Tambaram, –

DEPARTMENT OF

MECHANICAL ENGINEERING

ME 6511 – DYNAMICS LABORATORY

V SEMESTER - R 2013

LABORATORY MANUAL

Name : ________________________________

Register No. : ________________________________

Section : ________________________________

VISION

is committed to provide highly disciplined, conscientious and enterprising professionals conforming to global standards through value based quality education and training.

MISSION

- To provide competent technical manpower capable of meeting requirements of the industry
- To contribute to the promotion of Academic Excellence in pursuit of Technical Education at different levels
- To train the students to sell his brawn and brain to the highest bidder but to never put a price tag on heart and soul

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

Rendering the services to the global needs of engineering industries by educating students to become professionally sound mechanical engineers of excellent caliber

MISSION

To produce mechanical engineering technocrats with a perfect knowledge intellectual and hands on experience and to inculcate the spirit of moral values and ethics to serve the society

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Fundamentals

   To impart students with fundamental knowledge in mathematics and basic sciences that will mould them to be successful professionals

2. Core competence

   To provide students with sound knowledge in engineering and experimental skills to identify complex software problems in industry and to develop a practical solution for them

3. Breadth

   To provide relevant training and experience to bridge the gap between theory and practice which enable them to find solutions for the real time problems in industry and organization and to design products requiring interdisciplinary skills

4. Professional skills

   To bestow students with adequate training and provide opportunities to work as team that will build up their communication skills, individual, leadership and supportive qualities and to enable them to adapt and to work in ever changing technologies

5. Life-long learning

   To develop the ability of students to establish themselves as professionals in mechanical engineering and to create awareness about the need for lifelong learning and pursuing advanced degrees

PROGRAMME OUTCOMES (POs)

On completion of the B.E. (Mechanical) degree, the graduate will be able

1. To apply the basic knowledge of mathematics, science and engineering
2. To design and conduct experiments as well as to analyze and interpret data and apply the same in the career or entrepreneurship
3. To design and develop innovative and creative software applications
4. To understand a complex real world problem and develop an efficient practical solution
5. To create, select and apply appropriate techniques, resources, modern engineering and IT tools
6. To understand the role as a professional and give the best to the society
7. To develop a system that will meet expected needs within realistic constraints such as economical environmental, social, political, ethical, safety and sustainability
8. To communicate effectively and make others understand exactly what they are trying to tell in both verbal and written forms
9. To work in a team as a team member or a leader and make unique contributions and work with coordination
10. To engage in lifelong learning and exhibit their technical skills
11. To develop and manage projects in multidisciplinary environments

ME6511 – DYNAMICS LABORATORY

SYLLABUS

COURSE OBJECTIVES

1. To supplement the principles learnt in kinematics and dynamics of machinery
2. To understand how certain measuring devices are used for dynamic testing

LIST OF EXPERIMENTS:

1. a. Study of gear parameters.
   b. Experimental study of velocity ratios of simple, compound, epicyclic and differential gear trains.
2. a. Kinematics of four bar, slider crank, crank rocker, double crank, double rocker, oscillating cylinder mechanisms.
   b. Kinematics of single and double universal joints.
3. a. Determination of mass moment of inertia of fly wheel and axle system.
   b. Determination of mass moment of inertia of axisymmetric bodies using turn table apparatus.
   c. Determination of mass moment of inertia using bifilar suspension and compound pendulum.
4. Motorized gyroscope – Study of gyroscopic effect and couple.
5. Governor – Determination of range sensitivity, effort etc., for watts, porter, proell and hartnell governors
6. Cams – cam profile drawing, motion curves and study of jump phenomenon
7. a. Single degree of freedom spring mass system – determination of natural frequency and verification of laws of springs – damping coefficient determination.
   b. Multi degree freedom suspension system – determination of influence coefficient.
8. a. Determination of torsional natural frequency of single and double Rotor systems. Undamped and damped natural frequencies.
   b. Vibration absorber – Tuned vibration absorber.
9. Vibration of equivalent spring mass system – Undamped and damped vibration.
10. Whirling of shafts – Determination of critical speeds of shafts with concentrated loads.
11. a. Balancing of rotating masses
    b. Balancing of reciprocating masses
12. a. Transverse vibration of free-free beam – with and without concentrated masses.
    b. Forced Vibration of cantilever beam – mode shapes and natural frequencies.
    c. Determination of transmissibility ratio using vibrating table.

COURSE OUTCOMES

1. Ability to demonstrate the principles of kinematics and dynamics of machinery
2. Ability to use the measuring devices for dynamic testing.

ME6511 - DYNAMICS LABORATORY

CONTENTS

Expt. No.01 **STUDY OF GEARS**

Aim:

To study the various types of gears and its parameter

Apparatus required:

Arrangement of gear system

Introduction:

Gears are used to transmit motion from one shaft to another or between a shaft. This is accomplished by successful engaging of tooth. Gears are intermediate links or connections and transmit the motion by direct contact. In this method the surface of two bodies have either a rolling or sliding motion along the tangent at the point of contact to transmit the definite motion of one disc to another or to prevent slip between the surface projection and recession on two discs can be made which can mesh with each other. The discs with teeth are known as gears or gear wheel.

Classification of gear:

The different kinds of gears are:

1. Based on the peripheral velocity of gears
   a. Low velocity gears – Gears with peripheral velocity < 3 m/s
   b. Medium velocity gears – Gears with peripheral velocity = 3-15 m/s
   c. High velocity gears – Gears with peripheral velocity > 15 m/s
2. Based on the position of axes of revolution
   a. Gears with parallel axes
      i. Spur gear
      ii. Helical Gear
         a) Single Helical Gear
         b) Double Helical Gear (or) Herringbone Gear
   b. Gears with intersecting axes
      i. Bevel Gear
         a) Straight bevel gear
         b) Spiral bevel gear
         c) Zerol bevel gear
         d) Hypoid bevel gear
      ii. Angular gear

iii. Miter gear

c. Gears with non-parallel and non-intersecting axes

i. Worm gear

a) Non-throated worm gear

b) Single-throated worm gear

c) Double-throated worm gear

ii. Hypoid gear

iii. Screw gear (or crossed helical gear)

3. Based on the type of gearing

a. Internal gear

b. External gear

c. Rack and Pinion

4. Based on the tooth profile on the gear surface

a. Gears with straight teeth

b. Gears with curved teeth

c. Gears with inclined teeth

1. Spur Gear:

Spur gears have straight teeth parallel to the rotating axis and thus are not subjected to axial thrust due to teeth load. Spur gears are the most common type of gears. They have straight teeth, and are mounted on parallel shafts. Sometimes, many spur gears are used at once to create very large gear reductions.

Each time a gear tooth engages a tooth on the other gear, the teeth collide, and this impact makes a noise. It also increases the stress on the gear teeth. Spur gears are the most commonly used gear type. They are characterized by teeth, which are perpendicular to the face of the gear. Spur gears are most commonly available, and are generally the least expensive.

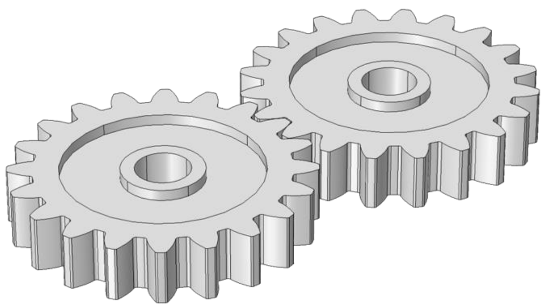


Fig. External spur gear

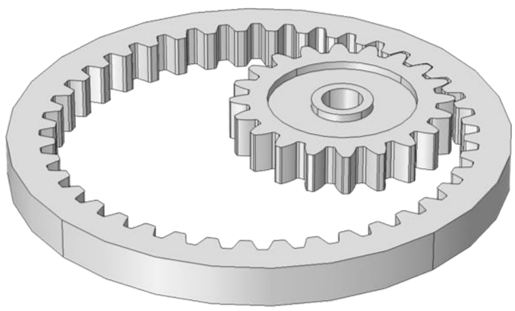
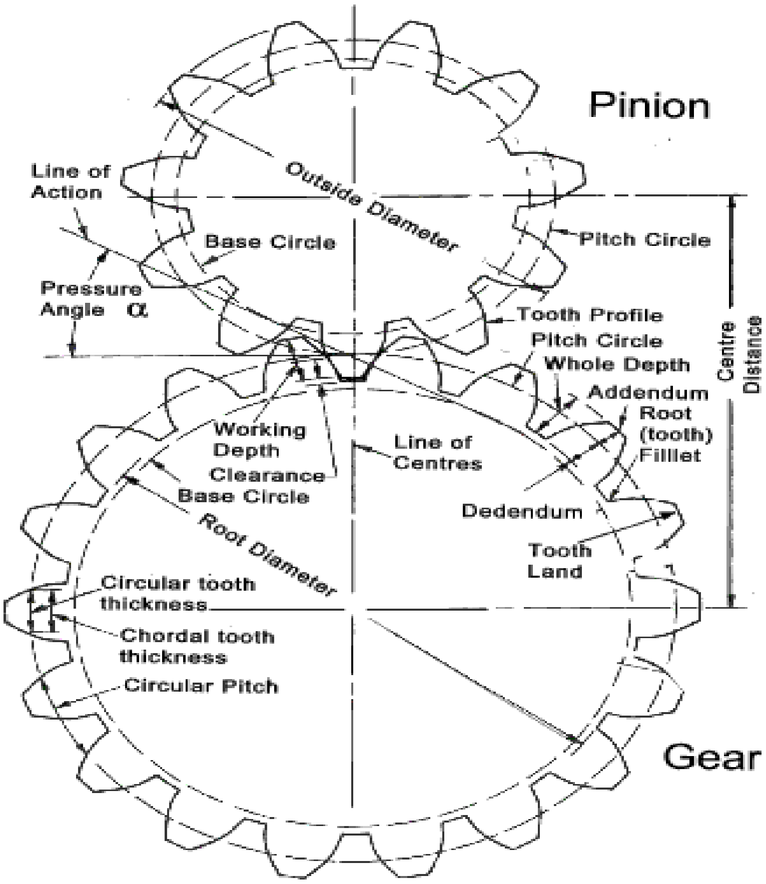


Fig. Internal spur gear

Spur Gear Terminology:



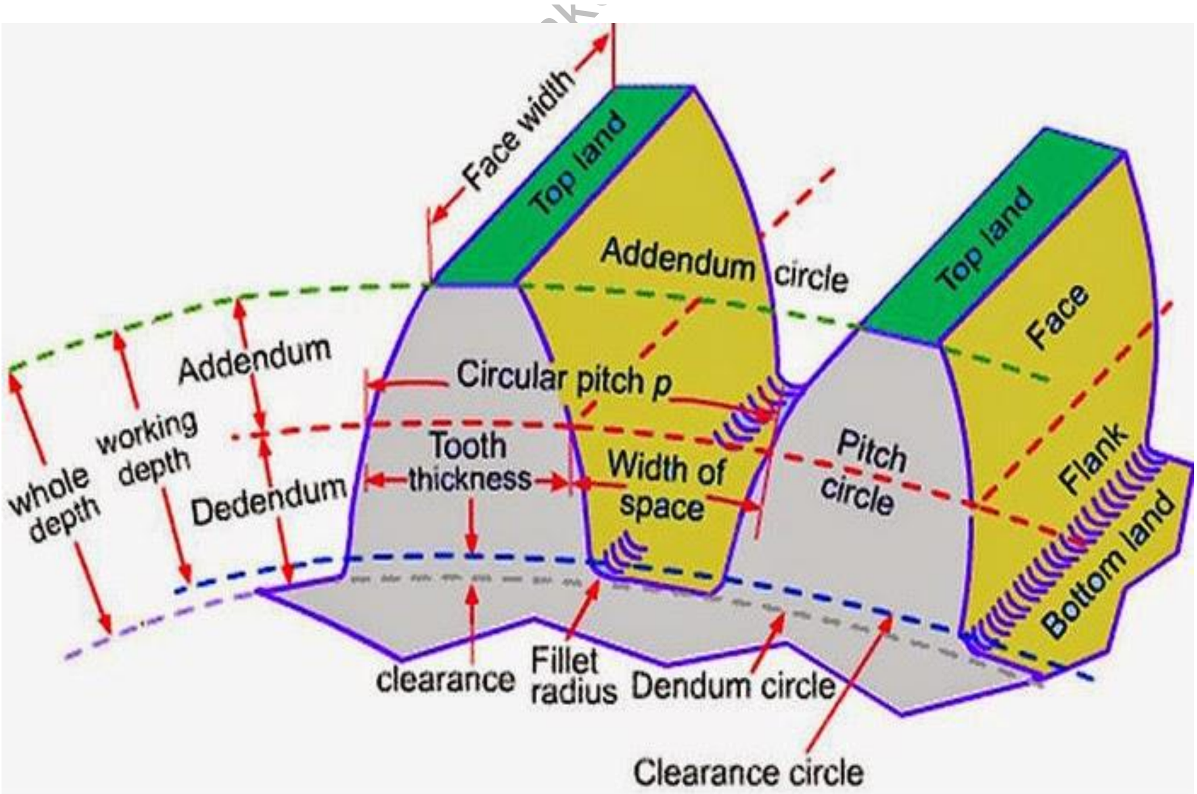


Fig. Spur Gear Terminology

The following terms, which are mostly used to describe a gear, are as follow:

- Face of tooth: It is defined as the surface of the tooth above the pitch circle is known as face.
- Flank of tooth: The surface of the tooth below the pitch circle is known as flank.
- Top land: The top most surface of the tooth is known as the top land of the tooth.
- Face width: Width of the tooth is known as face width.
- Pitch Circle: It is an imaginary circle which is in pure rolling action. The motion of the gear is describe by the pitch circle motion.
- Pitch Circle diameter: The diameter of the pitch circle from the center of the gear is known as pitch circle diameter. The gear diameter is described by its pitch circle diameter.
- Pitch point: When the two gears are in contact, the common point of both of pitch circle of meshing gears is known as pitch point.
- Pressure angle or angle of obliquity: Pressure angle is the angle between common normal to the pitch circle to the common tangent to the pitch point.
- Addendum: Distance between the pitch circle to the top of the tooth in radial direction is known as addendum.
- Dedendum: Distance between the pitch circle to the bottom of the tooth in radial direction, is known as dedendum of the gear.
- Addendum circle: The circle passes from the top of the tooth is known as addendum circle. This circle is concentric with pitch circle.
- Dedendum circle: The circle passes from the bottom of the tooth is known as dedendum circle. This circle is also concentric with pitch circle and addendum circle.
- Circular pitch: The distance between a point of a tooth to the same point of the adjacent tooth, measured along circumference of the pitch circle is known as circular pitch. It is plays measure role in gear meshing. Two gears will mesh together correctly if and only they have same circular pitch.
- Diametrical pitch: The ratio of the number of teeth to the diameter of pitch circle in millimeter is known as diametrical pitch.
- Module: The ratio of the pitch circle diameter in millimeters to the total number of teeth is known as module. It is reciprocal of the diametrical pitch.

- Clearance: When two gears are in meshing condition, the radial distance from top of a tooth of one gear to the bottom of the tooth of another gear is known as clearance. The circle passes from the top of the tooth in meshing condition is known as clearance angle.
- Total depth: The sum of the addendum and dedendum of a gear is known as total depth. It is the distance between addendum circle to the dedendum circle measure along radial direction.
- Working depth: The distance between addendum circle to the clearance circle measured along radial direction is known as working depth of the gear.
- Tooth thickness: Distance of the tooth measured along the circumference of the pitch circle is known as tooth thickness.
- Tooth space: Distance between the two adjacent tooth measured along the circumference of the pitch circle is known as the tooth space.
- Backlash: It is the difference between the tooth thickness and the tooth space. It prevents jamming of the gears in meshing condition.
- Profile: It is the curved formed by the face and flank is known as profile of the tooth. Gear tooth are generally have cycloidal or involute profile.
- Path of contact: The curved traced by the point of contact of two teeth form beginning to the end of engagement is known as path of contact.
- Arc of contact: It is the curve traced by the pitch point form the beginning to the end of engagement is known as arc of contact.
- Arc of approach: The portion of the path of contact from beginning of engagement to the pitch point is known as arc of approach.
- Arc of recess: The portion of the path of contact form pitch point to the end of the engagement is known as arc of recess.

2. Helical Gear:

The helical gear is used to connect two parallel shafts and teeth inclined or unused to the axis of the shafts. The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling causes the tooth shape to be a segment of a helix. Helical gears can be meshed in a parallel or crossed orientations.

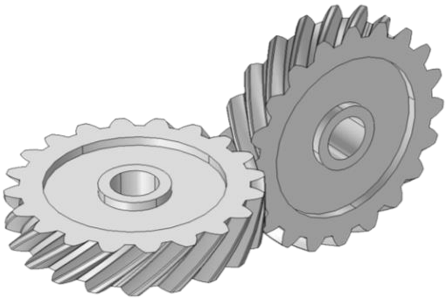


Fig. Helical Gear

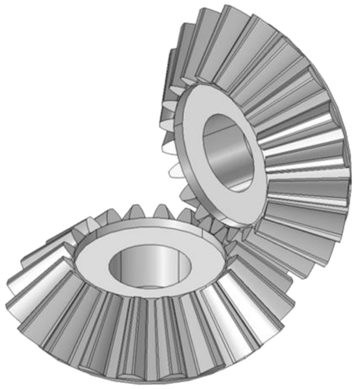


Fig. Bevel Gear

3. Bevel Gear:

Bevel gears transmit power between two intersecting shafts at any angle or between non- intersecting shafts. They are classified as straight and spiral tooth bevel and hypoid gears. When intersecting shafts are connected by gears, the pitch cones (analogous to the pitch cylinders of spur and helical gears) are tangent along an element, with their apexes at the intersection of the shafts where two bevel gears are in mesh. The size and shape of the teeth are defined at the large end, where they intersect the back cones. Pitch cone and back cone elements are perpendicular to each other. The tooth profiles resemble those of spur gears having pitch radii equal to the developed back cone radii.

4. Worm Gear:

Worm gears are usually used when large speed reductions are needed. The reduction ratio is determined by the number of starts of the worm and number of teeth on the worm gear. But worm gears have sliding contact which is quiet but tends to produce heat and have relatively low transmission efficiency.

The applications for worm gears include gear boxes, fishing pole reels, guitar string tuning pegs, and where a delicate speed adjustment by utilizing a large speed reduction is needed.

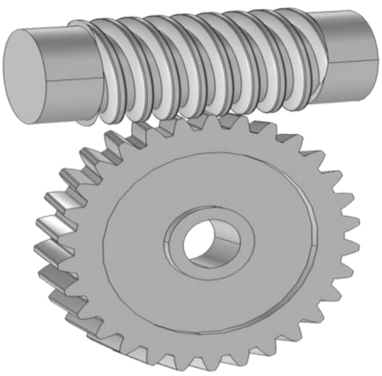


Fig. Worm and worm wheel

Fig. Screw gear

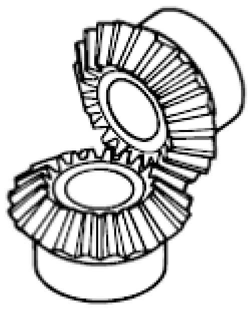


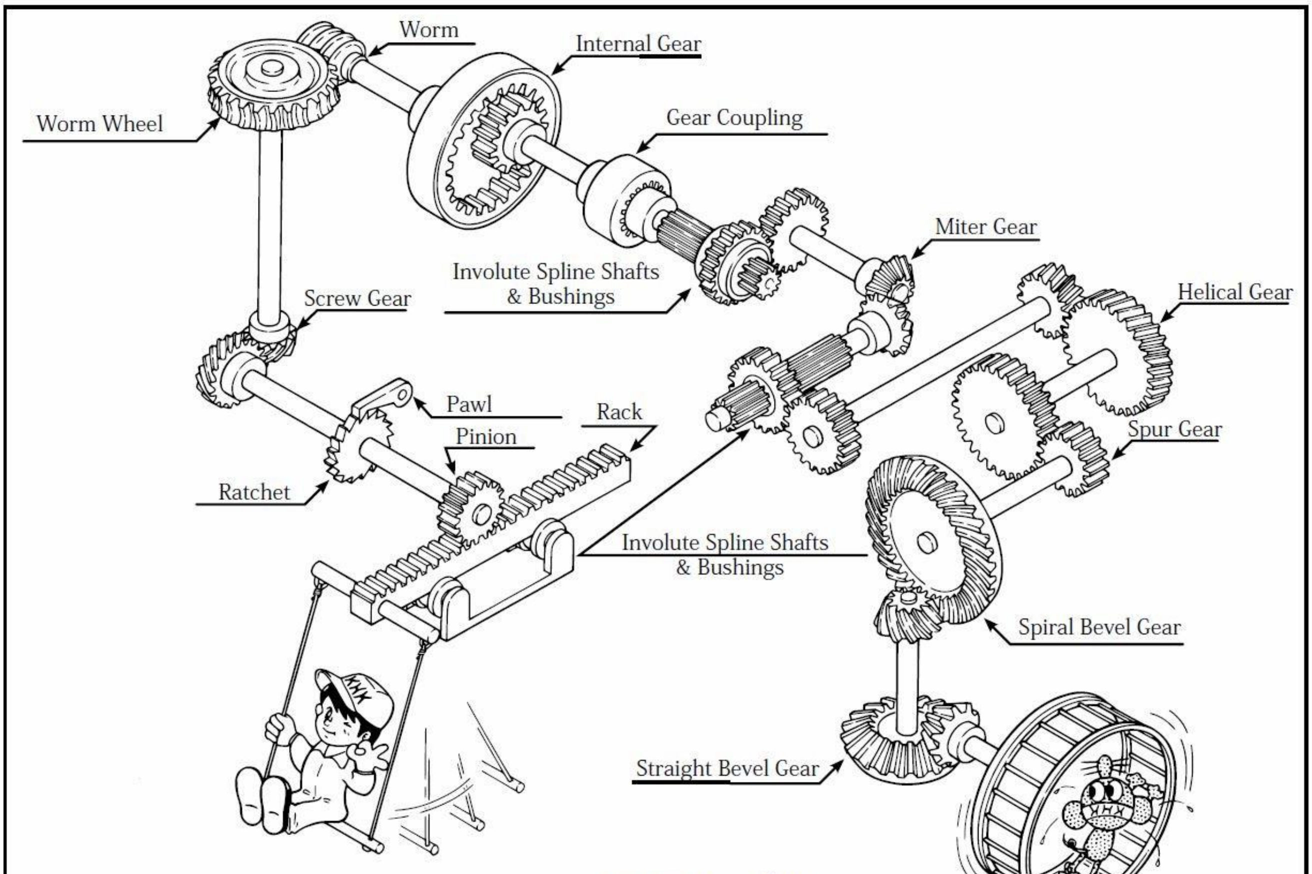
Fig. Miter gear

5. Screw gears:

Screw gears, also sometimes called crossed helical gears, are helical gears used in motion transmission between non-intersecting shafts. The helical gears used in parallel shafts have the same helix angle but in the opposite directions.

6. Miter gears:

Miter gears are one type of bevel gears where the two rotational axes intersect. When speaking of narrow definition of bevel gears with ability to increase or decrease speed, miter gears do not have that ability due to the pair's same number of teeth. Their purpose is limited to the change in transmission direction. Because they are a type of bevel gears, the basic characteristic of bevel gears exist such as presence of gear forms of straight cut, spiral cut and zerol types.



Gears - Overview

Result:

Thus gear, types and its parameters were studied.

Outcome:

From this experiment, students will be able to demonstrate the principles of gear, types and its parameters which is used in transmission systems.

Application:

1. They are used in back gear of the lathe, hoists, pulley blocks, clock, wrist watches and precision equipment.
2. They are popular for automatic transmission in automobiles.
3. They are used for power train between internal combustion engine and an electric motor.
4. They are also used in speed drives in textile and Jute machineries.

Viva-voce

1. Define – Pitch circle
2. Define – Pitch point
3. Define – Circular pitch
4. Define – Module
5. Define – Backlash
7. What is axial of a helical gear?
8. Define – Cycloid
9. Define – Undercutting gear
10. What is meant by contact ratio?
11. Define – Gear tooth system
12. State law of gearing.
13. What is an angle of obliquity in gears?
14. What is bevel gearing? Mention its types.
15. What are the methods to avoid interference?
16. What do you know about tumbler gear?
17. Define – Interference
18. Define – Backlash
19. What is meant by non – standard gear teeth?
20. Define – Cycloidal tooth profile

Expt. No.02 EXPERIMENTAL STUDY OF THE SPEED RATIO OF SPUR GEAR TRAIN

Aim:

To conduct the experimental study of speed ratio of spur gear train

Apparatus required:

Spur gear train, digital speed indicator, speed transformer

Formulae Used:

1. Total reduction in speed (N) = $(N_1 – N_2) / N_1 \times 100$ in **%**

   Where,
   N_1 = Input Speed in rpm
   N_2 = Output Speed in rpm
2. Speed Ratio = (Input Speed/ Output Speed)

Graph:

1. Input Speed Vs Output Speed.

Procedure:

1. Connect the main chord to the 230 V, 50 Hz power supply.
2. Connect the sensor 1and sensor 2 to the respective sensor sockets provided on the front panel of electronic speed control system.
3. Connect the motor cable to the terminal socket.
4. Initially, keep variable speed control knob in closed position.
5. Switch on the instrument.
6. Adjust the speed by tuning the knob and tabulate the readings and calculate.

Tabulation:

Sl. No.	Input Speed in rpm (N_1)	Output Speed in rpm (N_2)	Total reduction in Speed (N)	Speed Ratio (N_1/N_2)

Result:

Thus the speed ratio of a spur gear reducer is carried out and the graph is plotted.

Outcome:

From this experiment, students will be able to conduct the experimental study of speed ratio of spur gear train which is used in transmission systems.

Application:

The spur gear trains are used in electric screw driver, windup alarm clock, washing machine and clothes dryer.

Viva-voce

1. What is a simple gear train?
2. What are the types of gear trains?
3. What is a compound gear train?
4. What is reverted gear train?
5. What is an epicyclic or planetary gear train?
6. What is gear train or train of wheels?
7. Write velocity ratio in compound train of wheels?
8. State the methods to find the velocity ratio of epicyclic gear train.
9. What is the externally applied torque used to keep the gear train in equilibrium?
10. What is the maximum efficiency in worm and worm gear?
11. What are the advantage and limitations of gear train?
12. What is the condition and expression for maximum efficiency in spiral gears?
13. What is meant by slope of a thread?
14. Where will the interference occur in an involute pinion and gear mesh having same size of addendum?
15. What is the advantage when arc of recess is equal to arc of approach in meshing gears?
16. Write down the differences between involute and cycloidal tooth profile.
17. Name two applications of reverted gear train.
18. What are the advantages of planetary gear train?
19. What is the use of differential in automobile?
20. What are various types of torques in an epicyclic gear train?

Expt. No.03 EXPERIMENTAL STUDY OF SPEED RATIO OF AN EPICYCLIC GEAR TRAIN

Aim:

To conduct the experimental study of speed ratio of an epicyclic gear train

Apparatus required:

Epicyclic gear train, digital speed indicator, speed transformer

Procedure:

1. Connect the main chord to the 230 V, 50 Hz power supply.
2. Connect the sensor 1and sensor 2 to the respective sensor sockets provided on the front panel of electronic speed control system.
3. Connect the motor cable to the terminal socket.
4. Initially, keep variable speed control knob in closed position.
5. Switch on the instrument.
6. Adjust the speed by tuning the knob and tabulate the readings and calculate.

Formulae Used:

1. Total reduction in speed (N) = $(N_1 - N_2) / N_1 \times 100$ in %

   Where,

   N_1 = Input Speed in rpm

   N_2 = Output Speed in rpm

2. Speed Ratio = (Input Speed/ Output Speed)

Graph:

Input Speed Vs Output Speed.

Tabulation:

Sl. No.	Input Speed in rpm (N_1)	Output Speed in rpm (N_2)	Total reduction in Speed (N)	Speed Ratio

Result:

Thus the speed ratio of an epicyclic gear reducer is carried out and the graph is plotted.

Outcome:

From this experiment, students will be able to conduct the experimental study of speed ratio of an Epicyclic gear train which is used in transmission systems.

Application:

The epicyclic gear trains are used in the back gear of lathe, differential gears of the automobile, hoists, pulley blocks, wrist watches.

Viva-voce

1. Which type of gear box is used in automobiles?
2. What is meant by an idle gear?
3. In which type of vehicles, differential gear box is mounted on rear wheel axle?
4. In which type of gear trains, shaft axes which are mounted by gear wheels have relative motion between them?
2. Define the term Limiting friction.
3. Define pressure angle and explain the effect of different pressure angles.
4. What is axial pitch of a helical gear?
5. What are timing belts?
6. Explain the construction of involute teeth and its advantages.
7. State the conditions for constant velocity ratio of toothed wheels.
8. How to change the direction of rotation of the output gear in simple gear train without changing the direction of rotation of input gear?
9. What is the condition for self-locking in screws?
10. State the relationship between circular pitch and the module.
11. State the laws of dry friction.
12. Briefly write about reverted gear train with suitable sketch.
13. What is the effect of centrifugal tension in belt drives?
14. Explain any two methods of reducing or eliminating interference in gears.
15. Why lubrication reduces friction?
16. What is meant by crowning in pulley?

Expt. No.04 STUDY OF SPEED RATIO OF DIFFERENTIAL GEAR TRAIN

Aim:

To conduct the experimental study of speed ratio of differential gear train

Apparatus required:

Differential gear train, digital speed indicator, speed transformer

Procedure:

1. Connect the main chord to the 230 V, 50 Hz power supply.
2. Connect the sensor 1and sensor 2 to the respective sensor sockets provided on the front panel of electronic speed control system.
3. Connect the motor cable to the terminal socket.
4. Initially, keep variable speed control knob in closed position.
5. Switch on the instrument.
6. Adjust the speed by tuning the knob and tabulate the readings and calculate.

Formulae Used:

1. Total speed reduction in

Right wheel (N_R) $= (N_1 - N_2)/ N_1 \times 100$ in %

Left wheel (N_R) $= (N_1 - N_2)/ N_1 \times 100$ in %

where,

N_1 = input speed in rpm,

N_2 = output speed in rpm

2. Speed ratio

Right wheel (N_R) = (input speed / output speed)

Left wheel (N_L) = (input speed / output speed)

Tabulation:

Sl. No.	Input Speed (rpm) N	Output Speed (rpm)		Total reduction in Speed (N)		Speed Ratio	
		Right Wheel (N_1)	Left Wheel (N_2)	Right Wheel (N_1)	Left Wheel (N_2)	Right Wheel N_R	Left Wheel N_L

Graph:

Input Speed Vs Output Speed (for N_R and N_L)

Result:

Thus, the speed ratio of a differential gear train is carried out and the graph is plotted.

Outcome:

From this experiment, students will be able to conduct the experimental study of speed ratio of differential gear train which is used in differential unit.

Application:

The differential gear trains are used in the rear drive of an automobile.

Viva-voce

1. What is meant by an idle gear?
2. In which type of vehicle, differential gear box is mounted on rear wheel axle?
3. In which type of gear train, shaft axes which are mounted by gear wheels have relative motion between them?
4. What is meant by initial tension in belts?
5. What is meant by angle of contact?
6. Sate the law of belting?
7. What are the belt materials?
8. What is the effect of slip on velocity ratio of a belt drive?
9. What is meant by slope of a thread?
10. What are the effects of limiting angle of friction?
11. What do you know about tumbler gear?
12. What is the arc of contact between two gears of pressure angle?
13. What is the maximum efficiency in worm and worm gear?
14. What is the condition and expression for maximum efficiency in spiral gear?
15. What are the standard interchangeable tooth profiles?
16. What is the involute function in terms of pressure angle?
17. What is the minimum number of teeth on a pinion for involute rack in order to avoid interference?

Expt. No. 05 DETERMINATION OF TRANSMISSION EFFICIENCY OF A WORM GEAR REDUCER

Aim:

To determine the transmission efficiency of a worm gear reducer

Apparatus required:

Worm gear box with coupler, 1 HP Induction motor, energy watt meter, spring balance, stop clock, tachometer

Procedure:

1. Connect the power cable to 3 Phase electric supply.
2. Initially, balance the spring on no load position.
3. Switch ON the power and simultaneously give the equal range load on springs of both sides by tightening the knobs.
4. Note down the number of revolution of energy meter and time taken for the same.

Formulae Used:

Torque = $(W_1 - W_2) \times 9.81 \times r$ N-m

Effective radius (r) = $r_r + r_d$

Where,

W_1 and W_2 = Spring balance weight in Kg

r_d and r_r = Radius of drum and the radius of rope in m

Input Power = $(3600 \times N_E) / (\text{Energy meter constant} \times \text{Time})$ in KW

Output Power = $2\pi NT / 60$ in KW

Transmission Efficiency = (O.P / I.P) x 100 in %

Tabulation:

Sl. No.	Output Speed in rpm (N_2)	Input Speed in rpm (N_1)	Spring balance weight		No. of revolutions in wattmeter (N_E)	Time taken for 2 revolutions (Sec)	Torque (N-m)	Output Power (KW)	Input Power (KW)	Transmission Efficiency (ŋ%)
			W_1 (Kg)	W_2 (Kg)						

Result:

Thus experimentally the transmission efficiency of a worm gear reducer is determined.

Outcome:

From this experiment, students will be able to determine the transmission efficiency of a worm gear reducer which is used in transmission systems.

Application:

The worm gear drives are used in gate control mechanisms, hoisting machines, automobile steering mechanisms, lifts, conveyors, presses.

Viva-voce

1. Under what situation, worm gears are used?
2. Where do we use worm gears?
3. What is irreversibility in worm gears?
4. What are single – enveloping and double - enveloping worm drives?
5. How can you specify a pair of worm gears?
6. Define – Normal pitch of a worm gear
7. What is the velocity ratio range of worm gear drive?
8. Differentiate self – locking and over running worm drives.
9. Why phosphor bronze is widely used for worm gears?
10. List out the main types of failure in worm gear drive.
11. In worm gear drive, only the wheels are designed. Why?
12. Why is dynamic loading rarely considered in worm gear drives?
13. What are the various losses in the worm gear?
14. In worm gearing heat removal is an important design requirement. Why?
15. What are preferred numbers?
16. What situations demand use of gear boxes?
17. List out the main types of failure in worm gear drive.
18. What is the velocity ratio range of worm gear drive?
19. What is a speed reducer?
20. Define – Progression ratio

Expt. No.06 STUDY OF INVERSIONS OF FOUR BAR MECHANISMS, SINGLE AND DOUBLE SLIDER MECHANISMS

Aim:

To study the inversions of Four bar Mechanisms, Single & Double slider crank mechanisms

Apparatus Required:

Arrangement of four bar mechanisms, single and double slider crank mechanisms

Theory:

1. Definitions of 4 bar mechanisms, single & double slider crank mechanisms
2. Classifications of 4 bar mechanisms, single & double slider crank mechanisms
3. Diagrams of 4 bar mechanisms, single & double slider crank mechanisms
4. Working & construction of 4 bar mechanisms, single & double slider crank mechanisms
5. Applications of 4 bar mechanisms, single & double slider crank mechanism

Grashof's Law:

The Grashof condition for a four-bar linkage states: If the sum of the shortest and longest link of a planar quadrilateral linkage is less than or equal to the sum of the remaining two links, if there is to be continuous relative motion between two members. In other words, the condition is satisfied if $S+L \leq P+Q$ where S is the shortest link, L is the longest, and P and Q are the other links.

Single Slider Crank Chain

It is a modification of a basic four bar chain. It consists of one sliding and turning pair. It consists of one sliding and turning pair. It is usually used in reciprocating engine mechanisms. This type of mechanisms converts reciprocating motion in to rotary motion. E.g. IC Engines.

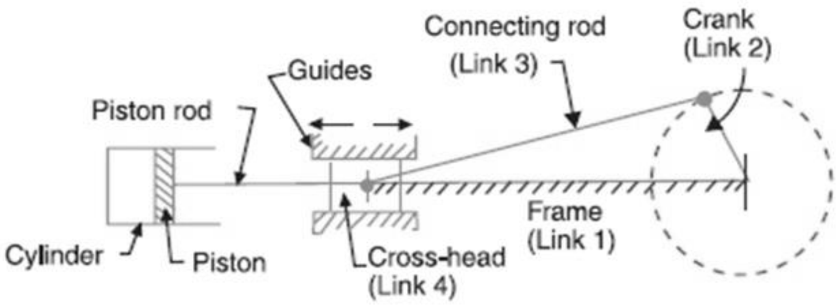


Fig. Single Slider Crank Chain

Four bar mechanism:

A four bar link mechanism or linkage is the most fundamental of the plane kinematics linkages. It is a much preferred mechanical device for the mechanization and control of motion due to its simplicity and versatility. Basically it consists of four rigid links which are connected in the form of a quadrilateral by four pin joints. A link that makes complete revolutions is the crank, the link opposite to the fixed link is the coupler and the fourth link a lever or rocker if oscillates or an another crank, if rotate. By fixing the link:-

- Shortest Link Fixed
- Link opposite to Shortest Link fixed

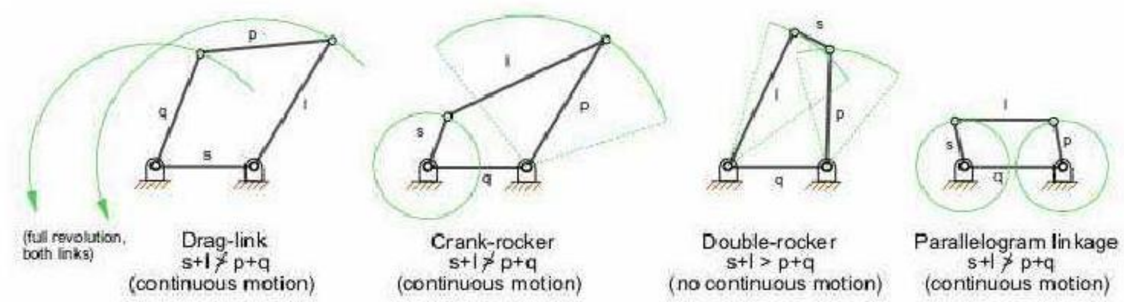


Fig. Four Bar Mechanism

The four links of a four bar chain are

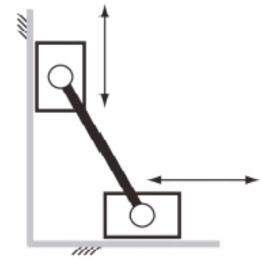
1. Crank or Driver – A crank is a part that makes complete revolutions.
2. Coupler – It is a link which is opposite to the fixed link of the mechanism that is used to connect the crank and rocker.
3. Lever or Rocker – The link that makes a partial rotation is called as Lever or Rocker.
4. Frame – The fixed link of a mechanism is called as Frame.

Different mechanisms obtained by fixing different links of a kinematics chain are known as its inversions. A slider –crank chain has the following inversions:-

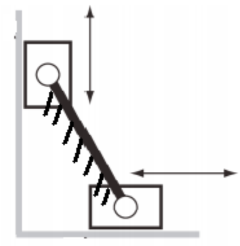
1. First inversion (i.e; Reciprocating engine and compressor) – this inversion is obtained when link 1 is fixed and links 2 and 4 are made the crank and the slider respectively.
2. Second inversion (i.e., Whitworth quick return mechanism and Rotary engine) – fixing of link 2 of a slider – crank chain.
3. Third inversion (i.e., Oscillating cylinder engine and crank & slotted – lever mechanism) – By fixing link 3 of the slider crank mechanism.
4. Fourth inversion (Hand pump) – If link 4 of the slider crank mechanism is fixed, the

fourth inversion is obtained.

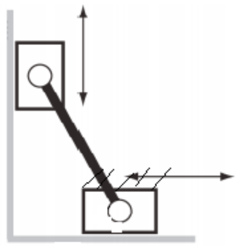
Double-slider crank-chain:



Frame Fixed Elliptical Trammel



Crank Fixed Oldhams Coupling



One Slider Fixed Scotch Yoe mechanism

A four-bar chain having two turning and two sliding pairs such that two pairs of the same kind are adjacent is known as a double-slider-crank chain. The following are its inversions:

1. First inversion (i.e., Elliptical trammel)
2. Second inversion (i.e., Scotch yoke)
3. Third inversion (i.e., Actual Oldham's coupling)

Applications:

1. In reciprocating engine.
2. In reciprocating compressor.
3. In Whitworth quick – return mechanism and Rotary engine.
4. In oscillating cylinder engine and crank & slotted-lever mechanism.
5. In hand pump.
6. In scotch yoke.

Result:

Thus the inversions of four bar mechanisms, single & double slider cranks mechanisms and its comparison and motion to be named were studied.

Outcome:

From this experiment, students will be able to study inversions of four bar mechanisms, single & double slider crank mechanism which is used in shaper and planer machines.

Application:

1. The four bar chain mechanism is used in deep boring machines and locomotives.
2. The slider and crank mechanism is used in lathes.

Viva-voce

1. What is meant by mobility?
2. What is meant by spatial mechanism?
3. What is meant by number synthesis?
4. What are the important inversions of four bar chain mechanism?
5. What is toggle position?
6. What is pantograph?
7. What are the important applications of single slider crank mechanism?
8. Compare machine and structure.
9. Give some examples for kinematic pairs.
10. Discuss Elliptical trammel.
11. Differentiate kinematic pair and kinematic chain.
12. Define – Transmission angle
13. Define – Toggle position
14. What is simple mechanism?
15. Define – Inversion mechanism
16. What is meant by mechanical advantages of mechanism?
17. Define – Sliding pair
18. Define – Turning pair
19. Define – Rolling pair
20. Define – Higher pair

Expt.No.07 KINEMATICS OF UNIVERSAL JOINT

Aim:

To study the kinematics of universal joint

Apparatus Required:

Universal joint with protractor

Description:

Universal joint is used to connect two parallel intersects shafts, the end of each shaft is forked and each fork provides two bearings for arms of a cross. The two forks line in places at right angles. The arms crossing are at right angles.

Procedure:

1. Rotate the driving shaft to some angle and note down the angle for the same that as shown in the protractor.
2. For the same angle of rotation of driver shaft, note down the angle of rotation of driven shaft.
3. Increase the angle of rotation of driver shaft for periodic angular intervals, observe and tabulate the driven angular positions.

Tabulation:

Sl. No.	Input Angle (Driver) Degrees	Output Angle (Driven) Degrees

Result:

Thus the kinematics of Universal Joint was studied successfully.

Outcome:

From this experiment, students will be able to demonstrate the principles of the kinematics of universal joint which is used in automobile industry.

Application:

The universal joint is used in each end of the propeller shaft, connecting the gear box on one end and the differential on the other end in automobiles.

Viva-voce

1. Define - Cylindrical pair
2. Define - Lower pair
3. Define - Single slider crank mechanism
4. Define - Double slider crank mechanism
5. List out few types of rocking mechanism.
6. What is free body diagram?
7. What are the important inversions of four bar chain mechanism?
8. What is the important application of single slider crank mechanism?
9. What is meant by Ackermann steering?
10. What are the two components of acceleration?
11. Define - Kennedy's theorem
12. What are the properties of instantaneous centre?
13. What is meant by the efficiency of a mechanism?
14. State the kutzback criterion.
15. Define - Rubbing velocity
16. What is meant by virtual centre?
17. What is meant by indexing mechanism?
18. State Coriolis law.
19. Explain normal component of acceleration.
20. State the condition for a link to experience coriolis acceleration.

Expt. No.08 DETERMINATION OF MASS MOMENT OF INERTIA USING TURN TABLE

Aim:

To determine the moment of inertia using turn table apparatus

Apparatus required:

Turn table, masses, steel rule and brass rod

Procedure:

1. Fix the required rod and measure the dimension (dia) at various points to calculate the mean diameter.
2. Fix the one end of the rod at the top chuck where the flywheel (disc) is suspended at the bottom end.
3. Give the twist to the flywheel and on release measure time for 10 oscillations.
4. Repeat the experiments at different length and tabulate the observations.

Formulae used:

Time period (T) = Time taken/ No. of oscillations (in Sec)

Frequency (F_n) = 1/T (in Hz)

Moment of Inertia = $Gd^4 / 128\,\pi \times (Fn)^2 \times l$ (in $Kg\text{-}m^2$)

Where, Rigidity Modulus (G) = 3.5×10^{10} (in N/m^2) (From PSG Data Book)

Tabulation:

Diameter of the brass rod = (m)

Sl.No.	Length L (m)	Time for 10 oscillations in (Sec)	Time Period T in (Sec)	Frequency (Hz)	Mass Moment of Inertia Kg m^2

Result:

Thus the moment of inertia of the brass rod using turn table apparatus is ___________.

Outcome:

From this experiment, students will be able to determine the moment of inertia using turntable apparatus.

Application:

The turn table is used in machine welding, scarfing and cutting, cladding, grinding, polishing, assembly and NDT.

Viva-voce

1. Define – Static force analysis
2. Define – D Alembert's principle
3. What do you meant by inertia?
4. What is meant by moment of inertia?
5. What is meant by polar moment inertia?
6. Define – Section modulus
7. Define – Parallel axis theorem
8. Define – Perpendicular axis theorem
9. Define – Natural frequency
10. Define – Piston effort
11. Define – Crank pin effort
12. Define – Inertia torque
13. Define – Crank effort
14. Define – Dynamics force analysis
15. State the principle of superposition.
16. Define – Coefficient of fluctuation of speed
17. What is meant by maximum fluctuation of speed?
18. Define – Coefficient of fluctuation of energy
19. What do you mean by equivalent offset inertia force?
20. Define – Radius of gyration

Expt. No.09 DETERMINATION OF RADIUS OF GYRATION USING BIFILAR SUSPENSION

Aim:

To determine the radius of gyration of a given rectangular plate

Apparatus required:

Main frame, bifilar plate, weights, stopwatch, thread

Formula used:

Time period (T) = t/N (in Sec)

Natural frequency (F_n) = 1/T (in Hz)

Radius of gyration (k) = (Tb/2) (g/L) (in mm)

Where, b = distance of string from center of gravity, T= Time period in Sec

L = Length of the string, N = Number of oscillations

t = Time taken for N oscillations (in Sec)

Procedure:

1. Select the bifilar plate.
2. With the help of chuck tighten the string at the top.
3. Adjust the length of string to desired value.
4. Give a small horizontal displacement about vertical axis.
5. Start the stop watch and note down the time required for ‘N’ oscillation.
6. Repeat the experiment by adding weights and also by changing the length of the strings.
7. Do the model calculation.

Graph:

A graph is plotted between mass added and radius of gyration.

Observation:

Type of suspension = bifilar suspension

Number of oscillation (n) =10

b = ________ (in m) b_1=___________(in m) b_2= ________(in m)

Tabulation:

Sl. No.	Mass added m (Kg)	Length of string L (m)	Time taken for "N" osc. T(Sec)	Time taken for one osc. (t) Sec	Natural frequency F_n (Hz)	Radius of gyration (k) (mm)

Result:

Thus the experiment is carried out and the radius of gyration of a given rectangular plate is __________ mm.

Outcome:

From this experiment, students will be able to determine the radius of gyration of a given rectangular plate.

Application:

The bifilar suspension is usually used for finding the moment of inertia of a connecting rod of an engine.

Viva-voce

1. Briefly explain elastic suspension.
2. Define - Transmissibility ratio
3. What is meant by transmissibility?
4. What is meant by indexing mechanism?
5. What is limiting angle of friction?
6. What is the use of differential in automobile?
8. What is pantograph?
9. What are the important applications of single slider crank mechanism?
10. What is the toggle position?
11. What is meant by spatial mechanism?
12. What are the requirements of an equivalent dynamical system?
13. What are the forces acting on the connecting rod?
14. Define - Resonance
15. Define - Steady state and transient vibrations
16. What is equivalent spring stiffness?
17. What are the causes of critical speed?
18. Define - Damping ratio
19. Define - Logarithmic decrement
20. What is meant by dynamic magnifier?
21. What are the factors that affect the critical speed of a shaft?

Expt. No.10 DETERMINATION OF MASS MOMENT OF INERTIA OF COMPOUND PENDULUM

Aim:

To determine the radius of gyration, mass moment of inertia and the natural frequency of the given circular rod experimentally

Apparatus required:

1. Vertical frame, 2.Circular rod, 3. Stop watch and 4. Steel rule

Formulae used:

Experimental Time period (T_{exp}) = t/N (in Sec)

Theoretical time period (T_{theo}) = 2π $((K^2 + h_1^2)/gh_1)$

Experimental radius of gyration (K_{exp}) = $h/\sqrt{12}$ (in m)

Theoretical radius of gyration (K_{theo}) = π $((gh_1T^2/4\pi^2)- h_1^2)$ (in m)

Where, h_1= distance from point of suspension to centre of gravity of rod

h = total length of the rod

Natural frequency (Fn) :

(by Experiment) = $1/ T_{exp}$ (Hz)

(by Theoretical) = $1/ T_{theo}$ (Hz)

Moment of inertia (I) = mk^2 in kg-m^2

Equivalent Length of pendulum (l) = $(K^2 + h^2)/h$ in m

Procedure:

1. Suspend the rod through any one of the holes.
2. Give a small angular displacement to the rod & note the time taken for 5 oscillations.
3. Repeat the step by suspending through all the holes.

Tabulation:

Sl. No.	Height h_1 (m)	Time for 10 oscillations t (Sec)	Time for a oscillation T (Sec)	Natural frequency Fn (Hz)		Experimental radius of gyration K (m)		Moment of inertia I (m)	Equivalent Length of pendulum l (m)
				Exp Fn(exp)	Theo Fn(theo)	Exp Kexp	Theo Ktheo		
Mean									

Result:

Thus the experiment was conducted for the circular rod and the following were calculated,

1. Radius of gyration = ____________ (in m)
2. Mass Moment of Inertia = ____________(in m)
3. Natural frequency = F_n (exp) _______________ (Hz), F_n (theo) ____________(Hz)

Outcome:

From this experiment, students will be able to determine the radius of gyration, mass moment of inertia and the natural frequency of the given circular rod experimentally

Application:

The compound pendulum is used to make gravity surveys in the field.

Viva-voce

1. Define - Two node frequencies
2. Define - Fundamental frequency
3. Define - Motion isolation
4. Define - Force isolation
5. What are the isolating materials?
6. Explain holzer method.
7. Define - Torsional equivalent shaft
8. Define - Node in torsional vibration
9. Briefly explain elastic suspension.
10. What are the methods of isolating the vibration?
11. What is dry friction damper?
12. What is meant by viscous damping?
13. Define - Influence coefficients
14. What is continuous system?
15. Define - Continuous beam
16. What is Rayleigh s method write its applications.
17. What is vibrometer?
18. Define - Spring stiffness and damping constant
19. What is an accelerometer?
20. What is the difference between deterministic and random vibration?

Expt. No.11 MOTORIZED GYROSCOPE – STUDY OF GYROSCOPIC EFFECT AND COUPLE

Aim:

To determine the active and reactive gyroscopic effect and its couples

Apparatus required:

Motorized gyroscope, tachometer, or stroboscope, variable voltage transformer, rotating disc with a light reflecting sticker for stroboscope speed measurement

Procedure:

1. The disc as made to rotate at a constant speed at a specific time using variable voltage transformer.
2. The speed of the (N) disc is measured using a tachometer or a stroboscope.
3. A weight /mass is added on the extending platform attached to the disc.
4. This causes an active gyroscopic couple and the whole assembly (rotating disc, rotor and weight platform with weight) is standing to move in a perpendicular plane to that of plane of rotating of disc. This is called gyroscopic motion.
5. The time taken (t) to traverse a specific angular displacement is noted.

Formula used:

Gyroscopic Couple (C) = $I\ \omega.\ \omega_p$

Angular velocity or Spinning velocity (v) = $2\pi N/60$ rad/sec

Torque applied = C = W X d N-m

Observed Velocity of precession (ω_p) = θ / T rad/sec

Theoretical Velocity of precession (ω_p) = C/I ω rad/sec

Tabulation:

Sl. No.	Speed of disc, N rpm	Applied Load m, kg	Angle of precision in Degrees	Time taken t, sec	Observed direction of displacement	Angular Velocity (rad/s)	Torque (N - m)	Observed Velocity m/sec	Theoretical Velocity m/sec	Theoretical Couple N - m

Result:

Thus the active and reactive gyroscopic effect and its couples for the motorized were conducted.

Outcome:

From this experiment, students will be able to determine the active and reactive gyroscopic effect and its couple which is used in aeroplanes and ships.

Application:

1. The gyroscopic effect is used in the gyrocompass in aeroplanes, missiles and space vehicles to sense the angular motion of a body.

2. The gyroscopic effect is used in the gyroscopic flowmeter and gyroscopic altitude indicator used for stabilization of the ships.

Viva-voce

1. What is gyroscopic couple?
2. What is gyroscopic torque?
3. Define - Steering
4. Define - Pitching
5. Define - Rolling
6. Give the applications of gyroscopic principle.
7. What is the effect of gyroscopic couple on rolling of ship?
8. Write the expression for gyroscopic couple.
9. Discuss the effect of the gyroscopic couple on a two wheeled vehicle when taking a turn.
10. How automatic controls are classified?
11. What will be the effect of gyroscopic couple on the aero plane?
12. Which part of the automobile such as engine rotor and vehicle wheels are subjected to the gyroscopic couple?
13. What is meant by reactive gyroscopic couple?
14. What is meant by applied torque and reaction torque?
15. Define - Gyroscopic acceleration

Expt. No.12 TO STUDY THE DISPLACEMENT, MOTION CURVE AND JUMP PHENOMENON OF 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
- To study the jump-speed characteristics of the cam & follower mechanism

Apparatus required:

Cam analysis system and Dial gauge

Description:

Cam is a machine element such as a cylinder or any other solid with a surface of contact so designed as to give a predetermined motion to another element called the follower. A cam is a rotating body importing oscillating motor to the follower. All cam mechanisms are composed of at least there links viz: 1.Cam, 2. Follower and 3. Frame which guides follower and cam.

Graph:

Displacement diagram and also the cam profile are drawn using a polar graph chart. The Velocity Vs acceleration curve is drawn.

Procedure:

Cam analysis system consists of cam roller follower, pull rod and guide of pull rod.

1. Set the cam at 0° and note down the projected length of the pull rod
2. Rotate the can through 10° and note down the projected length of the pull rod above the guide
3. Note down the corresponding displacement of the follower.

Jump-speed:

1. The cam is run at gradually increasing speeds, and the speed at which the follower jumps off is observed.
2. This jump-speed is observed for different loads on the follower.

Tabulation:

1. Cam profile

Sl. No.	Angle of rotation (degrees)	Lift in mm	Displacement in mm	Velocity in m/s	Acceleration (x 10^{-3}) m/s^2

2. Jump-speed.

Sl. No.	Load on the Follower, F (N)	Jump-speed N (rpm)

Result:

Thus the displacement and jump phenomenon were studied and the motion curve is plotted in polar curve.

Outcome:

From this experiment, students will be able to demonstrate using cam analysis system and to draw the displacement diagram for the follower and the cam profile, used in valve operating mechanism.

Application:

The cam mechanism is used in Internal combustion engine for operating rocker arm.

Viva-voce

1. What is a cam?
2. Give some examples for cams.
3. Define - Tangent cam
4. Distinguish radial and cylindrical cams.
5. How can high surface stress in flat faced follower be minimized?
6. Compare roller and mushroom follower be minimized?
7. Where are the roller follower extensively used?
8. Define - Dwell period
9. Explain offset follower.
10. Define - Trace point
11. Define - Pressure angle with respect to cams
12. Define - Stroke in cam
13. Define undercutting in cam. How it occurs?
14. How could you prevent undercutting in cam?
15. What do you know about monogram?
16. State the advantages of tangent cam.
17. Sketch any four types of follower with cam arrangement.
18. State the basic requirements for high speed cams.
19. Construct the displacement diagram for the follower motion to be cycloidal.
20. What is prime circle of a cam?

Expt. No.13 FREE VIBRATION OF SPRING-MASS SYSTEM

Aim:

To calculate the longitudinal undamped natural frequency of an open coil helical spring mass system

Apparatus required:

Open coil helical spring, Masses, Thread, Ruler, and Stopwatch

Description:

The setup is designed to study the free or forced vibration of a spring mass system either damped or undamped condition. It consists of a mild steel flat firmly fixed at one end through a trunnion and in the other end suspended by a helical spring, the trunnion has got its bearings fixed to a side member of the frame and allows the pivotal motion of the flat and hence the vertical motion of a mass which can be mounted at any position along the longitudinal axes of the flat. The mass unit is also called the exciter, and its unbalanced mass can create an excitation force during the study of forced vibration experiment. The experiment consists of two freely rotating unbalanced discs. The magnitude of the mass of the exciter can be varied by adding extra weight, which can be screwed at the end of the exciter.

Formula used:

Stiffness, k = load/deflection N/m

Experimental natural frequency, $f_{n(exp)}$ $=1/t_p$ Hz, Where, $t_p = 2\pi\sqrt{g/\partial}$

Theoretical natural frequency, $f_{n(the)}$ $= 1/2\pi\sqrt{(g/\partial)}$ Hz

Procedure:

Determination of spring stiffness

1. Fix the top bracket at the side of the scale and Insert one end of the spring on the hook.
2. At the bottom of the spring fix the other plat form
3. Note down the reading corresponding to the plat form
4. Add the weight and observe the change in deflection
5. With this determine spring stiffness

Determination of natural frequency

1. Add the weight and make the spring to oscillate for 10 times

2. Note the corresponding time taken for 10 oscillations and calculate time period
3. From the time period calculate experimental natural frequency.

Graph:

Load vs Deflection

Load vs Theoretical natural frequency

Load vs Experimental natural frequency

Tabulation:

Sl no	Mass added M (kg)	Length of the Spring L (mm)		Deflection (mm)		Stiffness k (N/m)	Time for 10 oscillation T (sec)	Time period for one tp (sec)	Experimental natural frequency, $f_{n(exp)}$, Hz	Theoretical natural frequency $f_{n(the)}$, Hz
		Initial	Final	Initial	Final					

Result:

Thus the longitudinal undamped natural frequency experiment of an given open coil helical spring mass system was conducted, and the frequency is _____________(in Hz).

Outcome:

From this experiment, students will be able to calculate the longitudinal undamped natural frequency of an open coil helical spring mass system which is used in suspension systems.

Application:

The spring mass system concept is used to designing the helical spring.

Viva-voce

1. What are the causes and effect of vibration?
2. Define - Free vibration
3. What are the different types of vibrations?
4. State different methods of finding natural frequency of a system
5. What is meant by free vibration and forced vibration?
6. What is meant by damping and damped vibrations?
7. What is meant by degrees of freedom in a vibrating system?
8. Define - Steady state vibration
9. Define - Transient vibration
10. What are the areas of application of transient vibration?
11. What is equivalent spring stiffness?
12. List the various methods of finding the natural frequency of free longitudinal vibrations.
13. What is the natural frequency of simple spring – mass system?
14. What is the effect of inertia on the shaft in longitudinal and transverse vibrations?
15. State the expression for the frequency of simple pendulum.
16. Distinguish between critical damping and large damping.
17. When do you say a vibrating system in under – damped?
18. What is the limit beyond which damping is determined and why?
19. What is the difference between viscous damping and coulomb damping?
20. What is the difference between frequencies of Undamped and damped vibration?

Expt. No.14 UNDAMPED AND DAMPED NATURAL AND FORCED FREQUENCIES

Aim:

To study the undamped natural and forced vibration of equivalent spring mass system

Description of set up:

The arrangement is shown in the equipment. It is designed to study, free and forced undamped vibrations. It consists of M.S rectangular beam supported at one end by a turn union pivoted in ball bearing. The bearing housing is fixed to the side member of the frame. The other end of the beam is supported by the lower end of helical spring. Upper end of spring is attached to the screw.

The exciter unit is coupled to D.C. variable speed motor through the belt drive. Speed of the motor can be varied with the dimmer stat provided on the control panel. Speed of rotation can be known from the speed indicator on the control panel. Amplitude record vibration is to be obtained on the strip-chart recorder.The exciter unit can be mounted at any position along the beam.

Procedure:

1. Support one end of the beam in the slot turn union and clamp it by means of screw.
2. Attach the other end of beam to the lower end of spring.
3. Adjust the screw to which the spring attached such that beam is horizontal in the above position.
4. Weight the exciter assembly along with discs and bearing and weight platform and clamp the assembly at any convenient position.
5. Measure the distance L1 of the assembly from pivot. Allow system to vibrate freely.
6. Measure the time for any 10osc and find the periodic time and natural frequency of vibrations.
7. Repeat the experiment by varying L1.
8. Arrange the set up as described above.
9. Connect the exciter to D.C. Motor through belt.
10. Start the motor and allow the system to vibrate.
11. Wait for 1 to 2 minutes for the amplitude to build for particular forcing frequency and adjust the position of strip-chart recorder.
12. Take the recorder of amplitude Vs. time on strip chart starting recording motor.
13. Press the recorder platform on the pen gently. Pen should be wet with ink.

14. Avoid excess pressure to get good record.
15. Take record by changing forcing frequencies.
16. Plot the graph of amplitude Vs. frequency for various damping conditions.

Observation table:

Free vibration of a spring mass system

Sl. No.	Length L1 (mm)	No. of oscillations n	Time for n oscillation T (s)	Periodic time (Expt.) T	Natural frequency(Expt.)

Where,

M = Mass of excited assembly. (Kg)

L_1= Distance of w from pivot. (m)

L = Distance of spring from pivot i.e. length of beam. (m)

Forced vibration of a spring mass system

Sl. No.	Speed rpm	Forcing frequency c.p.s	Amplitude mm

Result:

The free undamped frequency = (Hz)

The forced undamped frequency = (Hz)

Outcome:

From this experiment, students will be able to demonstrate the undamped natural and forced vibration of equivalent spring mass system

Application:

The natural and forced frequency concepts are used to designing musical instrument, shock absorber.

Viva-voce

1. What is neutral layer?
2. When is a beam said to be in a state of pure or simple bending?
3. What is section modulus?
4. How does the bending stress depend on section modulus?
5. Write the expression for section modulus.
6. Define - Moment of resistance
7. What are flitched beams?
8. Sate natural frequency of torsional vibration of a simple system.
9. What are the conditions to be satisfied for an equivalent system to that of geared system in torsional vibration?
10. How will you treat the inertia of gears while calculating the frequency of torsional vibrations of geared system?
11. Define – Torsion
12. Write the polar moment of inertia of a solid circular shaft.
13. Write the polar moment of inertia of a hollow circular shaft.
14. Define - Polar modulus for a circular section
15. Write the polar modulus for solid shaft.

Expt. No.15 TRANSVERSE VIBRATIONS - I

Aim:

To find the natural frequency of transverse vibration of the cantilever beam with concentrated masses

Apparatus required:

Displacement measuring system (strain gauge) and masses

Description:

Strain gauge is bound on the beam in the form of a bridge. One end of the beam is fixed and the other end is hanging free for keeping the weights to find the natural frequency while applying the load on the beam. This displacement causes strain gauge bridge to give the output in millivolt. Reading of the digital indicator will be in mm.

Formulae used:

1. Natural frequency = 1/2π(g/∂) Hz

   Where, g= acceleration due to gravity in m/s^2 and = deflection in m.

2. Theoretical deflection ∂ = Wl3/3EI

   Where,

   W = applied load in Newton, L = length of the beam in mm

   E = young's modules of material in N/mm^2, I= moment of inertia in mm^4 = bh3/12

3. Experimental stiffness = W/∂ N-mm and Theoretical stiffness = W/∂ =3EI/l3 N/mm

Procedure:

1. Connect the sensors to instrument using connection cable.
2. Plug the main cord to 230v/ 50 Hz supply.
3. Switch on the instrument.
4. Keep the switch in the read position and turn the potentiometer till displays reads "0".
5. Keep the switch at cal position and turn the potentiometer till display reads 5.
6. Keep the switch again in read position and ensure at the display shows "0".
7. Apply the load gradually in grams.
8. Read the deflection in mm.

Graph:

1. Draw the characteristics curves of load vs. displacement, natural frequency.
2. Draw the characteristics curves of displacement vs. natural frequency.

Tabulation:

Observation:

Cantilever beam dimensions: Length=_______, Breadth=_______and Height=___________

Sl. No.	Applied mass m (kg)	Deflection (mm)	Theoretical deflection T (mm)	Experimental Stiffness k (N/mm)	Theoretical Stiffness k (N/mm)	Natural frequency f_n (Hz)

Result:

Thus the transverse vibration frequency of a cantilever beam is experimentally studies and the frequency is _________ (in Hz) and the characteristic graphs are plotted.

Outcome:

From this experiment, students will be able to find the natural frequency of transverse vibration of the cantilever beam with concentrated masses

Application:

The transverse vibration concept is used to enhanced submerged hollow fibre membrane distillation crystallizer for hypersaline water treatment.

Viva-voce

1. Write down any four types of beams.
2. What is meant by overhanging beam?
3. Define - Shear force and bending moment
4. State the sign convention for shear force.
5. State the sign convention for bending moment.
6. What does the area under shear force diagram give?
7. Define - Point of contra flexure
8. What is the value of bending moment corresponding to a point having zero shear force?
9. What is neutral layer?
10. When is a beam said to be in a state of pure or simple bending?
11. What is section modulus?
12. How does the bending stress depend on section modulus?
13. Write the expression for section modulus.
14. Define - Moment of resistance
15. What are flitched beams?
16. What is meant by shear centre?
17. What is meant by neutral axis of a beam?
18. State any two assumptions in theory of shear stresses in beams.
19. Define - Shear flow
20. Define - Obliquity

Expt. No.16 TRANSVERSE VIBRATIONS - II

Aim:

To study the transverse vibrations of a simply supported beam subjected to central or offset concentrated load

Apparatus Required:

Trunnion bearings, Beam set up and masses

Formulae used:

Defection at the center, ∂_T $= Wl^3/48EI$ for central concentrated load.

Defection at the load point, ∂_T $= Wa^2b^2/3EI$ for offset concentrated load.

Defection at the center, ∂_T $= 5wl^4/384EI$ for uniformly distributed load.

$I = bd^3/12$; b = width of the beam, d = depth of the beam, l = length of the beam.

Natural frequency of transverse vibrations, $f_n = 1/2\pi\ (g/\partial)$ Hz

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

∂ = deflection in m

Procedure:

1. Fix the beam into the slots of trunnion bearings and tighten.
2. Add the concentrated load centrally or offset, or uniformly distributed.
3. Determine the deflection of the beam for various weights added.

Observations:

b =__________, d =__________, l =__________, E =__________

Tabulation:

Sl. No.	Mass added m , kg	Experimental Deflection ∂, m	Theoretical Deflection ∂_T, m	Theoretical Nat. freq. f_n , Hz	Experimental Stiffness K, N/m	Theoretical Stiffness K, N/m

Graphs:

1. Deflection Vs. load (N) from this get stiffness (graph)
2. Deflection Vs. Natural frequency
3. Load in N Vs. natural frequency

Stiffness experimental, $K = load/deflection = W/\delta = mg/\delta$ N/mm

Stiffness theoretical, $K = W/\delta_T = 48EI/l^3$ for center load,

$= 3EIl/a^2b^2$ for offset load,

$= 384EI/5l^3$ for uniformly distributed load

Result:

Thus the transverse vibration frequency of a simply supported beam subjected to central load is experimentally studied and the frequency is ___________(in Hz).

Outcome:

From this experiment, students will be able to demonstrate the transverse vibrations of a simply supported beam subjected to central or offset concentrated load

Application:

The transverse vibration concept is used to enhanced submerged hollow fibre membrane distillation crystallizer for hypersaline water treatment.

Viva-voce

1. Write the polar modulus for a hollow shaft.
2. Express the strength of a solid shaft.
3. Why are hollow shafts preferred to solid shafts?
4. Write the polar moment of inertia of a hollow circular shaft.
5. Define - Polar modulus for a circular section
6. Write the polar modulus for solid shaft.
7. Write the polar modulus for a hollow shaft.
8. Express the strength of a solid shaft.
9. Why are hollow shafts preferred to solid shafts?
10. List the loads normally acting on a shaft.
11. Define - Modulus of rigidity
12. State the elastic constants.
13. Define - Frequency response curve
14. What is phase response curve?
15. What is force isolation?

Expt. No.17 DETERMINATION OF TORSIONAL NATURAL FREQUENCY OF DOUBLE ROTOR SYSTEM

Aim:

To determine the torsional natural frequency of double rotor system

Apparatus Required:

Main Frame, Two Masses, Shaft, Stop Clock

Procedure:

1. Fix the two rotor discs to the shaft and fix the both ends of shaft in bearings.
2. Manually, twist the disc in opposite direction to each other and release it.
3. Note down the time for 10 oscillations.
4. Repeat the same experimentation with different masses attached with the ends and tabulate the readings.

Formulae:

Let, L – Length of shaft (in m)

I_A and I_A – MI of disc A and B respectively (in Kg-m^2)

D – Dia of the shaft (in m)

R – Radius of fixation of weight on arm from disc center. (with loads in cross arm)

W – Weight attached to cross arm

I_A – $(W_A/g) \times (D_A/8)^2 = m_A. D_A/8^2$

I_B – $(W_B/g) \times (D_A/8)^2 + (2W_1/g) x (R/8)^2 = (m_B. D_B/8) + (2mR/8)$

Dia of disc A (D_A) = ____________________m

Dia of disc B (D_B) = ____________________m

Weight of disc A (m_A) = ____________________Kg

Weight of disc B (m_B) = ____________________Kg

Length of cross arm(L) = ____________m

Torsional stiffness of shaft (k_t) = G.Ip/L

Time period:

$T_{theo} = 2\pi\sqrt{((I_A . I_B) / k_t (I_A + I_B))}$ in Sec

$T_{exp} = t/N$ in Sec

Where,

G – Modulus of rigidity

Ip – Polar MI of shaft = $(\pi d^4/32)$ in m

Tabulation:

Sl. No.	Load (Kg)	No. of oscillations	Time for 10 oscillations	Time for 1 oscillation	MMI of disc A (I_A) Kg-m^2	MMI of disc B (I_B) Kg-m^2	Experimental Frequency Hz

Result:

Thus the natural frequency for torsional vibration of double rotor system is determined. The results are:

1. Moment of Inertial of I_A = ____________________ Kg – m^2
2. Moment of Inertial of I_B = ____________________ Kg – m^2
3. Theoretical Frequency = ____________________ Hz
4. Experimental Frequency = ____________________ Hz

Outcome:

From this experiment, students will be able to determine the torsional natural frequency of double rotor system

Application:

The torsional natural frequency of the double rotor system concept is used in designing of aircraft.

Viva-voce

1. Define - Torsional vibration
2. Differentiate between transverse and torsional vibration.
3. Define - Torsional equivalent shaft
4. Sate natural frequency of torsional vibration of a simple system.
5. What are the conditions to be satisfied for an equivalent system to that of geared system in torsional vibration?
6. How will you treat the inertia of gears while calculating the frequency of torsional vibrations of geared system?
7. Define - Torsion
8. Write the polar moment of inertia of a solid circular shaft.
9. Write the polar moment of inertia of a hollow circular shaft.
10. Define - Polar modulus for a circular section
11. Write the polar modulus for solid shaft.
12. Write the polar modulus for a hollow shaft.
13. Express the strength of a solid shaft.
14. Why are hollow shafts preferred to solid shafts?
15. List the loads normally acting on a shaft.
16. Define - Modulus of rigidity
17. State the elastic constants.
18. Define - Flexural rigidity
19. What is dry friction damper?
20. Mention important types of free vibrations.

Expt. No.18 DETERMINATION OF WHIRLING OF SHAFT

Aim:

To determine theoretically the critical speed of the given shaft with the given end conditions

Apparatus required:

Shaft set up

Description:

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

Normally the centre of gravity of a loaded shaft will always displace from the axis of rotation although the amount of displacement may be very small. As a result of this displacement, the centre of gravity is subjected to a centripetal acceleration as soon as the Shaft begins to rotate. The inertia force acts radially outwards and bends the shaft. The bending of shaft not only depends upon the value of eccentricity, but also depends upon the speed at which the shaft rotates.

Formula used:

$f_n = K\sqrt{(EgI/wl4)}$ and $N= f_n \times 60$

Where,

f_n = natural frequency of vibration in Hz

g = acceleration due to gravity, (9.81 m/s2), E= modules of elasticity of the shaft

I = moment of inertia of shaft in m4, w= weight /unit length in N/m

L = effective length of the shaft between supports in m. and N= speed of the shaft in rpm

K = constant (2.45)

Procedure:

1. Connect the shaft cord to the power source.
2. Increase the speed of the shaft with the speed controller.
3. Find the speed which the shaft rotates vigorously
4. Note the speed at the digital indicates in which the deflection is more.
5. Find the frequency for the speed in which the deflection is more.

Calculation:

1. Moment of inertia

2. Weight of solid shaft
3. Natural frequency
4. Critical speed

Result:

Thus the critical speed of the given shaft is determined.

Outcome:

From this experiment, students will be able to determine theoretical speed of the given shaft with the given end conditions

Application:

The whirling of shaft concept is used in designing of ball mill, roller mill, cone crusher.

Viva-voce

1. Define - Frequency response curve
2. What is phase response curve?
3. What is force isolation?
4. What is motion isolation?
5. Define - Amplitude
6. What is longitudinal vibration?
7. What are the causes of critical speed?
8. What are the factors that affect the critical speed of a shaft?
9. Define - Critical speed
10. Briefly explain elastic suspension.
11. Specify the important of vibration isolation?
12. What is meant by harmonic forcing?
13. State different methods of finding natural frequency of a system.
14. Define - Critical damping
15. What is the limit beyond which damping is detrimental and why?
16. What type of motion is exhibited by a vibrating system when it is critical damped?
17. Why is critical speed encountered?

Expt. No.19 BALANCING OF ROTATING MASSES

Aim:

To balance the given rotor system dynamically with the aid of the force polygon and the couple polygon

Apparatus required:

Rotor system, weights, steel rule, etc…

Procedure:

1. Fix the unbalanced masses as per the given conditions: radius, angular position and plane of masses.
2. Find out thee balancing masses and angular positions using force polygon, and couple polygon
3. Fix the balancing masses (calculated masses) at the respective radii and angular position.
4. Run the system at certain speeds and check that the balancing is done effectively.
5. If the rotor system rotates smoothly, without considerable vibrations, means the system is dynamically balanced.

Tabulation:

Sl. No.	Planes of mass	Mass m, kg	Radius r, m	C. Force / ω^2mr, kg-m	Distance from Ref. Plane l, m	Couple / ω^2mrl, kg-m^2
1	A					
2	B					
3	C					
4	D					

Diagrams:

1 Plane of the masses 2. Angular position of the masses 3. Force polygon

4 Couple polygon

Result:

The given rotor system has been dynamically balanced with the aid of force polygon and couple polygon.

Outcome:

From this experiment, students will be able to balance the given rotor system dynamically with the aid of the force polygon.

Application:

The balancing of rotating masses is important to avoid vibration in heavy industrial machines such as gas turbines and electric generators.

Viva-voce

1. What is the effect of hammer blow and what is the cause it?
2. Why radial engines are preferred?
3. Give the reason for selecting different firing orders.
4. Why cranks of a locomotive are generally at right angles to one another?
5. Differentiate static and dynamic balancing.
6. Define - Dalby's method of balancing masses
7. Why complete balancing is not possible in reciprocating masses?
8. What are the various cases of balancing revolving masses?
9. Define - Tractive force
10. Define - Swaying couple
11. What are in – line engines?
12. Define - Dynamic balancing
13. Write the important of balancing?
14. Why balancing of dynamic forces are necessary?
15. Write the different types of balancing.

Expt. No.20 BALANCING OF RECIPROCATING MASSES

Aim:

To balance the given rotor system dynamically with the aid of the force polygon and the couple polygon

Apparatus required:

Reciprocating system, weights, steel rule, etc

Procedure:

1. Fix the unbalanced masses as per the given conditions: radius, angular position and plane of masses.
2. Find out thee balancing masses and angular positions using force polygon, and couple polygon
3. Fix the balancing masses (calculated masses) at the respective radii and angular position.
4. Run the system at certain speeds and check that the balancing is done effectively.
5. If the rotor system rotates smoothly, without considerable vibrations, means the system is dynamically balanced.

Tabulation:

Sl. No.	Planes of mass	Mass m, kg	Radius r, m	C. Force / $\omega^2 mr$, kg-m	Distance from Ref. Plane l, m	Couple / $\omega^2 mrl$, kg-m^2
1 2 3 4	A B C D					

Diagrams:

1. Plane of the masses 2. Angular position of the masses 3. Force polygon
4. Couple polygon

Result:

The given reciprocating system has been dynamically balanced with the aid of force polygon and couple polygon.

Outcome:

From this experiment, students will be able to balance the given rotor system dynamically with the aid of the force polygon

Application:

The balancing of reciprocating masses is important to avoid shaking forces and shaking couples in heavy industrial machines such as gas turbines and electric generators.

Viva-voce

1. What is meant by balancing of rotating masses?
2. Why rotating masses are to be dynamically balanced?
3. Define - Static balancing
4. Define - Dynamic balancing
5. Write the important of balancing?
6. Why balancing of dynamic forces are necessary?
7. Write the different types of balancing.
8. State the condition for static balancing.
9. Write the condition for complete balancing.
10. Differentiate static and dynamic balancing.
11. Define - Dalby's method of balancing masses
12. Why complete balancing is not possible in reciprocating masses?
13. What are the various cases of balancing revolving masses?
14. Define - Tractive force
15. Define - Swaying couple
16. What are in – line engines?
17. What is the effect of hammer blow and what is the cause it?
18. Why radial engines are preferred?
19. Give the reason for selecting different firing orders.
20. Why cranks of a locomotive are generally at right angles to one another?

Expt. No.21 MEASUREMENT OF DISPLACEMENT, VELOCITY AND ACCELERATION USING VIBRATION ANALYSIS

Aim:

To measure the displacement, velocity and acceleration using vibration analysis

Apparatus required:

Oscillation power amplifier, vibration oscillator, vibration amplifier

Graph:

1. Frequency Vs Displacement
2. Frequency Vs Velocity
3. Frequency Vs Acceleration

Procedure:

1. Connect the power amplifier output to vibration exciter.
2. Place acceleration probe upon the vibration exciter as spindle.
3. Connect the vibration probe up cable to the accelerator.
4. Set the varying range as 100.
5. Vary the input and note down the observations.

Tabulation:

Sl.No.	Frequency in Hz	Displacement X 200 μ	Velocity X 200 mm/s	Acceleration X 200 m/s^2

Result:

Thus the displacement, velocity and acceleration are measured using vibration analysis and the characteristics were studied from the plotted graph.

Outcome:

From this experiment, students will be able to measure the displacement, velocity and acceleration using vibration analysis

Application:

The vibration analysis concept is used in service equipment, such as helicopter transmissions and turbine engines.

Viva-voce

1. When involutes interference occurs?
2. Define - Cycloid
3. Define - Gear tooth system.
4. What are the conditions to be satisfied for interchangeability of all gear?
5. Define - Circular pitch
6. What is meant by angle of dwell?
7. What is meant by contact ratio?
8. Define - Pressure angle
9. Discuss the advantages of involutes gear tooth profile.
10. Define - Gear tooth system
11. Define - Coefficient of fluctuation of energy
12. Define - Coefficient of fluctuation of speed
13. Explain the term maximum fluctuation of energy in fly wheel.
14. Define - Direct and reverse cranks
15. What is meant by degrees of freedom in a vibrating system?
16. Define - Coefficient of sensitiveness
17. Explain controlling force?
18. Define - Isolation factor
19. Define - Influence co- efficient
20. Define - Inertia force

Expt. No.22 HARTNELL GOVERNOR

Aim:

To find the stiffness, sensitivity and effort of the spring using Hartnell governor

Apparatus required:

Hartnell governor setup and Tachometer

Description:

Hartnell governor is a centrifugal type spring controlled governor where the pivot of the ball crank lever is carried by the moving sleeve. The spring is compressed between the sleeve and the cap is fixed to the end of the governor shaft. The ball crank is mounted with its bell and the vertical arm pressing against the cap.

Formula:

$Fc_1 = m\,\omega_1^2\ r_1$ (N) and $Fc_2 = m\,\omega_2^{\,2}\,r_2$ (N)

$\omega_1 = 2\pi N_1/60$ rad/s and $\omega_2=2\pi N_2/60$ rad/s

$S_1 = 2Fc_1\ (x/y)$ N and $S_2=2Fc_2\ (x/y)$ N

$r_2 = r-R(x/y)$ (mm)

Sensitivity = (maximum speed-minimum speed)/mean speed = $(N_1-N_2)/N$

Effort = (spring force at maximum speed- spring force at minimum speed)/2

Spring stiffness = $(S_1-S_2)/R$ N/mm

Where, m= mass of the ball is (m=0.18 kg)

ω_1 & ω_2 = angular speed of governor at maximum radius and minimum radius respectively in rad/sec

r_1& r_2 = maximum and minimum radius of rotation

Fc_1 & Fc_2 =centrifugal forces at ω_1 and ω_2 in N

X= length of the vertical ball arm of lever in m

Y= length of the horizontal ball arm of lever in m

S_1& S_2 = spring forces at ω_1 & ω_2 in N

Procedure:

1. Keep the speed regulation in 0 position before starting the motor.
2. Increase the regulated output gradually till the motor takes the critical speed and immediately control the speed of the governor

3. Maintain the speed for each and every graduation as required to take the direct reading

Tabulation:

Sl. No.	Speed, N (rpm)			Sensitivity	Effort (N)	Stiffness (N/mm)
	Min	Max	mean			

X=______ , Y=______ , $r_1 = r$

Graph:

1. Mean speed Vs. Sensitivity
2. Mean speed Vs. Effort

Result:

Thus the stiffness, sensitivity and effort of the spring is found using Hartnell governor.

Outcome:

From this experiment, students will be able to find the stiffness, sensitivity and effort of the spring using Hartnell governor which is used in diesel engines.

Application:

The hartnell governor is used in stationary steam engines, traction engines

Viva-voce

1. What is the function of governor?
2. How governors are classified?
3. Differentiate between governor and fly wheel.
4. What is meant by sensitiveness of a governor?
5. What is the effect of friction on the governor?
6. Define - Coefficient of sensitiveness
7. What is meant by hunting?
8. What is meant by isochronous conditions governor?
9. Define - Stability of a governor
10. What is the principle of working of centrifugal governor?
11. Define - Power of governor
12. Explain the term stability of governor.
13. Explain sensitiveness of governors.
14. Explain governor effect.
15. What is the principle of inertia governors?
16. What is equilibrium speed?
17. Differentiate hunting from sensitiveness.
18. When is a governor said to be hunt?
19. Derive an expression for the height in the case of a watt governor.
20. When is a governor said to be stable?

ADDITIONAL EXPERIMENTS BEYOND THE SYLLABUS

Expt. No.23 **STUDY OF VIBRATION**

Aim:

To study the vibration, causes and its characteristics

Vibration:

Vibration is simply the motion of a machine of machine part back and forth from its position of rest. The simplest way to show vibration is to follow the motion of a weight suspended on the end of a spring. This is typical of all machines since they too have weight and spring like property. Vibration of the response of a system to some internal or external or force applied to the system.

Causes of vibrations:

The most common problems that produce vibration are,

1. Unbalance of rotating parts
2. Misalignment of couplings and bearings
3. Bent shaft
4. Worn eccentric or damaged gears
5. Bad drive belts and drive chains
6. Bad bearings
7. Torque variations
8. Electromagnetic force
9. Aerodynamic forces
10. Hydraulic forces
11. Looseness
12. Rubbing
13. Resonance

The characteristics of vibration:

A machine's condition and mechanical problems are determined by measuring its vibration characteristics. The more important of these characteristics include,

1. Frequency
2. Displacement
3. Velocity
4. Acceleration

5. Phase
6. Spike energy

Vibration frequency:

Vibration frequency is the measure of the number of complete cycle that occurs in a specified period of time. Frequency is related to the period of a vibration pattern by this simple formula,

$$\text{Frequency} = \frac{1}{\text{Time period}}$$

Vibration displacement:

The total distance travelled by the vibrating part from one extreme limit of travel to the other extreme limit of travel to the other extreme limit of travel is referred to as the "peak to peak displacement". The peak to peak displacement is expressed in micro meter.

Vibration velocity:

Since the vibration weight is moving, it must be moving at some speed. However the speed of the weight is constantly changing. The speed of velocity is greatest as the weight passes the neutral position and zero at extreme ends. For measurement highest peak velocity is taken and unit is millimeter.

Vibration acceleration:

As the velocity changes there is change in acceleration. The acceleration of the part is maximum at the extreme limit and zero when it passes neutral position. Vibration acceleration is normally expressed in "g's" peak, where one "g" is the acceleration produced by the force of gravity at the surface of the earth i.e. 9.81 m/s^2.

Vibration phase:

Another important characteristic of vibration is phase. Phase is defined as the position of vibrating part at a given instance with reference to a fixed point or another vibrating part. In a practical sense, phase measurements offer a convenient way to compare one vibration motion with another; or to determine how one part is vibrating relative to another part.

Vibration spike energy:

Spike energy measurements include very short duration, high frequency, spike like pluses of vibration energy that occur in machinery as a result of,

1. Surface flows in rolling elements of bearings or gears.
2. Rubs, impact and metal to metal contact in rotating machine.
3. High pressure steam or air leaks.
4. Cavitation of flow turbulence in fluids.

Spike energy measurement has its own unique units of measurement. Although spike energy measurements are basically a measure of vibration acceleration. For this reason spike energy measurements are expressed in "g-SE" units.

Vibration analysis data acquisition:

Vibration analysis is a 2 step process involving the acquisition and interpretation of machinery vibration data. Its purpose is to determine the mechanical condition of a machine and pinpoint any specific mechanical or operational defects.

Digital stroboscope:

Digital stroboscope is a microprocessor circuit design. High accuracy, digital readout, light duty. It is ideal for inspecting and measuring the speed of moving gears, fan centrifuges, pump, motors and other equipment used in general industrial maintenance, production, quality control.

This stroboscope employs an exclusive chip of microcomputer LSI circuit & crystal control time base which results in accuracy over a wide dynamic range.

Result:

Thus the study of vibration, causes and its characteristics was studied.

Outcome:

From this experiment, students will be able to demonstrate the vibration, causes and its characteristics

Application:

The vibration concept comes in designing of every mechanical equipment like lathe, drilling, tool box, gear box.

Viva-voce

1. What are the causes and effect of vibration?
2. Define - Free vibration
3. What are the different types of vibrations?
4. State different methods of finding natural frequency of a system
5. What is meant by free vibration and forced vibration?
6. What is meant by damping and damped vibrations?
7. What is meant by degrees of freedom in a vibrating system?
8. Define - Steady state vibration
9. Define - Transient vibration
10. What are the areas of application of transient vibration?
11. What is equivalent spring stiffness?
12. List the various methods of finding the natural frequency of free longitudinal vibrations.
13. What is the natural frequency of simple spring – mass system?
14. What is the effect of inertia on the shaft in longitudinal and transverse vibrations?
15. State the expression for the frequency of simple pendulum.

Expt. No.24 STROBOSCOPE

Aim:

To study of speed measurement by using stroboscope

Apparatus required:

Digital stroboscope, variable speed motor variable motor, speed control

Tabulation:

Observation Table:

Sl. No.	Variable speed motor Controller (in Volts)	Stroboscope reading (in RPM)	Contact Tachometer (in RPM)

Graph:

1. Variable speed motor controller (rpm) Vs stroboscope reading (rpm)
2. Stroboscope reading (rpm) Vs non-contact type tachometer (rpm)

Procedure:

3. Preparation of the Set Up:
   a. Plug unit into a properly power source.
   b. Turn the power switch to “ON” position.
   c. Determine the range switch to “low” or “high” position.
3. Checking speed:

When checking speed, care must be taken to ensure that stroboscope is flashing in unison with the object being monitored. A stroboscope will also stop motion at 2:1,3:1, 4:1 etc.; this is normally referred to as harmonics. To be sure of unison, turn the dia., until 2 images appears this is the actual speed.

4. Connect the motor cable in to motor controller
5. Keep variable knob to zero volts.
6. Plug into 230V A.C. power supply.
7. Keep required speed.
8. Note down the reading in tabular column.
9. Make a graph.

Result:

Thus the study of speed measurement by using stroboscope was conducted.

Outcome:

From this experiment, students will be able to demonstrate speed measurement by using stroboscope

Application:

1. Stroboscopes play an important role in the study of stresses on machinery in motion.
2. They are used to measuring instruments for determining cyclic speed.
3. In medicine, stroboscopes are used to view the vocal cords for diagnosis of conditions that have produced dysphonia (hoarseness).

Viva-voce

4. What is step ratio?
5. What are preferred numbers?
6. What kinematic arrangement is as applied to gear boxes?
7. What does the ray – diagram of gear box indicates?
8. What is a speed reducer?
9. What do you understand by dynamically equivalent system?
10. What is the function of a flywheel?
11. What do you infer from the term cam dynamics?
10. What do you understand by out – of – balance?
11. State conditions for the complete balancing of rotating masses.
12. How are the different masses rotating in different planes are balanced?
13. Explain reasons in detail for partial balancing of reciprocating masses.
14. What do you mean by balancing linkages?
15. What is mean by over damping?
16. Define - Amplitude
17. Define - Free vibrations
18. What do you mean by correction couple?
19. Define - Power of a governor
20. Define - Unbalance and spring surge
21. Why flywheels are needed in forging and pressing operations?

LIST OF PROJECT TITLES

- Create a four bar linkage and demonstrate its motion with a hand crank.
- Design, build and test a system to isolate a sensitive instrument from ground – borne vibrations.
- Shock Absorber Design for Rickshaw.
- Design a Gearless power transmission
- Various types of Governor arrangement
- Create a Whitworth quick return mechanism
- Create a Cam profile mechanism
- Create a Crank slotted link mechanism
- Create an Open and cross belt drive mechanism