310}{\left(\frac{315 + 310}{2}\right)}$

$$= 1.6\%$$

4. Equilibrium Speed,

$$N^2 = \frac{\left(w + \frac{W}{2}(1+k)\right)}{m} \times \frac{1}{h} \times \left(\frac{60}{2\pi}\right)^2.$$

$$= \frac{\left(1.432 + \frac{45.12}{2}(1+1)\right)}{0.143} \times \frac{1}{0.095} \times \left(\frac{60}{2\pi}\right)^2$$

$$N = 561.33 \text{ rpm.}$$

Name of Experiment .... Date : ....

Experiment No. ....

Formula used:

1. Height of the governor

$$h = h_i - x/2$$

where,

h = height of governor in m.

h_i = Initial height of governor.

x = Sleeve lift in m.

2. Radius of rotation.

$$r = 0.05 + l \sin\alpha$$

r = radius of rotation in m.

l = length of each arm in m.

α = angle = $\cos^{-1}(h/l)$.

3. Controlling force due to each ball.

$$F = m\omega^2 r$$

F = Controlling force in N.

m = mass of Governor ball in kg.

ω = rotation of Spindle in rad/m.

r = radius of rotation in m.

4. frictional force.

$$f = \frac{N^2 mgh}{895} - (m+M)g.$$

where,

f = frictional force in N.

m = mass of governor in kg.

g = acceleration due to gravity in m/s^2

5. Coefficient of insensitiveness $= \dfrac{f}{\dfrac{2w}{1+K} + W}$

$$= \frac{-31.94}{\dfrac{2 \times 9.81 \times 0.146}{1+1} + 45.12}$$

$$= 0.68\%$$

N = Speed of governor in rpm.
h = height of governor in m.

Result:
The characteristics curve of
1. Force v/s radius of rotation.
2. Speed v/s Sleeve displacement is plotted and is shown in fig and found that.

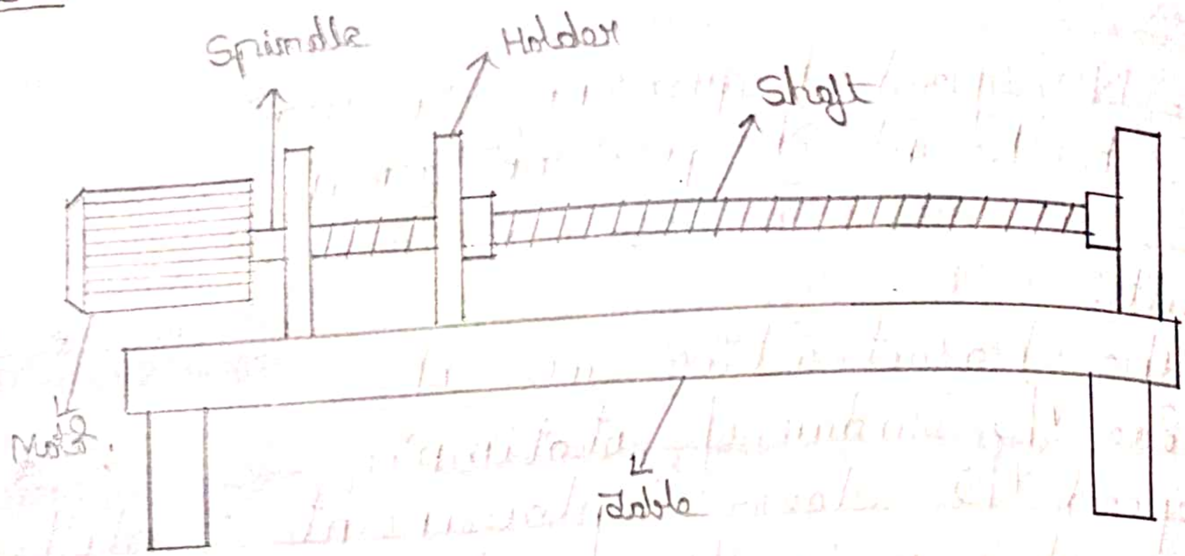
i) As sleeve displacement increases and Speed increases.
ii) As the radius of rotation increases and Controlling force increases.

Governor effort, $Q = 0.74N$
Power, $P = 0.00428$ N-m
Sensitiveness = 1.6 %
Equilibrium Speed, $N = 561.33$ rpm
Coefficient of insensitiveness, = 0.68 %

06/11/19

12/12

Figure:



Observation:

1. Length of the shaft in mm $l = 1050$ mm
2. Young's modulus $E = 2.06 \times 10^5$ N/mm^2
3. Moment of inertia, $I = 3.066 \times 10^{-11}$ m^4
4. Density of Shaft material, $\rho = 7.086 \times 10^3$ kg/m^3
5. Acceleration due to gravity $= 9.81$ m/sec^2
6. weight of Shaft / unit length $w = 1.36$ kg/m.

Tabular Column-1:

End Condition	Value of K	
	1st mode	2nd mode
Fixed-fixed	3.51	14.24
Fixed-hinged	2.45	9.8

whirling of shaft:

Aim: To determine Critical Speed of the shaft and Compare the theoritical value.

Apparatus: Critical speed shaft, setup, ~~digital~~ whirling shaft apparatus.

Theory: In actual practice a rotating shaft may carry gears pulley etc. Normally the Centre of gravity of the gear pulley dos not Co-inside with the axis of the shaft. It means the Centre gravity of the pully of gear is slightly shifted from the axis of Shaft and due to this, the shaft is subjected to the Centrifugal force. This radially outwards force bend the shaft in the direction of the initial displacement which increases the distance of the Centre gravity further from the axis of rotation.

The bending of shaft depends upon
i) Eccentricity: i.e, initial distance between Centre gravity of the pully and the axis of rotation (or) shaft axis.
ii) Speed of which the shaft rotates.

Rotating shaft tend to vibrate in transverse direction of Critical Speed which is known as Critical Speed (or) whirling Speed.

Tabular Column - 2

Sl No.	End Condition	Mode	Dia of Shaft in mm	weight per unit length in N/m	Critical Speed: Theoritical Speed in rpm	Critical Speed: Experimental Speed in rpm
1.	Both Side fixed	I	5	1.36	1307	752
		II		1.36	5230	1341
2.	one end fixed & other end hinged	I	5	1.36	899	442
		II		1.36	3599	1048

Calculation:

1. Area of Shaft $= \frac{\pi d^2}{4} = \frac{\pi \times 0.005^2}{4}$

$A = 1.962 \times 10^{-5}\ m^2$.

2. Volume, $V = A \times L = 1.962 \times 10^{-5} \times 1.05$

$V = 2.06 \times 10^{-5}\ m^3$.

3. Mass $= \rho \times V = 2.06 \times 10^{-5} \times 7.086 \times 10^{3}$

$m = 0.145$ kg.

4. weight per unit length $= \frac{m \times 9.81}{1.05} = \frac{0.145 \times 9.81}{1.05}$

$w = 1.36\ N/m$.

Procedure:

- Arrange the Experimental instrument.
- Fix the shaft at both the ends and measure the diameter.
- Switch on the Control unit.
- Increase the voltage To increase speed.
- Note down the speed for 1st mode displacement.
- Calculate the theoritical frequency and compare with actual frequency.
- Repeat the same procedure for different diameter of the shaft.

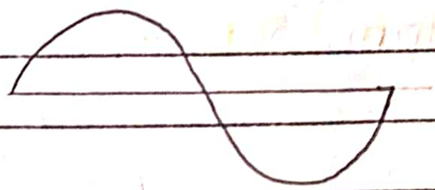
Formula used:

$$f_{the} = k\sqrt{\frac{EIg}{wI}} \text{ rps}$$

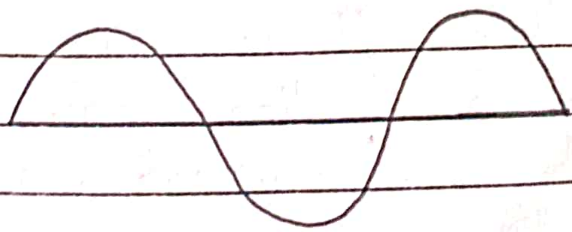
Modes:

1.

2.



3.



Both Sides are fixed:

I^{st} Mode: $f_{the} = k\sqrt{\frac{EIg}{wL^4}}$ in rps.

$$f_{the} = 3.56\sqrt{\frac{2.06\times10^{11}\times3.066\times10^{-11}\times9.81}{1.36\times(1.05)^4}}$$

$= 21.79$ rps

$f_{the} = 1307$ rpm.

II^{nd} Mode: $f_{the} = 14.24\sqrt{\frac{2.06\times10^{11}\times3.066\times10^{-11}\times9.81}{1.36\times(1.05)^4}}$

$= 87.17$ rps

$f_{the} = 5230$ rpm.

One end is fixed and other end is hinged.

I^{st} Mode: $f_{the} = 2.45\sqrt{\frac{2.06\times10^{11}\times3.066\times10^{-11}\times9.81}{1.36\times(1.05)^4}}$

$= 14.99$ rps

$f_{the} = 899$ rpm.

II^{nd} Mode: $f_{the} = 9.8\sqrt{\frac{2.06\times10^{11}\times3.066\times10^{-11}\times9.81}{1.36\times(1.05)^4}}$

$= 59.99$ rps

$f_{the} = 3599$ rpm.

Result:

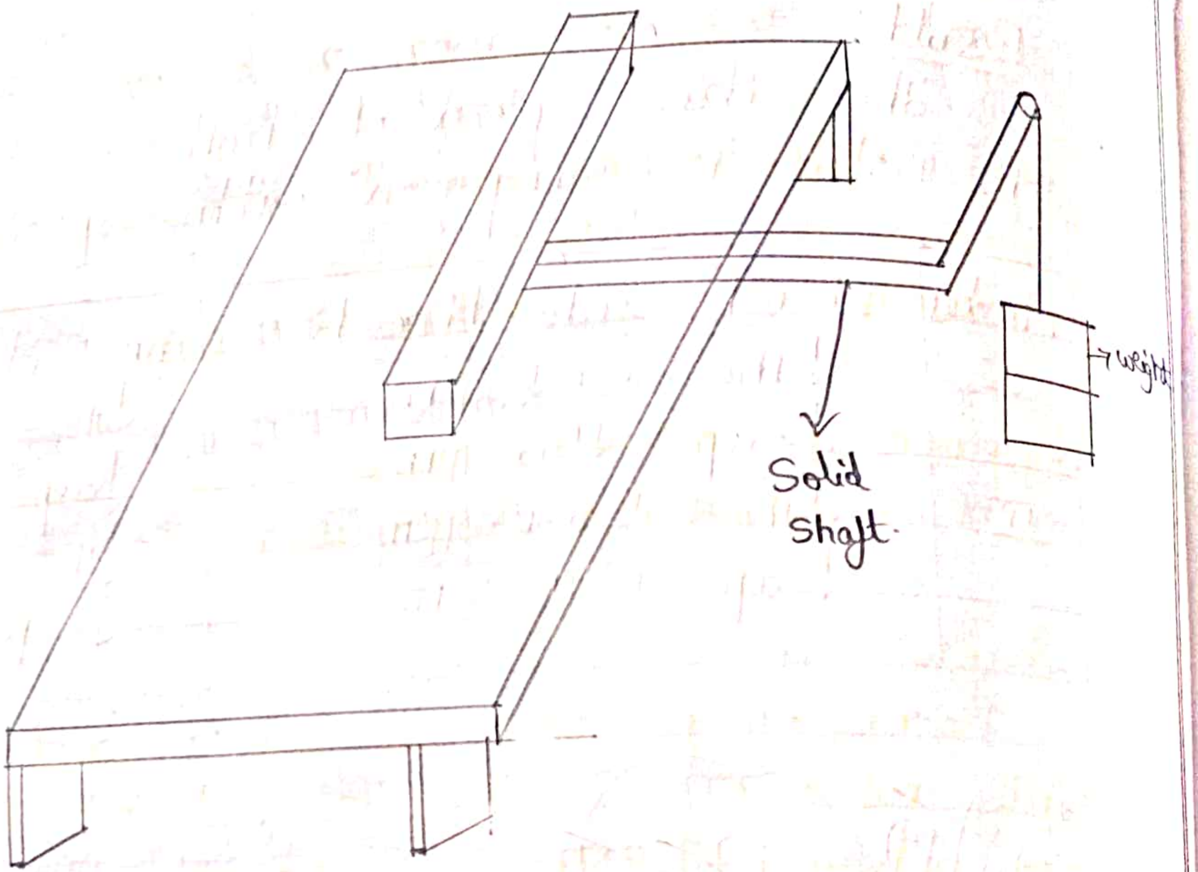
The Critical Speed of shaft is Calculated and the value is Compared with experimental value.

Modes	Both Side fixed	One Side fixed & other end hinged
I	f_{the} = 1307 rpm	f_{the} = 899 rpm
	f_{exp} = 758 rpm	f_{exp} = 1143 rpm
II	f_{the} = 5830 rpm	f_{the} = 3593 rpm
	f_{exp} = 1341 rpm	f_{exp} = 1012 rpm

06/11/19

12/12

Figure:



Observation:

1. Material of the shaft = Mild steel
2. Young's modulus of a steel shaft E = 210 GPa.
3. Poission's ratio μ = 0.3
4. Length of torque arm L = 1000 mm.
5. Length of the shaft l = 265 mm.
6. dia of the shaft d = 24.7 mm.
7. Modulus of rigidity of Shaft = 73 GPa.

Strain gauge apparatus

Aim: Determination of principale stress and strain in member subjected to combined loading using strain rosettes.

Apparatus: Strain gauge setup, shaft with lever arm, measuring tape, load etc.

Theory:
Principale planes are the planes on which only normal stresses will at all other will zero shear stresses the normal stress the principal stresses is known as plane in principal stress.
At any point is strained material under the dimensional stress system these are such planes mutually orthogonal to each other which carry direct stress only and shear stress at of the plane carrying the maximum stress is called adding on the plane is called major principale stress. The plane carrying maximum stress is called major principal stress.

Procedure:
1. Note down the young's modulus and poisson's ratio of the material.

Tabular Column:

SL No	Load N	Strain gauge reading $\varepsilon_A \times 10^{-6}$	$\varepsilon_B \times 10^{-6}$	$\varepsilon_C \times 10^{-6}$	Principle stress N/mm² σ_1	σ_2	Principle Strain $\varepsilon_1 \times 10^{-6}$	$\varepsilon_2 \times 10^{-6}$	Max Shear stress τ_{max} N/mm²
1	1×9.81	10	29	-2.7	10.81	+1.628	2.94×10^{-5}	-2.84×10^{-5}	4.586
2	2×9.81	18	55	-5.7	14.696	-2.9001	6.24×10^{-5}	-10.345×10^{-5}	8.798
3	3×9.81	27	78	-8.6	35.56	-4.675	9.206×10^{-5}	-15.7×10^{-5}	20.1206

Calculation:

Trial No 1

$M = W \times l = 9.81 \times 265 = 2599.65$ N-mm.

$T = W \times L = 9.81 \times 1000 = 9810$ N-mm

$$\sigma = \frac{32M}{\pi d^3} = \frac{32 \times 2599.65}{\pi \times (24.7)^3} = 1.7572 \text{ N/mm}^2.$$

$$\tau = \frac{16T}{\pi d^3} = \frac{16 \times 9810}{\pi \times (24.7)^3} = 3.315 \text{ N/mm}^2.$$

Theoritical formula:

$$\sigma_1 = \frac{16}{\pi d^3}\left[M_b + \sqrt{M_b^2 + T^2}\right] = \frac{16}{\pi \times (24.7)^3} \times \left[2599.65 + \sqrt{2599.65^2 + 9810^2}\right]$$

$\sigma_1 = 4.30$ N/mm²

$$\sigma_2 = \frac{16}{\pi d^3}\left[M_b - \sqrt{M_b^2 + T^2}\right] = -2.55 \text{ N/mm}^2.$$

$$\varepsilon_1 = \frac{1}{E}(\sigma_1 - \mu\sigma_2) = \frac{1}{210 \times 10^3}\left[4.30 - 0.3(-2.55)\right]$$

$\varepsilon_1 = 2.411 \times 10^{-5}$

$$\varepsilon_2 = \frac{1}{E}(\sigma_2 - \mu\sigma_1) = -1.822 \times 10^{-5}.$$

* Make the necessary Connection to the digital strain flow indicator form and Corresponding Strain gauge.
* Connect the instrument to power outlet and Switch on the instrument.
* Adjust the indicator to zero for all Strain gauges.
* Load the Specimen by placing weights on the loading pair.
* Note down the Strain in microns by during towards each stress indicator.
* Among six three readings one will be negative and other two will be positive.
* Repeat the above procedure for different load in steps.
* Determine the required parameter by using the Suitable equation.

Formula used:

1. $\sigma = \frac{32M}{\pi d^3}$ in N/mm^2
2. Shear stress, $\tau = \frac{16T}{\pi d^3}$ in N/mm^2.
3. Bending moment, $M = W \times L$ in N-mm.
4. Torsional moment, $T = W \times L$ in N-mm.
5. $\tau_{max} = \frac{\sigma_1 - \sigma_2}{2}$

Experimental formula:

$$\sigma_1 = \frac{E}{2}\left[\frac{\varepsilon_A+\varepsilon_B}{1-\mu} + \frac{\sqrt{2}}{1+\mu}\sqrt{(\varepsilon_A-\varepsilon_B)^2+(\varepsilon_B-\varepsilon_C)^2}\right]$$

$$\sigma_1 = \frac{210\times10^3}{2}\left[\frac{10\times10^{-6}\times 2.9\times10^{-6}}{1-0.3} + \frac{\sqrt{2}}{1+0.3}\sqrt{(10\times10^{-6}-29\times10^{-6})^2+(29\times10^{-6}-(-2.7\times10^{-6}))^2}\right]$$

$\sigma_1 = 10.8\ N/mm^2.$

$$\sigma_2 = \frac{E}{2}\left[\frac{\varepsilon_A+\varepsilon_B}{1-\mu} - \frac{\sqrt{2}}{1+\mu}\sqrt{(\varepsilon_A-\varepsilon_B)^2+(\varepsilon_B-\varepsilon_C)^2}\right]$$

$\sigma_2 = 1.628\ N/mm^2.$

$$\varepsilon_1 = \frac{\varepsilon_A+\varepsilon_C}{2} + \frac{1}{\sqrt{2}}\sqrt{(\varepsilon_A-\varepsilon_B)^2+(\varepsilon_B-\varepsilon_C)^2}$$

$$= \frac{10\times10^{-6}+(-2.7\times10^{-6})}{2} + \frac{1}{\sqrt{2}}\times\sqrt{(10\times10^{-6}-29\times10^{-6})^2+(29\times10^{-6}-(-2.7\times10^{-6}))^2}$$

$\varepsilon_1 = 2.97\times10^{-5}$

$$\varepsilon_2 = \frac{\varepsilon_A+\varepsilon_C}{2} - \frac{1}{\sqrt{2}}\sqrt{(\varepsilon_A-\varepsilon_B)^2+(\varepsilon_B-\varepsilon_C)^2} = -2.24\times10^{-5}$$

$$\tau_{max} = \frac{\sigma_1-\sigma_2}{2} = \frac{10.8-1.628}{2} = 4.586\ N/mm^2.$$

Trail No. 2

* $M = 19.62\times265 = 5199.3$ N-mm.
* $T = W\times L = 19.62\times1000 = 19620$ N-mm
* $\sigma = \frac{32M}{\pi d^3} = \frac{32\times5199.3}{\pi\times(24.7)^3} = 3.5144\ N/mm^2.$
* $\tau = \frac{16T}{\pi d^3} = \frac{16\times19620}{\pi\times(24.7)^3} = 6.6309\ N/mm^2.$

Theoritical formula:

$$\sigma_1 = \frac{16}{\pi d^3}\left(M_b+\sqrt{M_b^2+T^2}\right) = \frac{16}{\pi\times(24.7)^3}\times\left(5199.3+\sqrt{(5199.3)^2+(19620)^2}\right)$$

$\sigma_1 = 8.617\ N/mm^2.$

$\sigma_2 = -2.55\ N/mm^2.$

Theoritical formula:

1. $\sigma_1 = \frac{16}{\pi d^3}\left[M_b + \sqrt{M_b^2 + T^2}\right]$

2. $\sigma_2 = \frac{16}{\pi d^3}\left[M_b - \sqrt{M_b^2 + T^2}\right]$

3. $\varepsilon_1 = \frac{1}{E}\left[\sigma_1 - \mu\sigma_2\right]$

4. $\varepsilon_2 = \frac{1}{E}\left[\sigma_2 - \mu\sigma_1\right]$

Experimental formula:

1. $\sigma_1 = \frac{E}{2}\left[\frac{\varepsilon_A + \varepsilon_B}{1-\mu} + \frac{\sqrt{2}}{1+\mu}\sqrt{(\varepsilon_A - \varepsilon_B)^2 + (\varepsilon_B - \varepsilon_C)^2}\right]$

2. $\sigma_2 = \frac{E}{2}\left[\frac{\varepsilon_A + \varepsilon_B}{1-\mu} - \frac{\sqrt{2}}{1+\mu}\sqrt{(\varepsilon_A - \varepsilon_B)^2 + (\varepsilon_B - \varepsilon_C)^2}\right]$

3. $\varepsilon_1 = \frac{\varepsilon_A + \varepsilon_C}{2} + \frac{1}{\sqrt{2}}\sqrt{(\varepsilon_A - \varepsilon_B)^2 + (\varepsilon_B - \varepsilon_C)^2}$

4. $\varepsilon_2 = \frac{\varepsilon_A + \varepsilon_C}{2} - \frac{1}{\sqrt{2}}\sqrt{(\varepsilon_A - \varepsilon_C)^2 + (\varepsilon_B - \varepsilon_C)^2}$

$$\varepsilon_1 = \frac{1}{210\times10^3}\left[8.617 - 0.3(-2.55)\right]$$

$$\varepsilon_1 = 4.467\times10^{-5}$$

$$\varepsilon_2 = -2.445\times10^{-5}.$$

Experimental formula:

$$\sigma_1 = \frac{210\times10^3}{2}\left[\frac{16\times10^{-6} + 54\times10^{-6}}{1-0.3} + \frac{\sqrt{2}}{1+0.3}\sqrt{(16\times10^{-6} - 54\times10^{-6})^2 + (54\times10^{-6} + 57\times10^{-6})^2}\right.$$

$$\sigma_1 = 14.696 \text{ N/mm}^2$$

$$\sigma_2 = -2.9001 \text{ N/mm}^2.$$

$$\varepsilon_1 = \frac{16\times10^{-6} - 57\times10^{-6}}{2} + \frac{1}{\sqrt{2}}\sqrt{(16\times10^{-6} - 54\times10^{-6})^2 + (54\times10^{-6} + 57\times10^{-6}}$$

$$\varepsilon_1 = 6.245\times10^{-5}$$

$$\varepsilon_2 = -10.345\times10^{-5}.$$

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{14.696 + 2.9001}{2}$$

$$\tau_{max} = 8.798 \text{ N/mm}^2.$$

Trail NO3

$$M = 29.43\times265 = 7798.95 \text{ N-mm}$$

$$T = W\times L = 29.43\times1000 = 29430 \text{ N-mm}$$

$$\sigma_1 = \frac{32\times7798.95}{\pi\times(24.7)^3} = 5.871 \text{ N/mm}^2.$$

$$\tau = \frac{16\times29430}{\pi\times(24.7)^3} = 9.946 \text{ N/mm}^2.$$

Theoritical formula:

$$\sigma_1 = \frac{16}{\pi\times(24.7)^3}\times\left[7798.95 + \sqrt{(7798.95)^2 + (29430)^2}\right]$$

$$\sigma_1 = 12.92 \text{ N/mm}^2$$

$$\sigma_2 = -7.6539 \text{ N/mm}^2.$$

$$\varepsilon_1 = \frac{1}{210\times10^3}\left(12.92 - 0.3(-7.6539)\right)$$

$$\varepsilon_1 = 7.245 \times 10^{-5}$$

$$\varepsilon_2 = -5.4904 \times 10^{-5}.$$

<u>Experimental formula:</u>

$$\sigma_1 = \frac{210\times10^3}{2}\left[\frac{25\times10^{-6}+78\times10^{-6}}{1-0.3} + \frac{\sqrt{2}}{1+0.3}\sqrt{(25\times10^{-6}-78\times10^{-6})^2 + (78\times10^{-6}+90\times10^{-6})^2}\right]$$

$$\sigma_1 = 35.5663 \text{ N/mm}^2$$

$$\sigma_2 = -4.675 \text{ N/mm}^2$$

$$\varepsilon_1 = \frac{25\times10^{-6}-90\times10^{-6}}{2} + \frac{1}{\sqrt{2}}\sqrt{(25\times10^{-6}-78\times10^{-6})^2 (78\times10^{-6}+90\times10^{-6})}$$

$$\varepsilon_1 = 9.206 \times 10^{-5}$$

$$\varepsilon_2 = -15.7 \times 10^{-5}$$

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{35.5663 + 4.675}{2}$$

$$\tau_{max} = 20.1206 \text{ N/mm}^2.$$

Result:

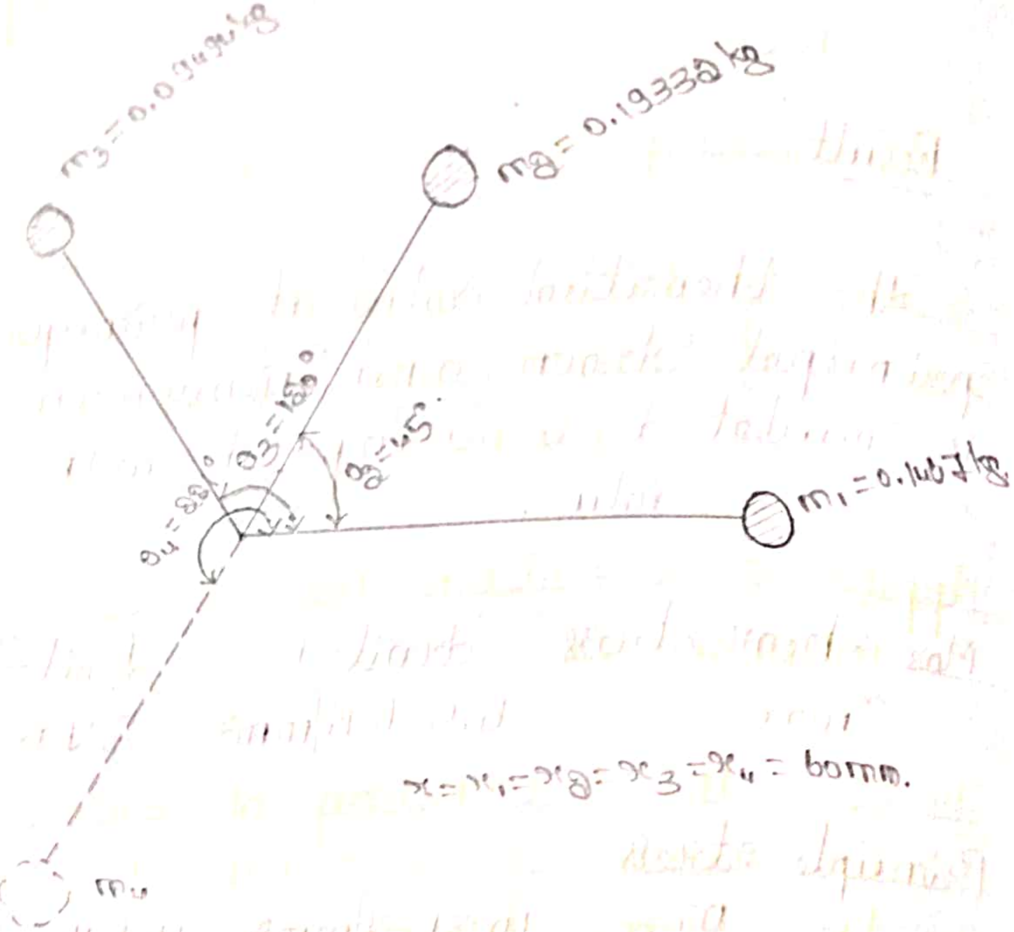
The theoritical value of principal stress, principal Strain and maximum shear stress is Calculated & Compared with experimental value.

Max shear stress	Trail-1	Trail-2	Trail-3
τ_{max}	4.586 N/mm²	8.798	20.1206.
Principle stress			
σ_1	10.81 N/mm²	14.696 N/mm²	35.56 N/mm²
σ_2	1.628 N/mm²	-2.9001 N/mm²	-4.675 N/mm²
Principle strain			
ε_1	2.94×10^{-5}	6.24×10^{-5}	9.206×10^{-5}
ε_2	-2.24×10^{-5}	-10.345×10^{-5}	-15.7×10^{-5}

13/11/19

12/12

Figure:



Tabular Column:

SL No	unbalanced masses in kg	Radius of rotation in mm	Angular position	Centrifugal force m×x in kg-mm
1	0.146	0.06	$\theta_1=0$	8.76
2	0.193	0.06	$\theta_2=45°$	11.58
3	0.094	0.06	$\theta_3=180°$	5.64
4	m_4	0.06	$\theta_4=221°$	$m_4 60$

Balancing of Several masses in Same plane

Aim: To check Experimentally to calculate values of balancing masses are in Same plane.

Apparatus: Vibration balancing equipment, weights etc.

Theory: The balancing of Several masses of Several radius of rotating at balancing masses in the same plane can be done analytically.

Consider a masses m_1, m_2, m_3 & m_4 of a distance of r_1, r_2, r_3 & r_4 from the axis of rotation of the shaft. Let $\theta_1, \theta_2, \theta_3, \theta_4$ be the angle of the masses with horizontal line as shown in fig. Let these masses rotate about an axis through plane.

The magnitude & direction of the balancing mass may be obtained through analytical method. Find out the each rotating masses & radius of rotation at 3 masses.

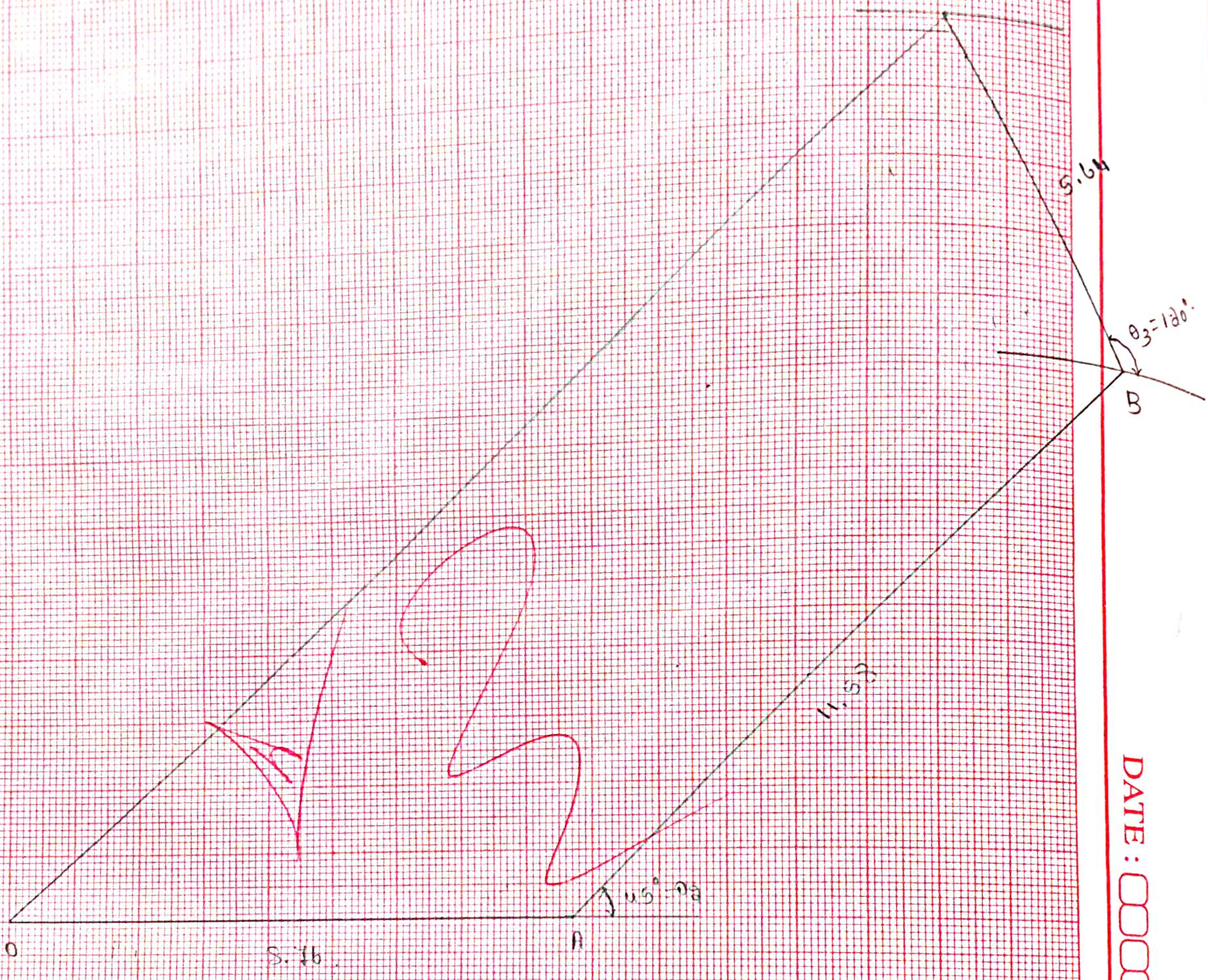
Resolve all forces horizontally,

$$\Sigma_H = m_1 r_1 \cos\theta_1 + m_2 r_2 \cos\theta_2 + m_3 r_3 \cos\theta_3$$

$$\Sigma_V = m_1 r_1 \sin\theta_1 + m_2 r_2 \sin\theta_2 + m_3 r_3 \sin\theta_3$$

Magnitude of CF is

$$F_C = \sqrt{\Sigma_H^2 + \Sigma_V^2}.$$



DATE :

Three balancing torque will be equal to the resultant torque but opposite in direction.

$F = mr$

m = Balancing masses.

r = radius of rotation.

If θ is the angle made by balancing mass with horizontal reference then

$$\tan\theta = \frac{\Sigma V}{\Sigma H}$$

Procedure:

* Determine either graphically (or) analytically the balancing of several masses which are rotating in angle plane the given masses $m_1, m_2, \& m_3$ when radius of r_1, r_2, r_3 with angle $\theta_1, \theta_2, \theta_3$.
* Run the equipment without fixing masses & observe the vibration.
* Fix the known mass m_1, m_2, m_3 with their radius $r_1, r_2, \& r_3$ angular position $\theta_1, \theta_2, \theta_3$.
* Run the equipment & observe the vibration produced by disturbing masses m_1, m_2, m_3.
* Now fix the balancing mass and radius of rotation r_4 the angular position θ_4.
* Reset the system & observe the vibration of the system.

Result:
The balancing of several mass rotating in the same plane is done.

22/11/19

12/12

Planes	unbalanced masses in kg	Radius of rotation in mm
A	ma	20
B	0.193	40
C	0.094	60
D	md	80

Tabular Column:

Plane	Mass in kg	Radius in mm	Force ÷ 10^2 $m \times r$ in kg-mm	Distance from Reference plane	Couple ÷ 10^2 $m \times r \times L$
A	0.315	20	6.3	0	0
B	0.193	40	7.72	15	115.8
C	0.094	60	5.64	30	169.2
D	0.068	80	5.51	45	248

Calculation:

a) From Couple polygon

$8md \times 45 = 245$

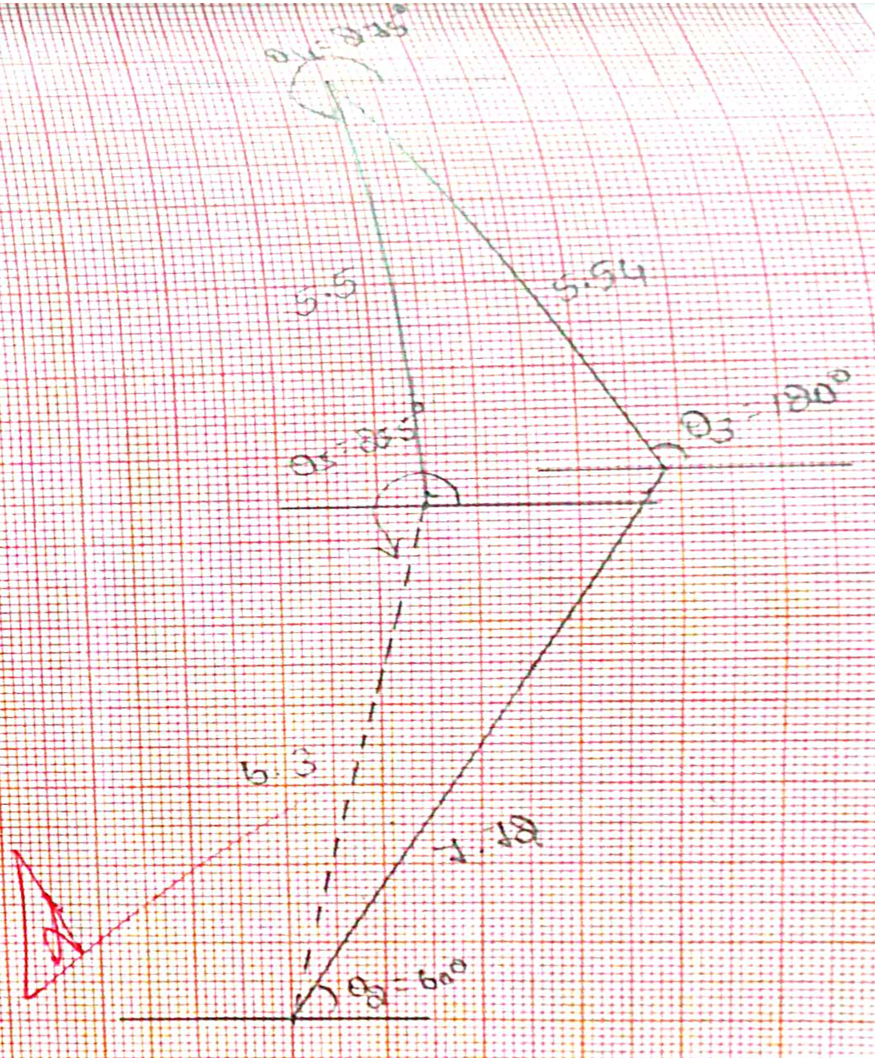
$8md = \frac{245}{45}$

$md = 0.063$ kg

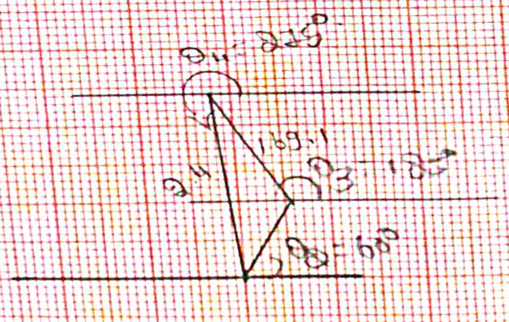
b) From force polygon

$ma \times 20 = 6.3$

$ma = 0.315$ kg.



Force polygon



Couple polygon

Balancing of Several masses in different plane.

Aim: Balancing of Several masses by a single mass rotating in different planes.

Apparatus: Balancing System, masses, nuts, Bolts etc

Theory: when Several masses revolve in a different plane they must be transferred to a reference plane which may be defined as in order to the System in Compute balancing masses are placed in two different plane parallel to the plane of rotation of the distribute mass in such Condition of equilibrium.

The net dynamic force acting on the shaft is equal to zero require that the link of action of three Centrifugal forces must be in same in other words the Centre of the masses of the System must be less on the axis of rotation. This is the Condition for the static balance. The Couple due to dynamic force acting on the shaft is equal to zero in other words to algebraic Sum of moment about any point in the plane must be zero the Condition is together give dynamic balancing the following the two possibility may arise.

Procedure:

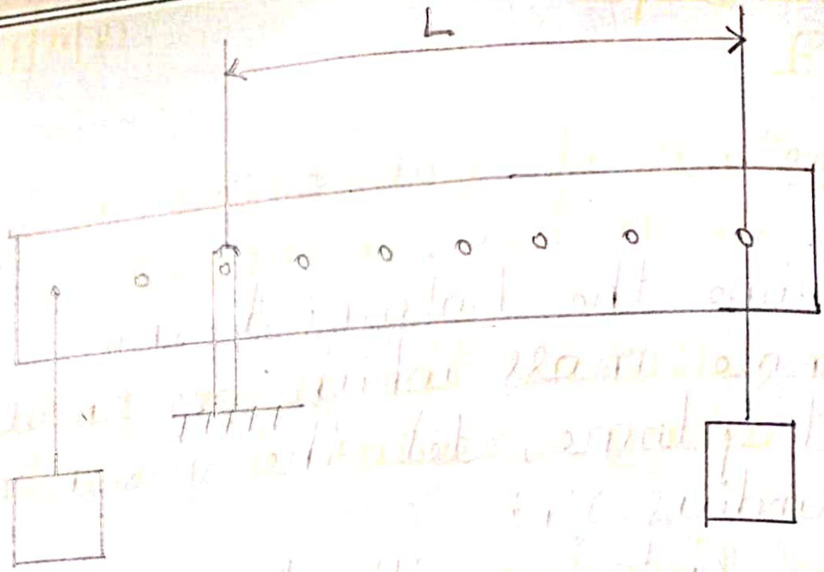
* Determine the balanced masses graphically for a single mass which are rotating in different plane, let the given mass be m_1 at radius r_1.
* Run the system without giving the masses & absence of vibration in the system.
* Now for the known mass m_1 at radius r_1.
* Run the system & absence. the vibration produced by distributed mass m_1.
* Now fix the balanced mass m_2 & m_3 of radius of vibration r_2 & r_3 in the different plane.
* Run the system & absence of vibration in the system.

Result:
when graphically solved balancing is applied to the experimental setup the system become the free from vibration.

22/11/19

12/12

Figure:



Observation:

1. Diameter of the Specimen D = 60 mm
2. Thickness of the Specimen, t = 5 mm
3. Length of the point of application of load to the fringe point L = 500 mm
4. Length from fulcrum point to mid of Specimen Li = 200 mm.

Tabular Column:

SL NO	Fringe Order NO (N)	Load applied kg	Load applied N	Effective load in N	material fringe Constant N/mm/fringe
1	1.61	5	49.05	122.62	3.23
2	2.48	10	98.1	245.25	4.88
3	3.46	15	147.15	367.87	4.512

Calibration of photoelastic material under diametric Compression.

Aim: To Calibrate the given photoelastic material using Circular disc under Compression.

Apparatus: Circular polariscope, with photoelastic modes on the form of Circular disc with hole.

Theory:

Photoelasticity is a non-distructive graphic stress analysis technique based on the mechanical property called wire based on the op to mechanical property.

Polariscope is an optical Set up that allows the wire flunger in Specimen to 'x' is analysed it Consist of a light Source polarizer optical rotator wave polariscope Consist of light Source polarism Speciment and analyser that is always with respect to polarism.

Procedure:

* Make all arrangements as shown in fig.
* Apply weights gradually and measure the fringe order and Corresponding from the inner bounded along horizontal.
* Take metal fringe Constant. determine from Calibration experiment.

$$P = \frac{WL}{L_i} = \frac{49.05 \times 500}{200} = 122.62\ N$$

$$P = \frac{98.1 \times 500}{200} = 245.25\ N$$

$$P = \frac{147.15 \times 500}{200} = 367.87\ N$$

$$F_{the} = \frac{8}{\pi D} \times \frac{P}{N} = \frac{8}{\pi \times 60} \times \frac{122.62}{1.61} = 3.23\ \cancel{N/mm}/\text{fring}$$

$$F_{the} = \frac{8}{\pi \times 60} \times \frac{245.25}{2.48} = 4.28\ N/mm/\text{fring}$$

$$F_{the} = \frac{8}{\pi \times 60} \times \frac{367.875}{3.46} = 4.512\ N/mm/\text{fring}$$

$$\text{Avg of } F_{the} = \frac{3.23 + 4.28 + 4.512}{3} = 4.008.\ N/mm/\text{frin}$$

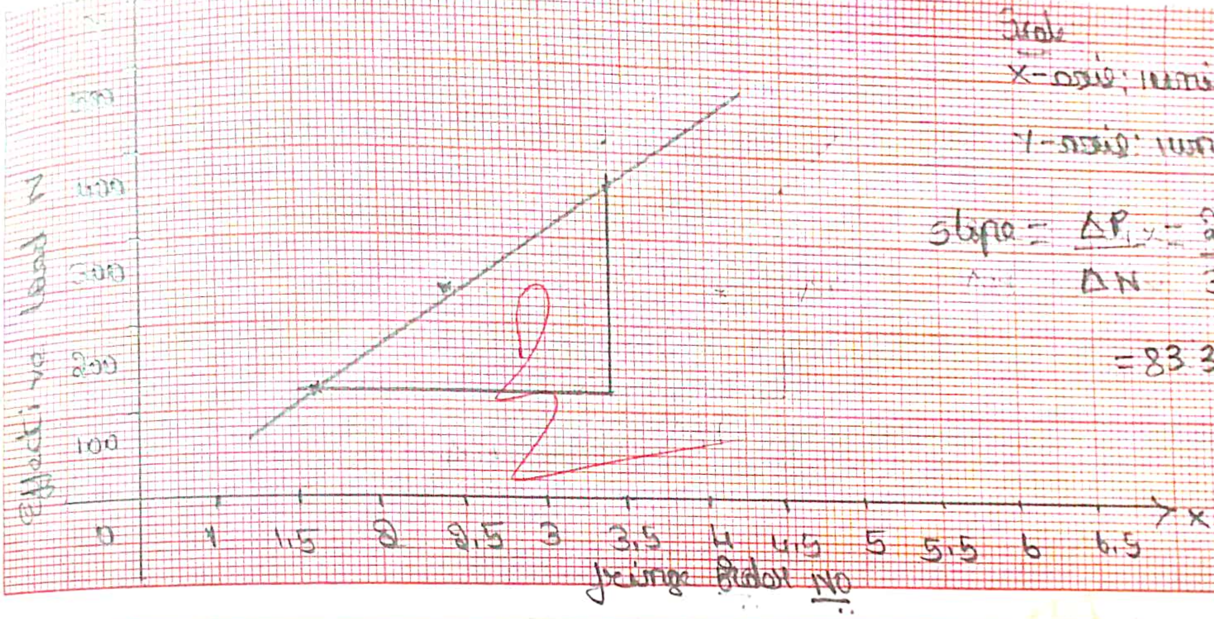
From the graph

$$\text{Slop} = \frac{\Delta P}{\Delta N} = 83.33$$

$$f_{exp} = \frac{8}{\pi D} \times \frac{\Delta P}{\Delta N}$$

$$= \frac{8}{\pi \times 60} \times 83.33$$

$$f_{exp} = \underline{3.536}\ N/mm\ \text{fring}$$



Scale:

X-axis: 1 unit = 0.5

Y-axis: 1 unit = 100N

$$\text{slope} = \frac{\Delta P}{\Delta N} = \frac{25 \times 240}{36 \times 2}$$

$$= 83.33$$

240

2

ARUN'S GOLD

* Draw a graph between effective load and fringe position.
* Calculate the slope of timer.

Formula used:

1. Effective load = $P = \frac{WL}{L_i}$

2. Material fringe Constant

$$f_{the} = \frac{8}{\pi D} \times \frac{P}{N}$$

3. Experimental fringe Constant

$$f_{exp} = \frac{8}{\pi D} \times \frac{\Delta P}{\Delta N}.$$

Result: Material fringe Constant is found th

1. f_{the} = 4.008 N/mm/fring.
2. f_{exp} = 3.536 N/mm/fring.

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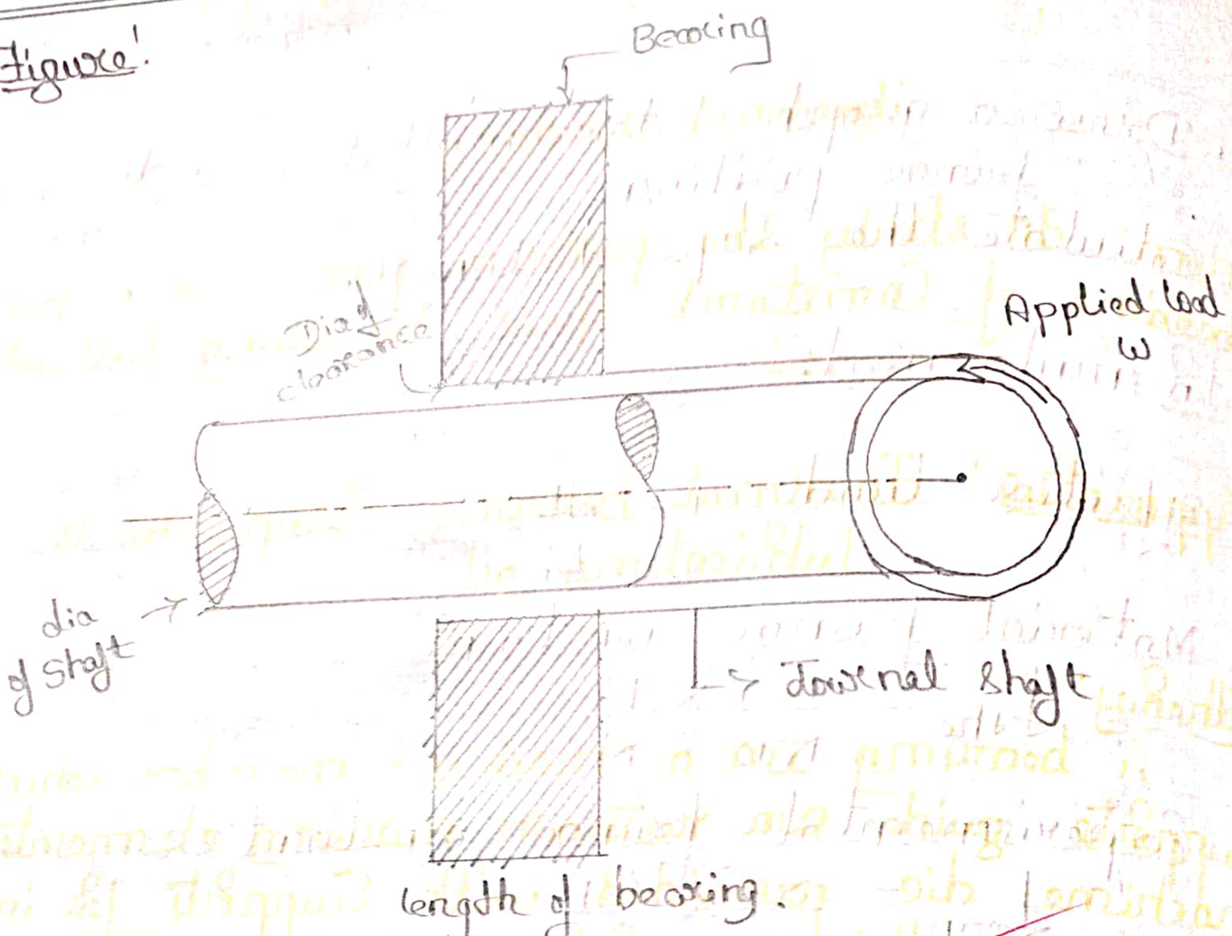
22/4/19

12/12

Figure:



Observation:

1. Supply head or static head = 88 cm.
2. Speed of Journal bearing = 250 mm.
3. Journal bearing dia, D = 50 mm.

Formula used:

1. $\cos\theta_{max} = \frac{-3n}{2+n^2}$

2. $(P_i - P_s)_{max} = \frac{-k\sin\theta_{max}(2+n\cos\theta_{max})}{(1+n\cos^2\theta_{max})}$

Journal bearing

Aim: To study the pressure profile in a journal bearing of Constant speed by using lubricating oil.

Apparatus: Journal bearing, Setup, SAE 30, lubricating oil.

Theory:

A bearing in a machine member which Supports guide an restrain moving elements all machine are provided with Supports for intiating Shaft, this supporting device is Called bearing. It is a stationary member which Carries the load. The position of the shaft supported by the bearing if the relative motion b/w the two machine tooth is at rotating and pressure on the bearing is perpendicular to the axis of the shaft Bearing is known as journal bearing.

Procedure:

* Fix the oil tank by using the SAE lubricating oil under heat and position the tank at desired height.
* ① Drain out the air tubes from the manometer by removing the tubes from the manometer.

Tabular Column:

SL NO	Pressure points P_i	Pressure head P_i	P_S	$(P_i - P_S)$
1	1	~~137~~ 95	88	7
		98	88	10
2	2			
3	3	100	88	12
4	4	98	88	10
5	5	95	88	7
6	6	90	88	2
7	7	85	88	-3
8	8	84	88	-4
9	9	86	88	-2
10	10	87	88	-1
11	11	89	88	1
12	12	93	88	5

$\theta_{max} = 240°$

$\cos 240° = \frac{-3n}{2+n^2}$

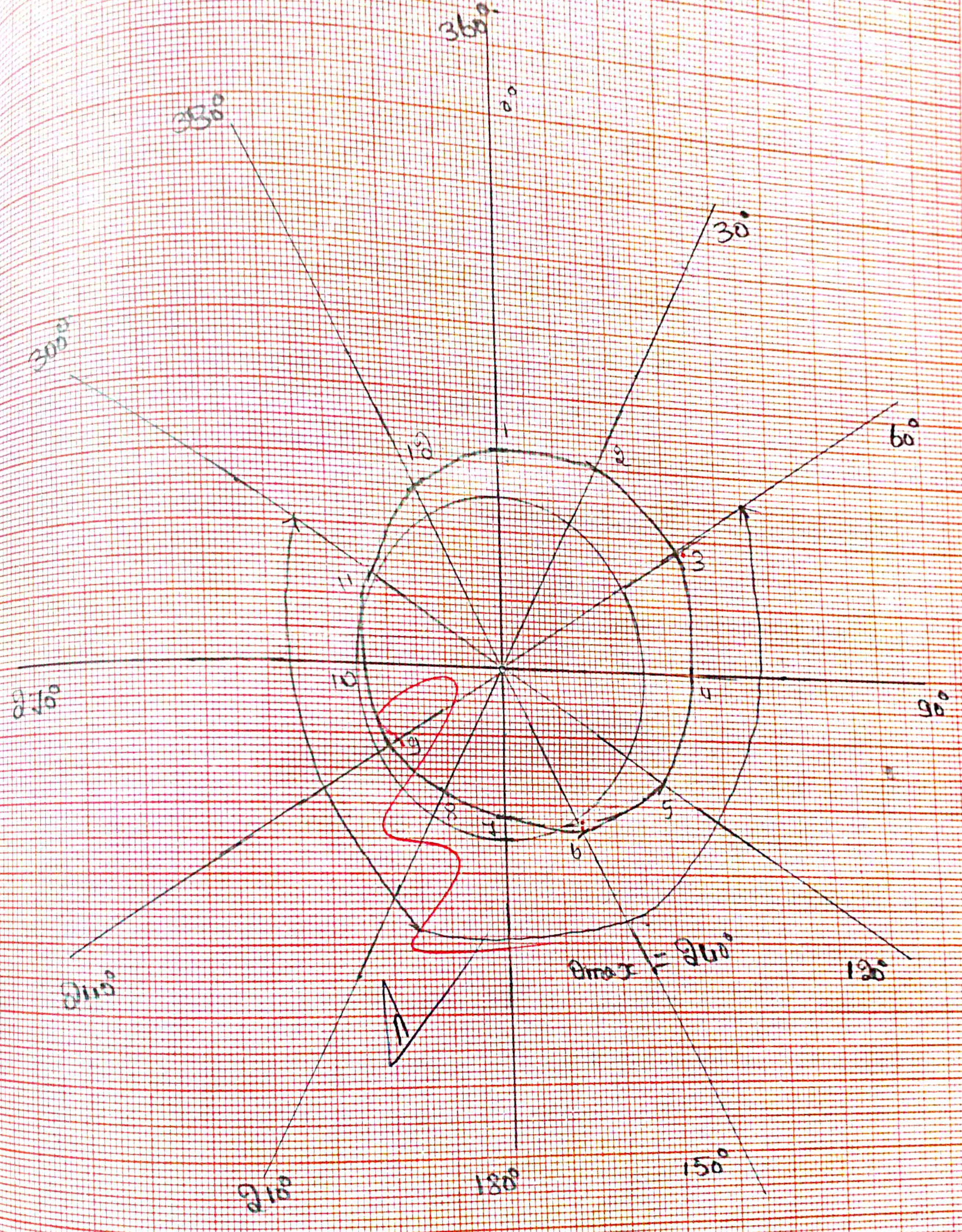
$n = 0.35$

$(P_i - P_S)_{max} = \frac{-k \sin\theta_{max} (2 + n\cos 240°)}{(1 + 0.35 \times \cos\theta_{max})^2}$

$12 = \frac{-k \times \sin 240° \times -0.82}{2.41}$

$k = 5.16$

Z.



360°
0°
330°
30°
300°
60°
270°
90°
240°
120°
210°
180°
150°
1
2
3
4
5
6
7
8
9
10
11
12
θmax = 240°

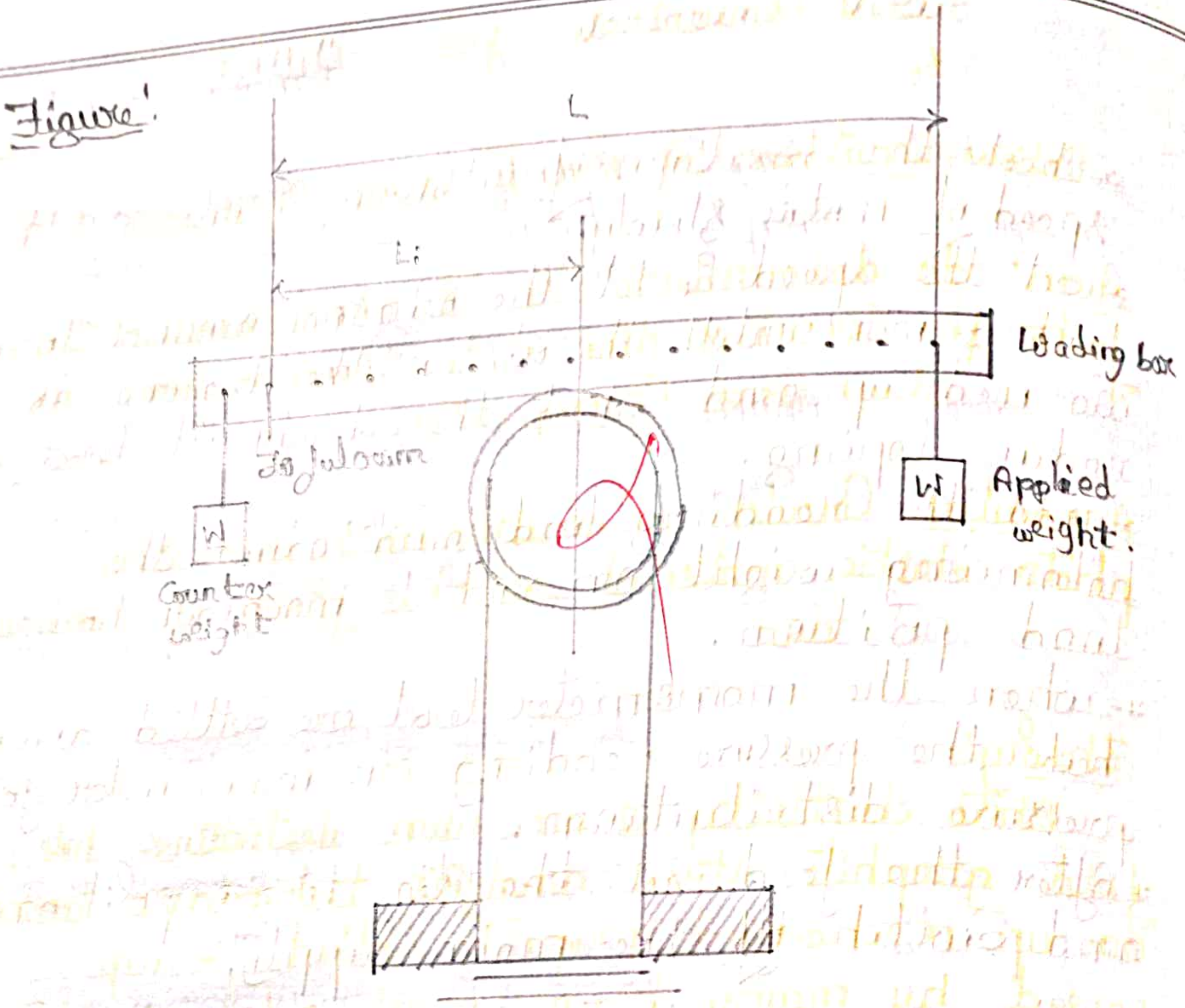
* check the direction of rotation & increase the speed of motor slowly.
* Set the speed & let the original journal for at least 2 min untill the oil in the bearing is warmed up and check the steady oil level of radius toping.
* Add the reading load and adjust the balancing weight on rod to maintain horizontal load position.
* when the manometer level are settled down check the pressure reading on manometer for pressure distribution.
* After the load set the dia to zero position and switch off the main supply.

Result: The pressure distribution in a journal bearing bearing at constant speed
k = 5.16

12/12

A 22/4/19

Figure:



Observation:

1. Outer diameter of disc, D = 60 mm
2. Inner dia of disc, d = 25 mm
3. thickness of specimen, t = 5 mm.
4. Length of application of load point, L = 0.5 m
5. Length from fulcrum point to mid of specimen L_i = 0.2 m
6. Material fringe Constant, f_r = 2.26

Determination of stress Concentration factor:

Aim: To determine the stress Concentration factor for Circular disc with Circular hole under diametral Compression.

Apparatus: Circular polariscope with accessories photo elastic material in the form of Circular disc.

Theory:

Photo elasticity is an non destructive hole, field graphite stress analysis technique based on up mechanical property Called fringe passed by many transparent polymer this method is used primaries for analysis two dimensional plane problems.

A polariscope is an optical setup that allow the fringe in Specimen to be analysed two types of polariscope and the Circular polariscope.

The plane polariscope Consists of a light source polariser specimen and with respect the polarise the Circular polariscope Consists of light source. the Circular polariscope Consists of light source. polariser quarter to wave plate Oriented at 45° with respect to polariser Specimen and analyser.

Tabular Column:

Sl No	Fringe Order N	Load applied kg	N	Effective load (P) in N	σ_{nom} N/mm^2	σ_{act} N/mm^2	k
1	1.61	5	49.05	122.625	0.7007	0.7277	1.038
2	2.48	10	98.1	245.25	1.4014	1.1209	0.79
3	3.46	15	147.15	367.875	2.102	1.5632	0.74.

$$P = \frac{WL}{L_i}$$

$$P_1 = \frac{49.05 \times 500}{200} = 122.625 N$$

$$P_2 = \frac{98.1 \times 500}{200} = 245.25 N$$

$$P_3 = \frac{147.15 \times 500}{200} = 367.87 N.$$

$$\sigma_{nom_1} = \frac{P}{(D-d)t}$$

$$\sigma_{nom_1} = \frac{122.625}{(60-25) \times 5} = 0.7007 \; N/mm^2$$

$$\sigma_{nom_2} = \frac{245.25}{(60-25) \times 5} = 1.4014 \; N/mm^2$$

$$\sigma_{nom_3} = \frac{367.875}{(60-25) \times 5} = 2.102 \; N/mm^2$$

$$\sigma_{act_1} = \frac{N f_r}{t} = \frac{1.61 \times 2.26}{5} = 0.7277 \; N/mm^2.$$

Procedure:

* Make all arrangement as shown in fig.
* Apply weight gradually then measure the fringe order and Corresponding load boundary to outer boundary along horizontal diameter.
* Take metal fringe Constant are determined from Calibrated experiment and Calculated the stress Concentration.

Formula used:

1. Effective load $P = \frac{WL}{L_i}$ N

2. Normal Stress

$$\sigma_{norm} = \frac{P}{(D-d)t} \ N/mm^2.$$

P = effective load in N.
t = thickness in mm.
D = outer dia of the disc in mm.
d = Inner dia of the disc in mm.

3. Actual Stress

$$\sigma_{act} = \frac{N f_r}{t} \ N/mm^2$$

N = fringe order
f_r = fringe Constant
t = thickness in mm.

$$\sigma_{act_2} = \frac{2.48 \times 2.26}{5} = 1.12096\ N/mm^2$$

$$\sigma_{act_3} = \frac{3.46 \times 2.26}{5} = 1.56392\ N/mm^2$$

$$k_1 = \frac{\sigma_{act_1}}{\sigma_{nom_1}} = \frac{0.72772}{0.7007} = 1.038,$$

$$k_2 = \frac{1.12096}{1.4014} = 0.7998$$

$$k_3 = \frac{1.56392}{2.102} = 0.7436$$

$$k_{avg} = \frac{1.038 + 0.7998 + 0.7436}{3}$$

$$k_{avg} = 0.86046$$

4. Stress Concentration factor.

$$k = \frac{\sigma_{actual}}{\sigma_{nominal}}$$

σ_{act} = Actual stress in N/mm^2.
σ_{nom} = Nominal stress in N/mm^2.

Result: The stress concentration factor of a Specimen, k = 0.86046.

22/11/19

11/12