MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT
(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
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DEPARTMENT MECHANICAL ENGINEERING

KINEMATICS AND DYNAMICS OF MACHINERY LAB MANUAL

SUBJECT NAME	**Kinematics and Dynamics of Machinery Lab**
SUBJECT CODE	**2050378**
COURSE-BRANCH	**B. Tech - Mechanical Engineering**
YEAR-SEMESTER	**III - I**
ACADEMIC YEAR	**2022-2023**
REGULATION	**MLRS-R20**

MARRI LAXAMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT

MISSION AND VISION OF THE INSTITUTE:

Our Vision:

To establish as an ideal academic institutions in the service of the nation the world and the humanity by graduating talented engineers to be ethically strong globally competent by conducting high quality research, developing breakthrough technologies and disseminating and preserving technical knowledge.

Our Mission:

To fulfill the promised vision through the following strategic characteristics and aspirations:

- Contemporary and rigorous educational experiences that develop the engineers and managers;
- An atmosphere that facilitates personal commitment to the educational success of students in an environment that values diversity and community;
- Prudent and accountable resource management;
- Undergraduate programs that integrate global awareness, communication skills and team building across the curriculum;
- Leadership and service to meet society's needs;
- Education and research partnerships with colleges, universities, and industries to graduate education and training that prepares students for interdisciplinary engineering research and advanced problem solving;
- Highly successful alumni who contribute to the profession in the global society.

Vision and Mission statements of the Department of Mechanical Engineering:

Vision Statement:

"The Mechanical Engineering Department strives immense success in the field of education, research and development by nurturing the budding minds of young engineers inventing sets of new designs and new products which may be envisaged as the modalities to bring about a green future for humanity"

Mission Statement:

1. Equipping the students with manifold technical knowledge to make them efficient and independent thinkers and designers in national and international arena.
2. Encouraging students and faculties to be creative and to develop analytical abilities and efficiency in applying theories into practice, to develop and disseminate new knowledge.

3. Pursuing collaborative work in research and development organizations, industrial enterprises, Research and academic institutions of national and international, to introduce new knowledge and methods in engineering teaching and research in order to orient young minds towards industrial development.

PROGRAM EDUCATIONAL OBJECTIVE

PEO 1: Graduates shall have knowledge and skills to succeed as Mechanical engineer's for their career development.

PEO 2: Graduates will explore in research.

PEO 3: Mechanical Graduates shall have the ability to design products with various interdisciplinary skills

PEO 4: Graduates will serve the society with their professional skills

PROGRAM OUTCOMES

- **A.** Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization for the solution of complex engineering problems.
- **B.** Problem Analysis: Identify, formulate, research, review the available literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural science and engineering sciences.
- **C.** Design and development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specific needs with appropriate considerations for public health safety and cultural, societal and environmental considerations.
- **D.** 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.
- **E.** Modern tool usage: Create, select and apply appropriate techniques, resources and modern engineering and IT tools including predictions and modeling to complex engineering activities with an understanding of the limitations.
- **F.** 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 practices.
- **G.** Environment and sustainability: Understand the impact of the professional engineering solutions in society and environmental context and demonstrate the knowledge of and need for sustainable development.
- **H.** Ethics: Apply ethical principles and commitment to professional ethics, responsibilities and norms of the engineering practice.
- **I.** Individual and team work: Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings.
- **J.** Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend, write effective reports, design documentation, make effective presentations, give and receive clear instructions.
- **K.** 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.
- **L.** Life – long learning: Recognize the need and have the preparation, ability to engage in independent and life – long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES:

PS01: Students acquire necessary technical skills in mechanical engineering that make them employable graduate.

PSO2: An ability to impart technological inputs towards development of society by becoming an entrepreneur.

COURSE OBJECTIVES:

1. To impart the knowledge of basic concepts on kinematics and dynamics of mechanical elements.
2. To illustrate the effect of gyroscope for different motions.
3. To Impart the knowledge of various Governors.
4. To facilitate the students to know the concepts of balancing of rotating masses and reciprocating masses.
5. To introduce mathematical models and solution methods to study torsional vibration.

COURSE OUTCOMES:

ME 378.1 Understand types of motion.

ME 378.2 Analyze forces and torque of components in linkages.

ME 378.3 Understand forward and inverse kinematics of open loop mechanism.

ME 378.4 Illustrate how to balance forces and moments produced by machine members.

ME 378.5 Understand concept of whirling of shafts to determine critical speed.

ME 378.6 Illustrate various governors, cam and followers.

INSTRUCTIONS TO THE STUDENTS

1. Every student should obtain a copy of the laboratory manual
2. It is important that all students arrive at each session on time.
3. Dress code: Students must come to the laboratory wearing:
    - Trousers.
    - half-sleeve tops.
    - Leather shoes.
    - Half pants, loosely hanging garments and slippers are not allowed.
4. Students should come with thorough preparation for the experiment to be conducted.
5. Students will not be permitted to attend the laboratory unless they bring the practical record fully completed in all respects pertaining to the experiment conducted in the previous class.
6. Experiment should be started only after the staff-in-charge has checked the experimental setup.
7. All the calculations should be made in the observation book. Specimen calculations for one set of readings have to be shown in the practical record.
8. Wherever graphs are to be drawn, A-4 size graphs only should be used and the same should be firmly attached to the practical record.
9. Practical record and observation should be neatly maintained.
10. They should obtain the signature of the staff-in-charge in the observation book after completing each experiment.
11. Theory regarding each experiment should be written in the practical record before procedure in your own words.

LABORATORY SAFETY PRECAUTIONS

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

LIST OF EXPERIMENTS

1. To determine the state of balance of machines for primary and secondary forces.
2. To determine the frequency of torsional vibration of a given rod.
3. Determine the effect of varying mass on the centre of sleeve in porter and proell governor.
4. Find the motion of the follower if the given profile of the cam.
5. The balance masses statically and dynamically for single rotating mass systems.
6. Determine the critical speed of a given shaft for different n-conditions.
7. For a simple pendulum determine time period and its natural frequency.
8. For a compound pendulum determine time period and its natural frequency.
9. Determine the effect of gyroscope for different motions
10. Determine time period, amplitude and frequency of un damped free longitudinal vibration of single degree spring mass systems.
11. Determine the pressure distribution of lubricating oil at various load and speed of a Journal bearing.
12. Determine time period, amplitude and frequency of damped free longitudinal vibration of single degree spring mass systems.

1.To determine the state of balance of machines for primary and secondary forces

KIMEMATICS AND DYNAMICS LAB

Experiment no:1

To determine the state of balance of machines for primary and secondary forces

Aim:

To study the balancing of primary and secondary forces in reciprocating masses.

Apparatus required: Reciprocating balancing system, weights, etc.

Description:

This experiment set up is simple apparatus solely designed and developed for studying the effect of unbalance on any reciprocating mass. The unit has 4-cylinders in line prototype engine crank shaft model and is suspended by 2 sturdy chains, so that unbalance of primary forces and couples can be observed by vibrations produced on the system.

The crank shaft, connecting rod and piston assembly is constructed in four sections and the whole assembly is driven by FHP AC/DC variable speed electric motor. Each crank assembly section carries a single crank pin, which can be rotated relative to adjacent angles and locked into position by locknut. Thus whatever crank angles are set, the assembly remains substantially balanced for rotating effects.

Ball bearings support the crank shaft , which is coupled to a electric motor by rubber belt and pulley system. The unbalance is observed in the form of vibrations of the frame.

A balancing weight is attached to the main frame and is acting as counter balance to the weight of drive motor. A belt and pulley system is used to rotate the crank assembly. Proviso is made to add weights on piston to change its weight.

Specifications:

1. A 4-cylinders in line prototype engine.
2. Connecting rod length 80mm, radius 30mm
3. Stroke length 50mm
4. AC/DC motor, variable speed of $1/6^{th}$ HP capacity 5000 rpm 230V AC.
5. Support frame no.1 made from thick MS angle and channel-for suspending the main frame assembly.
6. Main frame no-2 made from thick MS flat with crankshaft, connecting rod and piston assembly.
7. Control panel consisting of on/off switch and open type dimmerstat- 2 Amp capacity dimmer is provided to vary the speed as required.
8. 2MS chain links are provided to suspended the main frame.

PROCEDURE:

1. Select any four cylinders and fit known weights.
2. Take any one cylinder as reference and measure the distance from the cylinder.
3. Now after finding the W (weight),R(radius),L(length) values fill the observation table and draw the couple polygon by considering any one cylinder in horizontal position out of three cylinders.
4. From the couple polygon find out the crank angle of cylinder 2,3 and 4.
5. Draw force (W*R) polygon by knowing the angles of cylinders 2,3 &4. From this force polygon you will get the angle of cylinder-1.

6. Plot the space diagram for angular positions of cylinders 1,2,3,&4.
7. As per the crank angles fix the crank pin positions and lock it firmly with the lock nut. Use the setting gauge to support the central disc while locking it.
8. After locking of crankpin is over remove the setting gauge, before starting the experiment.
9. Ensure that the pistons are freely reciprocating in the cylinders by rotating the crankshaft manually. There should not be any tightness of piston in the cylinder, it should reciprocate freely in cylinder without any effort.
10. Now, gradually increase the speed with the help of speed controller up to you observe minimum vibrations of the frame no-1. This condition is dynamic balancing of reciprocating masses.
11. Note down the speed for this particular minimum vibration condition.
12. After the speed is noted, bring the dimmer position to zero and stop the motor. Remove any one weight attached and observe the unbalanced produced on the system at the noted speed.
13. Now, disturb any one crank angle position and relock it by locknut firmly. Due to this change in angular position, you can observe the unbalance produced in the system for that particular speed.
14. The crank angles are set to random values in order to observe the vibrations of the system due to unbalanced forces and couples. After checking that all crankshafts locking nuts have been adequately tightened, the motor should be started and the speed slowly increased.
15. Tests my be repeated with the additional weights fitted to one or more pistons, and the crank angles necessary for balance determined by calculation and experiment.

Observations:

Data:

- Weight of reciprocating parts=1.05kg
- Crank radius R=3cm
- Weight set : round weights
  30gms
  50gms
  80gms

Dynamic balancing:

Cylinder no	Basic weight Kg	Weight added Kg	Total weight Kg
1			
2			
3			
4			

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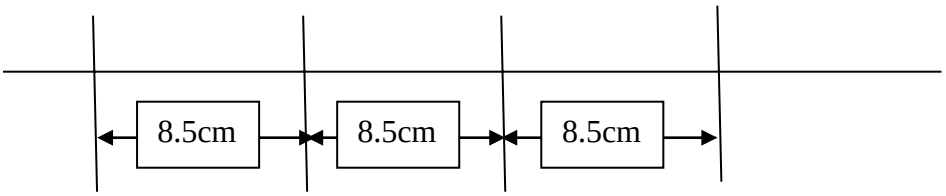
Distance:



Couple chart:

Cylinder no	Total weight Kg	Distance from unknown weight cm	Couple Kg-cm	Angle found

Couple polygon:

Force polygon:

Arrangement chart:

Cylinder no	Total weight Kg	Distance from unknown weight cm	Angle found

Precautions:

1. Operate the speed controller gradually.
2. Do not increase the speed beyond the limit 350rpm.
3. Do not allow the system to vibrate more.
4. While fitting the crankpin fit it properly by seeing the angle.

Result:

Viva voce:

1. What is the force required to accelerate the reciprocating mass in slider crank mechanism?
2. What is the acceleration of reciprocating mass in slider crank mechanism?
3. What is the maximum value of primary force?
4. What is the maximum value of secondary force?
5. Define swaying couple?
6. Define hammer blow with respect to locomotives?
7. What are the effect of hammer blow and swaying couple?
8. What are the different types of balancing machines?
9. List the effect of partial balancing of locomotives?
10. Why are the crank of a locomotive with two cylinders placed in 90^0 to each other?

11.How can one balance primary forces?
12.How can one balance secondary forces?
13.What is the different between primary and secondary forces? 14.Different between static and dynamic forces?
15.Why is dynamic balancing important? 16.What is a vibration?
17. What is couple?
18. How are balancing of rotating mass different from balancing of reciprocating mass?
19.What is the significance of coriolis component of acceleration, is does it have effect in this experiment?

2.To determine the frequency of torsional vibration of a given rod

Experiment-2

TO DETERMINE THE FREQUENCY OF TORSIONAL VIBRATION OF A GIVEN ROD

Aim: To determine the natural frequency of torsional vibration of a given rod theoretically and Experimentally in a two rotor system.

Equipment: Shaft, two rotor disc, chuck, stop watch.

Procedure of Experiment:

1. Fix two disc of the shaft and fit the shaft in the bearing.
2. Deflect the disc in opposite direction by hand and then release.
3. Note down the time required for particular number of oscillations.
4. Fit cross arm to one end of the disc and again note down the time.
5. Repeat the procedure with different and equal masses attached to the ends of cross arm and note down the time.

Observation:

Dia of disc A=D_A=225mm
Dia of disc B=D_B=190mm
Wt of disc A= W_A=3.2kg
Wt of disc B= W_B=2.22kg
Length of the cross arm 110 and 160mm respectively
Dia of shaft= 3mm
Length of the shaft between rotors=L

Sr.no	No of oscillations	Time reqd. for „n“ oscillations	T_{expt} = t/n

Calculation:

I_p = pollar moment of inertia of the shaft= πd4/32

I_A = moment of inertia of disc A= $W_aD_a^2/8g$
I_B = moment of inertia of disc B= $W_BD_B^2/8g$

$$Kt = GI_p/L$$

Kt= Torsional stiffness of shaft
G= Modulus of rigidity of the shaft g=0.8*10^6 kg/cm^2
L= length of shaft

$$T_{THEO} = 2\pi \sqrt{((IA * IB)/Kt(IA + IB))}$$

Determine:

T_{expt} = time for n sec/ no of oscillation „n‟=

$F_{theoritical} = 1/T_{Theo}$ =

$F_{expe} = 1/T_{expt}$ =

I_A Kg/cm^2	I_B Kg/cm^2	T_{theo}Sec	F_{theo} CPS	T_{EXPT} Sec	F_{expt}CPS

Observation:

Observations are to taken for steel shafts.

Result:

The natural frequency of the torsional vibration in two rotor system is---------- Hz

Conclusion:

It is studied to determine the natural frequency of vibration of the given shaft. It is necessary to find out the natural frequency, so that during working resonance will be taken care of.

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TO DETERMINE NATURAL FREQUENCY OF TORSIONAL VIBRATION IN SINGLE ROTOR SYSTEM.

Aim: To determine the natural frequency of torsional vibration of a given rod theoretically and Experimentally in a single rotor system.

Equipment: Vibration machine, Shaft, chuck, stop watch.

Formula Used:

$$Tth = 2\pi\sqrt{I/Kt}$$

Procedure:

1. Fix the bracket at convenient position along the tower beam.
2. Grip one end of the shaft at bracket by the chuck.
3. Fix other end of shaft in the rotor.
4. Twist the motor rotor to some angle and then release.
5. Note down the time for no. of oscillations.
6. Repeat the procedure for different length of shaft.

Observation:

Observations are to taken for mild steel brass shafts.

Shaft dia=d= 3mm
Dia of Disc = D = 225mm
Wt. of the Disc =W= 3.120kg
G= Modulus of rigidityof the shaft $G=0.8*10^6$ kG/cm^2

Sr.no	Length of the shaft L cm	No fo oscillations n	Time for n osc Sec T	Periodic time $T_{expt}=t/n$

Calculation:

I_p = pollar moment of inertia of the shaft= $\pi d4/32$
I = moment of inertia of disc = $WD^2/8g$

Kt= Torsional stiffness of shaft

$Kt= GI_p/L$

$$Tth = 2\pi\sqrt{I/Kt}$$

Determine:
T_{expt} = time for n sec/ no of oscillation „n"=
$F_{theoritical} = 1/T_{Theo}$ =
$F_{expe} = 1/T_{expt}$ =

Sr.no	Length of shaft L	Kt	T_{theo} sec	T_{EXPT} Sec	F_{theo}CPS	F_{expt}CPS

Result:
The natural frequency of the torsional vibration in single rotor system is----------
---Hz

Conclusion:
Natural frequency of torsional vibration experimental to theoretical is nearly same.

Viva voce:

1. What do you mean by mechanical vibration? What are the three types of free vibrations generally observed?
2. Difference between longitudinal and transverse vibrations?
3. What do you mean by natural frequency of vibrations?
4. What are the different end fixing conditions generally for rotating shafts?
5. How do you achieve the hinged end conditions for a rotating shaft?
6. What is whirling speed of rotation for a shaft?
7. Why does the whirling of shaft occurs?
8. What are the nodes observed while studying whirling phenomenon?
9. Why it is necessary to pass the first node speed range quickly and increase the speed further to observe the second node?
10. What is the effect of end conditions, size of the shaft on whirling speed of the shaft?
11. How does the material of the shaft affects the whirling speed?
12. How to prevent the whirling of shaft in operation?
13. What is the formula for tensional stiffness of shaft?
14. What is mean by forced vibration?
15. What is free vibration?
16. What is critical speed?
17. Explain dynamic analysis?
18. Explain static analysis?
19. Write the expression for critical speed of shaft?
20. Give some example for torsional system?
21. What is the use of bearing?
22. Differentiate the speed and whirling speed?
23. What is the use of bearing in rotating shaft condition?
24. What is the use of shaft in I.C engine?
25. What are the terms used in vibration?

3. Determine the effect of varying mass on the centre of sleeve in porter and proell governor

Experiment-3

DETERMINE THE EFFECT OF VARYING MASS ON THE CENTRE OF SLEEVE IN PORTER AND PROELL GOVERNOR

AIM :-To perform experiment on Porter and Proell Governors to prepare performance characteristic Curves, and to find stability & sensitivity.

APPARATUS USED:-Porter Governors.

SPECIFICATIONS:-

1. Electric Motor : DC Motor, Capacity - ¼ hp, 1500rpm speed, Single Phase, 230 V AC.
2. Dimmerstat – 2 Amp., DC Type – for controlling the speed.

3. Separate linkages with balls are provided for Watt & Porter type governor and proell governor mechanism.

INTRODUCTION &THEORY :-

The function of a governor is to regulate the mean speed of an engine, when there are variations in the load e.g. when the load on an engine increases, its speed decreases, therefore it becomes necessary to increase the supply of working fluid. When the load on the engine decreases, its speed increases and thus less working fluid is required. The governor automatically controls the supply of working fluid to the engine with the varying load conditions and keeps the mean speed within certain limits.

The governors may, broadly, be classified as
1. Centrifugal governor
2. Inertia governor

PROCEDURE :-

The Governor mechanism as desired, to be tested is fitted with the chosen weights and spring, where applicable, to the spindle shaft. Ensure that the nut & bolts of all the moving parts and of the spindle shaft are properly tightened. Then following simple procedure is to be followed.

1. Keep the knob of the dimmerstat in zero position before switching on the main supply.

2. Switch on the main supply and gradually go on increasing the speed of the motor. Due to this the center sleeve rises from the lower stop aligning with the marking on the scale. This is initial lift of the sleeve.
3. Note down the readings of the sleeve position and speed for this initial lift. Speed of the motor is to be measured by hand tachometer, from the counter hole provided on the spindle.
4. Then increase the speed in steps to give suitable sleeve movement and note down the readings of sleeve displacement and the corresponding speed. All the readings are to be entered in a tabular observation table.
5. This procedure is adopted for all the other Governor mechanisms by properly fitting the assembly to the spindle shaft.
6. After completing the experiment bring the knob of the dimmerstat to its original position i.e. zero slowly and gradually. Then switch off the main supply.
7. Then the results may be plotted as.

a) The graph of speed v/s sleeve displacement for Porter & ProellGovernor.
b) Plot the graph of centrifugal force V/s radius of the governor.

SERVICES REQUIRED:-

Earthed A.C. Single Phase, Stabilised Electric Supply, 230V, 50Hz, as standard supply.

Porter Governor :-

Arrange the set-up as shown in bellow Fig. by using the proper linkages & weights provided. Tighten the bolts and nuts properly. The assembly is ready for conducting the experiment. Now follow experimental procedure as mentioned above.

Go on increasing the speed gradually and take the readings of speed of rotation `N` and corresponding sleeve displacement `X`.

Dimensions

a) Length of each link - L = m.

b) Initial height of Governor – ho = m.

c) Initial radius of rotation – ro = m.

d) Weight of each ball - W = kgs.

e) Weight of Sleeve weight = kgs. – 4 Nos.

Radius of rotation `r` at any position could be found as follows

a) Find height h = ho – X/2 mtr.

b) Find " α " by using $\alpha = \text{Cos}^{-1}(h/L)$ in Degrees

c) Then r = 0.055 + L Sin α mtr.

d) Angular Velocity 'ω' = $2\pi N/60$ rad/sec

OBSERVATION TABLE

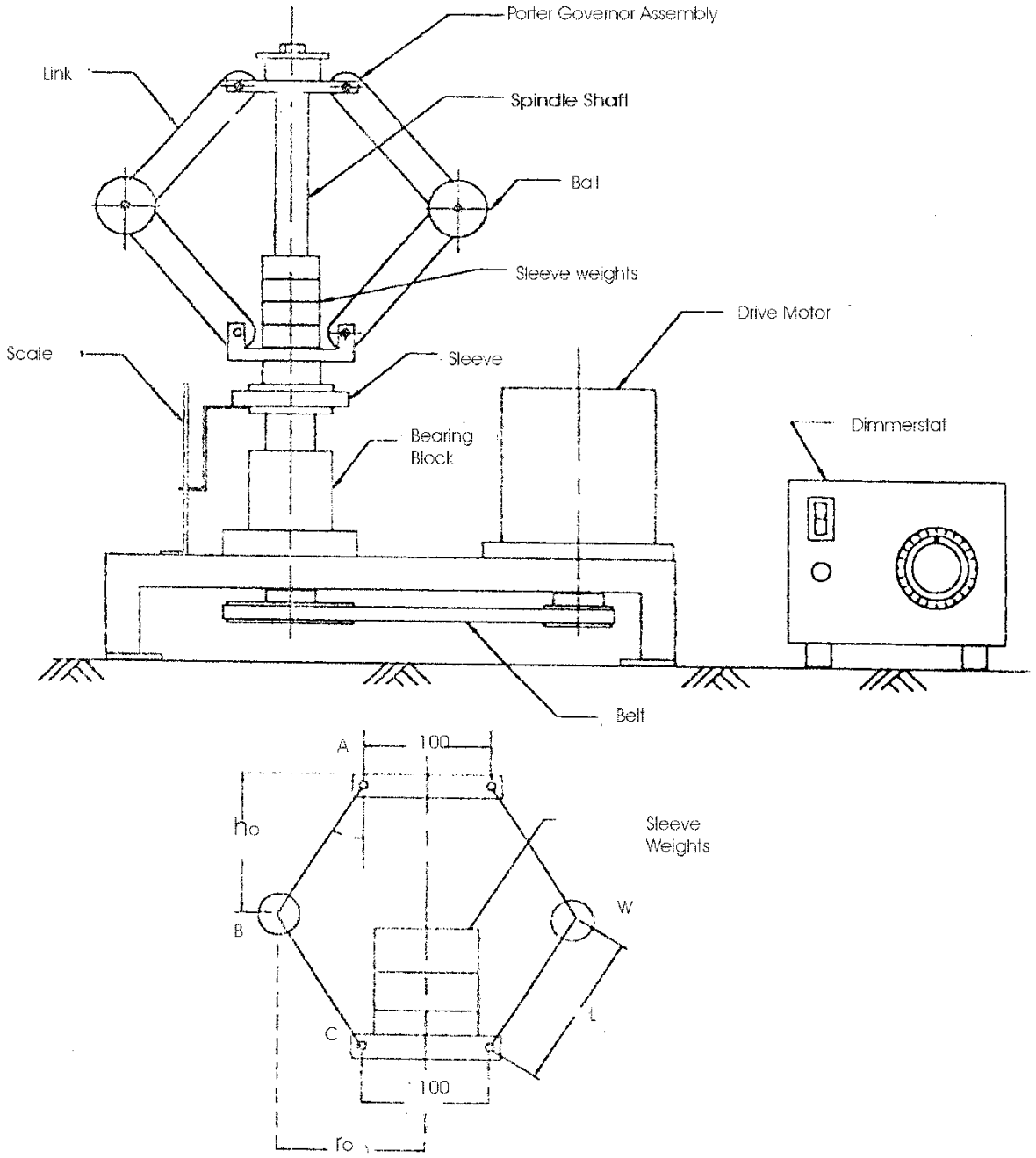
Sr.No.	Speed	Sleeve Displacement	Height	Radius of rotation	Force $F = (W/g) \times \omega^2 r$
	N rpm	X in meter	h in m	r in m	in Kgf

Following graphs to be plotted :

a) Force Vs Radius of rotation.

b) Speed Vs Sleeve Displacement.

Conclusion: Centrifugal force increases with increase in Speed & Sleeve Displacement.



Schematic Layout of Governor Apparatus

Setup - Porter Governor Arrangement

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PROEL GOVERNOR:

Arrange the set-up as shown in bellow Fig.

In the Proell governor, with the use of fly weights (forming full ball) the governor becomes highly sensitive. Under these conditions large sleeve displacement is observed for very small change in speed. Hence, it is suggested that increase the speed of the motor very slowly and carefully to get the lift.

Dimensions

a) Length of each link - L = m.
b) Initial height of Governor – ho = m.
c) Initial radius of rotation – ro = m.
d) Weight of ball - W = kg.
e) Extension of length BG = m.

Go on increasing the speed gradually and take the readings of speed of rotation „N‟ and corresponding sleeve displacement „X‟. Complete the following observation table.

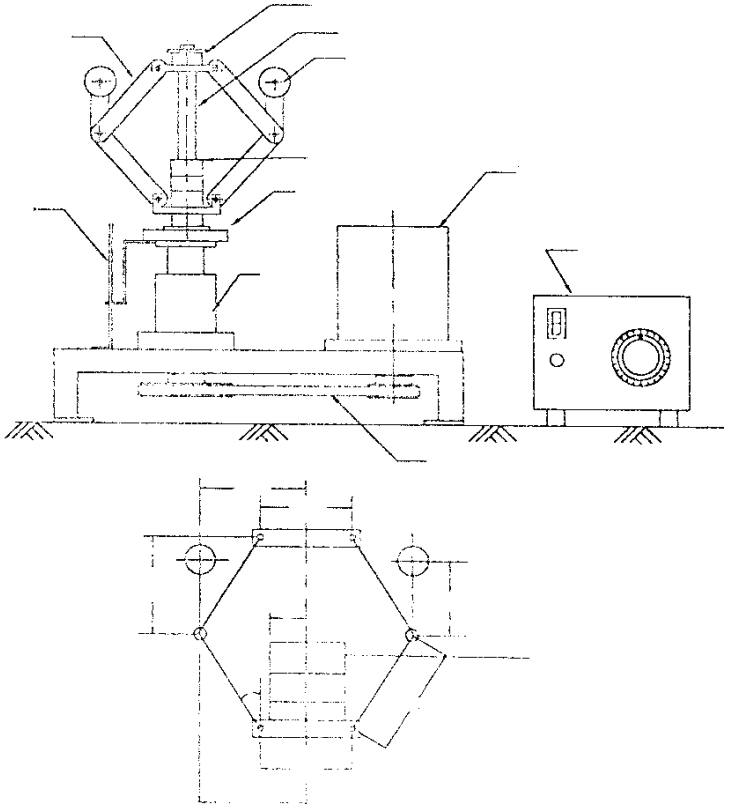
Sr.No.	Speed	Sleeve Displacement	Height	Radius of rotation	Force $F = (W/g) \times \omega^2 r$
	N rpm	X in meter	h in m	r in m	in Kgf

a) Find height h = ho – (x/2)
b) Find r in static condition for different sleeve displacement
c) Angular Velocity „ω‟ = $2\pi N/60$ rad/sec

Following graphs to be plotted :

a) Sleeve Disp. 'X' Vs 'r' Radius of rotation.
To draw this graph proceed as follows :
1) Keep the Governor in static position.
2) By lifting the Governor Mechanism manually measure the sleeve displacement and corresponding radius of rotation „r‟ of balls.
b) Force Vs Radius of rotation 'r'.
c) Speed Vs Sleeve Displacement.

Conclusion: Centrifugal force increases with increase in Speed & Sleeve displacement.



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PROELL GOVERNER

PRECAUTIONS:-

1. Do not keep the mains ON when the trial is complete.
2. Make proper connections of field of armature of the DC motor.
3. Increase the speed slowly & gradually. Avoid abrupt use of dimmerstat for controlling the speed.
4. Take the sleeve displacement reading when the pointer is steady.
5. See that at higher speed the load on sleeve does not hit the upper sleeve of the Governor.
6. While closing the test bring the dimmer to zero position and then switch OFF the motor.
7. Put some lubricating oil on the spindle shaft before it is driven.

Result:

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VIVA – QUESTIONS :-

1. Define governor.
2. Name two types of governor.
3. State the principle of working of centrifugal governor.
4. Define height of governor.
5. Define equilibrium speed in case of governor.
6. Define sleeve lift.
7. Define effort of a governor.
8. Define power of a governor.
9. Define sensitiveness of a governor.
10. Define hunting of a governor.
11. Define stability of a governor.
12. Define isochronisms of a governor.
13. What is meant by centrifugal governor?
14. What is meant by inertia governors?
15. What is the use of governors?
16. What is mean by governing?
17. How to use governors in engines?
18. What is the purpose of governing?
19. Application of governor?
20. Explain watt governor?
22. Classification of governor?
23. What is the working principle of governor?
24. What is the difference between flywheel and governor?

4. Find the motion of the follower if the given profile of the cam

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Experiment no:4

Find the motion of the follower if the given profile of the cam

Aim:

To study the profile of given can using cam analysis system and to draw the displacement diagram for the follower and the cam profile. Also to study the jump-speed characteristics of the cam & follower mechanism.

Apparatus required:

Cam analysis system and Dial, TACHOMETER .

SHORT NOTE ON JUMP PHENOMENON

The jump phenomenon occurs in case of a cam operating under the action of compression spring load. This is a transient condition that occurs only with high speed & highly flexible cam-follower system. With the jump cam and follower separate owing to excessively unbalanced forces exceeding the spring force during the period of negative acceleration. This is undesirable since the fundamental function of the cam-follower system; the constraint and control of follower motion are not maintained. Also related are the short lives of the cam flank surface, high noise, and vibrations and poor action.

DESCRIPTION AND WORKING INSTRUCTIONS

DESCRIPTION

The machine is a motorized unit consisting of a camshaft driven by a D.C.motor. The shaft runs in a ball bearing. At the free end of the cam shaft a cam can be easily mounted. As the follower is properly guided in gunmetal bushes and the type of the follower can be changed to suit the cam under test. A graduated circular protractor is fitted coaxially with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A spring is used to provide controlling force to the follower system. Weights on the follower rod can be adjusted as per the requirements. The arrangement of speed regulation is provided.

USE

The machine is particularly very useful for testing the cam performance for jump phenomenon during operation. This machine clearly shows the effect of change of inertia forces on jump action of cam follower during operation. It is used for testing various cam follower pairs i.e. 1) Circular arc cam with mushroom follower, 2) Tangent cam with roller follower, 3) an eccentric cam with knife edge followers.

ASSEMBLY

The unit is provided with the push rod in the two-bush bearing. The same push rod is to be used for all the followers provided. Should the unit be dissembled, for any reason, while assembling following precautions should be taken.

1. The horizontality of the upper and lower glands should be checked by a spirit level.
2. The supporting pillars should be properly tightened with the lock nuts provided.

3. SPECIFICATIONS:

A) The following types of cams are supplied along-with the unit.
1) Circular Arc Cam. 2) Eccentric Cam. 3) Tangent Cam.

B) Three types of followers are provided
1) Mushroom Follower. 2) Roller Follower, 3) Knife Edge Follower.

C) COMPRESSION SPRINGS
Spring is provided having (approx.) stiffness_____Kg/cm.

D) WEIGHTS
One set of two weights are provided. All the weights have a central hole so that they can be accommodated in the push rod.

(Weights -)

E) Motor: 0.5 HP, 1500 rpm, 230 V AC.
F) Dial Gauge : 0 – 10 mm
G) Speed Control Unit :Dimmerstat, 0-2 Amp, 230 V AC.
H) Digital speed indicator with proxy sensor.

WORKING INSTRUCTIONS

For good performance of the cam-testing machine, the instructions given below should be followed. It is required to observe strict adherence to these instructions to obtain good working of the machine.

1) LUBRICATION
It is imperative that to minimize the sliding forces at the two bearing surfaces, lubrication is a must. Before starting, continuous supply of oil should be provided. The cam is to be lubricated by oil before starting.

2) STARTING AND STOPPING

i) See that instructions given in (1) above are observed.
ii) (a) Select a suitable cam and follower combination. Fix the cam on the driving shaft. Fix the follower on push rod and properly tighten the check nut, such that knife edge of follower (or axis of roller in case of roller follower) is parallel to axis of cam-shaft.

(b) Give required initial compression to the spring. In order that initial compression is not lost during operation, the check nut is to be tighten against spring seat.

(c) Choose suitable amount of weight to be added to the follower. Weights with central hole can be inserted from the top end of push rod. A rest plate for the weights should be firstly screwed to the lowest position, tightened fully, so that there will be no loosening of the rest plate after adding required weights. Tighten the second nut from the top to secure the weights tightly fitted to the push rod.

iii) See that the knob of dimmerstat is at zero position.

iv) Now switch on the supply and increase the speed of motor gradually with the help of dimmerstat. Do not operate the control unit vigorously.

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EXPERIMENTS

Combinations of Cam & Follower Assembly

a) Eccentric Cam with Knife Edge Follower.
b) Circular Arc Cam with Mushroom follower.
c) Tangent Cam with Roller Follower.

Following experiments can be conducted using this machine :

1. To plot n - θ (follower displacement Vs. angle of cam rotation) curve for different cam follower pairs. The n - θ plot can be used to find out the velocity and acceleration of the follower system. For this experiment, arrange the set up as shown in Fig. The exact profile of the cam can be obtained by taking observations 'n' Vs 'θ', where n = displacement of the follower from rotation initial position and θ = angle of cam rotation with reference from axis of symmetry chosen. By differentiating the n - θ curve once and twice, the velocity and acceleration curves can be plotted for the follower and cam under study.

OPERATING PROCEDURE :

a) Select any one pair of cam & follower.
b) Fix the follower to the Push rod and the fix Cam to the cam shaft.
c. Keep the cam at the lower most position. (Nose of the cam in downward position) And now tighten the follower in such a way that the follower and cam are in just contact.
d. Fix the Dial Gauge to the Stand and rotate the base plate, in order to touch the displacement rod of gauge. See that the gauge is showing zero position.
e. Also, note while fixing the cam position the angular scale pointer is at zero and even the dial gauge pointer at zero position. (Rotate the outer ring of gauge to make the pointer at zero position)
f. Now, gradually go on rotating the cam shaft by hand through 10^0 or 20^0 , and note down the dial gauge reading at this position. Likewise readings are to be taken upto 360^0. Note down the observations in Table.

2. **Speed**.

TO OBSERVE THE PHENOMENON OF JUMP. For this, use of a stroboscope is necessary. The speed of cam rotation and stroboscope frequency of neon lamp is gradually and simultaneously increased and at the time of jump to occur the follower is seen to lose contact with Cam. The jump speed thus can be obtained from the stroboscope. When jump occurs the follower pounds on the cam surface giving a good thumping sound.

3. To study the Effect of Follower Assembly Weight on the jump speed when the spring force is kept constant. To study this effect keep the initial spring compression at a certain level and observe jump speed for different follower weights by adding them successively and plot the graph of Follower Weights Vs. Jump Speed.

This relation shows that as the follower weights increases the jump speed goes on decreasing.

NOTE : BEFORE STARTING THE MOTORISED EXPERIMENT, SEE THAT THE DIAL GAUGE IS REMOVED FROM THE STAND AFTER TAKING THE n-θ READINGS AND THEN ONLY ONE SHOULD CARRY ON THE MOTORISED EXPERIMENT.

a) Observation table for 'n' – 'θ'

Displacement – 'n' mm	Angular position – 'θ' in deg.
	0^0
	10^0 / 20^0
	Up to 360^0 or 0

b) Observation Table for Jump Speed by varying the weights.

Added Weight on Push Rod kgs.	Jump Speed in rpm
0.0	

c) Graphs :

1. Plot the graph of Follower Weights Vs. Jump Speed.
2. plot graph of follower displacement Vs angular displacement of cam.

PRECAUTIONS :

01. Fix the basic unit on sturdy workbench / foundation.
02. Operate the unit carefully.
03. While starting the unit, increase the speed suddenly and then go on decreasing the speed gradually up to you hear the thumping sound in slow.
04. Fix the Cam & Follower pairs as per the combination given above.
05. Put sufficient oil on the cam surface.

RESULT:

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Viva voce:

1. Define about cam & follower.
2. Classification of cam & follower.
3. According to the surface in contact Followers can be classified in to .
4. According to the motion of the follower, followers are classified in to..
5. According to the path of motion of the follower, followers are classified in to.
6. What are the various motions of the follower?
7. Mention different types of follower motions?
8. define base circle?
9. define trace point?
10. define pressure angle?
11. Define pitch point?
12. Define pitch circle?
13. Define lift or stroke?
14. Define prime circle?
15. Define offset of follower?
16. Explain wedge cam?
17. Device used to calculate RPM?
18. Draw the mushroom cam?
19. Application of cam?
20. What is the use of cam used in engine?
21. 21.Draw tangent cam?
22. What is the jumping of follower?
23. What is mean by spring controller cam?
24. What is a cam mechanism used for?
25. Are camshaft and crankshaft the same?

5. The balance masses statically and dynamically for single rotating mass systems

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EXPERIMENT No.- 5

The balance masses statically and dynamically for single rotating mass systems Aim:
To perform the experiment of Balancing of rotating parts and find the unbalanced couple and forces.

Apparatus:
Static & Dynamic Balancing Apparatus.

THEORY:
Conditions for Static and Dynamic Balancing: If a shaft carries a number of unbalanced masses such that center of mass of the system lies on the axis of rotation, the system is said to statically balance. The resultant couple due to all the inertia forces during rotation must be zero. These two conditions together will give complete dynamic balancing. It is obvious that a dynamically -balanced system is also statically balanced, but the statically balanced system is not dynamically balanced.

Balancing of Several Masses Rotating in Different Planes:
When several masses revolve in different planes, they may be transferred to a reference plane (written as RP), which may be defined as the plane passing through a point on the axis of rotation and perpendicular to it. The effect of transferring a revolving mass (in one plane) to a reference plane is to cause a force of magnitude equal to centrifugal force of the revolving mass to act in the reference plane, together with a couple of magnitude equal to the product of the force and the distance between the plane of rotation and the reference plane. In order to have a complete balance of the several revolving masses in different planes, the following conditions must be satisfied: 1. The forces in the reference plane must balance i.e. the resultant force must be zero. 2. The couple about the reference plane must balance, i.e. the resultant couple must be zero. Let us now consider four masses m1, m2, m3 and m4 revolving in plane 1, 2, 3 and 4 shown in fig. The relative angular position and position of the balancing mass m1 in plane may be obtained as discussed below: 1. Take one of the plane, say 1 as the reference plane (R.P). The distance of all the other planes to the left of the reference plane may be regarded as negative, and those to the right as positive. 2. Tabulate the data as in table. The planes are tabulated in the same order i.e. 1, 2,

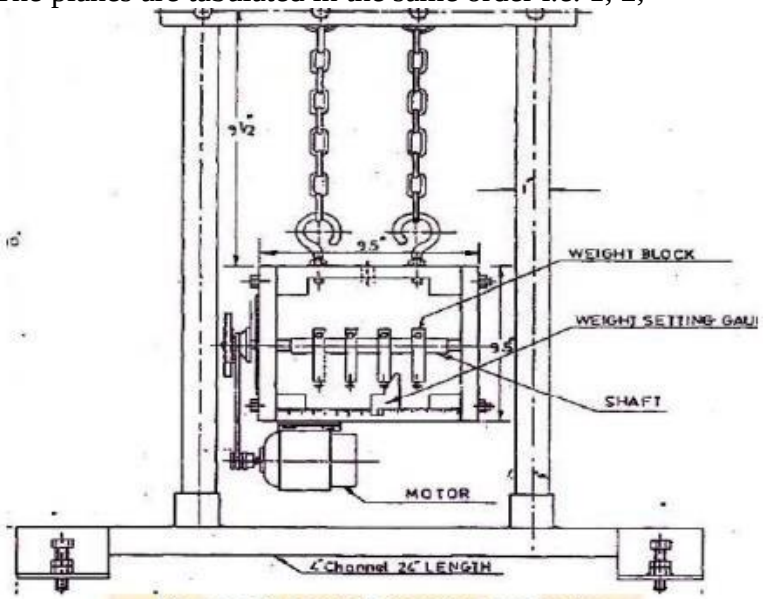

Figure: Dynamic balancing apparatus

1. The position of plane 4 from plane 2 may be obtained by drawing the couple polygon with the help of data given in column no. 8.
2. The magnitude and angular position of mass m1 may be determined by drawing the force polygon from the given data of column no.5 & column no.6 to some suitable scale. Since the masses are to be completely balanced, therefore the force polygon must be closed figure. The closing side of force polygon is proportional to the m1r1.

The angular position of mass m1 must be equal to the angle in anticlockwise measured from the R.P. to the line drawn in the fig. Parallel to the closing side of the polygon.

Description

The apparatus consists of a steel shaft mounted in ball bearings in a stiff rectangular main frame. A set of four blocks of different weights is provided and may be detached from the shaft.

A disc carrying a circular protractor scale is fitted to one side of the rectangular frame. A scale is provided with the apparatus to adjust the longitudinal distance of the blocks on the shaft. The circular protractor scale is provided to determine the exact angular position of each adjustable block. The shaft is driven by 230 volts, single phase, 50 cycles electric motor mounted under the main frame, through a belt. For static balancing of weights the main frame is suspended to support frame by chains then rotate the shaft manually after fixing the blocks at their proper angles. It should be completely balanced. In this position, the motor driving belt is removed.

For dynamic balancing of the rotating mass system the main frame is suspended from the support frame by two short links such that the main frame and supporting frame are in the same plane. Rotate the statically balanced weights with the help of motor. If they rotate smoothly and without vibrations, they are dynamically balanced.

PROCEDURE:

1. Insert all the weights in sequence 1-2-3-4 from pulley side.
2. Fix the pointer and pulley on shaft.
3. Fix the pointer on 0° ($\theta 2$) on the circular protractor scale.
4. Fix the weight no.1 in horizontal position.
5. Rotate the shaft after loosening previous position of pointer and fix it on $\theta 3$.
6. Fix the weight no. 2 in horizontal position.
7. Loose the pointer and rotate the shaft to fix pointer on $\theta 4$.
8. Fix the weight no.3 in horizontal position.
9. Loose the pointer and rotate the shaft to fix pointer on $\theta 1$.
10. Fix the weight no. 4 in horizontal position.
11. Now the weights are mounted in correct position.
12. For static balancing, the system will remain steady
13. Now put the belt on the pulleys of shaft and motor.
14. Supply the main power to the motor through dimmer stat.
15. Gradually increase the speed of the motor. If the system runs smoothly and without vibrations, it shows that the system is dynamically balanced.
16. Gradually reduced the speed to minimum and then switch off the main supply to stop the system.

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Data:

Mass of 1 = m1 gms = Plane 1 = Weight No. = 4
Mass of 2 = m2 gms = Plane 2 = Weight No. = 1
Mass of 3 = m3 gms= Plane 3 = Weight No. = 2
Mass of 4 = m4 gms = Plane 4 = Weight No. = 3
Radius 1, 2, 3, 4 = r cm. (Same radius)
Angle between 2 & 3 = θ3
Angle between 2 & 4 = θ4
Angle between 2 & 1 = θ1

Observation & calculations:

Plane	Weight No.	Mass (m)	Radius r	Angle (θ)	Mass moment mr	Distance from plane 1 (L)	Couple mrL

PRECAUTIONS:

1. Do not run the motor at low voltage i.e. less than 180 volts.
2. Increase the motor speed gradually.
3. Experimental set up is proper tightly before starting experiment.
4. Always keep apparatus free from dust.
5. Before starting the rotary switch, check the needle of dimmer stat at zero position.

RESULT:

Statically and dynamically balanced the rotating parts.

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VIVA-QUESTIONS :-

1. What is meant by balancing of reciprocating masses?
2. Why rotating masses are to be dynamically balanced?
3. Define static balancing?
4. Define dynamic balancing?
5. State the conditions for static and dynamic balancing?
6. State the conditions for complete balance of several masses rotating in different planes of a shaft?
7. Why complete balancing is not possible in reciprocating engine?
8. Difference between the unbalanced force caused due to rotating and reciprocating masses?
9. Write the importance of balancing?
10. Define tractive force.
11. Write a bending movement equation for SSB?
12. What are surface forces?
13. What are point forces?
14. What is secondary balancing? 15.What is primary balancing?
16. What is the single rotating mass unbalances
17. Why balancing of rotating parts of an engine is necessary?
18. How dynamic balancing is done?
19. Why is balancing of rotating parts is necessary for high speed engine?
20. How does a balancing machine work?
21. Why is a statically balanced shaft not dynamically in balance when it is in rotation?
22. What does a balancer do?
23. What is wheel balance?
24. How does a balancing machine

6. Determine the critical speed of a given shaft for different n-conditions

Experiment no:6

Determine the critical speed of a given shaft for different n-conditions

Aim:

To find out critical speed experimentally and to compare the Whirling Speed of a shaft with theoretical values.

Apparatus:

Whirling of shaft Apparatus, tachometer, and shafts of different diameters.

THEORY:

In actual practice, a rotating shaft carries different mountings and accessories in the form of gears, pulleys etc. when the gears or pulleys are put on the shaft, the center of gravity of the pulley or gear does not coincide with the center line of the bearings or with the axis of the shaft, when the shaft is stationary. This means that the center of gravity of the pulley or gear is at a certain distance from the axis of rotation and due to this, the shaft is subjected to centrifugal force. This force will bend the shaft, which will further increase the distance of center of gravity of the pulley or gear from the axis of rotation. The bending of shaft not only depends upon the value of eccentricity (distance between center of gravity of the pulley and axis of rotation) but also depends upon the speed at which the shaft rotates.

The speed, at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite, is known as critical or whirling speed.

DESCRIPTION:

The apparatus consists of a DC motor as the driving unit, which drives the shaft supported in fixing ends. Fixing ends can slide and adjust according to the requirement on the guiding pipes. Motor is connected to the shaft through flexible coupling. The shafts of different diameters can be replaced easily with the help of fixing ends. A dimmer stat is provided to increase or decrease the rpm of the motor. The whole arrangement is fixed on M.S. frame. Guards are provided to protect the user from accident.

PROCEDURE:

1. Fix the shaft to tube tested in the fixed ends.
2. Supply the main power to the motor through dimmer stat.
3. Gradually increase the speed of motor until the first mode of vibration is not arrived.
4. Study the first mode of vibration and note down the corresponding speed of the shaft with the help of hand tachometer.
5. Gradually increase the speed of motor again, until the second mode of vibration is not arrived.
6. Study the second mode of vibration and note down the corresponding speed of the shaft with the help of hand tachometer.
7. Reduce the speed gradually and when shaft stop rotating, cut off the main power supply.
8. Repeat the experiment for the shafts of different diameters.

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FORMULAE:

1. Moment of inertia of shaft, $I = (\pi/64) \times D^4$ m^4

L = length of the shaft in meters= 0.9m

E = Young"s modulus Kg/m = $2.18*10^{10}$

I = second moment of inertia

W= weight of the shaft per unit length Kg/m

g= acceleration due to gravity

the frequency of vibration for the various modes is given by the equation

f= K*$\sqrt{EIg/WL4}$ RPS

the various values for K are given bellow.

End condition	Value of K	
	1st mode	2nd mode
Supported, supported	1.57	6.28
Fixed, supported	2.45	9.80
Fixed, fixed	3.56	No value

Data:

Shaft dia	I=M^4	W=kg/m
5mm	$3.068*10^{-11}$	0.15
6mm	$6.362*10^{-11}$	0.24
8mm	$2.010*10^{-10}$	0.38

When both the ends are fixed:

S. No.	Actual whirling speed, Na	Theoretical Whirling speed, Nt

When both the ends are supported :

S. No.	Actual whirling speed, Na	Theoretical Whirling speed, Nt

When one end is fix and other end is supported:

S. No.	Actual whirling speed, Na	Theoretical Whirling speed, Nt

Possible Experiments with Elastic Rods:

Experiment No.	End Fixing	Mode of Whirl
1	One supported other Fixed	1 st Mode
2	One supported other fixed	2 nd Mode
3	Both ends supported	1 st Mode
4	Both ends supported	2 nd Mode
5	Both end Fixed	1 st Mode

PRECAUTIONS:

1. If the revolutions of an unloaded shaft are gradually increased, it will be found that a certain speed will be reached at which violent instability will occur, the shaft.
2. Deflecting in a single bow and whirling round like a skipping rope. If this speed is maintained the deflection will become so large that the shaft will be fractured.
3. It is advisable to increase the speed of shaft rapidly and pass through the critical speeds first rather than observing the 1st critical speed which increases the speed of rotation slowly. In this process, there is a possibility that the amplitude of vibration will increase suddenly bringing the failure of the shaft.
4. It is destructive test of shaft and it is observed that the elastic behavior of the shaft material changes a little after testing it for a few times and it is advisable to use fresh shaft afterwards.
5. Fix the apparatus firmly on the suitable foundation.
6. Do not run the motor at low voltage i.e. less than 180 volts.
7. Always keep apparatus free from dust.

RESULT:

Actual and theoretical whirling speed of the shaft compared.

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Viva voce:

1. What do you mean by mechanical vibration? What are the three types of free vibrations generally observed?
2. Difference between longitudinal and transverse vibrations?
3. What do you mean by natural frequency of vibrations? What are material and geometry parameters that affect the natural frequency of vibrations?
4. What are the different end fixing conditions generally for rotating shafts?
5. How do you achieve the hinged end conditions for a rotating shaft?
6. What is whirling speed of rotation for a shaft?
7. Why does the whirling of shaft occurs?
8. What are the nodes observed while studying whirling phenomenon?
9. Why it is necessary to pass the first node speed range quickly and increase the speed further to observe the second node?
10. What is the effect of end conditions, size of the shaft on whirling speed of the shaft?
11. How does the material of the shaft affects the whirling speed?
12. How to prevent the whirling of shaft in operation?
13. What is the need to find the whirl?
14. What is torsion?
15. Write the equation of torque?
16. What is the unit for time period?
17. Differentiate torque and couple?
18. What is Generator critical speed?
19. What is critical speed and critical resistance?
20. What is critical speed pump?
21. What is critical speed of turbine?
22. What is critical velocity?
23. What is critical speed of the shaft?
24. What is critical RPM of an engine?
25. What is barred speed range?

7. For a simple pendulum determine time period and its natural frequency

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Experiment no:7

For a simple pendulum determine time period and its natural frequency

Aim:

- To plot a L-T^2 graph using a simple pendulum.
- To find the time period and natural frequency of the pendulum at given using the graph.
- To calculate the acceleration due to gravity at a place.

Apparatus:

- Stand
- Bob
- Thread
- Stop watch
- Scale
- Chuck

Theory:

An ideal simple pendulum consists of a heavy point mass (called bob) tied to one end of a perfectly inextensible, flexible and weightless string. In practice, we make it by tying a metallic spherical bob to a fine cotton stitching thread.

Length of a Simple Pendulum:

The distance between the point of suspension of the pendulum and its Centre of Gravity (C.G.), which is the C.G. of the bob, is called the length of the simple pendulum. It is represented using the aphabet(l).

Time Period of a Simple Pendulum

Time period is the time taken by the bob of the simple pendulum to make one complete oscillation. It is represented by the letter T.

Finding the acceleration due to gravity

The time period of a simple pendulum depends on the length of the pendulum (l) and the acceleration due to gravity (g), which is expressed by the relation,

Time period theoretical is

$$T = 2\ \pi\sqrt{\frac{l}{g}} \text{ - - - - - - - - - - - - (1)}$$

For small amplitude of oscillations,

$$T^2 = 4\pi^2 \frac{l}{g}$$

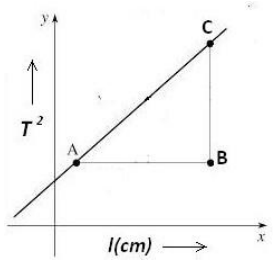
$$g = 4\pi^2 \frac{l}{T^2} - - - - - - - - - - - - (2)$$

ie;

If we know the value of l and g, we can calculate the T at that length of pendulum.

The L-T^2 graph:

We can plot a graph between l and T2 by taking l along the X axis and T2 along the Y axis. The graph is a straight line.



From the graph find the time period of the graph at a given length of the pendulum.

Procedure:

1. Attach the bob to one end of the thread. And calculate the diameter of the ball d.
2. From this calculate the radius of the ball (r=d/2).
3. And fix the other end of the thread to the hanger by using chuck.
4. Find the length of the thread l_1.
5. Now find the total length of the suspension $L= l_1+r$.
6. Allow the ball to oscillate and determine the periodic time T by knowing the time for say 20 oscillations.
7. Repeat the experiment by changing the length.
8. Complete the observation table given bellow.

Observations:

Sr.no	Length of L cm	No of oscillations N	Time for N oscilltions in sec t	T_{exp}= t/N	$F_{exp}=1/T_{exp}$	T_{theo}	$F_{theo}=1/T_{theo}$

Graph:
Plot the graph between time square (Y-axis) V/S length(X-axis) of pendulum

Result:

Viva voce:

1:Define „g‟‟?
2: What is the difference between „g‟ and „G‟‟?
3: What is the value of „g‟ at the C.G. of the earth?
4: How the value of „g‟ changes as we move from the surface towards the C.G. of the earth?
5: Where the „g‟ is greater, at equator or poles?
6: Where „g‟ will be smaller, at Karachi or at Muree?
7: What is the value of „g‟ at sea level?
8: Define simple harmonic motion (S.H.M).
9. Define vibratory system?
10: Define the following terms: (a) amplitude (xo) (b) oscillation or vibration (c) frequency (f) (d) time period (T)
11: What is the relation between frequency and time period?
12: What are the units of frequency?
13: What is the frequency of a second pendulum **at T = 2 s for a second's pendulum**?
14: Prove that $g = 4\pi^2 (L / T^2)$.
15: Let the time period of a simple pendulum is 4s at the place where g = 900 cm/s^2. What will be the time period at the place where g = 100 cm/s^2.
16: Time period will increase or decrease if we use a heavier bob.
17: Can you replace the thread by a metallic wire?
18: What is restoring force?
19: What is restoring force (net force) acting on the bob?
20: What is net force on the bob, at equilibrium (mean) position?
21: Define equilibrium.
22: Can you replace the thread by a rubber band?
23: Why the pendulum stops after some time?
24: How P.E. and K.E. of the pendulum interchange into each other during vibrations?
25: From where the length of the pendulum is measured?
26. What is the pendulum equation?
27. What is the length of a pendulum with a period of 1 second?
28. What will happen to the period of a pendulum if you increase its length?
29. What is second pendulum length?
30.Why does only length affect the period of a pendulum?

8. For a compound pendulum determine time period and its natural frequency

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Experiment no:8

For a compound pendulum determine time period and its natural frequency Aim:

- to determine the time period of oscillation and its natural frequency of given compound pendulum theoretically and experimentally.
- To plot the graph between time(T) V/S distance of suspension from CG.

Apparatus:

- A compound pendulum
- Stop watch
- Scale
- Knife edge with platform

Theory:

Any solid object mounted on a horizontal axis so as to oscillate under the force of gravity is a compound pendulum. The one used in this experiment is a uniform rod suspended at different locations along its length. The period T of a compound pendulum is given by

T_{theo}= 2p $\sqrt{I/mgh}$ .....(1)

Where:

„I‟ is the rotational inertia of the pendulum about the axis of suspension

“m” is the pendulum mass

And „h‟ is the distance of suspension point from the centre of mass.

Using the parallel axis theorem

$I=I_G + mh^2$ .....(2)

I_G is the rotational inertia of the body about its centre of mass and it is given by

$I_G = mk^2$ .....(3)

Substituting equation 3 in equation 2

$I= m (h^2 + k^2)$ .....(4)

Where k is the radius of gyration .substituting equation 4 in equation 1

k=L/2$\sqrt{3}$ L=length of rod

By Haifaaaltoumah& RababAlfaraj

$T_{theo}=2\pi\sqrt{h2 + k2/gh}$ ----------5

Theoritical frequency $f_{theo}= 1/T_{theo}$

Experimental frequency $f_{exp}= 1/T_{exp}$

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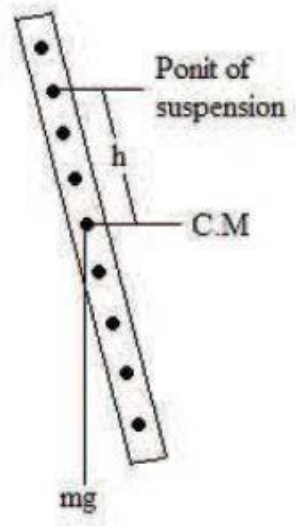

Fig.1 Compound pendulum

Procedure:

1. Note the length of compound pendulum (L) and determine radius of gyration (k).
2. Hang it vertically inserting the tip of the knife in the first hole from the center of mass. Then set it oscillating through a small angle.
3. Determine the distance between point of suspension and centre of mass note it as (h) see in Fig-1.
4. Allow the bar to oscillate and note down the time(t) for 20 oscillations.
5. And calculate time period for one oscillation T_{exp}.
6. Complete the observation table bellow.
7. Calculate T_{theo} and F_{theo} from formulae.
8. Take minimum three readings at each point of suspension.
9. Note down average time period at each point of suspension and frequency.
10. Repeat the experiment with different length of suspension.

Observations:

Sr.no	Length of rod (L) cm	Distance from point of suspension to CG (h) cm	No.of oscillations N	Time in 't' sec for N oscillations	Time period T_{exp} = t/N	Natural frequency of pendulum F_{exp} = 1/ T_{exp}	Time period T_{theo}	Natural frequency of pendulum F_{theo}

Result:

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Viva voce:

1. At centre of gravity of a compound pendulum time period T is?
2. Lowest time period of oscillations are happened at how many positions?
3. Difference between simple pendulum and compound pendulum?
4. Radius of gyration of the bar of length L about its CG?
5. Relation between time period and acceleration due to gravity in compound pendulum?
6. What is the Y-axis in compound pendulum graph?
7. What is the X-axis in compound pendulum graph?
8. length of Equivalent simple pendulum?
9. Define parallel axis theorem?
10. Define perpendicular axis theorem?

11.Unit and meaning of tp?
12.Unit and meaning of fn?
13.Define vibration?
14.Does the time period change with the change in position of suspension?
15.Different between beam and bar?
16.Define radius of gyration?
17.What is damping?
18.Define centroid? 19.Define
center of gravity?
20.Differentiate damped from undamped vibration?
21.Types of vibration?
22.How does stiffness affect natural frequency?
23.How can I increase my natural frequency?
24.What is natural frequency of vibration?
25.What causes natural frequency?

9. Determine the effect of gyroscope for different motions

Experiment no:9

Determine the effect of gyroscope for different motions

Aim:

To find experimentally the Gyroscopic couple on Motorized Gyroscope and compare with applied couple.

Apparatus:

Motorised Gyroscope Apparatus,weights,
tachometer.

THOERY:

AXIS OF SPIN:

If a body is revolving about an axis, the latter is known as axis of spin.

Velocity of spin:

the angular velocity of rotor is called velocity of spin. It is denoted by ω. It is measured in rad/sec.

PRECESSION:

Precession means the rotation about the third axis OZ that is perpendicular to both the axis of spin OX and that of couple OY.

Angular velocity of rotation of the rotor axis is called velocity of precession. This rotation is about the vertical axis. It is denoted by ω_p. it is measured in rad/sec.

AXIS OF PRECESSION:

The third axis OZ is perpendicular to both the axis of spin OX and that of couple OY is known as axis of precession.

GYROSCOPIC EFFECT:

To a body revolving (or spinning) about an axis say OX if a couple represented by a vector OY perpendicular to OX is applied, then the body tries to process about an axis OZ which is perpendicular both to OX and OY. Thus, the couple is mutually perpendicular. The above combined effect is known as precessional or Gyroscopic effect.

GYROSCOPE: It is a body while spinning about an axis is free to rotate in other direction under the action of external forces.

GYROSCOPIC COUPLE :

the couple generated due to change of direction of angular velocity of rotor, is called gyroscopic couple.

Applied torque:

The torque applied to change the direction of angular velocity of rotor is applied torque. Numerically, it is the product of weight placed in the weight stud and its distance from the centre of the disc.

$T_{applied}$= Mg*l

M= mass added in weights stud
g= acceleration due to gravity
L= distance from centre of disc to weight stud

Moment of inertia of rotor:
$I=mk^2$
m= mass of disc
K= radius of gyration
M=6.3kg
r= Radius of rotor= 0.15m

Angular momentum:
The product of angular velocity of rotor and moment of inertia of the disc is called angular momentum.
Angular momentum= $I\omega$

As the torque is applied direction of angular velocity is changed and hence angulr momentum is also changed. Thus,
Couple applied= rate of change of momentum
If, $I\omega$ is changed of momentum in the time interval
Then $T= d(I\omega)/dt$

Gyroscopic torque= $I\omega\omega_p$

Procedure:
1. Check the rotor for vertical position. Adjust the balance weight slightly, if required.
2. Keep the dimmer at zero position & put ON the supply.
3. Start the motor by applying the voltage of around 170 volts & then reduce.
4. Adjust the rotor speed as required.
5. Note down the rotor speed with the help of tachometer.
6. Speed is to be note down when the speed of the rotor becomes stabilized.
7. Put the required weight in the weight stud and at the same time start the stop watch. Note down the time required for 90^0precession.
8. Repeat the procedure for different weights and rotor speeds.

Observations:

Sr.no	Rotor speed N rpm	Rotor angular velocity ω rad/sec	Time for $\Theta=\Pi/2$ precession t sec	Angular velocity of precession $\omega_p=\Pi/2t$ rad/sec	Moment of inertia of disc $I=Mr^2/2$ kg-m^2	Gyroscopic couple: $C_G=I\omega\omega_p$	Weight added in stud W=Mg Newton‟s	Couple due to weight added in stud C=W*L

Calculations:
Velocity of spin:

ω=2πN/60 rad/sec
N= rotor speed rpm

Velocity of precession:
Time for 90^0precession is t sec
ω_p=π/2t rad/sec

Moment of inertia:
Moment of inertia= I= mk^2
M= mass of disc= 6.3 kg
Applied torque:
Applied torque:
$T_{applied}$= Mg*l
M= mass added in weights stud
g= acceleration due to gravity

Gyroscopic torque= I$\omega\omega_p$

Precautions:
1. Check all the fastenings to be tight before start.
2. Check balance of the rotor before start.
3. Lubricate the bearings periodically.
4. Keep the base over a leveled platform.

Result:

Viva voce:

1. A disc is a spinning with an angular velocity ω rad/s about the axis of spin. The couple applied to the disc causing precession will be?
2. The engine of an aeroplane rotates in clockwise direction when seen from the tail end and the aeroplane takes a turn to the left. The effect of gyroscopic couple on the aeroplane will be?
3. The engine of an aeroplane rotates in clockwise direction when seen from the tail end and the aeroplane takes a turn to the right. The effect of gyroscopic couple on the aeroplane will be?
4. The steering of a ship means?
5. The rolling of a complete ship side-ways is known as pitching of a ship?
6. The rotor of a ship rotates in clockwise direction when viewed from stern and the ship takes a left turn. The effect of gyroscopic couple acting on it will be?
7. The rotor of a ship rotates in clockwise direction when viewed from stern and the ship takes a right turn. The effect of gyroscopic couple acting on it will be?
8. When the pitching of a ship is upward, the effect of gyroscopic couple acting on it will be?

9.What is gyroscope used for?
10.How does it work gyroscope?
11.What is gyroscopic effect?
12.How does an airplane gyroscope work?
13.Why does a gyroscope not fall?
14.What is gyroscopic action?
15.What is gyroscope couple?
16.What are the three gyroscopic instruments?
17.Why is gyroscope used?
18.What is gyroscopic inertia?
19.What is gyroscopic plane?
20.What is gyroscopic torque?
21.What is gyroscopic motion?
22.What is the function of gyroscope?
23.What is gyroscopic force?
24.What is gyroscopic principle?
25.What is a free gyroscope?

10. Determine time period, amplitude and frequency of undamped free longitudinal vibration of single degree spring mass systems.

Experiment no:10

Determine time period, amplitude and frequency of undamped free longitudinal vibration of single degree spring mass systems.

AIM:

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

DESCRIPTION:

The arrangement is designed to study free undamped vibrations. It consists of M.S rectangular beam supported at one end by a trunion 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 helical spring is attached to screw. 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.

PROCEDURE:

1. Support one end of beam in the slot of turnnion and clamp it by means of screw.
2. Attach the other end of the beam to lower end of spring.
3. Adjust the screw to which the spring is attached such that beam is horizontal in position.
4. Weigh the exciter assembly along with discs, bearings and weight platform.
5. Clamp the assembly at any convenient position.
6. Measure the distance L1 of the assembly from pivot. Allow system to vibrate freely.
7. Measure the time for any 10 oscillations and find periodic time and natural frequency of vibration.
8. Repeat the experiment by varying L1 and by also putting different weights on platform.

OBSERVATIONS:

Sr.no	**Mass of exciter W grams**	**Distance of exciter from turnnion L_1 meters**	**Mass at the spring $M_e=(WL_1/L)$**	**No. of oscillations N**	**Time for N oscillations in sec t**	**Experimental Periodic time $T_{exp}=t/N$**	**Theoretical time period T_{Theo}**

CALCULATIONS:

Theoretical Frequency, $F_{theo} = (1/2\pi)\sqrt{K/}$ Hz

Where,

M=(W+w)/g

g : Acceleration due to gravity, 9.81m/s

$M_e=ML_1/L$

Where

W= weight of exciter assembly along with weight platform=15kg

w= weight attached to exciter assembly.

L_1= distance of weight from pivot.

L= distance of spring from pivot.

M= mass

M_e=equivalent mass at the spring

K= stiffness of spring=0.4Kg/cm

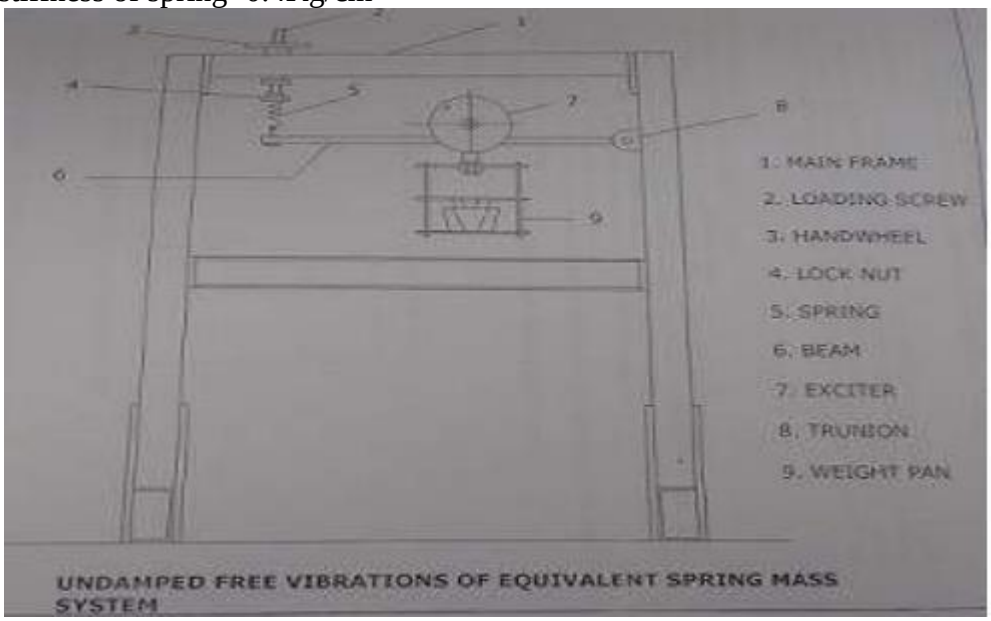

Figure 1 UNDAMPED FREE VIBRATION OF EQUIVALENT SPRING MASS SYSTEM

RESULT:

The percentage error of the theoretical and experimental natural frequency is _____

Viva voce:

1. what you know about vibration describe briefly.
2. Name different types of vibrations.
3. Explain about free vibrations.
4. what is the difference between forced and free vibrations.
5. Write about effect of damping in vibrations.
6. Explain briefly about resonance.
7. Explain relation between time period and natural frequency.
8. What are the units of frequency?
9. Name different types of free vibrations.
10. Name different types of free vibrations.
11. Define longitudinal vibrations.
12. Define transverse vibrations.
13. What is mean by periodic oscillation?
14. How can I reduce vibration?
15. What causes vibration?
16. How do you raise your consciousness to a higher vibration?
17. 17. What vibration means?
18. What is vibration in waves?
19. What is meant by a free vibration?
20. How does vibration affect sound?
21. What is damped freevibration?
22. What is simple pendulum?
23. What is vibration K factor?
24. What is the difference between forced vibration and resonance?
25. What happens resonance?

11. Determine the pressure distribution of lubricating oil at various load and speed of a Journal bearing.

Experiment no:11

Determine the pressure distribution of lubricating oil at various load and speed of a Journal bearing.

AIM:

To study the pressure distribution in Journal bearing and to draw experimental pressure curves.

Theory:

The major objective of lubrication of journal bearings is to induce and maintain a film of lubricant between the journal and the bearing. The purpose of this film of lubricant is to keep the two surfaces separate at all times and thus prevent metal to metal contact. Hydrodynamic lubrication is the most common method of lubrication of journal bearings. In this method, as the shaft rotates it will, due to the load applied to it (as well as its own weight), take a slightly eccentric position relative to the bearing. The eccentric rotation of the shaft in the bearing acts like a rotary pump and generates a relatively high hydrodynamic pressure in the con-verging zone. The hydrodynamic pressure for a properly designed bearing is responsible for supporting the shaft without allowing it to come in contact with the bearing. Metal or dry contact which otherwise will create bearing failure.

PROCEDURE:

1. Fill the oil tank by using SAE 40 oil and position the tank at desired height.
2. Adjust the pressure gauge at 0^0. Adjust the pointer on torque arm to match with the zero on the scale fitted on the frame.
3. Put on the oil supply and start the motor at require speed.
4. Pressure will start to develop put the required weight in the weight hanger.
5. Put small weight in balancing hook and adjust the distance so that the pointer should again coincide with zero on the scale note down the weights and its distances.
6. Wait for some time for pressure to build up. When pressure remains steady, note down pressure. Similarly note the pressures on either sides of 0^0 at intervals of 5^o to 10^0
7. Repeat the procedure for different speeds and loads and complete the observation table.
8. Plot the graph between angle Vs pressure distribution.

Observation table:

Sr.no	Speed N rpm	Load W Kg	Torque arm	
			Weight w kg	Distance m

Pressure distribution:

Angle	**0^0**	**10^0**	**20^0**	**30^0**	**40^0**	**-10^0**	**-20^0**	**-30^0**	**-40^0**
pressure									

Precautions:

1. Always put clean SAE 40 oil in tank.
2. Collect the oil collected in collecting tank and pour it in the oil tank every five minutes.

3. Operate all the switches and controls gently.
4. While applying the weights keep them gently.

Result:

Viva voce:

1. What is the function of bearing?
2. What are the types of bearings?
3. Difference between Antifriction Bearing and Journal Bearing?
4. Give examples of anti friction bearings?
5. Give examples of friction bearings?
6. Give few examples of lubricants used in bearings?
7. What are the parts in an bearing?
8. The bearing‟s smooth performance is assured by the_____.
   A. inner and outer race
   B. rolling elements
   C. separator
   D. all of the above

9. The_____is the part of the bearing that sits directly on the shaft.

   A. outer race
   B. inner race
   C. cage
   D. cup

10. The cone is another name for the_____.
    A. separator
    B. inner race
    C. cup
    D. retainer
11. The outer race_____.
    A. is the bearing‟s exterior ring
    B. protects the bearings internal parts
    C. must be machined smoothly and accurately
    D. all of the above
12. The_____is a metal retainer that keeps the rolling elements evenly spaced.

    A. seal
    B. separator
    C. bearing
    D. outer race

13. The shape of the rolling elements depends on the_____.

    A. type of load
    B. operating conditions
    C. particular applications
    D. all of the above

14. The rolling elements consist of_____.
    A. balls or rollers
    B. retainer or cage
    C. ring or cup
    D. ring or cone

15. what are the difference between hydrodynamic and hydro static bearings?

16. What is attitude in journal bearing?
17. Why is journal bearing used?
18. What is meant by journal bearing?
19. What are journal bearings made of?
20. What are the major components of a rolling element bearing?
21. Why are roller bearings used?
22. What is the difference between ball and roller bearing?
23. What is a ring bearing?
24. What is a journal bearing turbo?
25. How does a journal bearing work?

12. Determine time period, amplitude and frequency of damped free longitudinal vibration of single degree spring mass systems

Experiment no:12

Aim:
To study the forced vibration of equivalent spring mass system**.**

Description:
The arrangement is shown in the bellow fig. the exciter unit is coupled to D.C Variable speed motor through the flexible shaft. speed of the motor can be varied with the dimmerstat provided on the control panel. Speed of rotation can be known from the speed indicator on control panel. It is necessary to connect the damper unit to the exciter.
Amplitude record of vibration is to be obtained on the strip chart record is 33mm/sec.

Procedure:

1. support one end of the beam in the slot of turnnion and clamp it by means of screw.
2. Attach the other end of beam to the lower end of the spring.
3. Adjust the screw to which the spring is attached such that beam is horizontal in the position.
4. Weight the exciter assembly along with discs and bearing and weight platform.
5. Clamp the assembly at any convenient position.
6. Measure the distance L_1 of the assembly from pivot.
7. Connect the exciter to D.C motor through flexible shaft.
8. Start the motor and allow the system to vibrate.
9. Weight for 3 to 5 minutes for the amplitude to build the particular forcing frequency.
10. Adjust the position of strip chart recorder.
11. Take the record of amplitude Vs time on strip chart by starting recording motor. Press the recorder platform on pen gently. Pen should be wet with ink.avoid excessive pressure to get good record.
12. Take record by changing frequency.
13. Repeat the experiment for different damping.
14. Damping can be changed by adjusting the holes on the piston of the exciter.
15. Plot the graph of amplitude Vs frequency for each damping conditions.

Observations:

Sr.no	**Speed in RPM**	**Forcing frequency in CPS = speed/60**	**Amplitude mm**

CALCULATIONS:
Plot the graph of amplitude Vs frequency for each setting.

Result:

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Viva voce:

1. Write briefly about forced vibrations.
2. What is the effect of damping in vibrations.
3. What is spring stiffness constant.
4. Explain relation between force and spring stiffness.
5. Write units of frequency.
6. What is the difference between longitudinal and Transverse vibrations.
7. Explain few methods to reduce the vibrations.
8. What are the advantages of vibrations
9. What is vibration system?
10. What is mechanical vibration?
11. How does vibration happen?
12. Is sound a vibration?
13. What material absorbs vibration?
14. What are vibration dampers?
15. What is vibration isolation and transmissibility?

.

13.STUDY OF GEAR PARAMETRS

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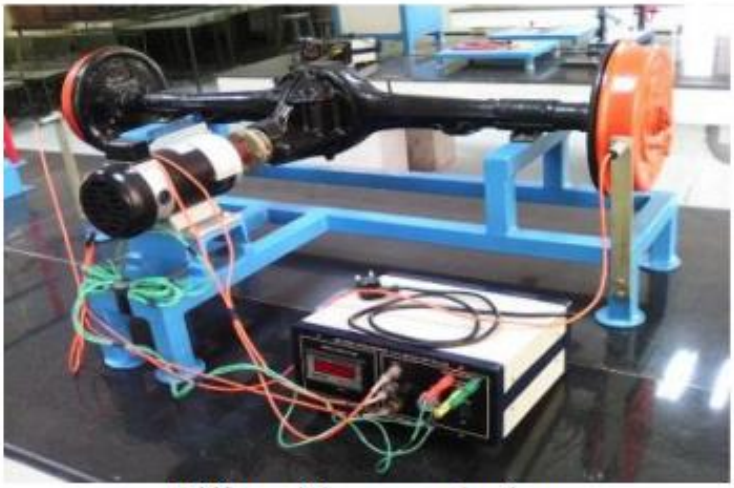
Exp.No: **Date:**

Simple Gear Train

A simple gear train uses two gears, which may be of different sizes. If one of these gears is attached to a motor or a crank then it is called the driver gear. The gear that is turned by the driver gear is called the driven gear.



Differential gear mechanism

Idler Gear

When a simple gear train has three meshed gears, the intermediate gear between the driver gear and the driven gear is called an idler gear.

An idler gear does not affect the gear ratio (velocity ratio) between the driver gear and the driven gear.

Compound Gear Train

Compound gear trains involve several pairs of meshing gears. They are used where large speed changes are required or to get different outputs moving at different speeds.
Gear ratios (or velocity ratios, VR) are calculated using the same principle as for simple gear trains, i.e. VR = number of teeth on the driver gear divided by the number of teeth on the driven gear. However, the velocity ratio for each pair of gears must then be multiplied together to calculate the total velocity ratio of the gear train:

Total VR = VR1 x VR2 x VR3 x VR4….

$$\frac{\text{No of teeth on B}}{\text{No of teeth on A}} \times \frac{\text{No of teeth on D}}{\text{No of teeth on C}} = \text{Gear Ratio}$$

Viva questions

1.Define spur gear.

A spur gear is a cylindrical gear whose tooth traces are straight line generation of the reference cylinder. They are used to transmit rotary motion between parallel shafts.

2. Define addendum and dedendum.

Addendum is the radial distance of a tooth from the pitch circle to the top of the tooth. Dedendum is the radial distance of a tooth from the pitch circle to the bottom of the tooth.

3. Define circular pitch.

It is the distance measured on the circumference of the pitch circle from a point of onetooth to the corresponding point on the next tooth. It is denoted by PcCircular pitch Pc= P/DT Where D = Diameter of pitch circle. T = Number of teeth on the wheel.

4. Define I) path of contact. II) Length of path of contact.

Path of contact: It is the path traced by the point of contact of two teeth from the beginning to the end of engagement.Length of path of contact: It is the length of common normal cut- off by the addendum circles of the wheel and pinion.

5. State the law of gearing.

Law of gearing states that, the common normal at the point of contact between a pair of teeth must always pass through the pitch point.

6. Define conjugate action.

When the tooth profiles are so shaped so as to produce a constant angular velocity ratioduring Meshing, then the surface are said to de conjugate.

7. Define angle of approach.

The angle of approach is defined as the angle through which a gear rotates from the instant a pair of teeth comes into contact until the teeth are in contact at the pitch point.

14.EPICYCLIC GEAR TRAIN

EPICYCLIC GEAR TRAIN

Exp.No: **Date:**

Objective:

The fundamental objectives of this study are:

1) Calculate and experimentally observe the angular velocity ratios of gear trains,

2) Experimentally obtain the torque ratios of gear trains,

3) Compute the efficiencies of gear trains.

Apparatus Required:

- Sanderson coupled epicyclic unit,
- Weights,
- Weight hanger.

Theory:

Gear trains of the type shown in Figures 1, 3, 4 and 5 are called epicyclic gear trains or planetary gear trains. In these gear trains, one or more gears are carried on a rotating planet carrier rather than on a shaft that rotates on a fixed axis. Several types of gear trains may be shifted manually to obtain greater or lesser values of speed reduction. The shifting process, however, is difficult to accomplish automatically with gears that rotate about fixed centers. On the other hand, epicyclic gear trains are readily adapted to automatic control. Some epicyclic gear trains are designed to change velocity ratios simply by using electrically or hydraulically operated band brakes to keep one or more of the gears stationary. Other epicyclic gear trains operating with fixed velocity ratios are selected for their compact design and high efficiency.

A simple epicyclic gear train consists of a sun gear (S) in the center, a planet gear (P), a planet carrier or arm (C), and an internal or ring gear (R). The sun gear, ring gear and planet carrier all rotate about the same axis. The planet gear is mounted on a shaft that turns in the bearing in the planet carrier and meshes with both the sun gear and the ring gear. (Figure 1)

The general expressions pertaining to the gear train are given below:

T_i = input torque,

θ_i = input angular displacement,

T_o = output torque,

θ_o = output angular displacement, then

Angular velocity ratio $R_v = \frac{\theta_i}{\theta_o}$

Input work = T_i xθ_i

Output work = T_ox θ_o, and

Efficiency (h) = $\frac{\text{Outputvork}}{\text{InputWork}} = \frac{T_o\theta_o}{T_i\theta_i}$

If the input shaft tends to rotate in the direction of Ti, the gear train is balanced if

$T_i \theta_i = M_{Friction} + T_o x\ \theta_o$

If there is no friction loss, the efficiency should be 1.0 and the output work equals to input work. The corresponding T_o is ideal and is equal to T_i / R_v

$T_o = T_i / R_v$

WhereT_o is the ideal output torque.

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With the existence of $M_{Friction}$, The actual output torque is smaller. The smallest Toto balance the gear train will be used to determine the system's efficiency. The efficiency can only be determined experimentally.

Calculation of velocity ratio can be performed by either the formula method or the tabular method. This ratio can also be experimentally obtained.

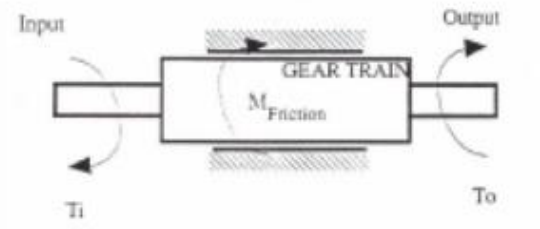

Figure 2. Schematic of a Gear Train and its balanced works.

Description of the Apparatus:

The Sanderson Coupled Epicyclic Unit consists of two standard epicyclic gear trains (Schematic Figs. 4 and 5) for laboratory demonstration of gear system similar to ones used in automotive applications. Pulleys fitted with protractors are attached to the input and output shaft so that torque and velocity ratios may be determined. Torques can be applied to the shaft by adding weights on ropes wrapped on the pulleys. Bearings are used in the entire unit to minimized friction losses. The Sanderson Coupled Epicyclic Unit can be operated in one of two modes by holding one of the ring gears stationary. The actual figure of the unit is shown in Fig. 3.

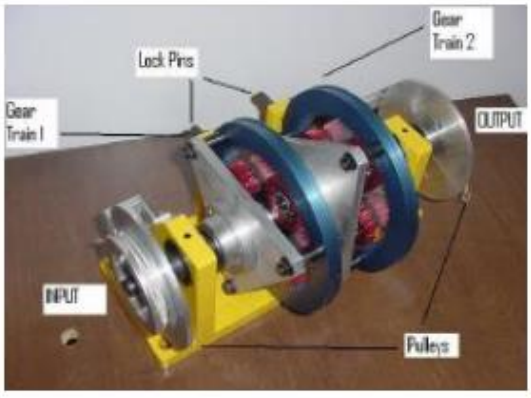

Figure 3. The Sanderson Coupled Epicyclic Unit

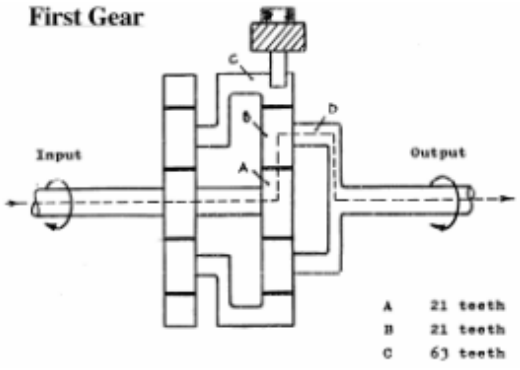

Figure 4. Schematic of the first epicyclic gear train

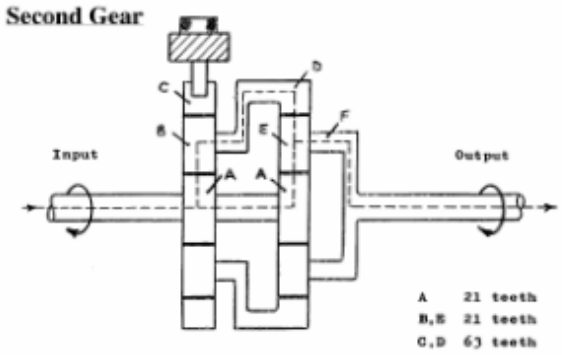

Figure 5. Schematic of the second epicyclic gear train

Experimental Procedure:

In this experiment the gear ratio is initially calculated using the formula involving the number of teeth. The angular velocity ratios and the torque ratios of the two gear units are calculated experimentally. The procedure is described below:

- To calculate the angular velocity of the 1st gear unit, lock the 2nd gear unit using the lock pin.
- Rotate the input shaft one full turn clockwise (as viewed from the input shaft end) and observe the sense and magnitude of rotation of the output shaft (as viewed from in input shaft end). Repeat the procedure for the 2nd gear unit with the 1st unit locked. From this $\frac{\theta_i}{\theta_o}$ is calculated where θ_i is the rotation of input shaft (360°) and θ_o is the rotation read at the output shaft.
- To estimate the torque ratios lock one of the gear units and hang a weight of 250gm at the input shaft.

- Start adding weights at the output shaft till equilibrium is achieved. Repeat the procedure for the other gear unit.
- Record the weight at the output shaft for calculation purposes.

Fig-6.Prototype Different Type of Gear Train

Results:

Obtain the following results for this experiment.

1. Theoretical gear ratio (show calculations, using the number of teeth, for both gear trains).
2. Angular velocity ratio $R_v = \frac{\theta_i}{\theta_o}$ which is equal to the experimental angular rotation ratio.
3. Torque ratio defined by To / Ti .
4. Efficiency.

Viva Questions

1.**How does an epicyclic gearbox work?**

The working principle of the epicyclic gearbox is based on the fact the fixing any of the gears i.e. sun gear, planetary gears, and annular gear is done to obtain the required torque or speed output. As fixing any of the above causes the variation in gear ratios from high torque to high speed. So let's see how these ratios are obtained.

2.**How many teeth does an epicyclic gear have?**

With respect to the epicyclic gear train shown in the figure below, A has 75 teeth and B has 25 teeth; A is fixed and arm C makes 5 revolutions: Where ω is the angular velocity and T is the number of teeth. A gear train is as shown in the figure below, in which gears A and B have 20 and 40 teeth, respectively.

3.**What is the difference between the planet gear and ring gear?**

The planet gear carrier is driven by an input torque. The sun gear provides the output torque, while the ring gear is fixed. The gear ratio in an epicyclic gearing system can be different by the design of the gear teeth and the ways of input rotation to the gear. 1. Sun: The central gear 2.