JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE	JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE JECRC Campus, Shri Ram Ki Nangal, Via-Vatika, Jaipur

LAB MANUAL

Lab	:	THEORY OF MACHINES LAB
Lab Code	:	4ME4-24
Branch	:	Mechanical Engineering
Year	:	Second Year

JAIPUR ENGINEERING COLLEGE
AND RESEARCH CENTRE

Department of Mechanical Engineering
Jaipur Engineering College and Research Centre, Jaipur
(RTU, Kota)

INDEX

1. VISION and MISSION

VISION:

- The Mechanical Engineering Department strives to be recognized globally for outcome based technical knowledge and to produce quality human resource, who can manage the advance technologies and contribute to society through entrepreneurship and leadership.

MISSION:

- To impart quality technical knowledge to the learners to make them globally competitive mechanical engineers.
- To provide the learners ethical guidelines along with excellent academic environment for a long productive career.
- To promote industry-institute relationship.

2. PROGRAM EDUCATIONAL OBJECTIVES

1. To provide students with the fundamentals of Engineering Sciences with more emphasis in Mechanical Engineering by way of analyzing and exploiting engineering challenges.

2. To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real life problems.

3. To inculcate professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, entrepreneurial thinking and an ability to relate engineering issues with social issues.

4. To provide students with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the self-motivated life-long learning needed for a successful professional career.

5. To prepare students to excel in Industry and Higher education by Educating Students along with High moral values and Knowledge.

3. PROGRAM OUTCOMES

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems in Mechanical Engineering.
2. **Problem analysis**: Identify, formulate, research literature, and analyze complex Mechanical Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex Mechanical Engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions in Mechanical Engineering.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex Mechanical Engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional Mechanical Engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional Mechanical Engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the Mechanical Engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings in Mechanical Engineering.
10. **Communication**: Communicate effectively on complex Mechanical Engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the Mechanical Engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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

4. COURSE OUTCOMES

On successful completion of this course, the students will be able to:

1. Express a good understanding of the principles of mechanisms and machines, and their practical applications in Mechanical Engineering.
2. Apply the concepts of power transmission by the application of friction.
3. Balance the wheel of automobiles.

Outcomes will be achieved through:

1. Lab Teaching (through presentation, chalk and board).
2. Practical.

5. MAPPING OF CO's with PO's

COURSE OUTCOMES	PROGRAM OUTCOMES											
	1	2	3	4	5	6	7	8	9	10	11	12
I	3	3	2	2	0	1	0	0	1	1	2	3
II	3	2	2	1	0	1	0	0	1	1	1	3
III	3	3	2	1	2	2	1	1	1	1	2	2

6. SYLLABUS

THEORY OF MACHINES LAB [4ME4-24]

Class: B. Tech. IV Semester	**Evaluation**
Branch: Mechanical Engineering **Schedule per week Practical: 3 hours**	**Examination Time: 2 hours** **Maximum Marks: 75** **[IA: 45, ETE: 30]**

S#	NAME OF EXPERIMENT
1	To study inversions of four bar chain and slider crank mechanism and their practical applications.
2	To study Steering Mechanisms: Davis and Ackerman.
3	Study of quick return mechanism and its practical applications.
4	Study of inversion of Double slider chain: Oldham Coupling, Scotch Yoke and Elliptical Trammel.
5	Study of various cam-follower arrangements. To plot displacement v/s angle of rotation curve for various cams.
6	To determine co-efficient of friction using two roller oscillating arrangement.
7	Study of various types of dynamometers, Brakes and Clutches.
8	Study of differential gear box.
9	To verify the torque relation for gyroscope.

10	To perform wheel balancing. To perform static and dynamic balancing on balancing set up.
11	Study of a lathe gear box, sliding mesh automobile gear box, planetary gear box.

7. REFERENCE BOOKS

1. Rattan, S.S., "Theory of Machines", Tata McGraw Hill

2. Bevan, T., "Theory of Machines", Pearson Education

3. Ghosh, A., "Theory of Mechanisms and Machines", Affiliated East West Press

4. Singh, S., "Theory of Machines", Pearson Education

8. INSTRUCTIONAL METHODS

8.1 Direct Instructions:

I. Black board presentation.

II. Power point presentation.

8.2 Interactive Instruction:

I. Practical on respective equipment.

II. Practical Examples.

8.3 Indirect Instructions:

I. Problem solving

9. LEARNING MATERIALS

9.1 Lab Manual

9.2 Reference Books

10. ASSESSMENT OF OUTCOMES

10.1 End term Practical exam (Conducted by RTU, KOTA)

10.2 Quiz/Viva-Voice

10.3 Daily Lab interaction.

11. INSTRUCTIONS SHEET

We need your full support and cooperation for smooth functioning of the lab.

DO's

1. Please switch off the Mobile/Cell phone before entering Lab.
2. Intimate the lab incharge whenever you are incompatible in using the machine.
3. Arrange all the peripheral and seats before leaving the lab.
4. Properly placed the equipments before leaving the lab.
5. Keep the bag outside in the racks.
6. Enter the lab on time and leave at proper time.
7. Maintain the decorum of the lab.
8. Utilize lab hours in the corresponding experiment.

DON'TS

1. Don't mishandle the machines.
2. Don't leave the machine on for long.
3. Don't bring any external material in the lab.
4. Don't make noise in the lab.
5. Don't bring the mobile in the lab. If extremely necessary then keep ringers off.
6. Don't enter in the lab without permission of lab Incharge.
7. Don't litter in the lab.
8. Don't carry any lab equipments outside the lab.

BEFORE ENTERING IN THE LAB

1. All the students are supposed to prepare the theory regarding the next experiment.
2. Students are supposed to bring the practical file and the lab copy.
3. Previous experiment should be written in the practical file.
4. Any student not following these instructions will be denied entry in the lab.

WHILE WORKING IN THE LAB

1. Adhere to experimental schedule as instructed by the lab incharge.

2. Get the previously executed program signed by the instructor.
3. Get the output of the current program checked by the instructor in the lab copy.
4. Take responsibility of valuable accessories.
5. Concentrate on the assigned practical and do not play games.
6. If anyone caught red handed carrying any equipment of the lab, then he will have to face serious consequences.

EXPERIMENT NO. 1

OBJECT: To study the inversions of four bar chain and slider crank mechanism and their practical applications.

THEORY: A four-bar chain as shown in figure is consists of four binary links. Link DA is fixed (called frame), DC is the crank (or driver link), CB is the coupler (or connecting rod) and AB the lever (or rocker or follower link). The number of degree of freedom of the four-bar chain is one.

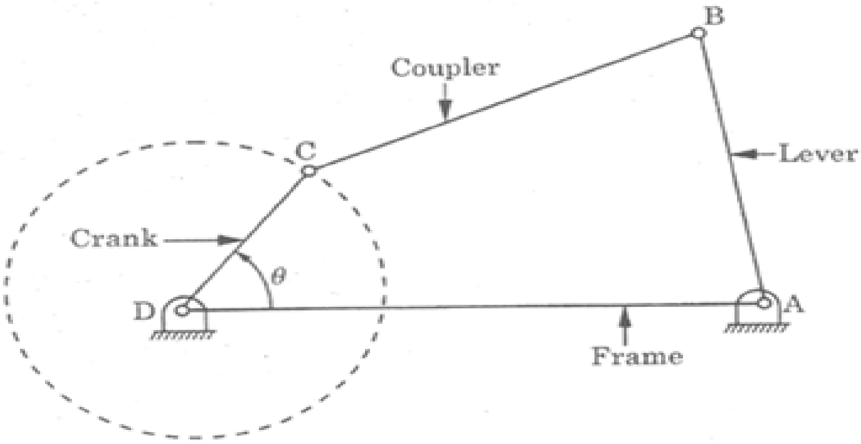


Fig. 1. Simple Four Bar Chain Mechanism

The single-slider crank chain as shown in figure consists of three turning pairs and one sliding pair. Link 1 corresponds to the frame of the mechanism, which is fixed. Link 2 is the crank and link 3 the connecting rod. Link 4 is the slider. It is used to convert rotary motion into reciprocation motion and vice-versa.

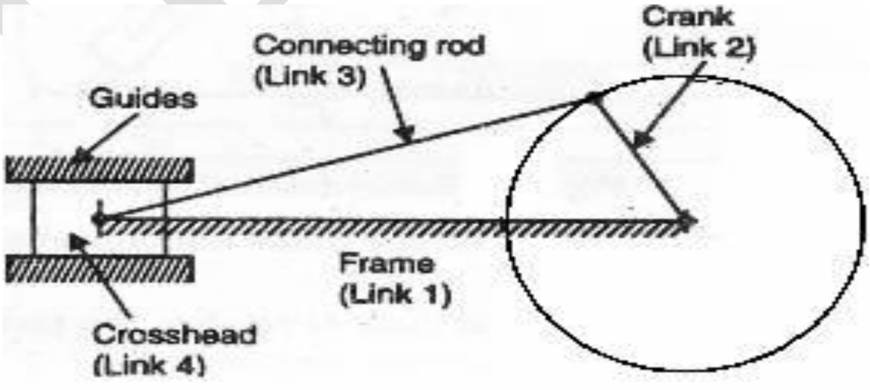


Fig. 2. Simple Single Slider Crank Chain Mechanism

INVERSIONS OF FOUR-BAR CHAIN:

(i) Beam Engine- The beam engine mechanism is as shown in fig. It consists of four links. When the crank AB rotates about the fixed centre A, the lever oscillates about a fixed centre D. The end E of the lever CDE is connected to a piston rod which moves the piston up and down in the cylinder. This mechanism is also called crank and lever mechanism.

Practical Application: Earlier used as I.C. engine mechanism

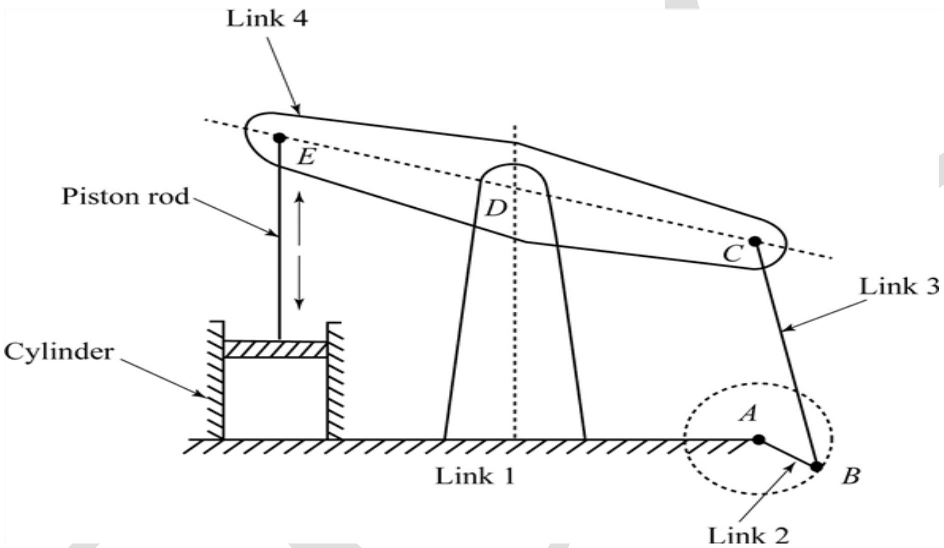


Fig. 3. Beam Engine (Inversion of Four bar Chain Mechanism)

(ii) Coupling Rod- In this mechanism as shown in fig., the link AB and CD are of equal length and act as cranks. These cranks are connected to the respective wheels. The link BC acts as the connecting rod. The link AD is fixed to maintain distance between the wheels. This mechanism is used to transmit rotary motion from one wheel to the other. This is also called the double crank mechanism.

Practical Application: Wheel mechanism of a locomotive

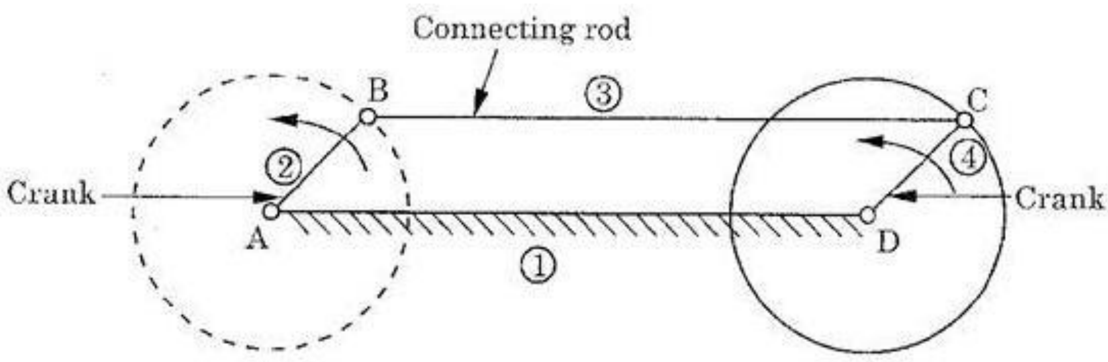


Fig. 4. Coupling Rod of Locomotive (Inversion of Four Bar Chain Mechanism)

OUTCOME: We have successfully studied the inversions of four bar chain mechanism and slider crank mechanism.

EXPERIMENT NO. 2

OBJECT: To study the Steering Mechanisms: Davis and Ackerman.

THEORY: The steering gear mechanism is used for changing the direction of two or more of the wheel axles with reference to the chassis, so as to move the automobile in any desired path. Usually the two back wheels have a common axis, which is fixed in direction with reference to the chassis and the steering is done by means of the front wheels.

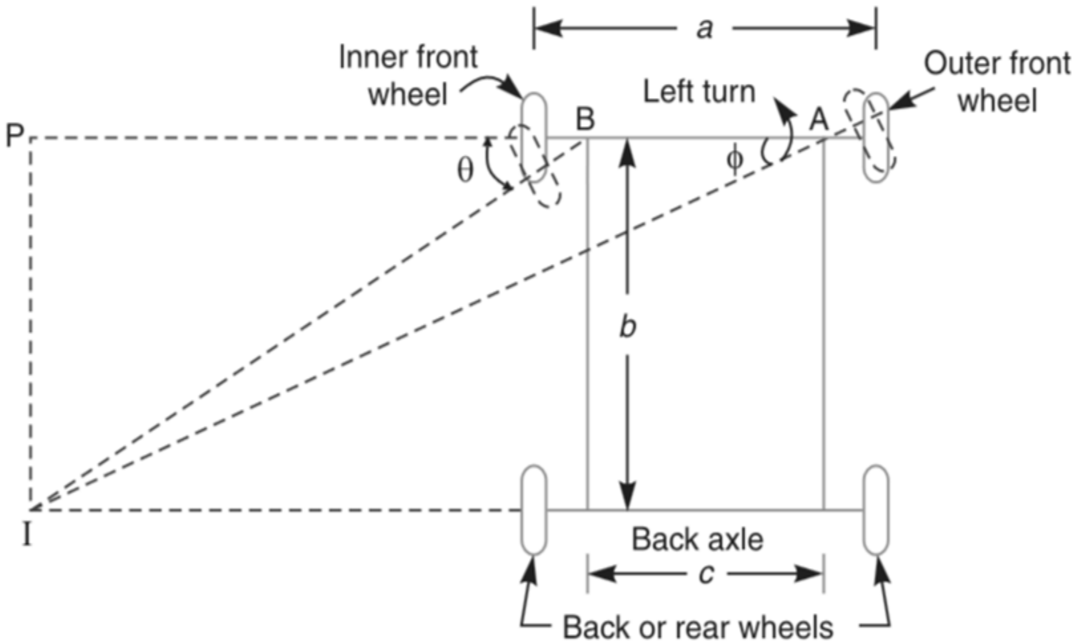


Fig. 1. Steering Gear mechanism

Where,

a = Wheel track,

b = Wheel base, and

c = Distance between the pivots A and B of the front axle.

The fundamental equation for correct steering is given by

$$\cot \varphi - \cot \theta = c / b$$

Two types of steering gear mechanisms are given below:

(i) Davis Steering Mechanism: The Davis steering gear is shown in Fig. 9.16. It is an exact steering gear mechanism. The slotted links AM and BH are attached to the front wheel axle, which turn on pivots A and B respectively. The rod CD is constrained to move in the direction of its length, by the sliding members at P and Q. These constraints are connected to the slotted link AM and BH by a sliding and a turning pair at each end. The steering is affected by moving CD to the right or left of its normal position. C ′D′ shows the position of CD for turning to the left.

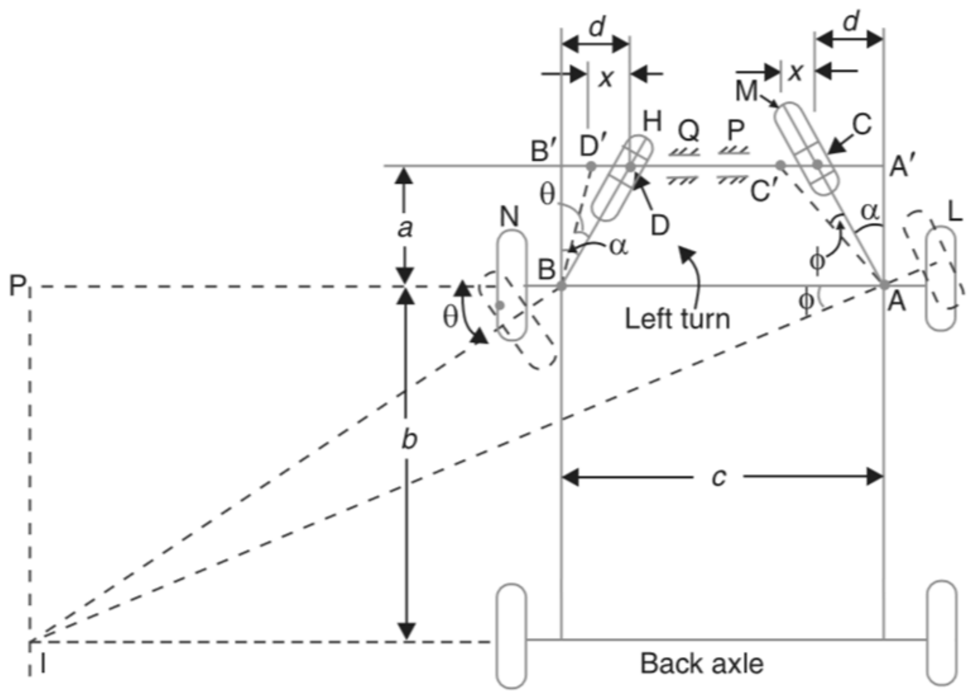


Fig. 2. Davis Steering Gear Mechanism

(ii) Ackerman Steering Gear Mechanism: In Ackerman steering gear, the mechanism ABCD is a four bar chain, as shown in fig. The shorter links BC and AD are of equal length and are connected by hinge joints with front wheel axles. The longer links AB and CD are of unequal length. In order to satisfy the fundamental equation for correct steering, the links AD and DC are suitably proportioned. The value of θ and Φ be obtained graphically or by calculations.

Practical Application: Steering mechanism of a automobile.

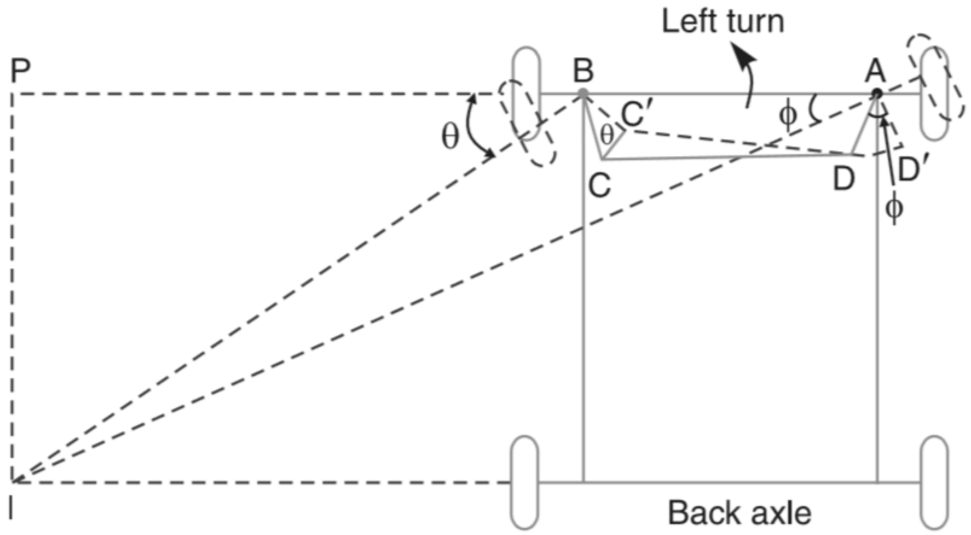


Fig. 3. Ackerman Steering Gear Mechanism

OUTCOME: We have successfully studied the Steering Gear mechanism.

EXPERIMENT NO. 3

OBJECT: To study the quick return mechanism and its practical applications.

THEORY: Quick-return mechanisms are used in machine tools such as shapers and power-driven saws for the purpose of giving the reciprocating cutting tool a slow cutting stroke and a quick-return stroke with a constant angular velocity of the driving crank. Some of the common types are discussed below. The ratio of the time required for the cutting stroke to the time for the return stroke is called the time ratio and is greater than unity.

Crank-Shaper: The mechanism employs an inversion of the slider-crank linkage which is illustrated in Fig. 1. Fig. 2 shows the arrangement in which link 2 rotates completely and link 4 oscillates. If the driver link 2, rotates anti-clockwise at constant velocity. Slider 6 will have a slow stroke to the left and a fast return stroke to the right. The time ratio equals θ_1/θ_2.

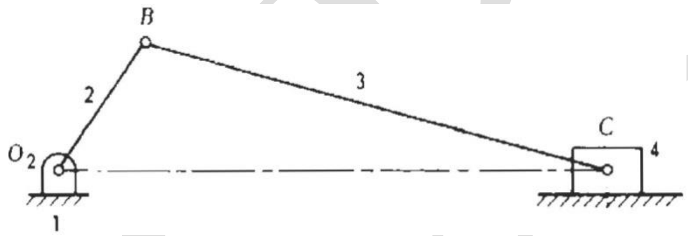


Fig. 1. **Slider Crank Mechanism**

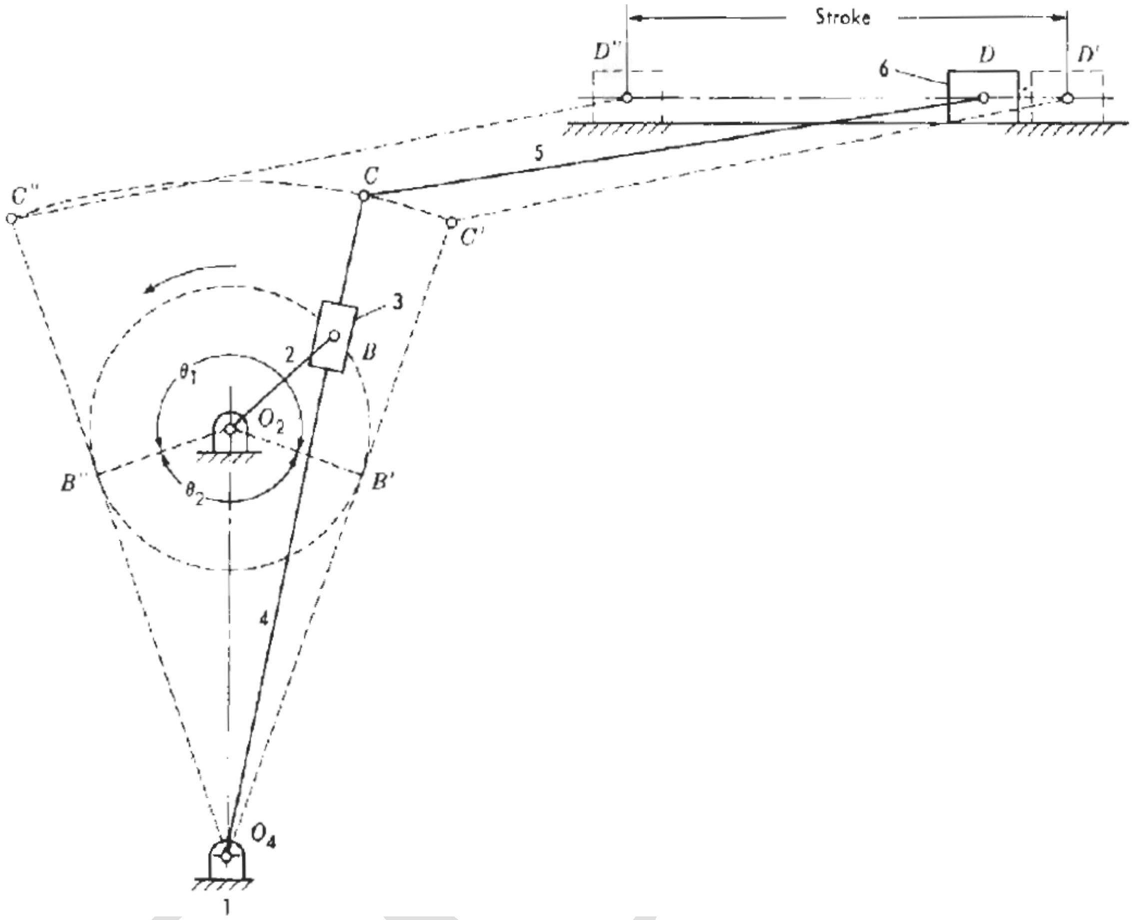


Fig. 2. **Crank-Shaper**

Whitworth: This mechanism is illustrated in Fig. 3 and is obtained by making the distance O_2O_4 in Fig. 2 less than the crank length O_2B. Both links 2 and 4 rotate completely. If the driver crank 2, rotates anti-clockwise with constant angular velocity, slider 6 will move from D' to D'' with a slow motion while 2 rotates through angle θ_1. Then as 2 rotates through the smaller angle θ_2, slider 6 will have a quick-return motion from D'' to D'. The time ratio is θ_1/θ_2.

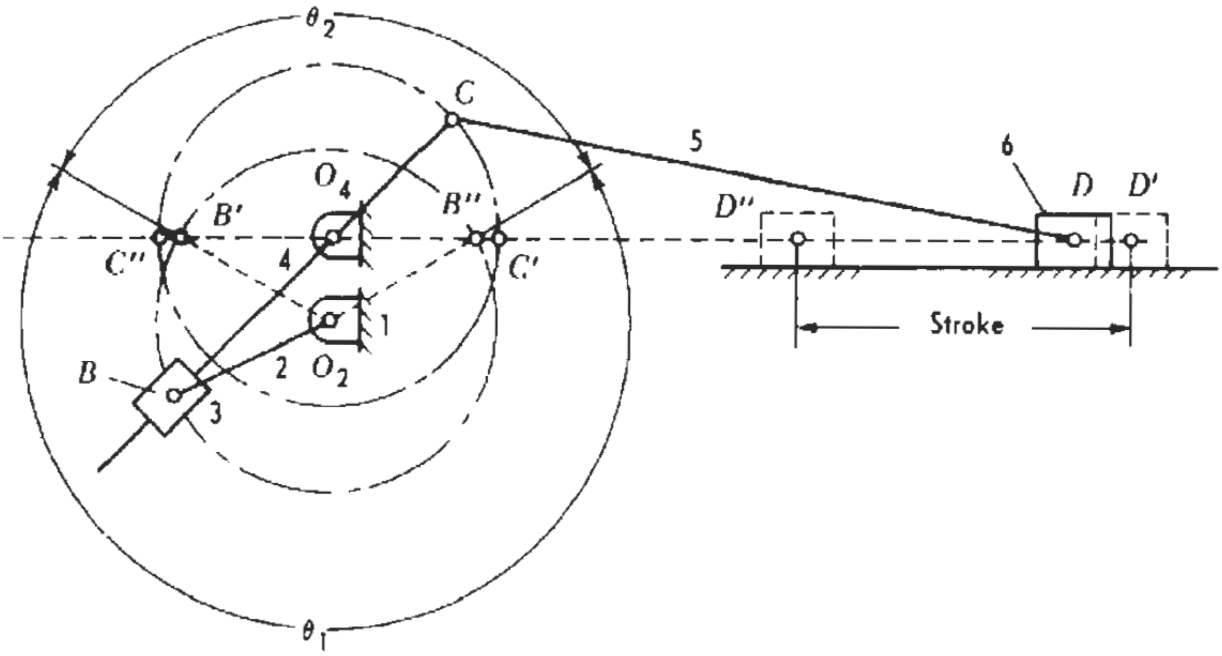


Fig. 3. **Whitworth**

Drag Link: This mechanism is shown in Fig. 4 where links 1, 2, 3 and 4 comprise a drag link mechanism. If link 2, the driver rotates anti-clockwise with constant angular velocity, then slider 6 makes a slow stroke to the left and returns with a quick stroke to the right. The time ratio is θ_1/θ_2.

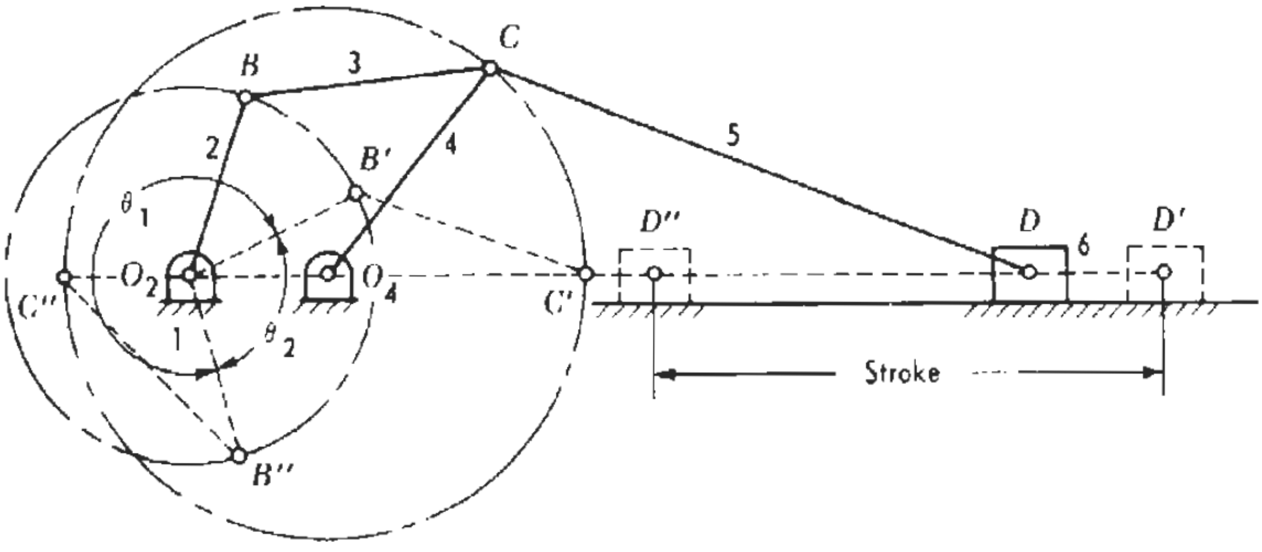


Fig. 4. **Drag Link**

Offset Slider Crank: The slider-crank mechanism can be designed with an offset ‘y’ as shown in Fig. 5 so that the path of the slider does not intersect the crank axis. It is then a quick-return mechanism, though not a very effective one since the time ratio θ_1/θ_2 is only a little larger than 1.

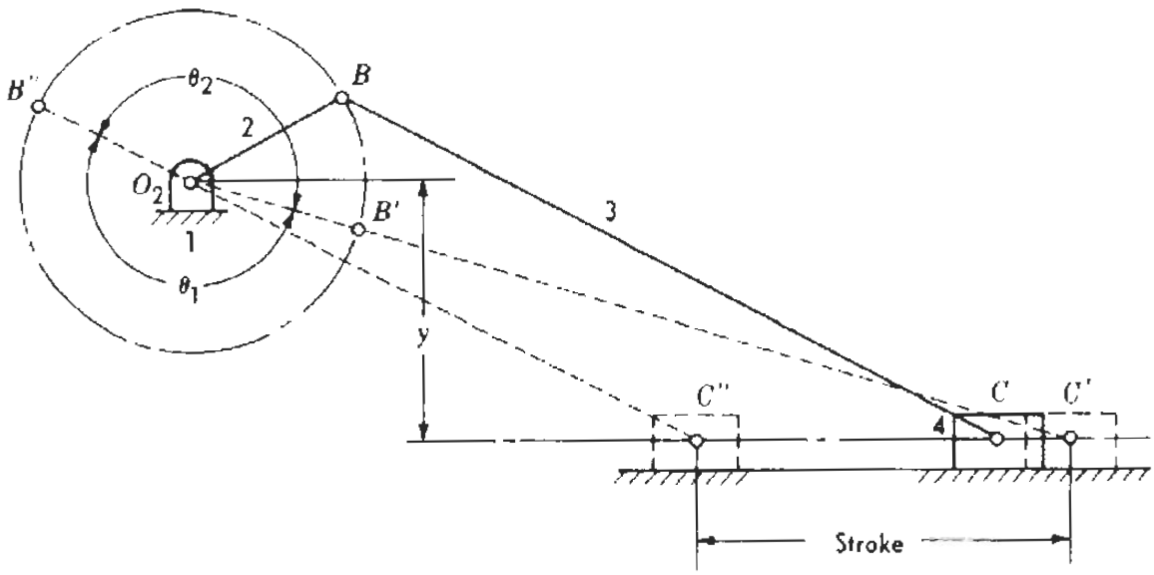


Fig. 5. **Offset Slider Crank**

APPLICATIONS:

1. Shaper
2. Screw press
3. Power-driven saw
4. Mechanical actuator
5. Revolver mechanisms

OUTCOME: We have successfully studied Quick-return mechanisms.

EXPERIMENT NO. 4

OBJECT: To study the inversion of Double slider chain: Oldham Coupling, Scotch Yoke and Elliptical Trammel.

THEORY: A kinematic chain consists of two turning pairs and two sliding pairs is called double-slider crank chain. There are three important inversions of double slider crank chain. 1) Oldham‘s Coupling. 2) Elliptical trammel. 3) Scotch yoke mechanism.

INVERSIONS OF DOUBLE SLIDER MECHANISM:

(i) Oldham's Coupling- Oldham's coupling shown in fig., is used to connect two parallel shafts, the distance between whose axes is small and variable. The shafts connected by the coupling rotate at the same speed. The shafts have flanges at the ends, in which slots are cut. These form links 1 and 3. An intermediate piece circular in shape and having tongues at right angles on opposite sides, is fitted between the flanges of the two shafts in such a way that the tongues of the intermediate piece get fitted in the slots of the flanges. The intermediate piece forms link 4 which slides or reciprocates in links 1 and 3. Link 2 is fixed.

Practical Application: Used to connects two shafts having axes parallel but not in line with each other

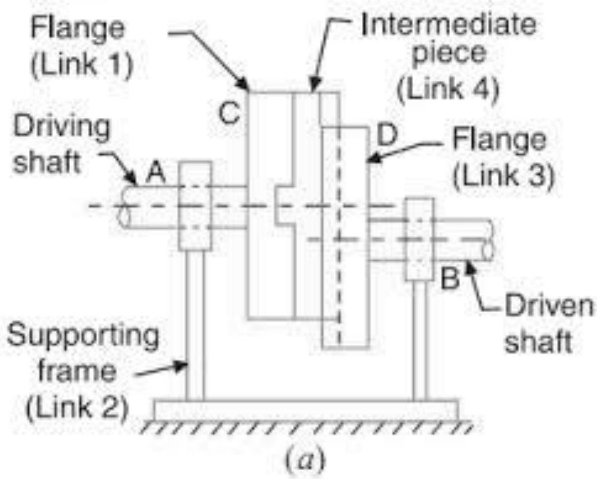


Fig. 1. Oldham's Coupling (Inversion of Double Slider Crank Mechanism)

(ii) Elliptical Trammel-Fig. shows an elliptical trammel in which two grooves are cut at right angles in a plate which is fixed. The plate forms the fixed link 4. Two sliding blocks are fitted into the grooves. The slides form two sliding links 1 and 3. The link joining slides form the link 2. Any point on link 2 or its extension traces out an ellipse on the fixed plate, when relative motion occurs.

Practical Application: Device to draw ellipse.

From fig.

x= AP cosθ or x/AP= cosθ

y= BP sinθ or y/BP =sinθ

squaring and adding. We get

$$x^2/AP^2 + y^2/BP^2 = 1$$

Which is a equation of an ellipse.

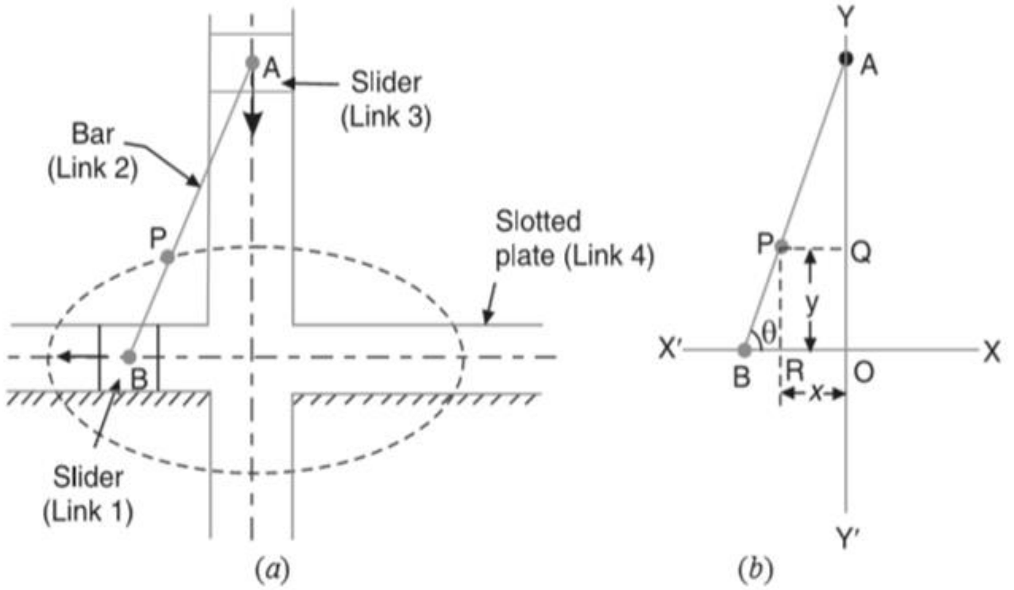


Fig. 2. Elliptical Trammel

(iii) Scotch Yoke Mechanism- This mechanism is used for converting rotary motion into a reciprocating motion. The inversion is obtained by fixing either the link 2 or link 4., link 1 is fixed. In this mechanism, when the link 2 (which corresponds to crank) rotates about B as centre, the link 4 (which corresponds to a frame) reciprocates. The fixed link 1 guides the frame.

Practical Application: Converts rotary motion into a reciprocating motion.

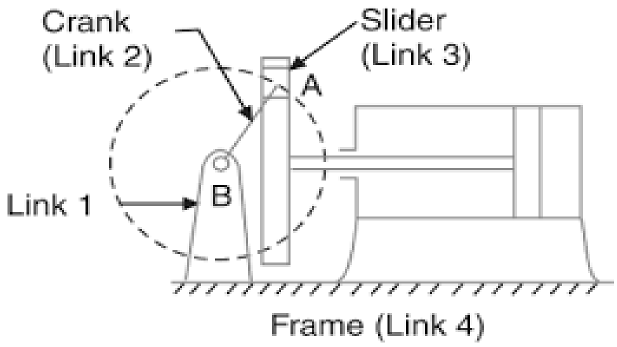


Fig. 3. Scotch Yoke Mechanism

OUTCOME: We studied the inversions of Double Slider Crank Chain Mechanism successfully.

EXPERIMENT NO. 5(a)

OBJECT: To study the various cam-follower arrangements.

THEORY: A cam is a rotating machine element which gives reciprocating or oscillating motion to another element known as follower. The cam and the follower have a line contact and constitute a higher pair. The cams are usually rotated at uniform speed by a shaft, but the follower is pre-determined and will be according to the shape of the cam.
Practical Applications: Operating the inlet and outlet valves of I.C. Engine, paper cutting machine, feed mechanism of automatic lathes.

TYPES OF FOLLOWERS:
1.According to surface in contact
(i) Knife edge follower- When the contacting end of the follower has a sharp knife edge, it is called a knife edge follower as shown in fig.

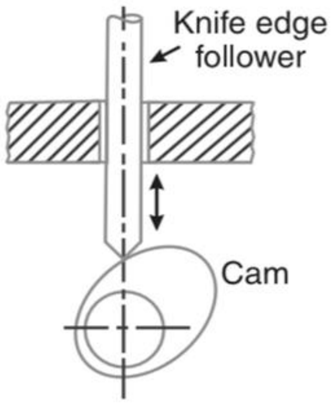


Fig. 1. Knife edge Follower

(ii) Roller follower- When the contacting end of the follower is a roller, it is called a roller follower, as shown in fig. Since the rolling motion takes place between the contacting surfaces, therefore the rate of wear is greatly reduced.

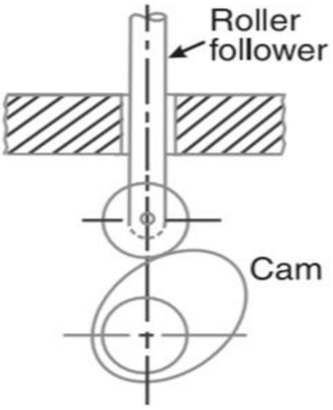


Fig. 2. Roller Follower

(iii) Flat faced follower- When the contacting end of the follower is a perfectly flat face, it is called a flat faced follower, as shown in fig. Side thrust between the follower and the guide is much reduced in case of flat faced followers.

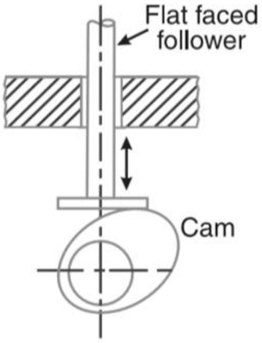
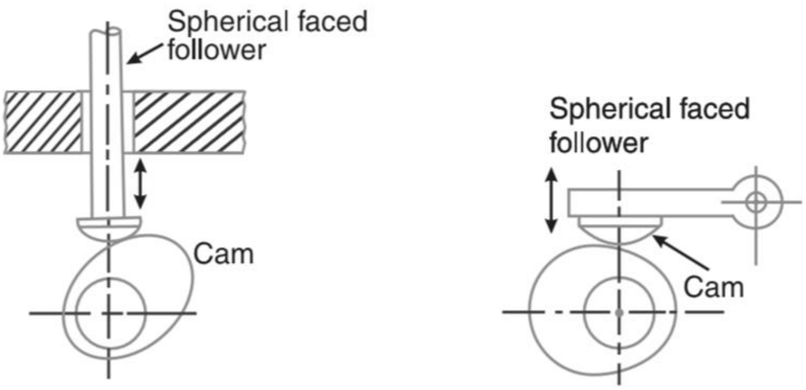


Fig. 3. Flat Faced Follower

(iv) Spherical faced follower- When the contacting end of the follower is of spherical shape, it is called a spherical faced follower, as shown in fig.



(a) (b)

Fig. 4. Spherical Faced Follower

2. According to the motion of the follower

(i) Reciprocating follower- When the follower reciprocates in guides as the cam rotates uniformly, it is known as reciprocating or translating follower, as shown in fig.

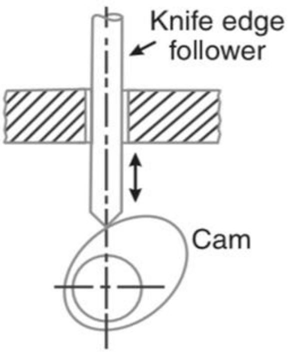


Fig. 5. Reciprocating Knife Edge Follower

(ii) Oscillating follower- When the uniform rotary motion of the cam is converted into predermined oscillatory motion of the follower, it is called oscillating or rotating follower, as shown in fig.

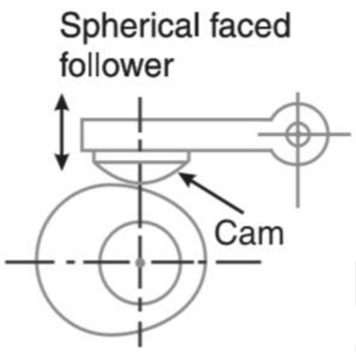


Fig. 6. Oscillating Spherical Faced Follower

3. According to the path of motion of the follower

(i) Radial follower- When the motion of the follower is along an axis passing through the centre of the cam, it is known as radial follower, as shown in fig.

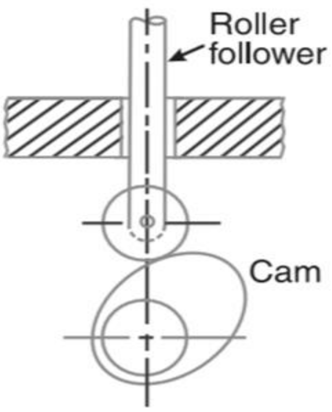


Fig. 7. Radial Roller Follower

(ii) Off-set follower- When the motion of the follower is along an axes away from the axis of the cam centre, it is called off-set follower, as shown in fig.

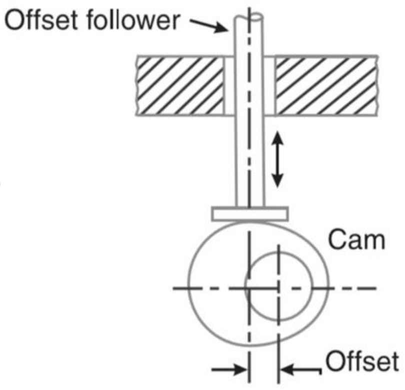


Fig. 8. Off-set Follower

TYPES OF CAM

(i) Radial cam- In radial cams, the follower reciprocates or oscillates in a direction perpendicular to the cam axis, as shown in fig.

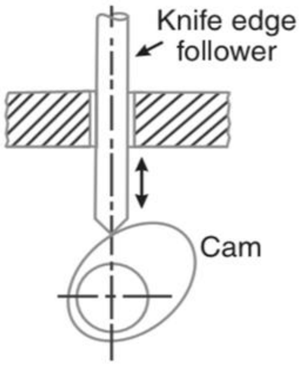


Fig. 9. Radial Cam

(ii) Cylindrical cam- In cylindrical cam, the follower reciprocates or oscillates inn a direction parallel to the cam axis. The follower rides in a groove at its cylindrical surface, as shown in the fig.

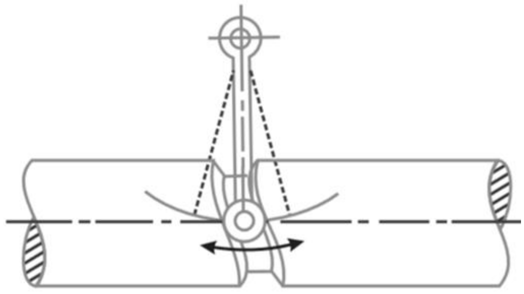


Fig. 10. Cylindrical Cam

OUTCOME: We have successfully completed the study of various cam-follower arrangements.

EXPERIMENT NO. 5(b)

OBJECT : To plot displacement v/s angle of rotation curve for various cams.

THEORY: A cam may be defined as a rotating or a reciprocation element of a mechanism, which imparts a rotating, reciprocating or oscillating motion to another element termed as follower. in most of the cases the cam is connected to a frame, forming a turning pair and the follower is connected to the frame to form a sliding pair. The cam and follower form a three-link mechanism of the higher pair type the three links of the mechanism are (a) the cam which is the driving link and has a curved or a straight contact surface; (b) the follower which is the driven link and it gets motion by contact with the surface of the cam and (c) the frame which is used to support the cam and guide the follower. The cam mechanism is used in clocks, printing machines, automatic screw cutting machines, internal combustion engines for operating valves etc.in fact all modern automatic machines require the help of a cam.

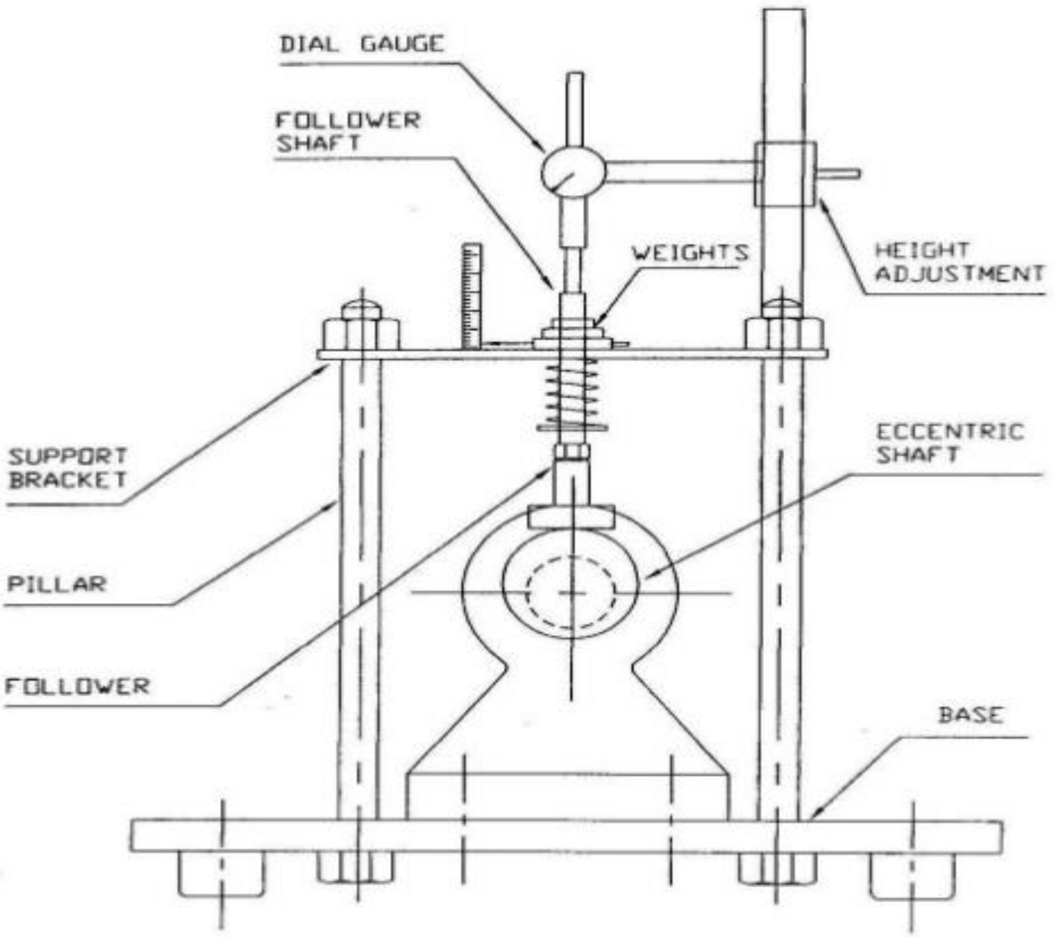


Fig. 1. Cam Analysis Apparatus

EXPERIMENTAL SET-UP:

The apparatus is designed to study the cam profile. At the free end of the camshaft, a cam (interchangeable) cam be easily mounted. A push rod assembly is supported vertically and various type of follower (interchangeable) can be attached to this push rod. 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 coaxial with the shaft and a dial gauge can be fitted to note the follower displacement for the angle of cam rotation. A set of cams is provided consisting of eccentric, tangent and circular are type. A set of followers is also provided consisting of mushroom, roller and knife-edge type

EXPERIMENTAL PROCEDURE:

Step 1: Select a suitable cam and follower combination.

Step 2: Fix the cam on the shaft.

Step 3: 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 camshaft.

Step4: Attach the dial gauge on the push rod.

Step 5: Take the reading of the lift of the follower with the help of the dial indicator at various cam angles.

Step6: Draw the profile of the cam (i.e. the θ v/s displacement curve).

Step7: Repeat the above steps for other cam-follower combinations.

OBSERVATION TABLE:

Cam : ____________________

Follower : ____________________

Least radius of cam in mm : ____________________

S. No.	Cam Angle θ	Displacement
1		
2		
3		
4		
5		
.		
.		

.		
18		
19		
20		

OUTCOME: Curve between displacement and angle of rotation for given cam and follower arrangment is plotted and the exact profile of the same cam is drawn.

PRECAUTIONS:

1. While assembling the horizontality of the upper and lower glands should be checked by a spirit level.
2. The cam is to be lubricated by oil before starting

COMMENTS:

EXPERIMENT NO. 6

OBJECT: To determine coefficient of friction using two roller oscillating arrangement.

THEORY: It has been established since long that the surfaces of the bodies are never perfectly smooth. It has been observed that whenever, even a very smooth surface is viewed under a microscope, it is found to have some roughness and irregularities, which may not be detected by an ordinary touch. It has also been observed that if a block of one substance is placed over the level surface of the same or different material, a certain degree or interlocking of the minutely projecting particles takes place. This does not involve any force, so long as the block does not move or tends to move. But whenever a block moves or tends to move tangentially with respect to the surface on which it rests, the interlocking property of the projection particles opposes the motion. This opposing force, which acts in the opposite direction of the movement of the block, is called force of friction or simply friction.

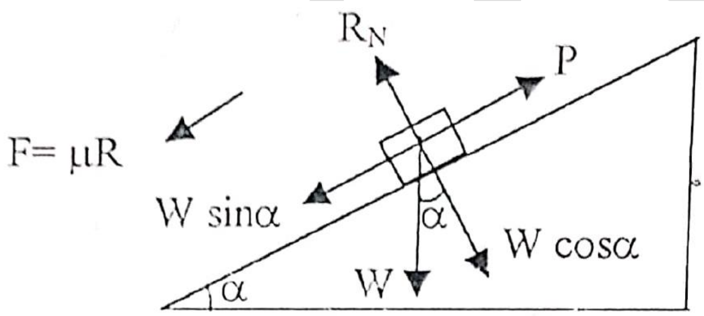


Fig. 1. Body on an Inclined Plane

Consider a body of weight W, on a plane having an angle of inclination α, i.e. resulting on an incline plane.
Suppose it just tends to move up the inclined plane when a force P is applied. Since the body tends to move upward the frictional force F will be acting downward.
The force on the can be resolved into two components perpendicular and parallel to the plane.
Resolving the forces parallel to the plane, we get,

$$P = \mu R + W \sin\alpha$$

The component (W cosα) perpendicular to the plane balance the normal reaction R_N and the component (W sinα) parallel to the plane provides the necessary force for the body to move down the plane.
Substituting the value of R in above equation, we get

$$P = \mu\ W \cos\alpha + W \sin\alpha$$

$$\mu = (P - W \sin\alpha) / W \cos\alpha$$

This μ is the coefficient of friction.

APPARATUS: The apparatus consists of a metal plane with the glass top hinged on an iron base to which a sector with graduate arc and vertical scale as provided. The plane may be clamped upto 45°. A frictionless pulley is attached to the end by means of a damp adjustable to any necessary position. Apparatus is supplied with a brass roller, string, pan and a set of weights.

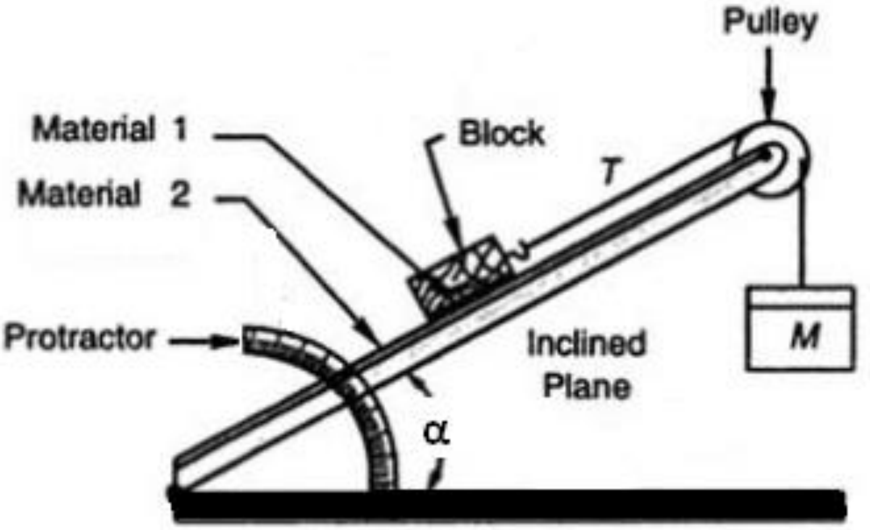


Fig. 2. Experimental Set-Up

EXPERIMENT WORK:

1. Place the block of known weight (W) on the inclined plane. Tie the slider to the pan (of known weight) with the help of the thread passing over the frictionless pulley.
2. Put on weight in the pan and note this weight.
3. Start decreasing the angle of inclination (α) of the inclined planed till the slider just begins to slide upwards and note this angle. The top surface of inclined plane is glass.
4. Repeat above procedure with different block of different materials.

OBSERVATION TABLE:

S#	Surface of slider (Material) with Glass	Weight of slider W (in kg)	Weight of pan + Weight in pan P (in kg)	Inclination of plane α	Coefficient of friction, $\mu = \frac{(P - W \sin\alpha)}{W \cos\alpha}$

1					
2					
3					
4					

OUTCOME: The calculated values of coefficient of friction (μ) for different surface in contact with glass (inclined plane) by using equation [$\mu = (P - W \sin\alpha) / W \cos\alpha$] are-

μ (Glass- G.I sheet) =

μ (Glass- Wood) =

μ (Glass- Sand paper) =

μ (Glass - Al) =

$\mu_{average}$ =

PRECAUTIONS:

1. Pulley should be frictionless.
2. There should not be any knot in the string.
3. Weight should be placed in effort pan only.
4. String should be parallel to the plane.
5. The surface of the inclined plane should be smooth and clean.
6. Proper lubrication of the pulley should be done to decrease friction.

COMMENTS:

EXPERIMENT NO. 7(a)

OBJECT: To study the various types of dynamometers.

THEORY: A dynamometer is a brake but in addition it has a device to measure the frictional resistance. Knowing the frictional resistance, we may obtain the torque transmitted and hence the power of the engine.

Practical Application: Measuring the Break Power of a Engine

TYPES OF DYNAMOMETER:

(i) Absorption Dynamometer- In the absorption dynamometer, the entire energy or power produced by the engine is absorbed by the friction resistance of the brake and is transmitted into heat, during the process of measurement.

(ii) Transmission Dynamometer- In the transmission dynamometer, the energy is not wasted in friction but is used for doing work. The energy or power produced by the engine is transmitted through the dynamometer to some other machines where the power developed is suitably measured.

Prony Brake Dynamometer:

A simplest form of an absorption type dynamometer is a prony brake dynamometer, as shown in fig. It consists of two wooden blocks placed around a pulley fixed to the shaft of an engine whose power is required to be measured. The blocks are clamped by means of two bolts and nuts, as shown in fig. A helical spring is provided between the nut and the upper block to adjust the pressure on the pulley to control its speed. the upper block has a long lever attached to it and carries a weight W at its outer end. A counter weight is placed at the other end of the lever which balances the brake when unloaded. Two stops S, S are provided to limit the motion of the lever.

Moment of the frictional resistance or torque on the shaft

$T = W.L$ N-m

Workdone per minute

$= T * 2\pi N$ N-m

Brake power of the engine,

$$B.P. = T * 2\pi N / 60 \text{ watts}$$

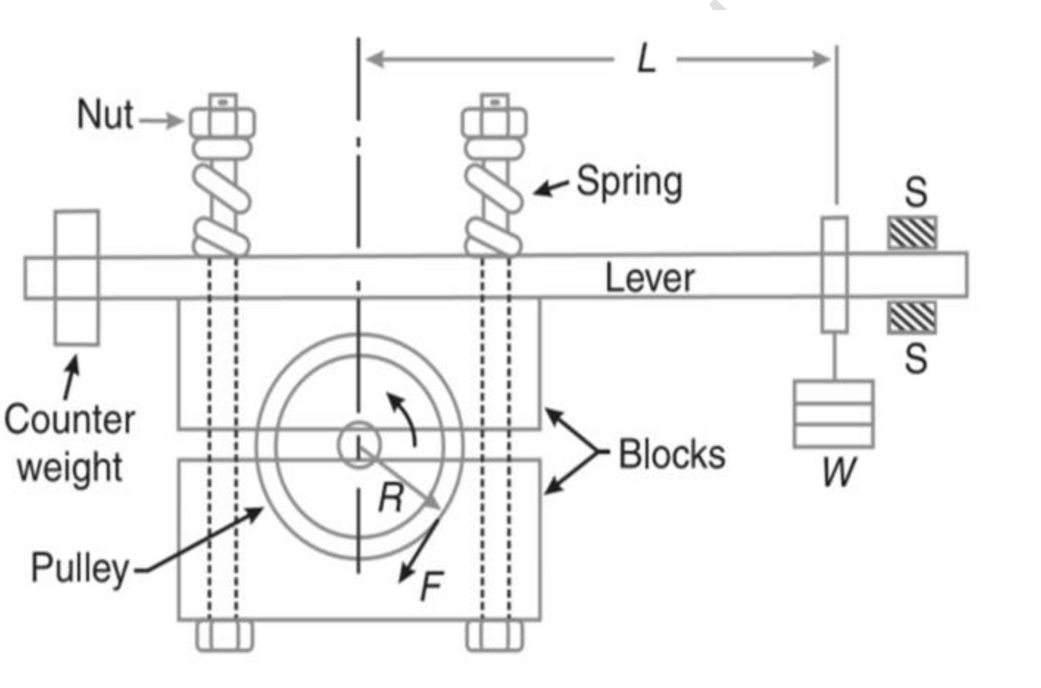


Fig. 1. Prony Brake Dynamometer

Rope Brake Dynamometer:

It is another form of absorption type dynamometer which is most commonly used for measuring the brake power of the engine. It consists of one, two or more ropes wound around the flywheel or rim of a pulley fixed rigidly to the shaft of the engine. The upper end of the ropes is attached to a spring balance while the lower end of the rope is kept in position by applying a dead weight as shown in fig. In order to prevent the slipping of the rope over the flywheel, wooden blocks are placed at intervals around the circumference of the flywheel.

In the operation of the brake, the engine is made to run at a constant speed. The frictional torque, due to the rope, must be equal to the torque being transmitted by the engine.

W = dead load (N)

S = Spring balance reading (N)

D = dia. of wheel (m)

d = dia. of rope (m)
N = speed of engine (rpm)

Net load on the brake = (W-S) newtons

Workdone per revolution = (W-S) π (D+d)N N-m

Brake power of the engine

$$B > P = \frac{(W-S)\,\pi\,(D+d)\,N}{60} \text{ watts}$$

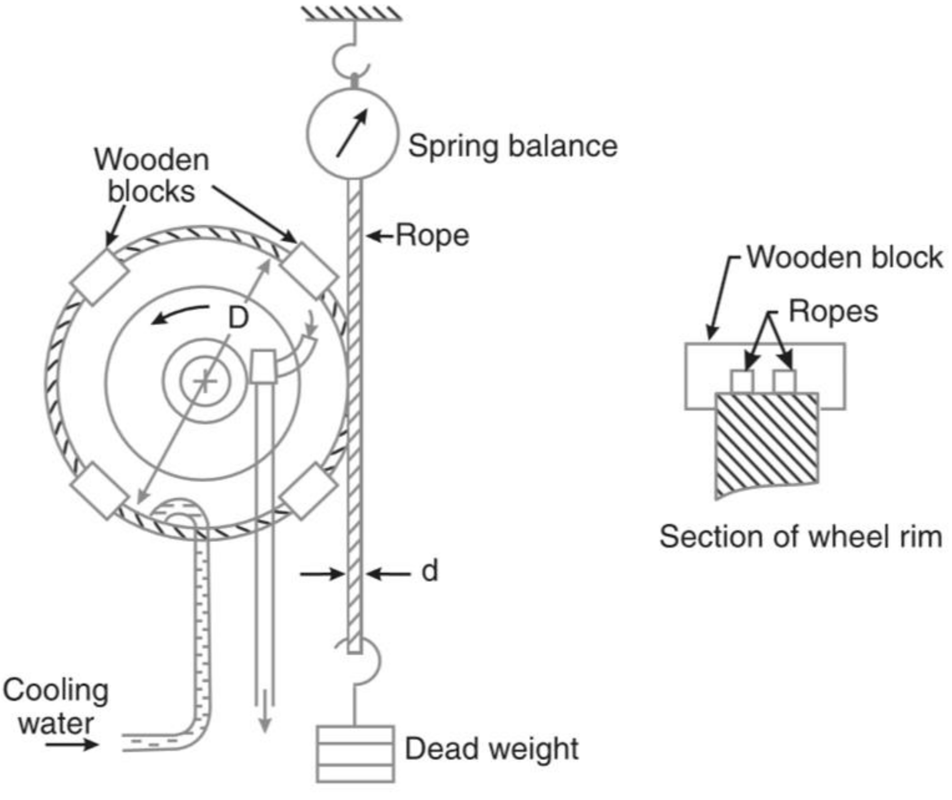


Fig. 2. Rope Brake Dynamometer

OUTCOME: We have successfully studied the various types of dynamometers.

EXPERIMENT NO. 7(b)

OBJECT: To study the various types of brakes.

THEORY: A brake is a device by means of which artificial frictional resistance is applied to a moving machine member, in order to retard or stop the motion of a machine. In the process of performing this function, the brake absorbs either kinetic energy of the moving member or potential energy given up by objects being lowered by hoists, elevators etc. The energy absorbed by brakes is dissipated in the form of heat.

TYPES OF BRAKES

(i) Single Block or Shoe Brake- A single block or shoe brake is shown in fig. It consists of a block or shoe which is pressed against the rim of a revolving brake wheel drum. The block is made of a softer material than the rim of the wheel. The friction between the block and the wheel causes a tangential braking force to act on the wheel, which retard the rotation of the wheel.

Practical Application: Railway trains

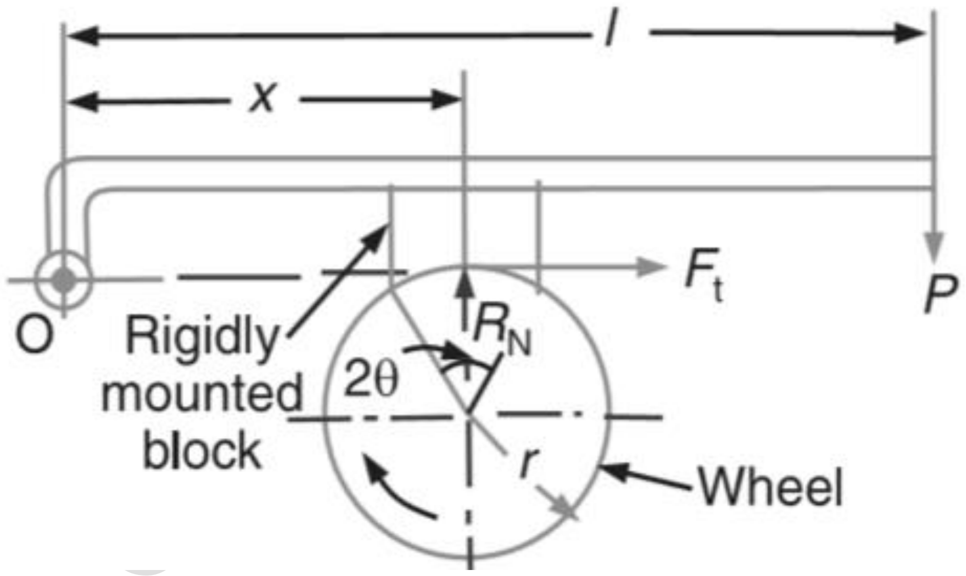


Fig. Single Block and Shoe Brake

(ii) Double Shoe or Block Brake- When a single block brake is applied to a rolling wheel, an additional load is thrown on the shaft bearings due to the normal force (Rn) . This produces bending of the shaft. In order to over come this drawback, a double block or shoe brake, as shown in fig. is used. It consists of two brake block applied at the opposite ends of a diameter of the wheel which eliminate or reduces the unbalanced force on the shaft.
Practical Application: Electric cranes

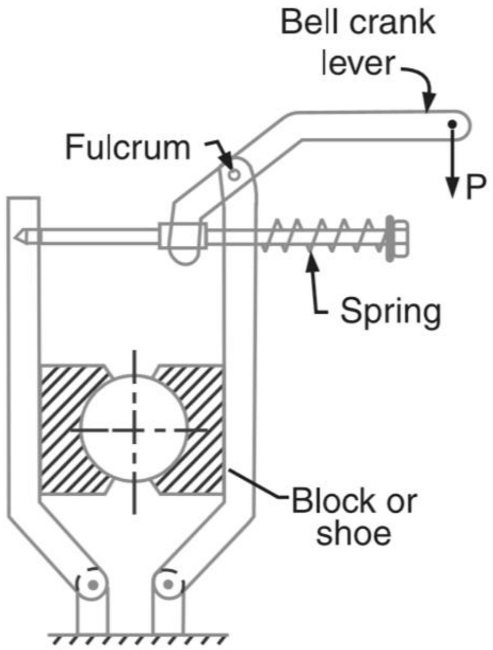


Fig. Double Shoe and Block Brake

(iii) Band Brake- A band brake consists of a flexible band of leather, one or more ropes, or steel band lined with friction material, which embraces a part of the drum. A band brake, as shown in fig. is called a *simple band brake* in which one end of the band is attached to a fixed pin or fulcrum of the lever while the other end is attached to the lever at a distance from the fulcrum. In differential band brake no end of the band is attached to the fulcrum, they attached at a distance to a lever from the fulcrum.
Practical Application: Railway train

Simple band brake:

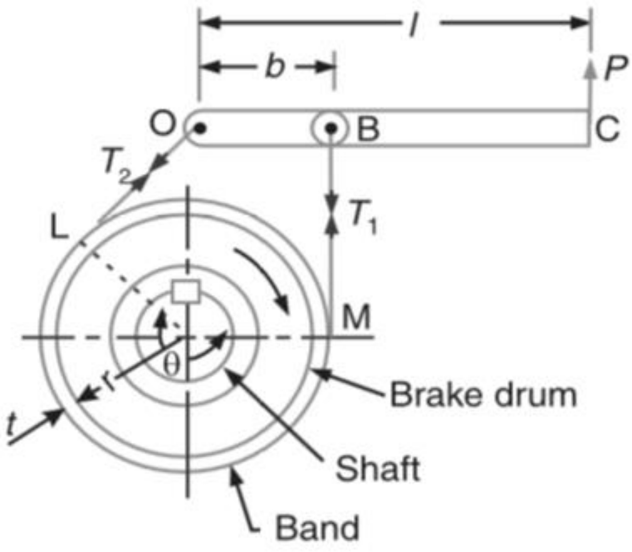


Fig. Simple Band Brake

Differential band brake:

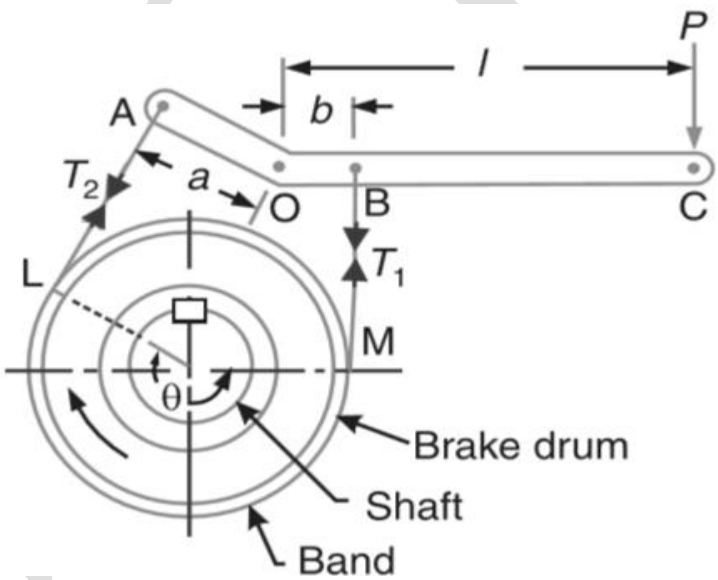


Fig. Differential band brake

(iv) Band and Block Brake- This is a band brake lined with blocks of wood or other friction material as shown in fig. The friction between the blocks and the drum provides braking action.

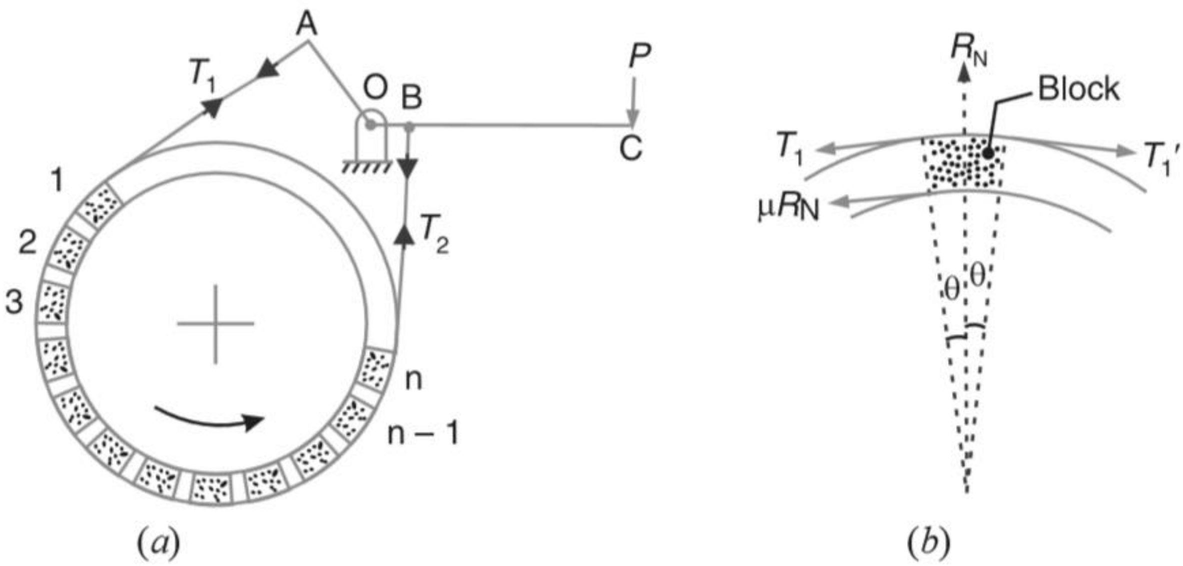


Fig. Band and Block Brake

(v) Internal Expanding Brake: An internal expanding brake consists of two shoes as shown in fig.. The outer surface of the shoes are lined with some friction material to increase the coefficient of friction and to prevent wearing away of the metal. Each shoe is pivoted at one end about a fixed fulcrum and made to contact a cam at the other end. When the cam rotates, the shoes are pushed outwards against the rim of the drum. The friction between the shoes and the drum produces the braking torque and hence reduces the speed of the drum.

Practical Application: Two and Four wheeled automobile

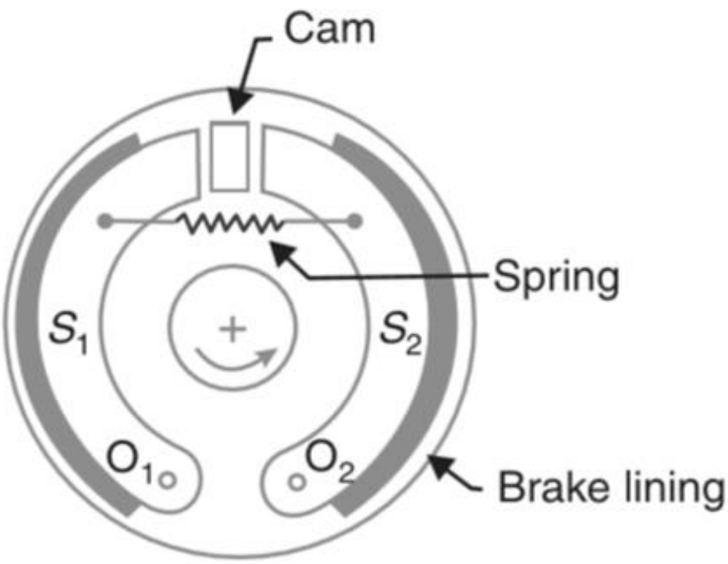


Fig. Internal Expanding Brake

(vi) Disc Brake- In this type of brake two shoes having a lining of friction material on them is pushed over a metallic disc (attached with wheel axle) by means of a mechanical linkage. Friction produces between the metal disc and shoes responsible for retarding the vehicle.
Practical Application: Bi-cycle

(vii) Hydraulic Brake- This is an internal expanding brake in which the cam is replaced by a wheel cylinder, having two pistons in it. In between the two pistons the pressurized fluid is entered from the master cylinder .A master cylinder is placed at a suitable place in the vehicle, having a piston and cylinder arrangement, when driver pushes the lever, the the fluid get pressurized and supplied in to the wheel cylinder.
Practical Application: Car, trucks etc.

OUTCOME: We have successfully studied the various types of brakes.

EXPERIMENT NO. 7(c)

OBJECT: To study the various types of clutches.

THEORY: A clutch works on the principle of friction and used in the transmission of power of shafts and machines which must be started and stopped frequently. Its application is also found in cases in which power is to be delivered to machines partially or fully loaded. The force of friction is used to start the driven shaft from rest and gradually brings it up to the proper speed without excessive slipping of the friction surfaces.

Practical Application: Automobiles

TYPES OF CLUTCHES:

(i) Single Plate Clutch- A single plate or disc clutch, as shown in fig. consists of a clutch plate whose both sides are faced with a friction material. It is mounted on the hub which is free to move axially along the splines of the driven shaft. The pressure plate is mounted inside the clutch body which is bolted to the flywheel. Both the pressure plate and the flywheel rotate with the engine crankshaft or the driving shaft. The pressure plate pushes the clutch plate towards the flywheel by a set of strong springs which are arranged radially inside the body.

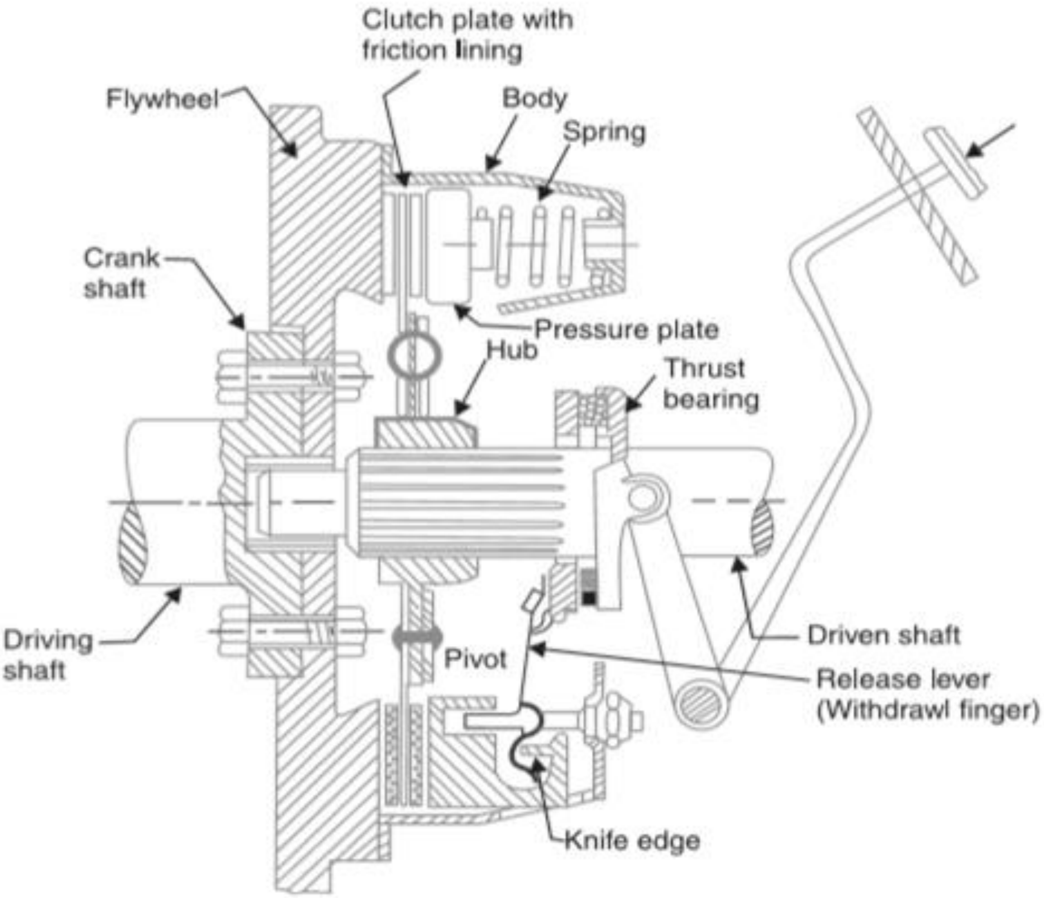


Fig. Single Plate Clutch

When the clutch pedal is pressed down, its linkage forces the thrust release bearing to move in towards the flywheel and pressing the longer ends of the levers inwards. The levers are forced to turn on their suspended pivot and pressure plate moves away from the flywheel by the knife edges, thereby compressing the clutch springs. This action removes the pressure from the clutch plate and thus moves back from the flywheel and the driven shaft becomes stationary. On the other hand, when the foot is taken off from the clutch pedal, the thrust bearing moves back by the levers. This allows the spring to extend and thus the pressure plate pushes the clutch plate back towards the flywheel.

The axial pressure exerted by the spring provides a frictional force in the circumferential direction when the relative motion between the driving and driven members tends to take place.

(ii) Multiple Disc Clutch- A multiple disc clutch, as shown in fig. may be used when a large torque is to transmitted. The inside discs (usually of steel) are fastened to the driven shaft to permit axial motion (except the last disc) . The outside discs (usually of bronze) are held by bolts and are fastened to the housing which is keyed to the driving shaft. The multiple disc clutches are extensively used in motor cars, machine tools etc.

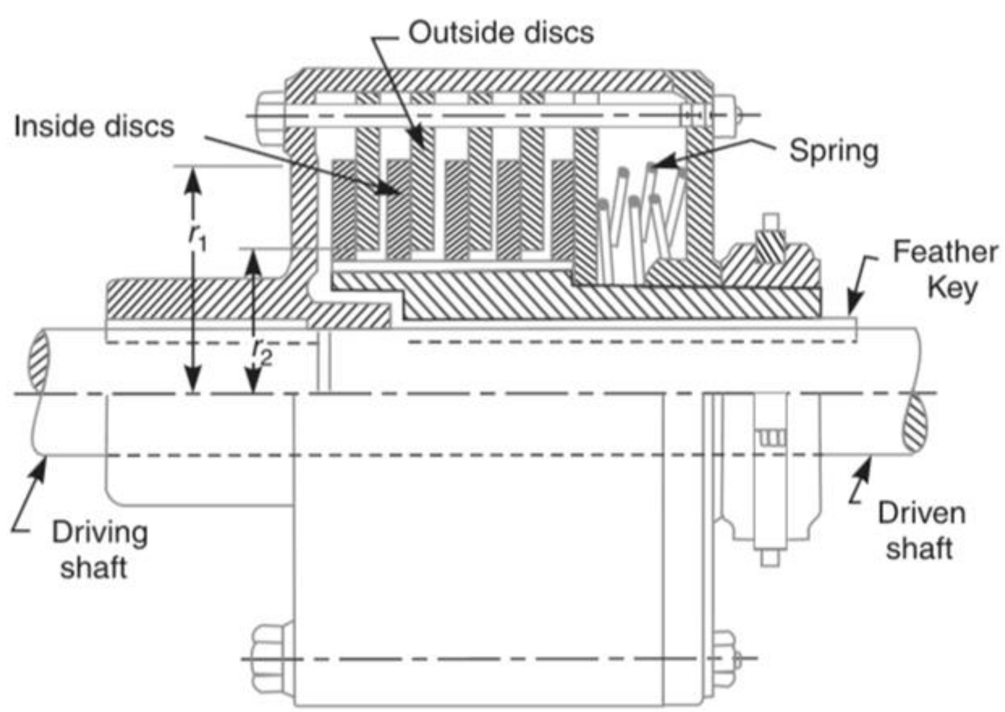


Fig. Multi Disc Clutch

(iii) Cone Clutch- A cone clutch, as shown in fig. was extensively used in automobiles but now-a days it has been replaced completely by disc clutch. It consists of one pair of friction surface only. In a cone clutch, the driver is keyed to the driving shaft by a sunk key and has an inside conical surface or face which exactly fits into the outside conical surface of the driven. The driven member resting on the feather key in the driven shaft, may be shifted along the shaft by a forked lever provided at B, in order to engage the clutch by bringing the two conical surfaces in contact. Due to the frictional resistance set up at this contact surface, the torque is transmitted from one shaft to another.

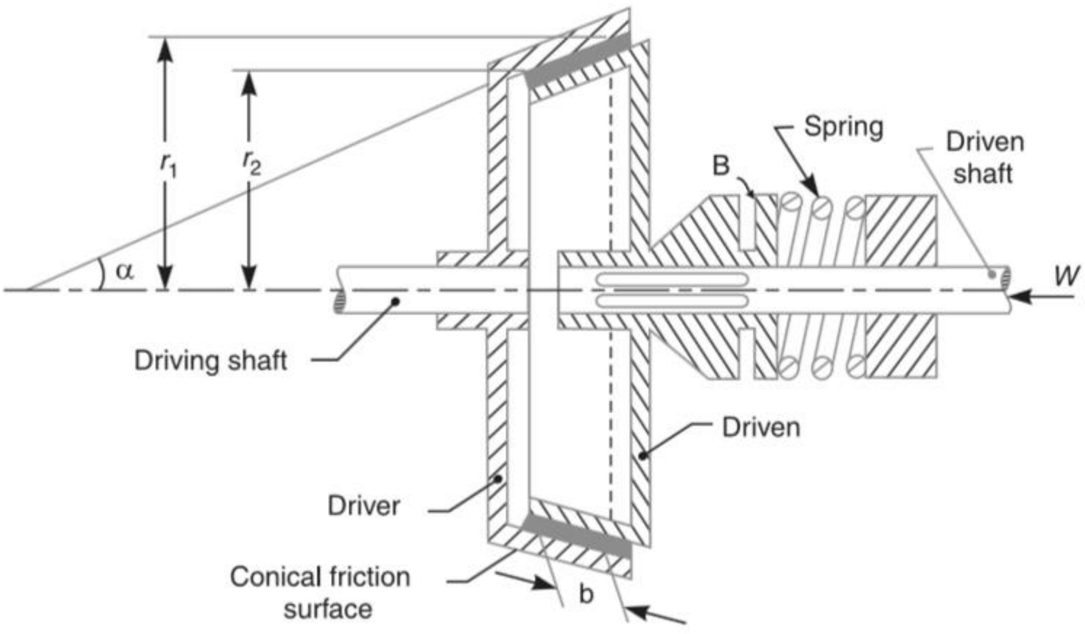


Fig. Cone Clutch

(iv) Centrifugal Clutch- The centrifugal clutches are usually incorporated into the motor pulleys. It consists of a number of shoes on the inside of a rim of the pulley, as shown in fig. The outer surface is covered with a friction material. These shoes, which can move radially in guides, are held against the boss (or spider) on the driving shaft by means of springs. The springs exert a radially inward force which is assumed constant. The mass of the shoe, when revolving, causes it to exert a radially outward force (i.e. centrifugal force).

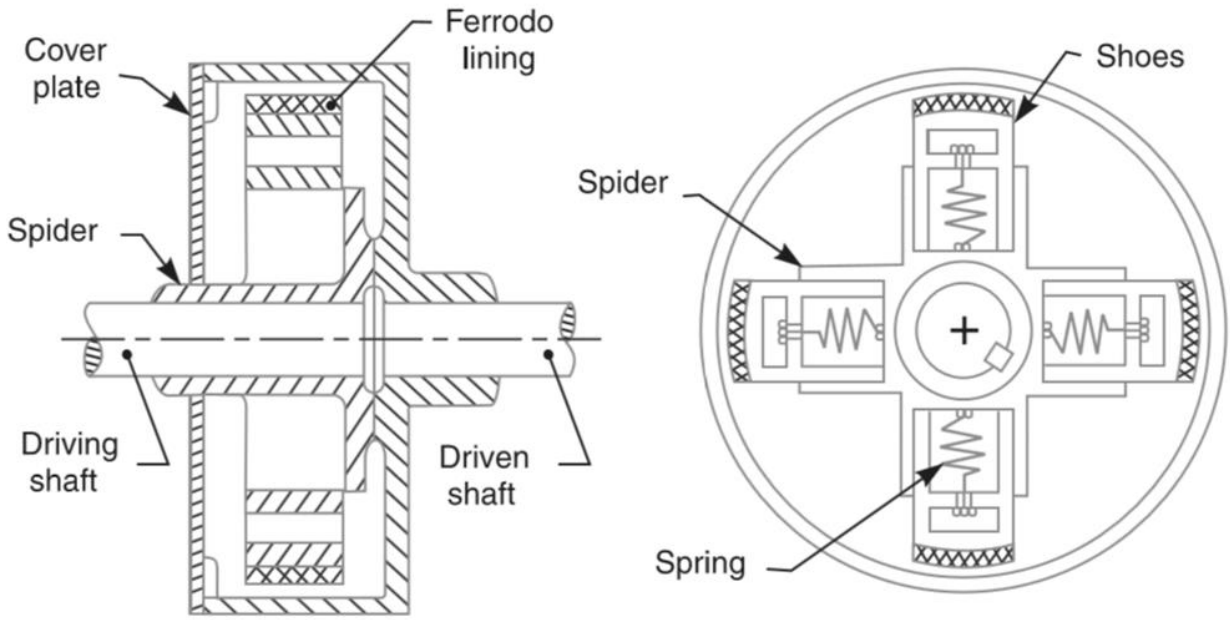


Fig. Centrifugal Clutch

When the centrifugal force exceeds the spring force, the shoe moves outward and comes into contact with the driven member and presses against it. The force with which the shoe presses against the driven member is the difference of the centrifugal force and the spring force. The increase of speed causes the shoe to press harder and enables more torque to be transmitted.

OUTCOME: We have successfully studied various types of friction clutches.

EXPERIMENT NO. 8

OBJECT: To study the differential gear box.

EQUIPMENT: A working or non working model of differential gear mechanism of any vehicle.

THEORY: The purpose of the differential assembly is to allow the two drive wheels to turn at different speeds when the car goes around a corner. This is necessary because when cornering, the wheel on the inside of the turn goes through a smaller arc or corner than the wheels on the outside. If the wheels were not allowed to turn at different speeds, they would tend to skip around the corner and steering would be very difficult.

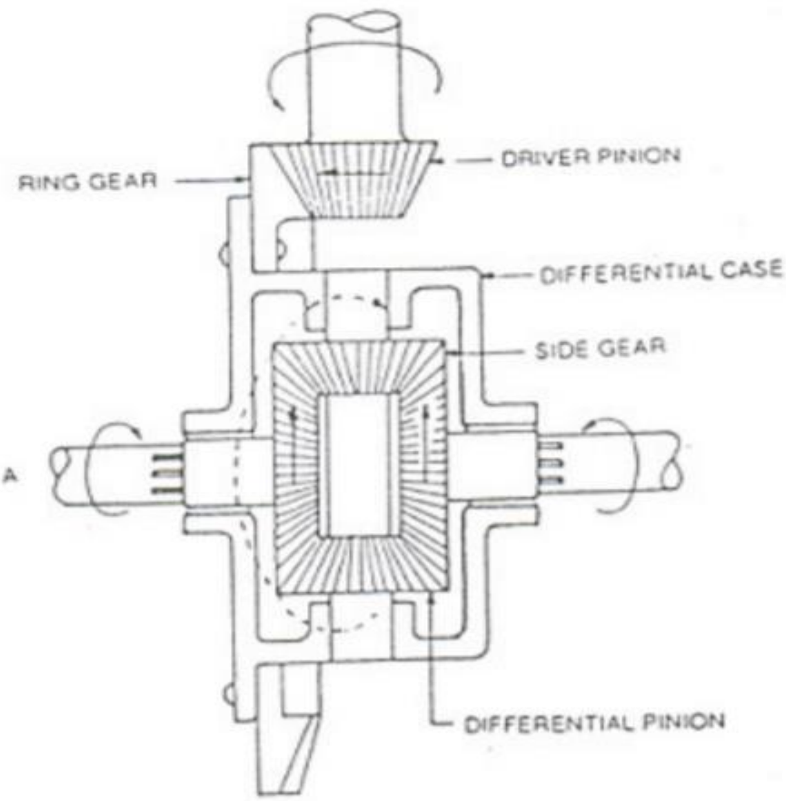
Differentials are used in:

i) The rear drive axle of front engine, rear wheel drives vehicles.

ii) The transaxles of front engine, front wheel drive and rear engine, rear wheel drive vehicles.

iii) The front drive axle and rear drive axle of four wheel drive vehicles.

iv) The transfer case of some four wheel drive vehicles.

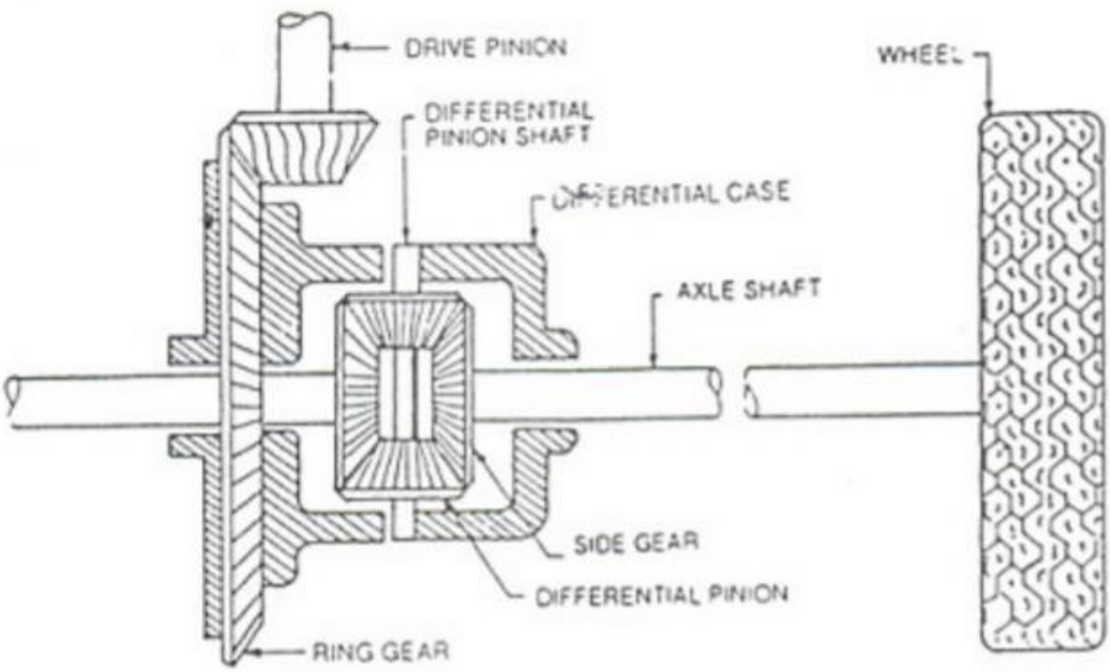


Both the front drive and rear drive differential have the same job to do. They also have many of the same parts. The basic difference is the way in which engine torque is delivered to the differential assembly.

Power enters the rear axle assembly from the final drive which consists of bevel pinion connected through a rear universal yoke to the propeller shaft. The bevel pinion is meshed with the crown wheel, which is bolted to the case. This arrangement allows the bevel pinion to turn the crown wheel.

As the crown wheel turns, the case attached to it also turns. A shaft through the case also goes through the middle of two small pinion gears. As the case turns, this shaft turns the small pinion gears, each of which meshes with a side gear. Each side gear is attached to a shaft called an axle, which on a rear drive system runs through housing to one of the rear wheels.

When the automobile is travelling in a straight line, the power flow through the system is fairly simple. The crown wheel turns the case. The case, through its shaft and pinion gears, turns each of the side gears at the same speed. The axles or drive shafts turn the drive wheels, which drive the vehicle.



When the vehicle makes a turn, however, the power flow becomes more complicated. If the automobile is making a left turn, the left drive wheel must go through a sharper corner or travel through a shorter distance than the right drive wheel. The crown wheel turns the case. Since the left wheel is going through a sharp corner, the left axle is slowed or stopped momentarily. The pinion gears in the case still turn with the case but they also rotate on the case shaft. Thus they can walk around the slowed or stopped left side gear and provide all the power to the right side gear so the right wheel will turn faster than the left wheel.

During a right turn there is more resistance on the right axle, because the right wheel must turn through a sharper corner than the left. The pinions in the case walk around the right side gear and drive the left axle gear.

OUTCOME: We have successfully studied the differential gear box.

EXPERIMENT NO. 9

OBJECT: To verify the torque relation for gyroscope.

THEORY:

Definitions:

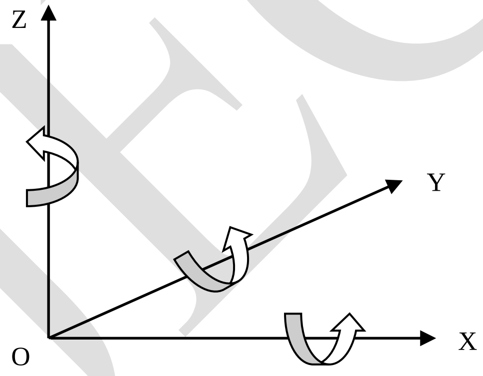
(a) **Axis of Spin:** If a body is revolving about an axis, the latter is known as axis of spin.

(b) **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 precess about an axis OZ which is perpendicular both to OX and OY. Thus the plane of spin, plane of precession and plane of gyroscopic couple are mutually perpendicular. The above combined effect is known as precessional or gyroscopic effect.

(c) **Precession:** Precession means the rotation about the third axis OZ, which is perpendicular to both the axis of spin OX and that of couple OY.

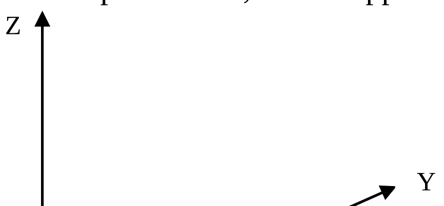
(d) **Axis of Precession:** The third axis OZ is perpendicular to both the axis of spin OX and that of couple OY is known as axis of precession.

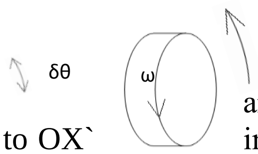
(e) **Gyroscope:** Gyroscope is a body while spinning about an axis is free to rotate in other directions under the action of external forces, e.g. locomotive, Automobile and aeroplane taking a turn. In certain cases the gyroscope forces are undesirable whereas in other cases the gyroscopic effect may be utilized in developing desirable forces. For minimizing rolling, yawing and pitching of ship or air-craft Gyroscope is used. Balloons use Gyroscope for controlling direction.



OX-Axis of Spin
OY-Axis of Couple
OZ-Axis of Precession

GYROSCOPIC COUPLE OF A PLANE DISC: Let a disc of weight W and having a moment of inertia I be spinning with an angular velocity about axis OX in a clockwise direction viewing from front. Therefore, the angular momentum of disc is I. Applying right hand screw rule, the sense of vector representing the angular momentum of disc which is also a vector quantity will be in the direction OX as shown. A couple, whose axis is OY perpendicular to OX and is in the plane XOZ, is now applied to precess the axis OX





Let axis OX turn through a small angular displacement δθ about axis OZ and in the plane XOY, from OX to OX` in time δt. The couple applied produces a change in the direction of angular velocity, the magnitude remaining constant. This change is due to the velocity of precession. Therefore, ‘OX’ represents the angular momentum after time δt.

Change of angular momentum $= \overrightarrow{OX`} - \overrightarrow{OX} = \overrightarrow{XX`}$

or rate of change of angular momentum $= \dfrac{\text{Angular Displacement}}{\text{Time}} = \dfrac{XX`}{\delta t}$

But rate of change of angular momentum = Couple applied, C

where, XX` = OX x δθ in direction of XX` = (I.ω).δθ

$$C = I.\omega.\frac{\delta\theta}{\delta t}$$

and in the limit, when δt is very small,

$$C = I.\omega.\frac{d\theta}{dt}$$

Let dθ / dt = ω_p, the angular velocity of precession of yoke, which is uniform and is about axis OZ.

Thus, we get $C = I.\omega.\omega_p$

The direction of the couple applied on the body is clockwise when looking in the direction XX` and in the limit this is perpendicular to the axis of ω and ω_p.

In the supplied apparatus, the reaction couple exerted by the body on its frame is equal in magnitude to that C, but opposite in direction.

EXPERIMENTAL SET-UP:

Schematic arrangement of the gyroscope is shown in figure. The motorized gyroscope consists of a disc rotor mounted on a horizontal shaft rotates about XX axis in two ball bearings of one frame number-2. This frame can swing about YY axis in bearings provided in the yoke type frame. The rotor shaft is coupled to a motor mounted on a trunnion frame having bearings in a yoke frame, which is free to rotate about vertical axis ZZ. Thus freedom of rotation about three perpendicular axes is given to the rotor (or the disc be rotated about three perpendicular axis). Angular scale and pointer fitted to frame helps to measure precession rate. In steady position, frame number-1 is balanced by providing a weight pan on the opposite side of the motor.

EXPERIMENTAL PROCEDURE:
Step-1: Balance the rotor position on the horizontal frame.
Step-2: Start the motor by increasing the voltage with the autotransformer and wait till the disc attains constant speed. Note down the speed.
Step-3: Put weight (0.5 kg, 1kg or 2 kg) in the weight pan, and start the stop watch to note the time in seconds required for precession through 30° or 45° etc.
Step-4: The vertical yoke precesses about OZ axis.
Step-5: Speed may be varied by the autotransformer provided on the control panel.

OBSERVATION: Given data of experiment

Weight of Rotor, kg = 6.7
Rotor Diameter, mm = 300
Rotor Thickness, mm = 10.5

Moment of inertia of the disc, coupling and motor rotor about central axis, I, kg cm sec^2 = $\frac{W}{g} \times \frac{D^2}{8}$ = 0.768

Distance of bolt of weight pan from disc centre, L, cm = 17.6

OBSERVATION TABLE:

S. No.	Weight, W (kg)	Time required for precession, dt (sec)	Speed, N (rpm)	Angle of precession, dθ (degree)

CALCULATION:
Angular velocity of disc in rad/sec, ω =
Angular velocity of precession of yoke in rad/sec, ω_p =
Gyroscopic Torque in kg cm, C = I.ω. ω_p =
C_{actual} = W x L = 0.5 x 17.6 = 8.8 kg cm

OUTCOME:
1. Calculated value of gyroscopic torque is ________ kg-cm.
2. Actual value of gyroscopic torque is 8.8 kg-cm.

PRECAUTIONS:

1. ω_p is to be calculated for short duration of time, as the balance of rotation of disc about the horizontal axis YY due to application of torque, because of which ω_p goes on reducing gradually.
2. Avoid using the tachometer while taking the reading of time as it will reduce the time taken for precession.
3. Autotransformer should be varied gradually.

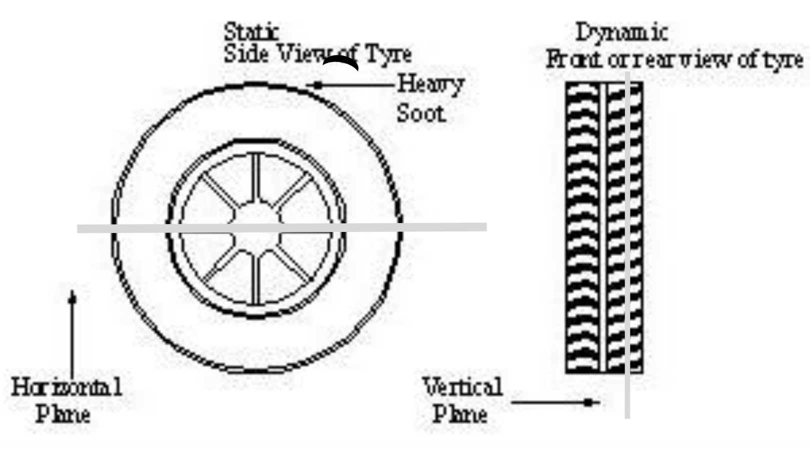
COMMENTS:

EXPERIMENT NO. 10(a)

OBJECT: To perform wheel balancing.

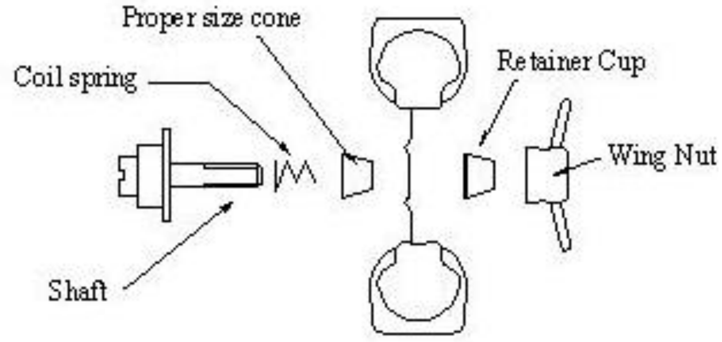
THEORY: In the past prior to 1945 wheels were balanced sing a static (not moving) balancing machine. The Static balancer held the wheel on the flat by a cone inserted in the middle of the rim. There was a level straight glass on this cone & a person added wheel weights until the level bubble filled the circle drawn on the sight glass. An equal distribution of weight around the wheel was accomplished. Static balancing was not highly accurate because it did not account for balancing problems while the wheel was spinning. In 1945, Marcellus Merrill Developed the first dynamic wheel balancing machine. This machine would test wheels for balance while they were still mounted on the vehicle.
The main purpose of the wheel balancer is to eliminate wheel vibrations as different rates of speed, improving drivability & control of the vehicle. It also stops abnormal tire wear & premature suspension wear.

WORKING PRINCIPLE: The wheel-balancing machine spins the wheel, detects & pinpoints and heavy spots on the wheel by using centrifugal force. The machine calculates how much weight is required to neutralize this imbalance and tells the operator where on the wheel to add weight.

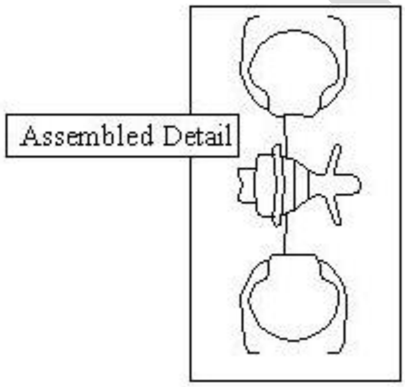


WHEEL BALANCER PROCEDURE SHEET:
STANDARD WHEEL MOUNTING: Nearly all standard wheels and many alloy wheels have accurately machined center holes and they should be mounted with center cones. Accurate balancing depends on accurate mounting insuring that the Wheel is centered on the shaft.
Mount the wheel as shown-

1. Mount coil spring inside backing plate.
2. Mount proper cone against spring.
3. Mount Wheel on shaft in the same manner as you would on the car.
4. Mount retainer cup against outside of wheel.
5. Tighten wing nut securely with both hands.



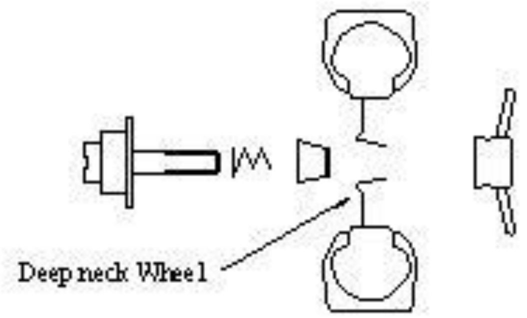
➢ Some wheels not center centric may require the use of an optional lug adapter plate. An adapter plate allows a wheel to be mounted using the lugholes as a center reference. Spring, cone, retainer cup and wing nut may not be needed if adapter plate is used to mount wheel to balancer shaft.



SPECIALITY WHEELS: Most specialty wheels can be accurately mounted and balanced using a centric cone. When using centering cones, be certain cone is properly seated in the pilot hole. Examine the hole for obvious damage and correct before balancing.

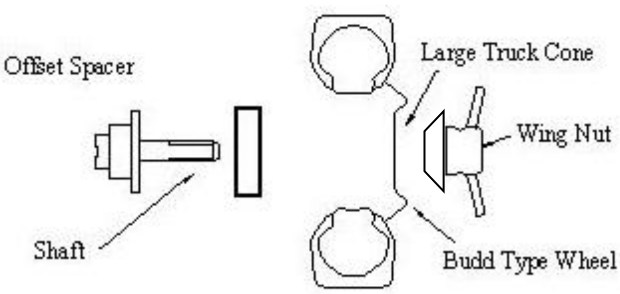
Mount the wheel as shown at right-

1. Mount coil spring inside backing plate.
2. Mount proper cone against spring.
3. Mount wheel on shaft as you would on the car.
4. Tighten wing nut securely with both hands.



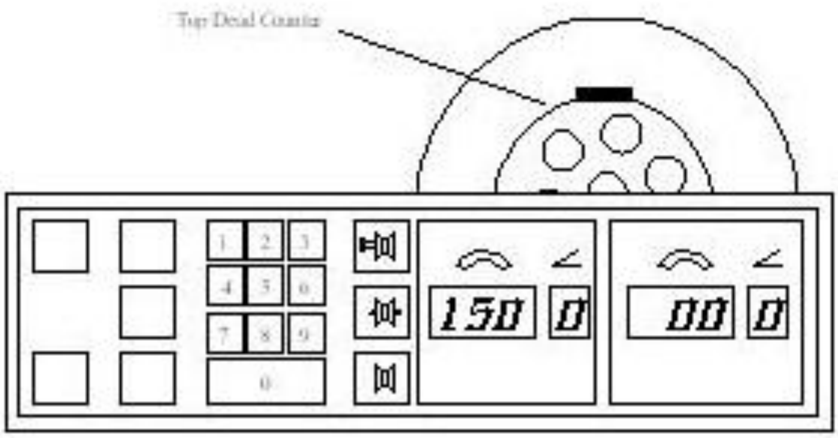
TRUCK WHEELS: For unusual application, an optional offset spacer may be used. Mount the wheel as shown at right and balance as a "Standard" wheel.

1. Mount offset spacer against backing plate.
2. Mount wheel on shaft as you would on the car.
3. Select proper cone and mount onto shaft as shown above.



SPINNING THE WHEELS: Lower the wheel guard to activate spin function. The balancer will automatically spin the wheel and stop itself. Imbalance reading will be displayed and stored as long as power is applied to the balancer. After wheel has come to a complete stop, raise the wheel guard.

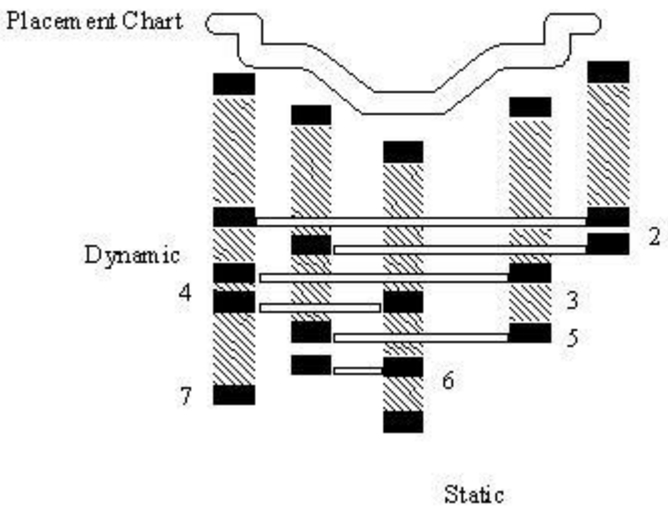
PLACING THE WEIGHT: Starting with either left or right of the wheel (inner and outer plane), rotate the wheel until a zero (0) appears in the appropriate weight position window. Apply weight displayed in the appropriate weight amount window at top dead center (12 o' clock) while weight position window displays zero (0). Repeat for the other side.



BALANCING SPECIAL/ALLOY WHEELS:
If standard clip weights are to be used, balance as a "Standard" Wheel. The Alloy Mode or Aluminum mode of operation is used when some specialty wheels are to be balanced, or when adhesive weights are required, i.e. hidden weight method. The ALU mode is entered by pressing the ALU button followed by the desired mode location number.

IF ADHESIVE WEIGHTS OR TAPE WEIGHTS MUST BE USED, FOLLOW THESE INSTRUCTIONS:

1. See Placement illustration below and select how weights will be applied.
2. Enter distance, wheel width and diameter as explained previously.



OUTCOME: The balancing of wheel is successfully perfomed on given wheel balancing set-up.

EXPERIMENT NO. 10(b)

OBJECT: To perform static and dynamic balancing on balancing set up.

APPARATUS:

The apparatus basically consists of a steel shall mounted in ball bearings in a stiff rectangular main frame. A set of four block of different weight is provided and may be clamped in any position on the shaft, and also be easily detached from the shaft.

A disc carrying a circular protractor scale is fitted to one side of the rectangular frame shaft carries a disc and rim of this disc is grooved to take a light cord provided with tow cylindrical metal containers of exactly the same weight.

A Scale is fitted to the lower member of the main frame and when used in conjunction with the circular protractor scale allows the exact longitudinal and angular position of each adjustable block to be determined.

For static balancing of individual weight the main frame is suspended to the supported frame by chains and in this position the motor driving belt is removed.

For dynamic balancing g of the rotating mass system the main frame is suspended from the support frame by two short links such that the mains frame and the supporting frame are in the same plane.

EXPERIMENTAL PROCEDURE:

Static Balancing:

Remove the drive belt. The value of W_r for each block is determined by clamping each block in turn on the shaft and with the cord and container system suspended over the protractor disc the number of steel balls, which are of equal weight are placed into one of the containers to exactly balance the blocks on the shaft. When the block becomes horizontal, the number of balls 'N' will give the value of W_r for the block. For finding out 'W_r' during static balancing proceed as follows:

1. Remove the belt.
2. Screw the combined hook to the pulley with groove. (This pulley is different than the belt pulley)
3. Attach the cord-ends of the pans to the above combined hook.
4. Attach the block No. 1 to the shaft at any convenient position and in vertical downward direction.
5. Put steel balls in one of the pans till the block starts moving up (upto horizontal position)
6. Number of balls gives the 'W_r' value of block 1 Repeat this for 2-3 times and find the average no of balls.
7. Repeat the procedure for other blocks.

Dynamic Balancing:

It is necessary to leave the machine before the experiment. Using the Values of W_r obtained as above, and if the angular positions and planes of rotation of three of four blocks are known, the student can calculate the position of the other block (s) for balancing of the complete system. From the calculation, the student finally clamps all the blocks on the shaft in their appropriate positions Replace the motor belt, transfer the main frame to its hanging position and then by running the motor, one can verify that these calculations are correct and the blocks are perfectly balanced.

OUTCOME: Static and dynamic balancing is successfully performed on given balancing set up.

PRECAUTIONS:

1. Do not run the motor for more time in unbalanced positions
2. Place the weights/ balls gently in the pan.
3. While placing the balls the pan should be hold gently and check that it should not jump its position.
4. Weight setting gauge should be check gently.

COMMENT:

EXPERIMENT NO. 11(a)

OBJECT: To study of the lathe gear box.

THEORY:

(1) General. In cutting threads on a lathe, the pitch of the thread or the number of threads per inch obtained is determined by the speed ratio of the headstock spindle and the lead screw which drives the carriage. Lathes that are equipped for thread cutting have gear arrangements for varying the speed of the lead screw. Most modern lathes have a quick-change gearbox for varying the lead screw to the spindle ratio, but many older lathes, modern inexpensive lathes, and special lathes come equipped with standard change gears which must be arranged by computation to achieve the desired speed ratio.

(2) *Quick-Change Gearbox*. For lathes equipped with quick-change gearboxes, the operator need only follow the instructions on the direction plates of the lathe to set the proper feed to produce the desired number of threads per inch. Once set to a specific number of threads per inch, the spindle speed can be varied depending upon the material being cut and the size of the workpiece, without affecting the threads per inch.

(3) *Standard-Change Gears*. Lathes equipped with standard-change gears require that the operator be familiar with the methods of selecting the proper gears to produce the desired thread pitch in case the manufacturer supplied gear tables are missing. On most lathes with standard change gears, the gears may be arranged in a simple gear train or in a compound gear train.

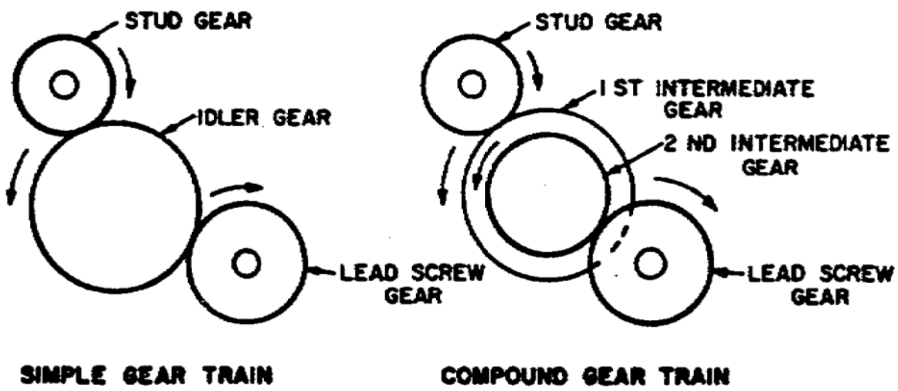
(a) *Simple Gear Train*

The basic gears which control the ratio between the spindle speed and the lead screw speed are the stud gear and the lead screw gear. The stud gear mounts to a shaft which revolves at the same speed as the spindle and, therefore, can be considered in this discussion as representing spindle speed in revolutions per minute. The lead screw gear is usually connected directly to the lead screw and, therefore, moves at the same speed as the lead screw. In a simple gear train, the stud gear and the lead screw gear are meshed together or coupled by an idler gear. If the idler gear is used, it can be of any size or number of teeth convenient for coupling since it only transmits motion from one gear to the other and does not affect the ratio of the stud or the lead screw gears.

The threads per inch of the lead screw must be known to compute the gearing for a specific ratio. The rule for determining the number of teeth of the stud gear and the lead screw gear for a simple gear train is as follows: Multiply the number of threads per inch of the lead screw and the number of threads to be cut by a common number. The products will be the number of teeth that the stud gear and the lead screw gear should have, respectively. For example, suppose that a machinist wants to cut a screw with 10 threads per inch on a lathe having a lead screw with 4 threads per inch. The procedure would be to multiply 10 and 4 by any convenient number, say 6. Then, 6 x 4 = 24 and 6 x 10 = 60. The stud gear should have 24 teeth and the lead screw gear should have 60 teeth to produce the desired ratio to cut 10

threads per inch. If gears of 24 and 60 teeth are not available, multiply 10 and 4 by another number until the products coincide with the number of teeth that are on available gears.
Whenever the thread to be cut is finer than the thread of the lead screw, the gear with the fewest teeth will be the stud gear. If the thread to be cut is coarser than the lead screw, the gear with the fewest teeth will be the lead screw gear.

(b) *Compound Gear Train*.
If the proper ratio between the spindle and the lead screw cannot be obtained by simple gearing, a compound gear train must be used on the previous page). For example, if it is desired to cut 80 threads per inch with a lead screw having 8 threads per inch, and the smallest change gear available has 24 teeth, the lead screw gear must have 240 teeth which would be too large in diameter to fit the lathe. By compounding the gears, it would be possible to cut 80 threads per inch with the gears generally available.
In the compound gear train, two intermediate gears replace the idler gear of the simple gear train. The intermediate gears are mounted to the same shaft and are keyed together. The gears driven by the stud gear is known as the first intermediate gear and the gear that drives the lead screw gear is known as the second intermediate gear. An idler gear can be used if necessary in this gear train, but will reverse the direction of the lead screw gear, and make reversal of the stud gear-to-spindle connection necessary.
To compute compound gear arrangements, the following rule should be applied: establish the ratio between the number of threads per inch to be cut and the number of threads per inch of the lead screw. Factor each term of the ratio; that is, determine two numbers for each term which, when multiplied by each other, result in the number of the ratio term. The resulting four numbers, when each are to be multiplied by a convenient number, will be the number of teeth in the four gears; the stud gear and the second intermediate gear representing the smaller term, and the first intermediate gear and the lead screw gear representing the larger term of the ratio.

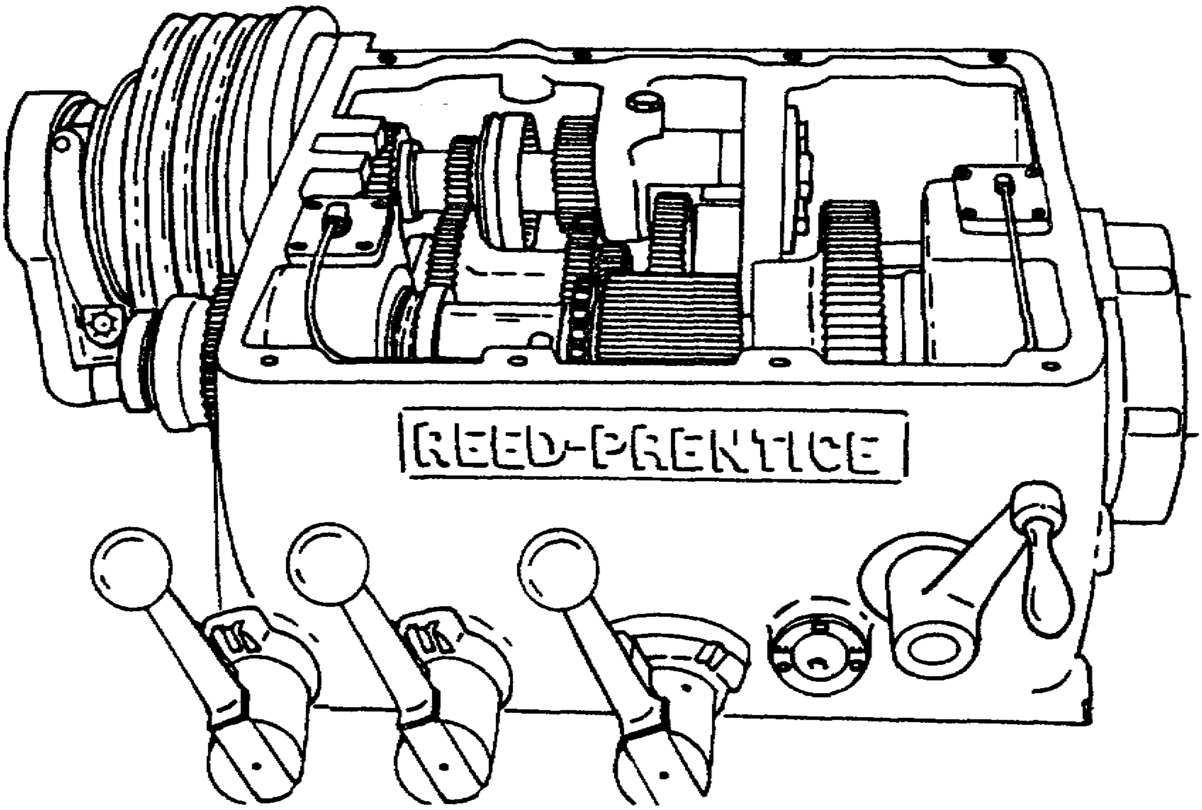


HEADSTOCK:

(a) The headstock carries the head spindle and the mechanism for driving it. In the belt-driven type headstock, the driving mechanism consists merely of a cone pulley that drives the spindle directly or through the back gears. When the spindle is driven directly, it rotates the cone pulley. When the spindle is driven through the back gears, it rotates more slowly than the cone pulley, which in this case turns freely on the spindle. Thus two speeds are available with each position of the belt on the cone; if the cone pulley has four steps, eight spindle speeds are available.

(b) The geared headstock shown in figure is more complicated but more convenient to operate, because the speed is changed by changing or by shifting the gears. This headstock is similar to an automobile transmission except that it has more gear-shift combinations and, therefore, has a greater number of speed changes. A speed index plate, attached to the headstock, indicates the lever positions for the different spindle speeds. To avoid damage to the gear teeth, the lathe is always stopped before the gears are shifted.

(c) Figure shows the interior of a typical geared headstock that has 16 different spindle speeds. The driving pulley at the left is driven at a constant speed by a motor located under the headstock. Various combinations of gears in the headstock transmit power from the drive shaft to the spindle through an intermediate shaft. Use the speed-change levers to shift the sliding gears on the drive shaft and the intermediate shaft to line up the gears in different combinations. This produces the gear ratios needed to obtain the various spindle speeds. Note that the back gear lever has a high and low speed for each combination of the other gears.



(d) The headstock casing is filled with oil to lubricate the gears and the shifting mechanism contained within it. The parts not immersed in the oil are lubricated by either the splash produced by the revolving gears or by an oil pump. Be sure to keep the oil to the full level as indicated on the oil gage, and drain and replace the oil when it becomes dirty or gummy.

(e) The headstock spindle is the main rotating element of the lathe and is directly connected to the workpiece which revolves with it. The spindle is supported in bearings at each end of the headstock through which it projects. The section of the spindle between the bearings carries the pulleys or gears that turn the spindle. The nose of the spindle holds the driving plate, the faceplate, or a chuck. The spindle is hollow throughout its length so that bars or rods can be passed through it from the left and held in a chuck at the nose. The chuck end of the spindle is bored to a Morse taper to receive the solid center. The hollow spindle also permits the use of the draw-in collet chuck (to be discussed later in this lesson). At the other end of the spindle is the gear by which the spindle drives the feed and the screw-cutting mechanism through a gear train located on the left end of the lathe. A collar is used to adjust the end play of the spindle.

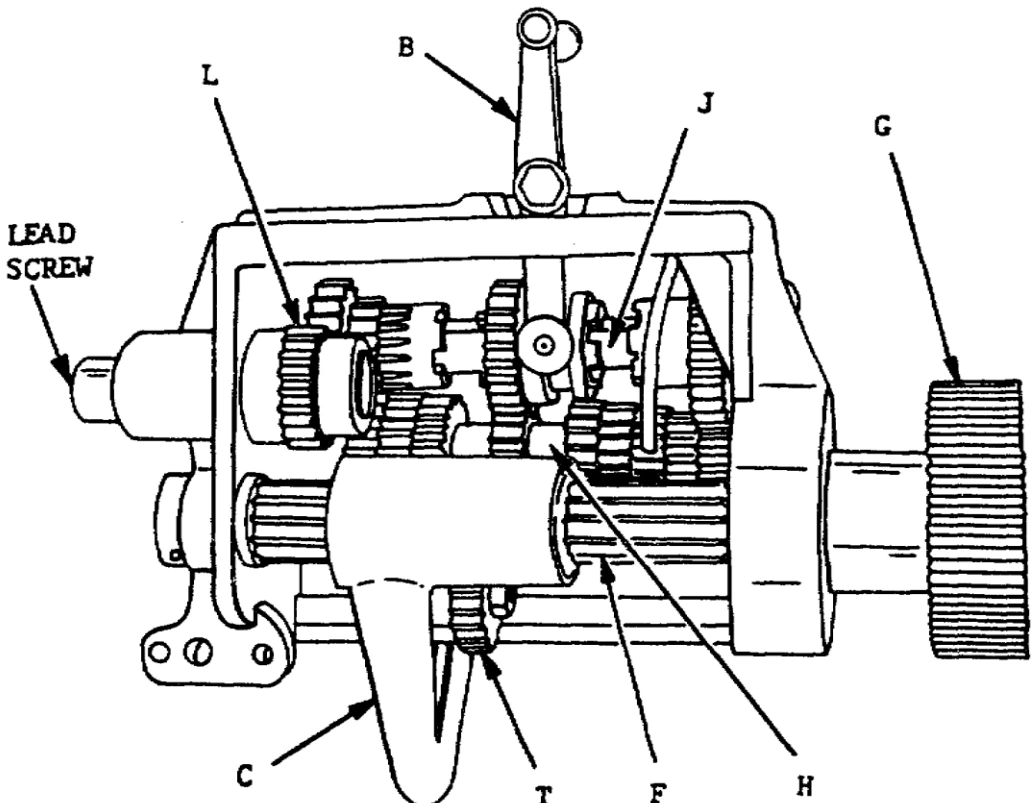
(f) The spindle is subjected to considerable torque because it drives the work against the resistance of the cutting tool, as well as driving the carriage that feeds the tool into the work.

Because of the torque and pressure applied to the spindle, adequate lubrication and accurately adjusted bearings are absolutely necessary.

QUICK-CHANGE GEAR MECHANISM:

(a) To do away with the inconvenience and loss of time involved in removing and replacing change gears, most modern lathes have a self contained change gear mechanism, commonly called a "quick-change gear box." There are a number of types used on different types of lathes, but they are all similar in principle.

(b) The quick-change gear box mechanism consists of a cone-shaped group of change gears. One can instantly connect any single gear in the gear train by a sliding tumbler gear controlled by a lever. The cone of gears is keyed to a shaft which drives the lead screw (or feed rod) directly or through an intermediate shaft. Each gear in the cluster has a different number of teeth and hence produces a different ratio when connected in the train. Sliding gears also produce other changes in the gear train to increase the number of different ratios one can get with the cone of change gears. All changes are made by shifting the appropriate levers or knobs. An index plate or chart mounted on the gear box indicates the position in which to place the levers to obtain the necessary gear ratio to cut the threads or produce the feed desired.



(c) Figure depicts the rear view of one type of gear box. The splined shaft turns with gear G, which is driven by the spindle through the main gear train mounted on the end of the lathe. Shaft F in turn drives shaft H through the tumbler gear T, which can be engage with any one of the cluster of eight different size gears on shaft H by means of the lever C. Shaft H drives shaft J through a double-clutch gear, which takes the drive through one of three gears, depending on the position of lever B (right, center or left). Shaft J drives the lead screw through gear L.

(d) Either the lead screw or the feed rod can he connected to the final driveshaft of the gear box by engaging the appropriate gears. The lathe gear box shown in figure has no feed rod.

(e) Twenty-four different gear ratios are provided by the quick-change gear box. The lower lever has eight positions, each of which places a different gear in the gear train and hence produces eight different gear ratios. The three positions of the upper level produce three different gear ratios for each of the 8 changes obtained with the lower lever, thus making 24 combinations in the box alone. This range can be doubled by using the sliding compound gear which provides a high- and low-gear ratio in the main gear train. This gives two ratios for every combination obtainable in the box, 48 combinations in all.

OUTCOME: We have successfully completed the study of lathe gear box.

EXPERIMENT NO. 11(b)

OBJECT: To study the sliding mesh automobile gear box.

INTRODUCTION:
An internal combustion engine produces little power at low r.p.m. and maximum power at the given speed depending on the particular engine with direct coupling, a set or fixed road speeds is provided the engine. In order to maintain engine speed on all conditions of load and vehicle speed, the gearbox uses a system of leverage of keeping the speed of the engine up while sacrificing some road speed. In order to enable the engine to run faster in relation to the road wheel as well as to multiply the torques, a gearbox is used.
Gearbox consists of various types of gears, which are constantly in mesh. The gear changes are made by sliding the dogs. The main function of the gearbox is to provide the necessary variation to the torque applied by the engine to the road wheel according to operating conditions. The necessary variations are provided due to the presence of different gear ratios among various meshing gars.

(a) Gearbox: In order to house the gears, a casing or the box usually made of aluminum alloy or malleable cast iron is used. It is supported by a chassis cross member as well as bolted to the clutch bell housing. Lubricating oil maintained at a predetermined level is contained in the box. In order to safeguard the gearbox against dirt and oil split off, a top cover or inspection plate is usually incorporated on the housing of the gearbox ball joint for gear selector mechanism. Different gear and bearing are lubricated by the rotation of the lay shaft splash.

(b) It is the driving shaft of the gearbox: In order to fit into the hub of the clutch plate, its forward end is splined. A pinion having both external as well as internal teeth is carried inside the gearbox by the rear end of the primary shaft. The external teeth are in constant mesh with the lay shaft driving pinion. When the top gear is selected, the internal teeth transmit the drive to main or sliding shaft. In order to carry the front end of the main shaft, the rear end of the primary shaft is bored.

(c) Lay shaft: It is a shaft which drives through the constant mesh gear wheel as well as carries two or three different sized gear wheels for transmitting the driving to give different gear ratios. One of the gear wheels on the main shaft.

(d) Main or sliding shaft: In order to support the gear end of the primary shaft a spigot is formed. For forming the spigot, the front end of a shaft, which is in line with the primary shaft, is machined. This shaft is known as main or sliding shaft has its rear end mounted in the gearbox bearings. With the help of a universal joint, rear end is connected to the propeller shaft. Most of the length of this shaft is splined for carrying the sliding mesh pinions. In order to mesh either a particular layshaft gear wheel or direct to the primary shaft the length of the main shaft is moved by a selector mechanism. The drive transmitted to propeller shaft is always through the main shaft.

(e) Reverse shaft: The shaft used to reverse the direction of the drive by bringing into mesh the largest gear wheel on the main shaft with the layshaft is known as the reverse.

(f) Gear change or selector Mechanism: In order to make gear changing easier, and select a particular gear train as well as bring it into operation gear change or selector mechanism is used. It consists of forks provided on the gearbox to engage slots on the gearboxes. In the normal layout of the central floor mounted gear lever, the selector mechanism is usually provided on the top of the gearbox. It may be fitted on the side of the gearbox when the gear change lever is mounted on the steering column. In the top of the boss of the selector fork, a slot with rounded ends is cut. The tip of the gear lever is fitted into it. When no gear is engaged, the lever is given its free sideway movement due to the movement of the lever across the slot either way in neutral position.
The gears usually slip out due to worn grooves on selector rods, worn balls, broken springs or springs of incorrect strength. In case the gear is not pushed fully into mesh, the working face may become worn from continuous contact with the revolving gear and the bore may wear resulting in tilting of the fork on its selector rod as well as the lever groove may become worn and the fork position may become bent.

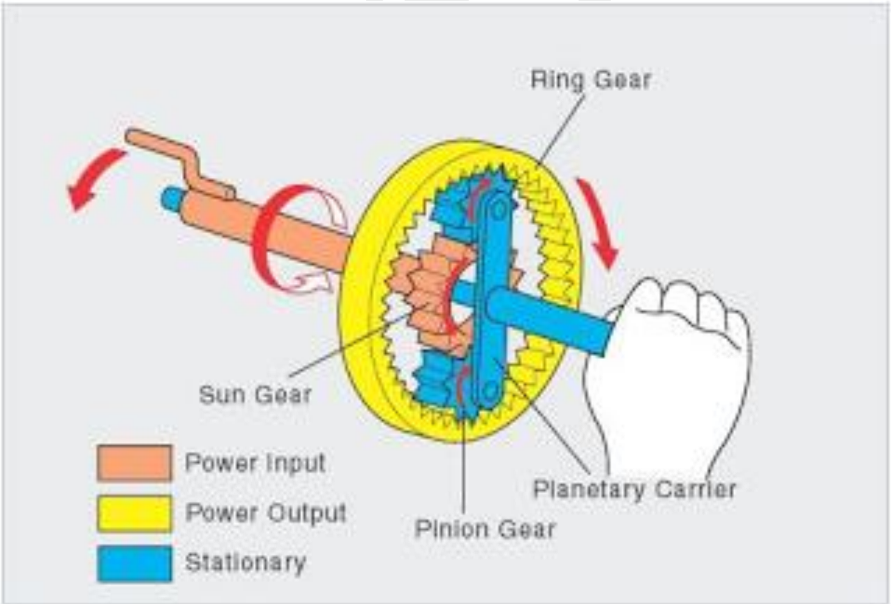
OUTCOME: We have successfully completed the study of sliding mesh automobile gear box.

EXPERIMENT NO. 11(c)

OBJECT: To study the planetary gear box.

THEORY: Planetary trains are used like a compound gear train when a large change in speed or power is needed across a small distance. There are four different ways that a planetary train can be hooked up.

A planetary gear train is a little more complex than other types of gear trains. In a planetary train at least one of the gears must revolve around another gear in the gear train. A planetary gear train is very much like our own solar system, and that's how it gets its name. In the solar system the planets revolve around the sun. Gravity holds them all together. In a planetary gear train the sun gear is at the center. A planet gear revolves around the sun gear. The system is held together by the planet carrier. In some planetary trains, more than one planet gear rotates around the sun gear. The system is then held together by an arm connecting the planet gears in combination with a ring gear.



The planetary gear set is the device that produces different gear ratios through the same set of gears. Any planetary gear set has three main components:

1. The sun gear
2. The planet gears and the planet gears' carrier
3. The ring gear

Each of these three components can be the input, the output or can be held stationary. Choosing which piece plays which role determines the gear ratio for the gear set.

These four combinations and the resulting speed and power outputs are listed in following table:

Sun Gear	Arm	Ring Gear	Speed	Power
Input	Output	Fixed	Decreased	Increased
Output	Input	Fixed	Increased	Decreased
Fixed	Output	Input	Decreased	Increased
Fixed	Input	Output	Increased	Decreased

ADVANTAGES:
- Compact size and low weight – as much as 50% reduction with same torque output.
- High power density – several planets share the load rather than one gear, the more planets the more sharing.
- Longer gear life at similar loads.
- Gearing can be very accurate with virtually no backlash.
- Coaxial arrangement – no offset output shaft.
- Modular, most planetary stages can be stacked.

DISADVANTAGES:
- Noisier Operation – some planetary gear-heads are noisy.
- Gearing must be accurate to assure load sharing.
- High bearing loads can lead to early wear in dead stud or sleeve bearing construction.
- Generally grease lubricated (oil bath is the better).
- High ratio of length to diameter when using multiple stages (gear-head gets very long).
- High cost if low backlash and long life are required.

APPLICATIONS:
- They are popular for automatic transmissions in automobiles.
- They are also used in bicycles for controlling power of pedaling automatically or manually.
- They are also used for power train between internal combustion engine and an electric motor.

OUTCOME: We have successfully completed the study of planetary gear box.