VIBRATION LABORATORY

LAB CODE: 6ME4-22

FOR III B.TECH- VI SEM –MECHANICAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

BHARTIYA INSTITUTE OF ENGINEERING & TECHNOLOGY

NEAR SANWALI CIRCLE, JAIPUR-BIKANER BYE-PASS, NH-11 PO-BAJAJ GRAM SANWALI, SIKAR, RAJASTHAN 332001

LIST OF EXPERIMENTS

1. To verify the relation of simple pendulum.
2. To determine the radius of gyration 'k' of a given compound pendulum.
3. To determine the radius of gyration of given bar by using bi-flier suspension.
4. To study the torsional vibrations of single rotor system.
5. To study the free vibration of two rotor system and to determine the natural frequency of vibration theoretically & experimentally.
6. To study the damped torsional oscillation & to determine the damping coefficient.
7. To verify the Dunkerley's Rule Viz.
8. To study the longitudinal vibration of helical spring and to determine the frequency and time period of oscillation theoretically and actually by experiment.
9. To study the undammed free vibration of equivalent spring mass system.
10. To study the forced damped vibration of equivalent spring mass system.
11. To study the forced vibration of the beam for different damping.

EXPERIMENT NO. 1

OBJECTIVE: TO VERIFY THE RELATION OF SIMPLE PENDULUM

$$T = 2\prod\sqrt{L/g}$$

Where T= Periodic time in sec.
L= Length of Pendulum in cm.

DESCRITION:

For conduction the experiment, a ball is supported by nylon thread into a chuck. It is possible to change the length of pendulum. This makes it possible to study the effect of variation of length on periodic time. A small ball may be substituted by large ball to illustrate that period of oscillating that period of oscillation is independent of the mass of ball.

UTILITIES REQUIRED:

- Pace Required : 0.90 * 1.30m
- Power supply: 220volt, single phase, 5Amp. Socket

EXPERIMENTAL PROCEDURE:

- Attach the ball to one end of the thread.
- Allow ball to oscillate and determine the periodic time T by knowing the time for say 10 oscillations.
- Repeat the experiment by changing the length.
- Complete the observation table given below.

Standard Data:

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

Formulae:

1. Time Period, T_{actual} = t/n sec.

2. Time Period, $T_{theo.}$ = $2\prod\sqrt{L/g}$ sec.

Where

T = Time taken by 'n' oscillations.

N = Nos. of oscillation.

L = Length of the pendulum.

OBSERVATION AND CALCULATION TABLE:

Sr. No.	L cm.	No. Of Osco 'n'	Time for n Osco. 'T' Sec.	T sec. (Act.) t/n	T Sec. (Theo)
1. 2. 3. 4.					

EXPERIMENT NO. 2

OBJECTIVE:

MECHANICAL VIBRATION

- TO DETERMINE THE RADIUS OF GYRATION 'K' OF A GIVEN COMPOUND PENDULUM.
- TO VERIFY THE RELATION OF COMPOUND PENDULUM.

$T = 2\prod\sqrt{(k^2 + (OG)^2 / g\,(OG))}$

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.

DESCRITION:

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

EXPERIMENTAL PROCEDURE:

- Support the rod on knife - edge.
- Note the length of suspended pendulum and determine T by knowing the time for say 10 oscillations.
- Repeat the experiment with different length of suspension.
- Complete the observation table given below.

Standard Data:

Length of compound pendulum (1) = ________ cm.

Length of compound pendulum (2) = ________ cm.

Formulae:

1. Actual time period, T_{act} = t/n
2. Actual radius of gyration, k_{act} from the equation T = $2\prod\sqrt{(k^2 + (OG)^2 / g\,(OG))}$
3. Theoretical radius of gyration, k_{Theo} = $L/2\sqrt{3}$

OBSERVATION AND CALCULATION TABLE:

Sr. No.	L cm.	OG	No. Of Osco N	Time for Osco.	T sec. act.	K act.	K Theoretical
1. 2. 3. 4.							

EXPERIMENT NO. 3

OBJECTIVE:TO DETERMINE THE RADIUS OF GYRATION OF GIVEN BAR BY USING BI-FLIER SUSPENSION

DESCRIPTION:

A uniform rectangular section bar is suspended from the pendulum support frame by two parallel cords. Top ends of the cords pass through the two small chucks fitted at the top. Other ends are secured in the Bi-Flier bar. It is possible to adjust the length of the cord by loosening the chucks.

The suspension may be used to determine the radius of gyration of any body. In this case the body under investigation is bolted to the center. Radius of gyration of the combined bar and body is then determined.

EXPERIMENTAL PROCEDURE:

- Suspend the bar from chuck, and adjust the length of the cord 'L' conveniently. Note the suspension length of each cord must be same.
- Allow the bar to oscillate about the vertical axis passing through center and measure the periodic time T by knowing the time for say 10 oscillations.
- Repeat the experiment by mounting the weights at equal distance from center.
- Complete the observation table given below.

Standard Data:

Distance between the 2 cords (2a) = 46cm.

1. Actual time period, T_{act} = t/n sec.
2. Actual radius of gyration, k_{act} from equation

$$T = 2\prod k/a\sqrt{L/g}$$

3. Theoretical radius of gyration, k Theo = $L/2\sqrt{3}$

Where

N = nos. of oscillation

T = time taken by 'n' oscillation

L = length of the suspended string

2a = distance between the two string

g = acceleration due to gravity

k = radius of gyration of Bi-Flier suspension.

OBSERVATION AND CALCULATION TABLE:

Sr. No.	L cm.	2a cm.	No. Of Oscial	Time of Oscial.	$T_{act.}$	$k_{act.}$	k_{Theo}
1.							
2.							
3.							
4.							

EXPERIMENT NO. 4

OBJECTIVE:TO STUDY THE TORSIONAL VIBRATIONS OF SINGLE ROTOR SYSTEM.

DESCRIPTION:

In this experiment 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 the shaft can be clamped at any convenient position along beam. Thus length of the shaft can be varied during the experiments. The ball bearing housing is fixed to side member of the main frame.

EXPERIMENTAL PROCEDURE:

- Fix the bracket at convenient position along the lower beam.
- Grip one end of the shaft at the bracket by chuck.
- Fix the rotor on the outer end of the shaft.
- Twist the rotor through some angle and release.
- Note down the time required for 10, 10 oscillations.
- Repeat the procedure for the different length of shaft.

Standard Data:

a). Shaft Dia. = 3mm

b). Dia. of Disc, D = 190mm

c) Wt. of the Disc, w = 2.1kg.

d) Modulus of rigidity for Shaft = 0.8×10^6 Kg/Cm^2

e) Acceleration due to gravity, g = 9.81 m/s^2

1). Torsional stiffiness,k1 = GI_p/L

2). Theoretical Time period, $T_{Theo} = 2\pi\sqrt{I/kt}$

3). Moment of inertia of disc,$I = w/g*d^2/8$

4). Actual time period, T exp = t/n

5).Theoretical Frequency,$f_{theo} = 1/T_{theo}$

6). Actual frequency, $f_{Exp} = 1/T_{exp}$

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Where

L = Length of shaft

Lp = Polar M.L.of shaft = $d^4/32$

D = Dia. Of shaft.

G = Modulus of rigidity of shaft = 0.8×10^6 Kg/Cm^2

W = Weight of the disc in Kg

D = Diameter of disc.

OBSERVATION TALE:

Sr. No.	Length of shaft-L cm.	No. of Osco. N	Time for n osco. T sec	Periodic time T = t/n(act.)
1. 2. 3. 4.				

CALCULATION TABLE:

Sr. No.	Length of shaft cm.	K_t	$T_{Theo.}$ sec	$T_{act.}$ sec	$F_{Theo.}$ hz	$F_{act.}$ hz

1. 2. 3. 4.						

EXPERIMENT NO. 5

OBJECTIVE:TO STUDY THE FREE VIBRATION OF TWO ROTOR SYSTEM AND TO DETERMINE THE NATURAL FREQUENCY OF VIBRATION THEORETICALLY & EXPERIMENTALLY.

DESCRITION:

In this experiment two discs having different mass moments of inertia are clamped one at each of the shaft by means of collect and chucks. Attaching the cross lever weights can changed Mass moment of inertia of an disc. Both discs are free to oscillate in ball bearing. This provides negligible damping during experiment.

EXPERIMENTAL PROCEDURE:

. Fix two discs to the shaft and fit the shaft in bearing.
. Deflect the disc in opposite direction by hand and release.
. Note down the required for particular number of oscillations.
. Fit the cross arm to one of the discs says B and again notr down the time.
. Repeat the procedure with different equal masses attached to the ends of cross arm and note down the time.

Standard Data

1.Dia. Of Disc A = 225 mm
2. Dia. Of Disc B = 190 mm
3. Weight of Disc A = 2.5 kg
4. Weight of Disc B = 2.1 kg
5. Length of Cross Arm = 150mm
6. Dia. of Shaft = 3mm
7. Length of shaft between Rotors –L = 957 mm

FORMULAE:

1). Torsional stiffness, k_1 = GIP/L

2). Polar moment of inertia, Imp = $\prod d^4/32$

3). Moment of inertia of disc A, $I_A = W_A/g*D^2_A/8$

4). Moment of inertia of disc B, IB = $W_B/g*D^2_B/8+2W_1/g*R^2/8$

5). Therotical Time period , $T_{theo} = 2\prod\sqrt{}I_A X I_B/kt(I_A+I_B)$ sec

6). Actual Time period, T_{ext} = t/n sec

7). Therotical frequency, $f_{theo} = 1/_{Theo}$ Hz

8). Actual frequency, $f_{exp} = 1/T_{exp}$ Hz

where

G = modulusof rigidity of shaft = $0.8*10^6 Kg/cm^2$

I_A = M.I of disc A

I_B = M.I of disc B

d = shaft dia

L = length of the shaft

W_1 = weight attached to the cross arm

R = radius of the fixation of wheight on the arm

Sample Calculation

OBSERVATION TABLE:

Sr. No.	No. of oscillations N	Time for n Osco. 'T' Sec.	Weight Attached (kg)	Radius of weight (cm)	I_a	I_b	T act. t/n sec.
1. 2. 3. 4.							

CALCULATION TABLE:

Sr. No.	I_a kg cm^2	I_a kg cm^2	T_{Theo} sec.	F_{Theo} hz	T_{exit} sec.	F_{exit} sec.
1. 2. 3. 4.						

EXPERIMENT NO 6

OBJECTIVE:TO STUDY THE DAMPED TORSIONAL OSCILLATION & TO DETERMINE THE DAMPING COEFFICIENT.

OBJECTIVE

DESCRIPTION:

This experiment consists of a long elastic shaft gripped at the upper end by chuck in the bracket. The bracket in clamped toupper beam of the main frame. A heavy steel flywheel clamped at the lower end of the shaft suspended from bracket. Damping drum in fixed to the lower face of the flywheel. This drum is immersed in water, which provides damping. Rotor can be taken up and down for varying the depth of immersion of damping drum.
Recording drum in mounted to the upper face of the flywheel. Paper is to be wrapped around the recording drum in mounted to the upper face of the flywheel. Paper is to be wrapped around the recording drum. Oscillations are recorded on paper with the help of specially designed piston of dashpot. this piston carries the attachment for fixing sketch pen.

EXPERIMENTAL PROCEDURE:

. With no water in the container allow the flywheel to oscillation & measure the time for say 10 oscillations.

. Put thin mineral oil(no. 10 or 20) in the drum and note the depth of immersion.

. Put the sketch pen in its bracket.

. Allow the flywheel to vibrate.

. Allow the pen to descend. See that the pen always makes contact with paper & record oscillation.

. Determine i.e. amplitude at any position & Entry. amplitude after 'r' cycle.

.After complete the experiment drain the water.

STANDARD DATA:

G = Modulus of rigidity of shaft = 0.8×10^6 kg/Cm^2

d = Shaft dia. = 3 mm

l = Length of suspension of shaft Cm.

W = Weight of disc. 9.500 Kg.

D = Dia. Of disc = 25 cm.

FORMULAE

1). Torsional stiffness, k1 = GIp/L

2). polar moment of inertia of shaft Ip = $\prod d^4/32$

3). Time period, T (act) = t/n

4). Time period, T (tho) = $2\prod\sqrt{I/K_1}$

5). Moment of inertia of fly wheel, I = $W/G*D^2/8$

6). Critical damping factor, Ctc = $2W/g\sqrt{k_t/I}$

7). Logarithmic decrement, = 1/r $\log_e$ [Xn/Xntr]

Where

T = Periodic time of oscillation.
Xn = Amplitude of Vibe . At the beginning of measurement to be found for record.
Xntr. Amplitude of Vib. After 'r' cycles for record.

Sample Calculation

OBSERVATION AND CALCULTION TABLE:

Sr. No.	Length of suspension of shaft - cm	Xn (cm.)	Xntr (cm.)	No. of cycles(r)	No. of 'n' oscillations	Time of 'n' oscillations

1. 2. 3. 4.						

Sr. No.	Kt	T act.	T tho.	ctc		Damping co-efficient, C_t
1. 2. 3. 4.						

EXPERIMENT NO 7

OBJECTIVE:TO VERIFY THE DUNKERLEY'S RULE VIZ.

$1/F^2 = 1/F^2_l+1/F^2_b$

Where:-

F = Natural frequency of given beam (considering the weight of beam) with central load W.

F_L = Natural frequency of given beam (neglecting the weight of beam) with central load W.

$F_L = ½π√48E.I.g/L^3W$

F_{ib} = Natural frequency of the beam.

DESCRIPTION

At rectangular bar is supported in trunion fitting at each end. Each trunion is provided in a ball bearing carried in housing. Each bearing housing is fixed to the vertical frame member. The beam carries at its center a weight platform.

Experimental Procedure:

. Arrange the set – up as shown in fig 10 with some wt. W clamped to wt platform.
. Pull the platform & release it to set the system in to natural vibrations.
. Find periodic time T & frequency of vibration F by measuring time for some oscillations.
. Repeat experiment by putting additional masses on weight platform.
. Plot graph of $1/F^2$ Vs. W.

Standard Data:

1. Length of Beam = L=105.5 cm.
2. Weight per cm of the beam = W/L
3. section of the beam = Small – 2.2 x 0.6 cm.
4. weight of the beam = Small – 1.26 Kg

Formulae:

1. Frequency of beam F_L = $½π√48E.I.g/L^3W$

2. Natural frequency of the beam, F_b =$2π√g.E.I/WL^4$

3. Moment of inertia os beam section, I = $bh^3/12$

4. Actual Time Period, T_{act} = t/n

5. Actual frequency, f_{acts} = $1/ T_{act}$

where

w = weight os beam per unit length = 0.0119 kg/cm

E = Central load of the beam, OR weight attached.

L = Length of the beam.

B = width of beam

H = thickness of beam

OBSERVATION AND CALCULATION TABLE:

Sr. No.	Wt. attached	No. of osc n	Time for n Osc, 't'	T act = t/n (sec)	Frequency Fact hz	F	T act. t/n sec.
1.							
2.							
3.							
4.							

EXPERIMENT NO.8

OBJECTIVE: TO STUDY THE LONGITUDINAL VIBRATION OF HELICAL SPRING AND TO DETERMINE THE FREQUENCY AND TIME PERIOD OF OSCILLATION THEORETICALLY AND ACTUALLY BY EXPERIMENT.

DESCRIPTION:

One end of open coil spring is fixed to the nut having a hole with itself is mounted on a MS strip fixed on one side of the main frame. The lower end of the spring is attached to the platform carrying the weights. The stiffness of the spring can be find out by varying the weight on the platform and by measuring the nos. of oscillation and time taken by them.

EXPERIMENTAL PROCEDURE:

. Fix one end of the helical spring to upper screw.
. Determine free length.
. Put some weight to platform and note down the deflection.
. Stretch the spring through some distance and release.
. Count the time required in Sec. for say 10,20 oscillations.
. Determine the actual period.
. Repeat the procedure for different weights.

Standard Data.

1) Weights = 0.5 Kg and 1.0 kg (One each)
2) g = 9.81 m/Sec ^{2}

Formulae :

1). Stiffness, k = w/delta kg/cm

2). Mean stiffness, $k_m = k_1+k_2+k_3/3$ kg/cm

3). Theoretical time period, $T_{theo} = 2\pi\sqrt{W/k_m g}$

4). Theoretical frequency, $f_{theo} = 1/T_{theo}$ Hz

5). Actual time period, T act = t/n sec

6). Actual frequency, $f_{act} = 1/T_{act}$ Hz

Where:

K	=	Stiffness of the spring
W	=	Weight applied
K m	=	Mean Stiffness.
G	=	Acceleration due to gravity = 9.81 m/S^2
N	=	No. of oscillations.
T	=	Time taken by 'n' oscillation

OBSERVATION & CALCULATION TABLE-1

S.NO	Wt.Attached w kg	Deflection in spring	Stiffness k	Mean stiffness

OBSERVATION & CALCULATION TABLE – 2

S.NO	WT.ATTACHED W	NO.	TIME	T theo	T expt	F theo	F expt

	Kg	OF OSC	REQD FOR N OSC	(sec)	(sec)	(Hz)	(Hz)

EXPERIMENT NO 9

OBJECTIVE: TO STUDY THE UNDAMPED FREE VIBRATION OF EQUIVALENT SPRING MASS SYSTEM.

DESCRIPTION:

MECHANICAL VIBRATION

The equipment is designed to study free damped and undamped vibration. It consists of M.S rectangular beam supported at one end by a tunion pivoted in ball bearing. The bearing housing is fixed to the side member of the frame. The other end of beam is supported by the lower end of helical spring, upper end of the spring is attached to screw, which engage with screwed hand wheel. The screw can be adjusted vertically in any convenient position and can be clamped with the help of lock nut.

The exciter unit can be mounted at any position along the beam. Additional known weights may be added to the weight platform under side exciter .

EXPERIMENTAL PROCEDURE :

. Support one end of beam in the slot of trunion and clamp it by means of screw.

. Attached the other end of the beam to lower end of spring.

. Adjust the screw to which the spring is attached with the help of hand wheel such that beam is horizontal is position .

. Weight the exciter assembly along with discs, bearing and weights platform.

. Clamp the assembly at any convenient position.

. Measure the distance L1 of the assembly from pivot. Allow system to vibrate freely.

. Measure the time for any 10 oscillation and periodic time and natural frequency of vibration.

. Repeat the experiment by varying L1 and also putting different weights on platform.

Standard Data

W	=	18.5kg.
w	=	0.5kg and 1.0kg(one each)
k	=	5kg/cm
L	=	93.5 cm.
g	=	9.81 m / sec^2

Weight of weight pan : 1 kg

Other weight : 0.5kg , 1 kg

Formulae

1). Time period, $t = 2\prod\sqrt{me/k}$

2). Equivalent mass at the spring, $me = m\ [L_1^2/L_2]$

3). m = W+w/g

4). Actual time period, Tact = t/n

Where

W = Weight of exciter assembly along with wt. Platform = 18.5 kg.

w = Weight attached on exciter assembly.

L1 = Distance of w from pivot.

k = Stiffness of spring = 5 kg/cm.

L = Distance of spring from pivot = Length of beam = 93.5 cm.

g = 9.81 m / sec^2

OBSERVATION & CALCULATION TABLE:

Wt (kg)	LI (cm)	No. of osc	Time for n osc	T act= t/n	Freq	T_{theo}	F_{theo}

EXPERIMENT NO. 10

OBJECTIVE: TO STUDY THE FORCED DAMPED VIBRATION OF EQUIVALENT SPRING MASS SYSTEM

DESCRIPTION:-

It is similar to that described for expt. no. 9. The exciter unit is coupled to D.C. variable speed motor. RPM of motor can be varied with the speed control unit. Speed of rotation can known from the RPM indicator on the control panel. It is necessary to connect damper unit to the exciter. Amplitude of vibration can be recorded on strip chart recorder.

DAMPING ARRANGEMENT:-

- Close the one hole of the damper for light damping.
- Close the two holes of the damper for medium damping.
- Close all the three holes of damper for heavy damping.

EXPERIMENTAL PROCEDURE:-

- Arrange the set-up as described in expt. no.9.
- Start the motor and allow the system to vibrate.
- wait for 1 to 2 minutes for amplitude to build the particular forcing frequency.
- Adjust the position of strip chart recorder. Take the recorder of amplitude v_s. time on strip chart recorder by starting recorder motor. Press recorder platform on the pen gently. pen should be wet with ink. Avoid excessive pressure to get good result.
- Take record by changing forces frequencies.
- Repeat the experiment by adjusting the holes on the piston of damper can change different damping.
- Plot the graph of amplitude v_s. frequency for each damping condition.

OBSERVATION TABLE:-

FORCING FREQUENCY (Hz)	AMPLITUDE (mm)

EXPERIMENT NO. 11

OBJECTIVE:TO STUDY THE FORCED VIBRATION OF THE BEAM FOR DIFFERENT DAMPING.

DESCRIPTION:-

In this experiment a slightly heavy rectangular section bar than used in expt. no. 10 is supported at both ends in trunion fittings. Exciter unit with the weight platform can be clamped at any conventional position along the beam. Exciter unit is considered to the damper, which provides the necessary damping.

DAMPING ARRANGEMENT:-

- Close the one hole of the damper for light damping.
- Close the two holes of the damper for medium damping.
- Close all the three holes of damper for heavy damping.

EXPERIMENTAL PROCEDURE:-

- Arrange the set-up as shown in fig 11.
- Connect the exciter motor to control panel.
- Start the motor and allow the system to vibrate.
- Wait for 5 minutes for amplitude to build up for particular forcing frequency.
- Adjust the position of the strip chart recorder. Take the recorder of amplitude v_s. time on strip chart recorder by starting recoeder motor.
- Take record by changing forcing frequency for each damping.
- Repeat the experiment for different damping.
- Plot the graph of amplitude v_s frequency for each damping.

OBSERVATION TABLE:-

FORCING FREQUENCY (Hz)	AMPLITUDE (mm)