LABORATORY MANUAL

Dynamics of Machines

(ME 506)

Department of Mechanical Engineering

Jorhat Engineering College
Jorhat – 785007 (Assam)

COLLEGE VISION AND MISSION

Vision:

To develop human resources for sustainable industrial and societal growth through excellence in technical education and research.

Mission:

1. To impart quality technical education at UG, PG and PhD levels through good academic support facilities.

2. To provide an environment conducive to innovation and creativity, group work and entrepreneurial leadership.

3. To develop a system for effective interactions among industries, academia, alumni and other stakeholders.

4. To provide a platform for need-based research with special focus on regional development.

DEPARTMENT VISION AND MISSION

Vision:

To emerge as a centre of excellence in mechanical engineering and maintain it through continuous effective teaching-learning process and need-based research.

Mission:

M1: To adopt effective teaching-learning processes to build students capacity and enhance their skills.

M2: To nurture the students to adapt to the changing needs in academic and industrial aspirations.

M3: To develop professionals to meet industrial and societal challenges.

M4: To motivate students for entrepreneurial ventures for nation-building.

Program Outcomes (POs)

Engineering graduates will be able to:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Educational Objectives (PEOs)

The Programme Educational Objectives of Department of Mechanical Engineering are given below:

PEO1: Gain basic domain knowledge, expertise and self-confidence for employment, advanced studies, R&D, entrepreneurial ventures activities, and facing challenges in professional life.

PEO2: Develop, improve and maintain effective domain based systems, tools and techniques that socioeconomically feasible and acceptable and transfer those technologies/developments for improving quality of life.

PEO3: Demonstrate professionalism through effective communication skill, ethical and societal commitment, team spirit, leadership quality and get involved in life-long learning to realize career and organisational goal and participate in nation building.

Program Specific Outcomes (PSOs)

The programme specific outcomes of Department of Mechanical Engineering are given below:

PSO1: Capable to establish a career in Mechanical and interdisciplinary areas with the commitment to the society and the nation.

PSO2: Graduates will be armed with engineering principles, analysing tools and techniques and creative ideas to analyse, interpret and improve mechanical engineering systems.

Course Outcomes (COs)

At the end of the course, the student will be able to:

CO1	Measure radius of gyration, moment of inertia for different components.
CO2	Analyse the dynamic behaviour of the machine elements/ components like Gyroscope and vibration parameters.

Mapping of COs with POs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2							2	1			1	1
CO2	2	2							2	1			1	1

STUDENT PROFILE	
NAME :	
ROLL NUMBER :	
SECTION :	
SEMESTER :	5th Semester
YEAR :	

PERFORMANCE RECORD		
EXP. NO.	**TITLE OF EXPERIMENT**	**REMARKS / GRADE**
1	Compound Pendulum Apparatus.	
2	Study of Longitudinal Vibration of Helical Spring.	
3	Torsional Pendulum (without damping).	
4	Torsional Pendulum (with damping).	
5	Gyroscopic Couple.	

OFFICE USE	
Checked By :	
Overall Grade / Marks :	
Signature of Teacher :	

Experiment No. 1

TITLE: Compound Pendulum Apparatus.

AIM:

1. To determine the radius of gyration ‘k’ of given pendulum.

2. To verify the relation:

$$T = 2\pi\sqrt{\frac{K^2 + (OG)^2}{g(OG)}}$$

Where,

T = Periodic time in sec.

K = Radius of gyration about the C.G. in cm.

OG = Distance of C.G. of the rod from support.

L = Length of suspended pendulum.

APPARATUS:

A steel rod with holes in it for suspension (bar pendulum), A knife edged fulcrum, stop watch, meter scale.

THEORY:

Compound pendulum is defined as a right body suspended in a vertical plane, from a point on the body other than centre of gravity. On giving small angular displacements, it oscillates and performs harmonic motion.

DESCRIPTION OF SET-UP:

The compound pendulum consists of a steel bar. The bar is supported by the knife edge. Two pendulums of different lengths are provided with the set-up.

PROCEDURE:

1. Support the rod on knife edge.
2. Note the length of suspended pendulum and determine OG.
3. Allow the bar to oscillate and determine T by knowing the time for say 10 oscillations.
4. Repeat the experiment with different length of suspension.
5. Complete the observation table given below.

OBSERVATION TABLE:

Sl. No.	L (cm)	OG	No. of Osc. (N)	Time or Osc.	$T_{Expt.}$=n/t	$K_{Expt.}$	$K_{Theoretical}$
1	57.2	28.5	10	12.3	1.23	16.13	16.51
2							
3							

CALCULATIONS:

Length of suspended pendulum L = 57.2 cm

Width of suspended pendulum b = 2.0cm

Find k experimental from relation:

$$k_{Exp} = \sqrt{\frac{L^2+b^2}{12}} \quad \text{or} \quad T = 2\pi\sqrt{\frac{K^2+(OG)^2}{g(OG)}}$$

Substituting for OG and T in above formula find k Experimental.

$$k_{Th} = \frac{L}{2\sqrt{3}}$$

Compare values of k obtained theoretical and experimental.

REMARKS:

Exp. No. 1	**Title:** Compound Pendulum Apparatus.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	
Signature of Teacher with Date of Check	**SEAL**

Experiment No. 2

TITLE: Study of Longitudinal Vibration of Helical Spring.

AIM:

To determine the frequency or period of vibration theoretically and experimentally.

APPARATUS:

VIB-LAB apparatus with an arrangement to suspend the helical spring.

THEORY:

A *helical spring,* is a mechanical device which is typically used to store energy and subsequently release it, to absorb shock, or to maintain a force between contacting surfaces. They are made of an elastic material formed into the shape of a helix which returns to its natural length when unloaded.

DESCRIPTION OF SET-UP:

One end of the helical spring is fixed to the nut having a hole which itself is mounted on the MS strip fixed on one side of the main frame. The lower end of the spring is attached with the platform carrying the weights. The stiffness of the spring can be found out by varying the weights and by measuring the deflection of the spring. The time period of the vibrations can be calculated by measuring the number of oscillations and time taken by them.

PROCEDURE:

1. Fix one end of the helical spring to the upper screw
2. Determine the free length
3. Put some weight to platform and note down the deflection.
4. Stretch the spring through some distance and release.
5. Count the time required for say 10, 25 or 30 oscillations.

6. Determine the actual time period.

7. Repeat the experiment for different weights.

FORMULA USED:

$$\text{For theoretical value: } T_t = 2\Pi\sqrt{\left(\frac{\delta_e}{g}\right)}$$

$$\text{For experimental value: } T_e = \frac{2\Pi}{\omega_n}$$

Where, δ_e = Deflection of spring after giving load.

OBSERVATION TABLE – I

Sl. No.	Weight attached W in gm.	Deflection of spring after giving load δ_e in cm	Theoretical time period (T_e) in second	Average theoretical time period (T_t) (in second)	Theoretical frequency $f_t = 1/T_t$
1					
2					
3					

OBSERVATION TABLE: II

Sl. No.	Weight attached W in gm.	No. of Oscillations (n)	Time required for n oscillation (t) in second	Time period $T = t/n$	Average experimental time period T_e (in second)	Experimental frequency $f_e = 1/T_e$
1						
2						
3						

RESULTS:

% variation of theoretical frequency = $\{(f_t - f_e)/f_t\} \times 100\% =$

REMARKS:

Exp. No. 2	**Title:** Study of Longitudinal Vibration of Helical Spring.
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	
Signature of Teacher with Date of Check	**SEAL**

Experiment No. 3

TITLE: Torsional Pendulum (without damping).

OBJECTIVE:

To determine the mass moment of inertia of a circular disc and compare it with the calculated value.

APPARATUS:

1. Experimental circular disc as a torsional pendulum.
2. Micrometer, scale and stop watch.

PROCEDURE:

1. Measure the diameter of rod (d), radius of the disc (R) and weight of the disc.
2. Give a small angular rotation to the disc and count the number of oscillation and the time required for it which will give the value of the frequency (f).
3. Assume that the vibration is purely torsional and there is no bending of the rod while displacing the disc.
4. Repeat it for three observations and tabulate the results.

FORMULA USED:

$$\text{For experimental value: } \mathrm{I_e} = \frac{\mathrm{C.\,d^4}}{128\pi \mathrm{Lf^2}}$$

$$\text{For theoretical value: } \mathrm{I_e} = \frac{\mathrm{W.\,R^2}}{2\mathrm{g_c}}$$

Where,

C	=	Modulus of rigidity for the shaft material $= 0.8 \times 10^6$ kg/cm
d	=	Diameter of the rod (cm)
f	=	Frequency in Cycles/second
W	=	Weight of the disc $= 9.389$ kg
R	=	Radius of the disc.

OBSERVATION TABLE:

Sl. No.	No. of oscillations	Time required for it (sec)	Frequency (f) $(cycles/sec)$	Mass MOI (I_e)	Average Mass MOI (I_e)	Theoretical Mass MOI (I_t)

REMARKS:

Exp. No. 3	**Title:** Torsional Pendulum (without damping).
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	
Signature of Teacher with Date of Check	**SEAL**

Experiment No. 4

TITLE: Torsional Pendulum (with damping).

OBJECTIVE:

To determine the damping coefficient of a torsional damping system for different level of oil.

APPARATUS:

(a) Experimental circular disc us a torsional pendulum.

(b) Micrometer, scale and stop watch.

PROCEDURE:

1. Measure the diameter of the rod. (d), radius of the disc (R) and weight of the disc.
2. Give a small angular rotation to the disc which is immersed in oil and count the number of oscillations and the time required for it.
3. Assure that the vibration is purely torsional and there is no bending of the rod while displacing the disc.
4. Repeat it for three observations and tabulate the results.

FORMULA USED:

$$\text{Damping coefficient, } \mathrm{C} = 2 \times \xi \times 1 \times \omega_{\mathrm{n}}$$

$$\text{Damping factor, } \xi = \sqrt{\{1 - (\mathrm{t}/\mathrm{T})^2\}}$$

Where,

I = Mass Moment of Inertia in $\mathrm{kg.cm.s}^2$.

ω_n = Natural frequency of the system (without oil) for the same length of wire

OBSERVATION TABL – I:

Sl. No.	Number of Oscillations	Time required for n oscillations (t) in seconds without oil	Natural frequency $\omega_n = n/t$ (cycles/sec)	Experimental Mass MOI (I) $\mathrm{kg.cm.s^2}$	Time required for n oscillations (T) in seconds with oil	Damping factor ξ

RESULTS:

Damping coefficient, $\mathrm{C} = 2 \times \xi \times 1 \times \omega_n =$

REMARKS:

Exp. No. 4	**Title:** Torsional Pendulum (with damping).
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	

Signature of Teacher with Date of Check **SEAL**

Experiment No. 5

TITLE: Gyroscopic Couple.

OBJECTIVE:

To determine percentage variation of theoretical and experimental variation of gyroscopic couple

APPARATUS:

1. Motorized Gyroscope with a speed control arrangement.
2. Tachometer.

SPECIFICATION OF THE APPARATUS:

1. Mass Moment of Inertia of the spinning disc, I = 0.800 $kg.cm^2$
2. Distance of bolt centre of weight pan from disc centre, h = 20.8 cm.
3. Motor = 0.25 hp, single phase, 4000 rpm, 50 Hz, with autotransformer provided for speed regulation.

PROCEDURE:

1. Balance the rotor position on the horizontal frame.
2. Start the motor by increasing the voltage with the autotransformer and wait till the motor attains a second speed.
3. Put the weights W = 1 kg, 2 kg or 5 kg on the weight pan and start the stop watch to note time in second required for precession.
4. The speed of spin is measured by tachometer.
5. Compute the gyroscopic couple.
6. Compare the couple applied by the weights and find the percentage variation.

FORMULA USED:

Experimental gyroscopic couple, $C_e = I\omega\omega_{p\max}$

Maximum angular velocity of precession (in the forward direction)

$$\omega_{pf} = \left({\theta_f}/{t_f}\right) \times (2\pi/360^\circ)\ rad/sec$$

Maximum angular velocity of precession (in the backward direction)

$$\omega_{pr} = \left({\theta_r}/{t_f}\right) \times (2\pi/360^\circ)\ rad/sec$$

Average angular velocity of precession $w_{pavg} = \{(\omega_{pf} + \omega_{pr})/2\}\ rad/sec$

Maximum angular velocity of precession $\omega_{pmax} = 2 \times \omega_{pavg}$

Theoretical Gyroscopic couple, $C_t = W \times h$

Observation Table:

Sl. No.	ω rad/s	**W** kg	Forward angle θ_f in rad	Forward time t_f in sec	ω_{pf} rad/sec	Backward angle θ_r in rad	Backward time t_r in sec	ω_{pr} rad/sec	ω_{max}	Gyroscopic couple C_e	Theoretical gyroscopic couple C_t	% variation

REMARKS:

Exp. No. 5	**Title:** Gyroscopic Couple
Name of Student:	
Roll No.:	
Date of Experiment:	
Date of Submission:	
Signature of Teacher with Date of Check	**SEAL**