DRONACHARYA
GROUP OF INSTITUTIONS

LABORATORY MANUAL

THEORY OF MACHINE LAB

SUBJECT CODE: KME-653

B.TECH. (ME)   SEMESTER -VI

Academic Session: 2022-23, Even Semester

Student Name:	
Roll. No.:	
Branch/Section:	

Dronacharya Group of Institutions
Plot No. 27, Knowledge Park-3, Greater Noida, Uttar Pradesh 201308
Affiliated to

Dr. A P J Abdul Kalam Technical University
Lucknow, Uttar Pradesh 226031

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Vision and Mission of the Institute

Vision:

"Dronacharya Group of Institutions, Greater Noida aims to become an Institution of excellence in imparting quality Outcome Based Education that empowers the young generation with Knowledge, Skills, Research, Aptitude and Ethical values to solve Contemporary Challenging Problems"

Mission:

We, at Dronacharya Group of Institutions, are absolutely committed to serve the society and improve the mode of life by imparting high quality education in the field of Engineering and Management catering to the explicit needs of the students, society, humanity, and industry. 'Shiksha evam Sahayata' i.e. Education and help are the two words etched on our banner soaring higher year after year.

Vision and Mission of the Department

Vision:

"To become a Centre of Excellence in teaching and research in Mechanical Engineering for producing skilled professionals having a zeal to serve society"

Mission:

M1: To create an environment where students can be equipped with strong fundamental concepts.

M2: To provide an exposure to emerging technologies by providing hands on experience for generating competent professionals.

M3: To promote Research and Development in the frontier areas of Mechanical Engineering and encourage students for pursuing higher education

M4: To inculcate in students ethics, professional values, team work and leadership skills.

Program Educational Objectives (PEOs)

PEO 1. Engineers will practice the profession of engineering using a systems perspective and analyze, design, develop, optimize & implement engineering solutions and work productively as engineers, including supportive and leadership roles on multidisciplinary teams.

PEO 2. Continue their education in leading graduate programs in engineering & interdisciplinary areas to emerge as researchers, experts, educators & entrepreneurs and recognize the need for, and an ability to engage in continuing professional development and life-long learning.

PEO 3. Engineers, guided by the principles of sustainable development and global interconnectedness, will understand how engineering projects affect society and the environment.

PEO 4. Promote Design, Research, and implementation of products and services in the field of Engineering through Strong Communication and Entrepreneurial Skills.

PEO 5. Re-learn and innovate in ever-changing global economic and technological environments of the 21st century.

Program Outcomes (POs)

PO1: Engineering knowledge: Apply knowledge of mathematics, science, and engineering in Mechanical Engineering.

PO2: Problem analysis: Design and conduct experiments, as well as to analyze and interpret data.

PO3: Design/development of solutions: To design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

PO4: 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.

PO5: Modern tool usage: Apply principles of engineering, basic science, and mathematics to design and realize physical systems, components, or processes.

Use the techniques, skills, and modern engineering tools necessary for engineering practice like AUTOCAD.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: 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.

Program Specific Outcomes (PSOs)

PSO 1: Graduates of the program will achieve excellence in product design, thermal engineering and manufacturing system by acquiring knowledge in mathematics, science and designing principles.

PSO 2: Graduate will be able to analyze, interpret and provide solutions to the real life mechanical engineering problems.

PSO 3: Graduate will develop an approach to solve multidisciplinary problems of manufacturing and allied industries.

University Syllabus

1. To study various types of kinematics links, pairs, chains & Mechanisms.

2. To Study of Inversions of Four bar linkage.

3. Draw the velocity and acceleration diagram for the given mechanism.

4. To study of inversions of single/double slider crank mechanisms.

5. To perform experiment on dead weight type governor to prepare performance characteristic Curves, and to find stability & sensitivity

6. To perform experiment on spring controlled governor to prepare performance characteristic Curves, and to find stability & sensitivity.

7. To study gyroscopic effects through models.

8. To determine whirling speed of shaft theoretically and experimentally

9. To perform experiment on brake.

Course Outcomes

CO 1	Demonstrate various mechanisms, their inversions and brake and clutches in Automobiles
CO 2	Apply cam-follower mechanism to get desired motion of follower.
CO 3	Apply the concepts of gears and gear train to get desired velocity ratio for power transmission.
CO 4	Apply the concept of governors to control the fuel supply in engine.

CO-PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	1		1		3			2	3	1	2	1
CO 2	1		1		2			2	2	1	3	1
CO 3	1		3		3			2	3	1	2	1
CO 4	1		2		3			2	2	1	3	1

CO-PSO Mapping

	PSO1	PSO2	PSO3
CO 1	1		2
CO 2	2	1	2
CO 3	2	1	2
CO4	2		2

Course Overview

1. To understand the natural frequency, logarithmic decrement, damping ratio and damping.

2. To understand the balancing of rotating masses.

3. To understand the concept of the critical speed of a rotating shaft.

4. To understand the concept of stress concentration using Photo elasticity.

5. To understand the equilibrium speed, sensitiveness, power and effort of Governor.

List of Experiments mapped with COs

S. No	Aim of the Experiment	COs
1.	To study various types of kinematics links, pairs, chains & Mechanisms.	CO1
2.	To Study of Inversions of Four bar linkage.	CO4
3.	Draw the velocity and acceleration diagram for the given mechanism.	CO1
4.	To study of inversions of single/double slider crank mechanisms.	CO2
5.	To study of inversions of single/double slider crank mechanisms.	CO3
6.	To perform experiment on spring controlled governor to prepare performance characteristic Curves, and to find stability & sensitivity.	CO3
7.	To study gyroscopic effects through models.	CO4
8.	To determine whirling speed of shaft theoretically and experimentally	CO5
9.	To perform experiment on brake.	CO2

DOs and DON'Ts

DOs

1. Student must carry record and observation.

2. Take signature of lab in charge after completion of observation and record.

3. If any equipment fails in the experiment report it to the supervisor immediately.

4. Students should come to the lab with thorough theoretical knowledge.

5. Put your bags in the designated area.

DON'Ts

1. Don't touch the equipment without instructions from lab supervisor.

2. Don't crowd around the experiment and behave in-disciplinary.

3. Using the mobile phone in the laboratory is strictly prohibited.

General Safety Precautions

Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as firewood   or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.

2. Unplug the risk of faulty equipment. If the main circuit breaker is accessible, turn   the circuit off.

3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth   resuscitation if necessary.

Precautions (In case of Fire)

1. Turn the equipment off. If the power switch is not immediately   accessible, take plug off.

2. If fire continues, try to curb the fire if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.

3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.

Guidelines to Students for Report Preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows:-

1) All files must contain a title page followed by an index page. ***The files will not be signed by the faculty without an entry in the index page.***

2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.

3) For each experiment, the record must contain the following

       (i) Aim/Objective of the experiment

       (ii) Pre-experiment work (as given by the faculty)

       (iii) Lab assignment questions and their solutions

       (iv) Test Cases (if applicable to the course)

       (v) Results/ output

Note:

1. Students must bring their lab record along with them whenever they come for the lab.

2. Students must ensure that their lab record is regularly evaluated.

Lab Assessment Criteria

An estimated 10 lab classes are conducted in a semester for each lab course. These lab classes are assessed continuously. Each lab experiment is evaluated based on 5 assessment criteria as shown in following table. Assessed performance in each experiment is used to compute CO attainment aswell as internal marks in the lab course.

| Grading Criteria	Exemplary (4)	Competent (3)	Needs Improvement (2)	Poor (1)
AC1: Pre-Lab written work (this may be assessed through viva)	Complete procedure with underlined concept is properly written	Underlined concept is written but procedure is incomplete	Not able to write concept and procedure	Underlined concept is not clearly understood
AC2: Program Writing/ Modeling	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied, Program/solution written is readable	Assigned problem is properly analyzed, correct solution designed, appropriate language constructs/ tools are applied	Assigned problem is properly analyzed & correct solution designed	Assigned problem is properly analyzed
AC3: Identification & Removal of errors/ bugs	Able to identify errors/ bugs and remove them	Able to identify errors/ bugs and remove them with little bit of guidance	Is dependent totally on someone for identification of errors/ bugs and their removal	Unable to understand the reason for errors/ bugs even after they are explicitly pointed out
AC4:Execution & Demonstration	All variants of input /output are tested, Solution is well demonstrated and implemented concept is clearly explained	All variants of input /output are not tested, However, solution is well demonstrated and implemented concept is clearly explained	Only few variants of input /output are tested, Solution is well demonstrated but implemented concept is not clearly explained	Solution is not well demonstrated and implemented concept is not clearly explained
AC5:Lab Record Assessment	All assigned problems are well recorded with objective, design constructs and solution along with Performance analysis using all variants of input and output	More than 70 % of the assigned problems are well recorded with objective, design contracts and solution along with Performance analysis is done with all variants of input and output	Less than 70 % of the assigned problems are well recorded with objective, design contracts and solution along with Performance analysis is done with all variants of input and output	Less than 40 % of the assigned problems are well recorded with objective, design contracts and solution along with Performance analysis is done with all variants of input and output

LAB EXPERIMENTS

EXPERIMENT NO. 1

Object:- To study various types of kinematics links, pairs, chains & Mechanisms.

Apparatus Required: Models of various Mechanisms.

Theory:

Link: A resistant body or a group of resistant bodies with rigid connections preventing their relative movement is known as a link. A link may also bedefined as a member or a combination of members of a mechanism, connecting other members and having motion relative to them.

A link is also known as kinematic link or element. Links can be classified into binary, ternary and quaternary depending upon their ends on which or turning pairs can be placed.

Binary link   Ternary link   Quaternary link
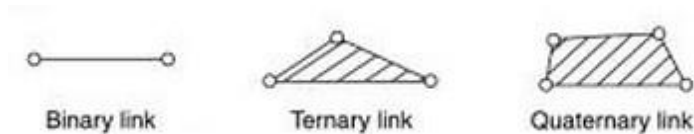
Kinematic Pair : A kinematic pair or simply a pair is a joint of two links havingrelative motion between them.

Types of Kinematic Pairs : Kinematic pairs can be classified according to

Nature of contact

Nature of relative motion

Kinematic Pairs according to Nature of Contact

Lower Pair: A pair of links having surface or area contact between the members is known as a lower pair. The contact surfaces of two links are similar, e.g., nut turning ona screw, universal joint, etc.

Higher Pair: When a pair has a point or line contact between the links, it is knownas a higher pair. The contact surfaces of the two links are dissimilar, e.g., wheel rolling on a surface, cam and follower pair, etc.

Kinematic Pairs according to Nature of Relative Motion

Sliding Pair: If two links have a sliding motion relative to each other, they form asliding pair, e.g., a rectangular rod in a rectangular hole in a prism.

Turning Pair: When one link has a turning or revolving motion relative to the other, they constitute a turning or revolving pair, e.g., a circular shaft revolving inside a bearing.

Rolling Pair: When the links of a pair have a rolling motion relative to each other, they form a rolling pair, e.g., a rolling wheel on a flat surface.

Screw Pair (Helical Pair): If two mating links have a turning as well as sliding motion between them, they form a screw pair, e.g., lead screw and nut of a lathe.

(a)   (b)   (c)

(d)   (e)
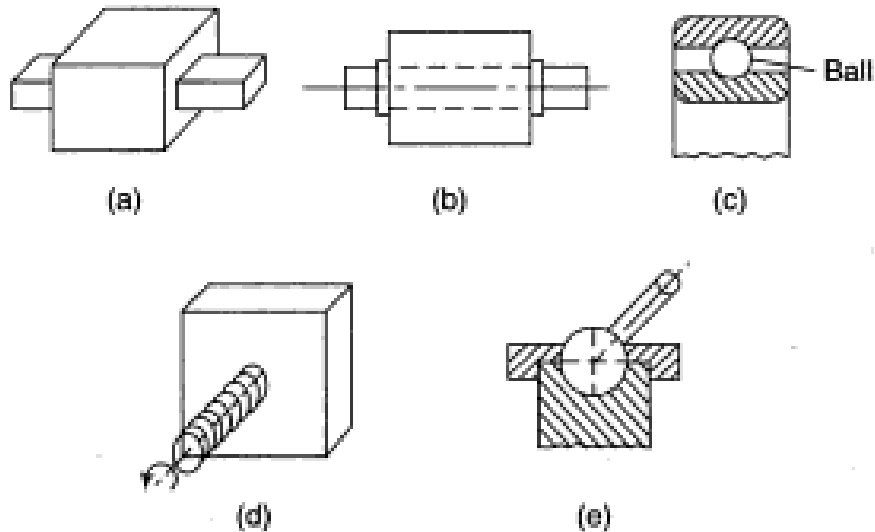
Spherical Pair: When one link in the form of a sphere turns inside a fixed link, it is a spherical pair, e.g., ball and socket joint.

Degree of Freedom: Number of independent motion, both translational and rotational, a pair can have. An unconstrained rigid body moving in space can have following independent motion.

-Translational motion along any other mutually perpendicular axes x, y and z

-Rotational motions about these axes

Thus a rigid body possesses 6 degree of freedom.

The connection of a link with another link imposes certain constraint on their relative motion.

Degree of freedom = 6-number of constraint.

Kinematic Chain: A kinematic chain is an assembly of links in which the relative motions of the links is possible and the motion of each relative to the other is definite.

In the figure given below (a), (b) & (c) are kinematic chains while (d) is a non- kinematic chain. Figure (e) shows a redundant chain as it does not allow any motion of a link relative to the other.
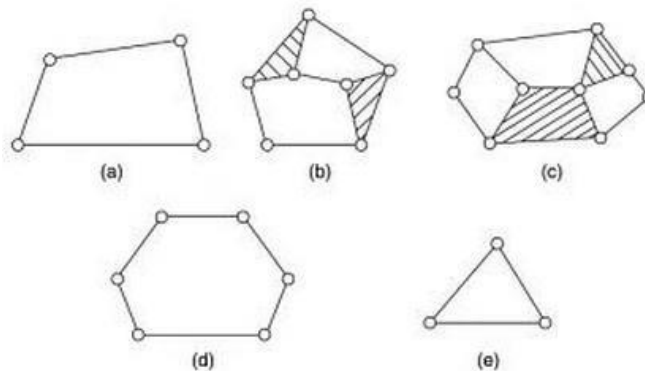
Mechanism: If number of bodies is assembled in such a way that the motion of one causes constrained and predictable motion to the others, it is known as a mechanism. A mechanism transmits and modifies a motion.

A **mechanism** is a kinematic chain with any one link fixed which is used to transmit the required motion.

Machine:-A machine is a mechanism or a combination of mechanisms which, apart from imparting definite motions to the parts also transmits and modifies the available mechanical energy into some kind of desired work. It is neither a source of energy nor a producer of work but helps in proper utilisation of the same. The motive power has to be derived from external sources.
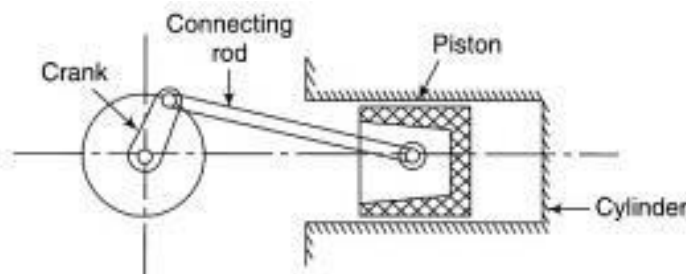
VIVA QUESTIONS

Give the examples of kinematic chain.

Difference between mechanism and machine.

What is degree of freedom?

Give some examples of lower and higher pairs.

EXPERIMENT NO. 2

Object: Study of inversions of four bar linkage.

Apparatus Used: Model of four bar, single slider crank and double slider mechanism.

Inversion of mechanism

Mechanism is a kinematic chain in which one link is fixed. By fixing the links of a kinematic chain one at a time, we get as much different mechanism as the number of links in the chain. This method of obtaining different mechanism by fixing different links of the same kinematic chain is known as INVERSION OF MECHANISM. In the process of inversion, the relative motions of the links of the mechanism produced remain constant.

TYPES OF KINEMATIC CHAIN:

The most important type of kinematic chains are those which consist of 4 lower pairs, each pair being a sliding or turning pair. The following 3 types of kinematic chains with four lower pair are important-

1.   Four bar chain
2.   Single slider crank chain
3.   Double slider crank chain

1)   FOUR BAR CHAIN:-

This is the simplest kinematic chain. It consists of four resistant bodies links which are connected in the form of a quadrilateral by 4 pin joints
It consist of four turning pairs. A link that makes complete revolution is known as crank. The fixed link is known as frame if the mechanism. The link opposite to the fixed link is known as coupler or connecting rod. The fourth link is called as lever or rocker (if it oscillates) or an another crank (if it rotates)

If different links of the four bar mechanism are fixed, four different mechanism (inversion) will be obtained.

(a)   (b)
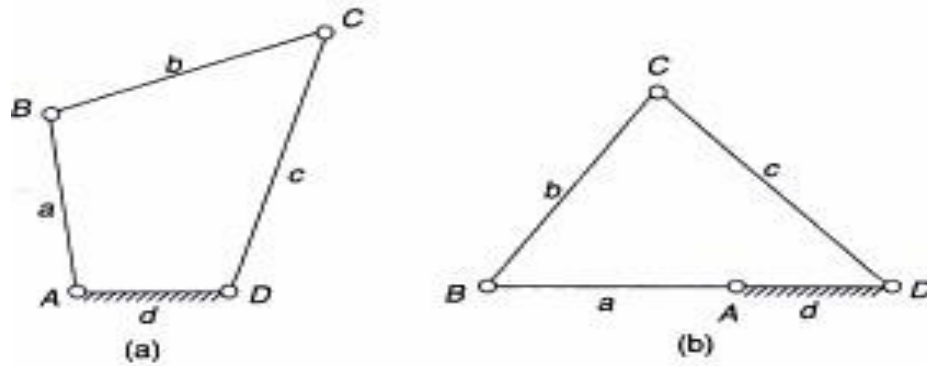
1. **First Inversions: Cranks and lever mechanism (oscillatory motion)**

The 4 links of the bar chain are 1, 2, 3 and 4.the link 1 is fixed and the lengths of the link 2,3 and 4 are proportionate in such a way that crank is able to rotate completely. Here for every complete revolution of link 2(crank), the link 4(lever) makes a complete oscillation.
Purpose of this mechanism is to convert rotary motion into oscillatory motion
Example – beam engine


Copyright 2000, Keveney.com
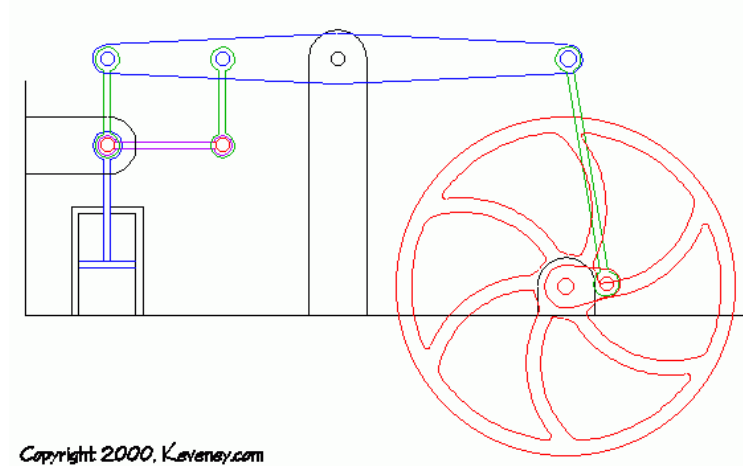
Second Inversion: Double crank mechanism (complete rotation of the crank and the follower)

The link 2 and 4 of the double crank mechanism make complete revolutions. Thereare two different forms of this mechanism.

(a)Parallel crank mechanism:
In this mechanism, the length of the fixed link is equal to the connecting rod and moreover the two cranks are of equal length. Ex- coupling rod of locomotive
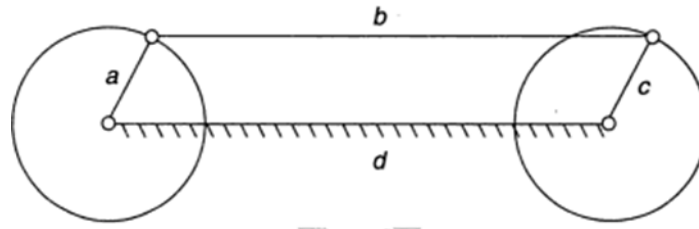
Third Inversion: Double lever mechanism

if the link opposite to shorter link fixed and the shortest link is made coupler ,the othertwo links 2and 4 would oscillate.

When the link 2 and 4 are of equal length and l3>l. This mechanism forms an automobile steering linkage. Ex-pantograph ,automobile steering.
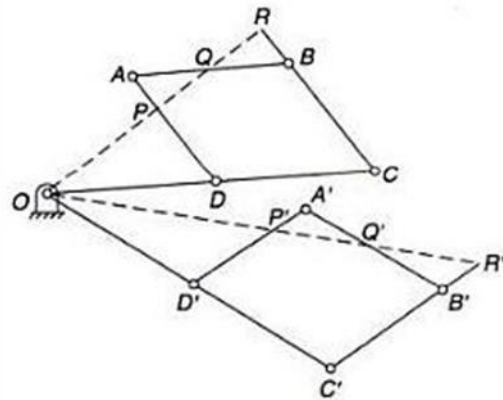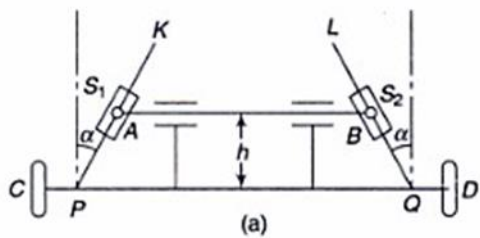

2) SLIDER CRANK MECHANISM:

It is the modification of basic 4 bar chain. It consist of four kinematic pairs out of whichone is sliding pair and three are turning pairs, link 1&2 and link 2&3 form turning pair link 3 and 4 form turning pair while link 1 and 4 forms sliding pair. Or this mechanism is formed by replacing one turning pair of 4 bar mechanism.

a) **First Inversion:**
   When link 1 is fixed link 2 is made crank and link 4 is made slider, then firstinversion of single slider crank chain is obtained.
   Ex- **Reciprocating engine, reciprocating compressor**
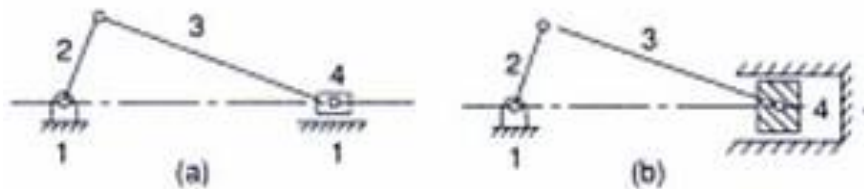
Here link 1 correspond to the frame which is fixed .link 2 correspond to the crank, link 3 correspond to the connecting rod and link 4 correspond to the slider (piston)

In reciprocating engine link 4 is the driver and link 2 is the follower and vice versareciprocating compressor.

    b) Second Inversion:

When link 2 is fixed, the second inversion is obtained of single slider crank chain, then link 3 along with the slider at its end c becomes a crank. Here link 3 along with slider (link 4) which reciprocates on link 1.

Ex whit worth quick return mechanism.

Whitworth Quick Return Mechanism:

This mechanism is used in workshop to cut metal. The forward stroke to cut the
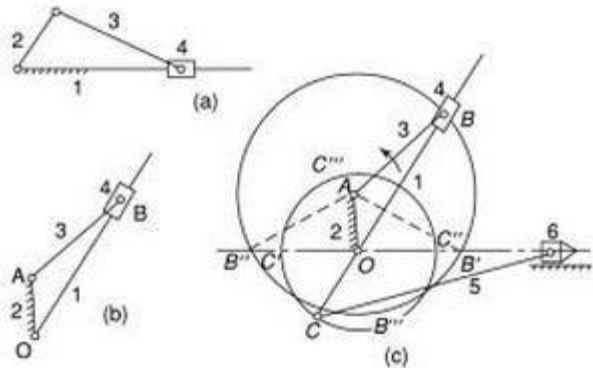
metal whereas return stroke is idle .The forward stroke takes a little longer periods whereas the return stroke takes a shorter period as shown in fig. link 2 Is fixed. The link 3 along with its slider (i.e. link 4) rotates in a circle about B. By doing so, the link 1 rotates about A along with the slider which reciprocates on link 1.On the link 1, produces downward there Is a point D ,where link 5 is connected. The other end of the link 5 is connected to the tool. The forward stroke of the tools cuts the metal whereas the return stroke is idle. The point D rotates in a circle point A.

    c) Third inversion:

When link3 is fixed, the third inversion of a single slider crank is obtained. Link 2 act as a crank rotates about point b link 4 oscillates .Ex. Quick Return Mechanism.

(a)   (b)
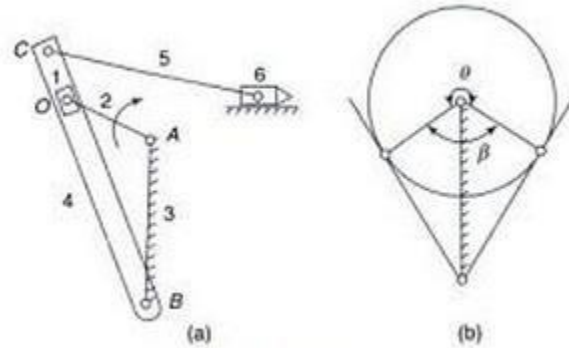
3) DOUBLE SLIDER CRANK CHAIN

A kinematic chain which consists of two turning pair and two sliding pair Is known asdouble slider crank chains. Here two pairs of same kind are adjacent.

a) First inversion

This inversion is obtained when link 1 is fixed and two adjacent pairs 2,3 and 4 areturning pairs and the other two pairs 1,2 and 4,1 hiding pairs.

Application:

Elliptical trammel-In this mechanism the fixed link 1 is in the form of guides for sliders2 and 4.With the movement of the sliders, any point c on the link 3 except the mid-point of AB will trace an ellipse on a fixed plate. The mid-point of AB will trace a circle.

(a)   (b)
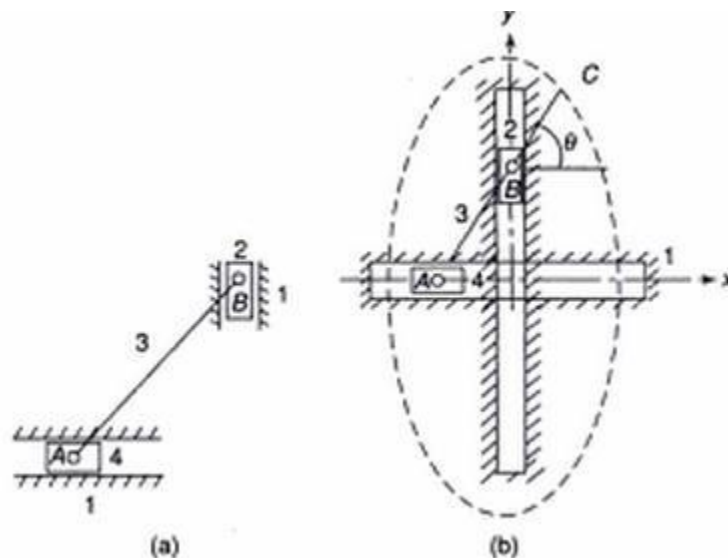
b) Second inversion

If any of the slide blocks of the first inversion is fixed ,frame is kept free.The second inversion of the double slider crank chain is obtained .When link 4 is fixed ,end B of crank 3 rotates about A and link 1 reciprocates in the horizontal direction. Application-

Scotch yoke mechanism is used to convert the rotary motion into a sliding motion. As crank 3 rotates, the horizontal portion of link 1 slides or reciprocates in the fixed link 4.
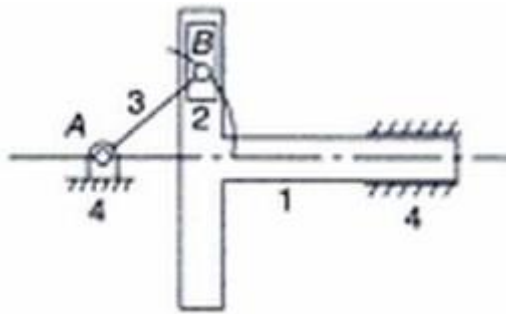
c) **Third inversion:**

This inversion is obtained when link 3 of the first inversion is fixed and link 1 is free tomove.

Application:

Oldham's coupling
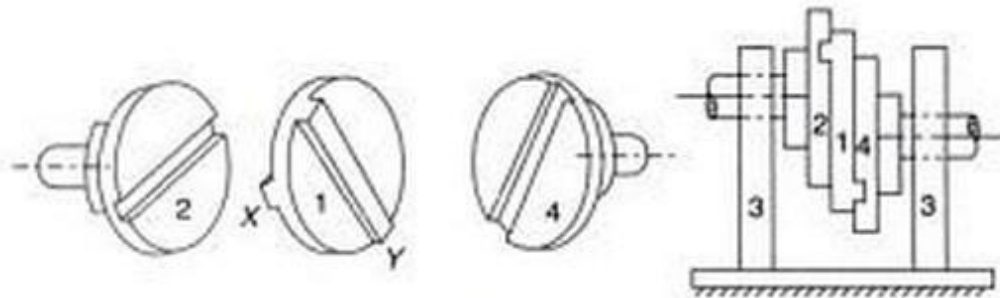
EXPERIMENT NO. 3

Object: To study the inversion of Single slider crank mechanism.

A

1

OA = 15 cm and AC =12 cm0   AB=50 cm,

B

6

0
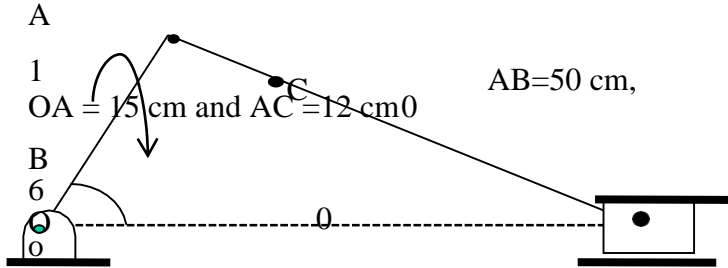
Velocity and acceleration of Point in a Mechanism:

Velocity and acceleration of various point can be determined by
1. Analytical Method
2. Relative Velocity Method
3. I-Centre Method
4. Kleins Construction

S. No.	Velocity of Piston	Acceleration of Piston	Angular Velocity of Connecting Rod	Angular Acceleration of Connecting Rod	Velocity of Point C
Analytical Method					
Relative Velocity Method					
I-Centre Method					
Kleins Construction					

EXPERIMENT NO. 4

Object:- To perform the experiment for Static/Dynamic Balancing.

Apparatus Used:- Static & Dynamic balancing machines, a set of 6 blocks of differentweights

Theory:-

Static Balancing: A system of rotating masses is said to be in static balance if the combined mass centre of the system lies on the axis of rotation. Whenever a certain mass is attached to a rotating shaft, it exerts some centrifugal force, whose effect is tobend the shaft and to produce vibrations in it.

Dynamic Balancing: When several messes rotates in different planes, the centrifugal force, in addition to being out of balance, also forms couples. A system of rotating masses is in dynamic balance when there does not exit any resultant centrifugal force aswell as resultant couple

.In order to prevent the effect of centrifugal force, another mass is attached to the opposite side of the shaft. The process of providing the second mass in order to counteract the effect of the centrifugal force of the first mass, is called balancing of rotating masses. The following cases are important from the subject point of view :
   1 Balancing of a rotating mass in the same plane.(Static Balancing)
   2 Balancing of a rotating mass in different planes. (Dynamic Balancing)

PROCEDURE:-

Static Balancing: Remove the belt, the value of weight 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 wt. for the block. For finding out Wr during static balancing proceed as follow:
  1 Remove the belt.
  2 Screw the combined hook to the pulley with groove. This pulley is diff. than the beltpulley.
  3 Attached the cord end of the pans to above combined hook.
  4 Attached 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 blocks starts moving up. (upto horizontalposition).
  6 Number of balls gives the Wr value of block-1. Repeat this for 2-3 times and find theaverage no. of balls.
  7 Repeat the procedure for other blocks.

Dynamic balancing

It is necessary to leave the machine before the experiment. Using the value of Wr, 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 calculations, 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 balls are perfectly balanced.

Observations:-

For Static Balancing

For static balancing, the Wr for unbalance are:-

BlockNo.	1	2	3	4	5	6
M.r						

For Dynamic Balancing

Consider the 4 blocks for finding the angular positions of these blocks for complete dynamic balancing, the table will be as follows:-

S.No.	Block No.	M.r (No. of Balls)	Distance (l)(cm)	Couple	Angular positions(θ)
1.					
2.					
3.					
4.					
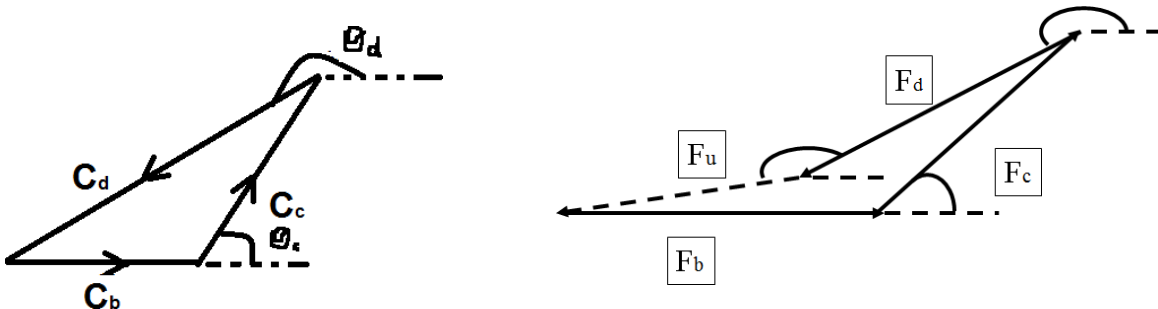
Calculation: - The balancing masses and angular positions may be determined graphically as given below:-
1. First of all, draw the couple polygon from the data which are calculated in table to some suitable scale. The vector distance represents the balanced couple. The angular position of the balancing mass is obtained by drawing, parallel to vector distance. By

measurement we will find the angle.

2. Then draw the force polygon from the data, which are calculated in table to some suitable scale. The vector distance represents the balanced force. The angular position of the mass is obtained by drawing, parallel to vector distance. By measurement we will find the angle in the anticlockwise direction from x axes.
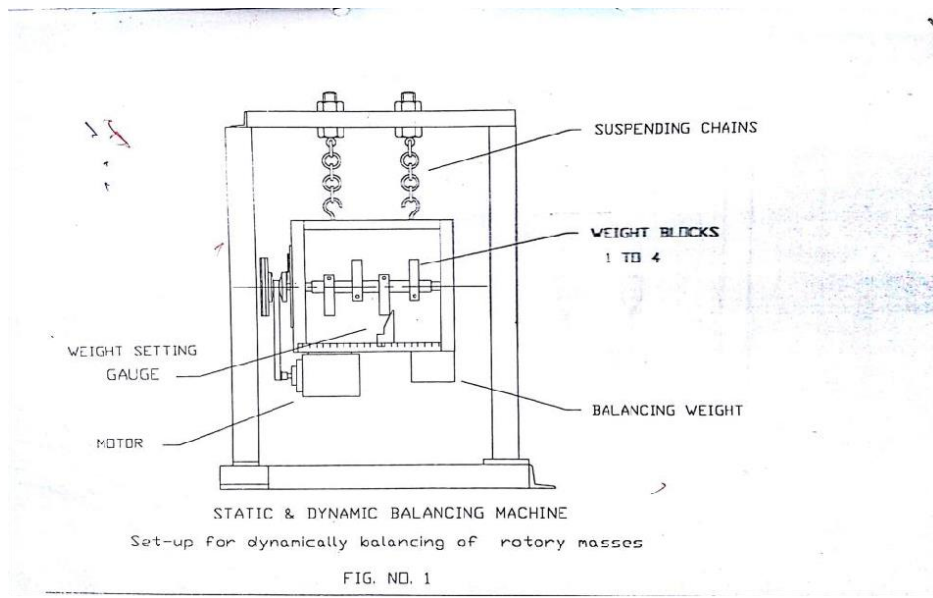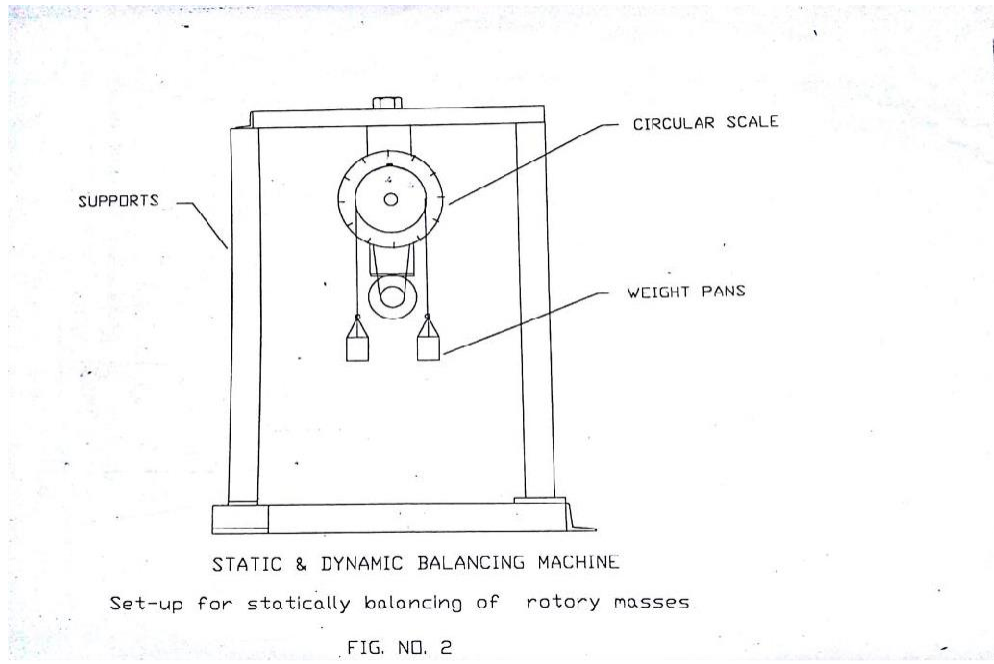
Result:-

Angular position of block are obtained from polygon and the magnitude of block U is also obtained Mr =……Adjust all angular and lateral position properly and find that the shaft rotates without vibrations.

PRECAUTIONS:-

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

4. Couple should be represented by a vector drawn perpendicular to the plane of the couple.
5. Angular position measure carefully in clockwise direction.
6. Vector diagram should be representing with suitable scale.

.
VIVA QUESTIONS:

1.   Why is balancing of rotating parts necessary for high speed engines?
2.   Explain the terms 'static balancing' and 'dynamic balancing'. State the necessary conditions to achieve them.
3.   Discuss how a single revolving mass is balanced by two masses revolving in different planes.
4.   How the different masses rotating in different planes are balanced?
5.   Explain the method of balancing of different masses revolving in the same plane.
6.   Why is balancing of rotating parts necessary for high speed engines?
7.   Explain the terms 'static balancing' and 'dynamic balancing'. State the necessary conditions to achieve them.
8.   Discuss how a single revolving mass is balanced by two masses revolving in different planes.
9.   How the different masses rotating in different planes are balanced?
10. Explain the method of balancing of different masses revolving in the same plane.

STATIC & DYNAMIC BALANCING MACHINE
Set-up for statically balancing of rotary masses
FIG. NO. 2

STATIC & DYNAMIC BALANCING MACHINE
Set-up for dynamically balancing of rotary masses
FIG. NO. 1

EXPERIMENT NO. 5

Object: To perform experiment on dead weight type governor to prepare characteristic curves, and to find stability and sensitivity.

Apparatus used: - Porter Governors.

(a) REST   (b) RUNNING

Introduction & theory:-The function of a governor is to regulate the mean speed of an engine, when there are variations in the load e.g. when the load on an engine increases, its speed decreases, therefore it becomes necessary to increase the supply of working fluid. When the load on the engine decreases, its speed increases and thus less working fluid is required. The governor automatically controls the supply of working fluid to the engine with the varying load conditions and keeps the mean speed within certain limits.
The governors may, broadly, be classified as
   1. Centrifugal governor
   2. Inertia governor
The centrifugal governors, may further be classified as follows:

   (1) **Dead weight**: Watt, Porter governor and Proell governor
   (2) **Spring controlled governors**: Hartnell governor, Hartung governor, Wilson-Hartnellgovernor and Pickering governor

1. **Watt Governor:-**The simplest form of a centrifugal governor is a Watt governor. It is basically a conical pendulum with links attached to a sleeve of negligible mass. The arms of the governor may be connected to the spindle in the following three ways:
   1. The pivot P, may be on the spindle axis.
   2. The pivot P, may be offset from the spindle axis and the arms when producedintersect at O.

3. The pivot P, may be offset, but the arms crosses the axis at O.
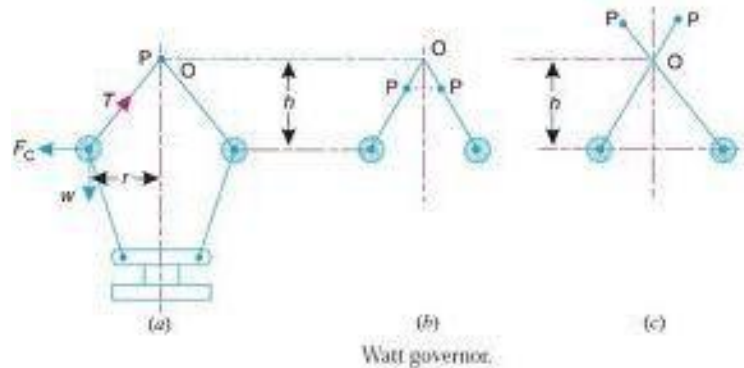
Watt governor.

2. **Porter Governor: -** The porter governor is a modification of a Watt's governor, with central load attached to the sleeve. The load moves up down the central spindle. This additional downward force increases the speed of revolution required to enable the balls to rise to any to any pre-determined level.

3. **Proell Governor: -** It is a modification of a Porter governor, in which balls are mounted on the extension of lower arms. Under normal conditions extension of lower arms remains vertical however it changes position with variation in speed. This governor is more sensitive than porter governor.

Calculations:-   Radius of rotation r can be calculated as follows:
a) Find height h = (ho-x/2)
b) Find α by using Cos α = h/L
c) Then r = 50 + L Sin α

N^2 = 895/h (For watt governor)

Force can be calculated as follows: a) Find the angular velocity ω of the spindle By 2π N/ 60
Where N is the speed of spindle.

b) Find the centrifugal force acting
on the ball Force F = m ω^2r
For Hartnell Governor

Radius of rotation r = ro + x.a/b
Where a, b are length pof bell crank lever

$N^2 = \dfrac{m + M (1+q)/2}{m\ h} \times 895$ (For porter governor), where, q = tan β/ tan α

Observation:- For watt and porter governor
Mass of the ball (m) =
o.6 kg. Length of each
link (L) = 125 mm
Initial height of the governor
(ho) = 94mm. Initial radius of
rotation (ro)= 136 mm Weight
of sleeve(M) = 0.6 kg

For Watt Governor

S. No.	Sleeve displacement(X) ,mm	Avg. Speed(RPM)	Height(h)	Cos α	r = 50 + L Sin α	Force F
1	10					
2	20					
3	30					
4	40					
5	50					

For Porter Governor
a) Weight of Sleeve= 0.5 kg

S. No.	Sleeve displacement(X) ,mm	Avg. Speed(RPM)	Height(h)	Cos α	r = 50 + L Sin α	Force F
1	10					
2	20					
3	30					
4	40					
5	50					

a) Weight of Sleeve= 1 kg

S. No.	Sleeve displacement(X) ,mm	Avg. Speed(RPM)	Height(h)	Cos α	r = 50 + L Sin α	Force F
1	10					
2	20					
3	30					
4	40					
5	50					

a) Weight of Sleeve= 1.5 kg

S. No.	Sleeve displacement(X) ,mm	Avg. Speed(RPM)	Height(h)	Cos α	r = 50 + L Sin α	Force F
1	10					
2	20					
3	30					
4	40					
5	50					

Performance Characteristic Curve: speed vs height of governor
Force vs radius of rotation

Precautions :-

- DO NOT KEEP THE MAINS ON when trial is complete
- increase the speed gradually.
- take the sleeve displacement reading when the pointer remain steady.
- see that at higher speed the load on sleeve does not hit the upper sleeve of the governor .
- while closing the test bring the dimmer to zero position and then switch OFF

VIVA – QUESTIONS:

1. What is the function of a governor ?
2. How does it differ from that of a flywheel?
3. State the different types of governors.
4. What is the difference between centrifugal and inertia type governors?
5. Explain the term height of the governor.
6. What are the limitations of a Watt governor?
7. What is the stability of a governor?
8. Define the Sensitiveness of governor.
9. Which of the governor is used to drive a gramophone?
10. The power of a governor is equal to -------------- --.
11. What is hunt?

WATT-WITHOUT WEIGHT

PORTER-WITH WEIGHT

Watt Governor

Porter Governor

Proell Governor
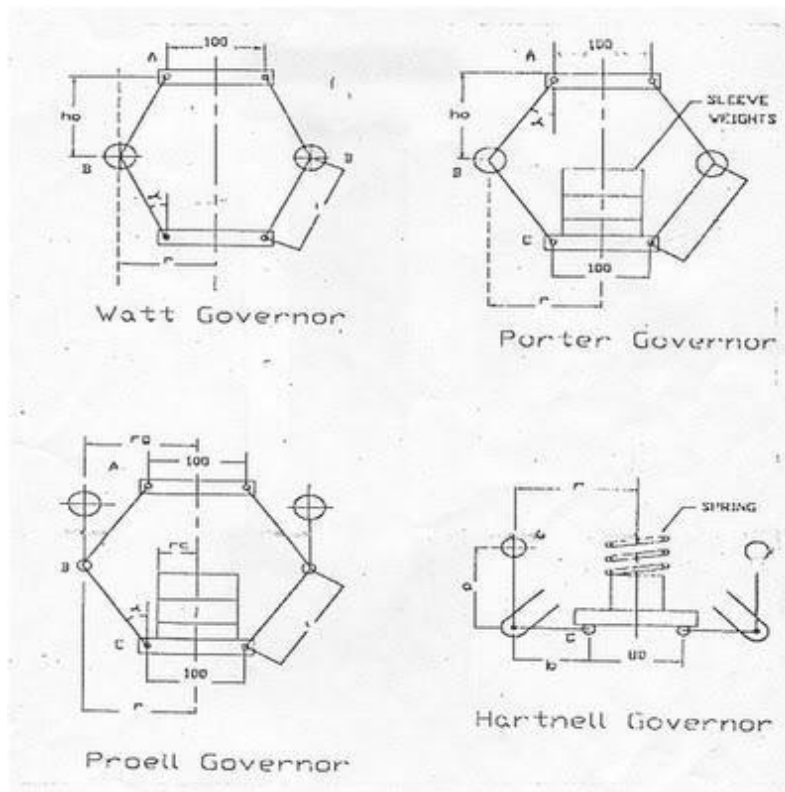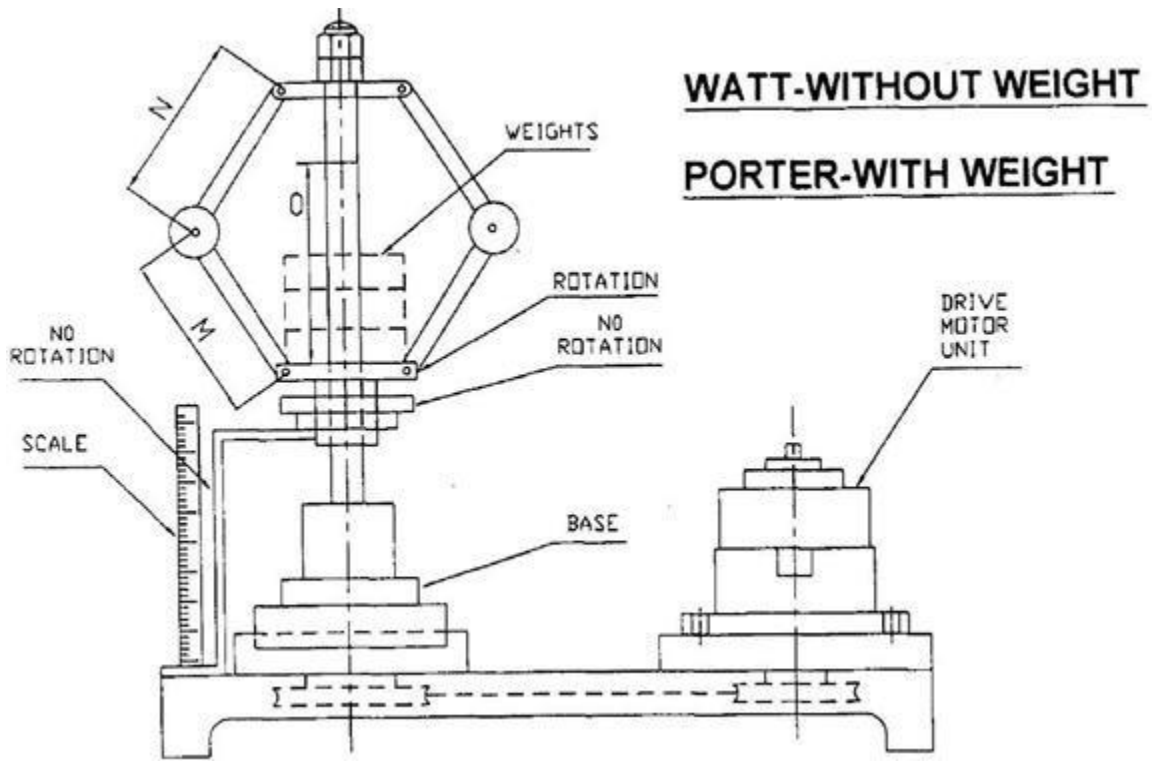
Hartnell Governor

EXPERIMENT NO. 6

Object: - To perform experiment on dead weight type governor to prepare characteristic curves, and to find stability and sensitivity.

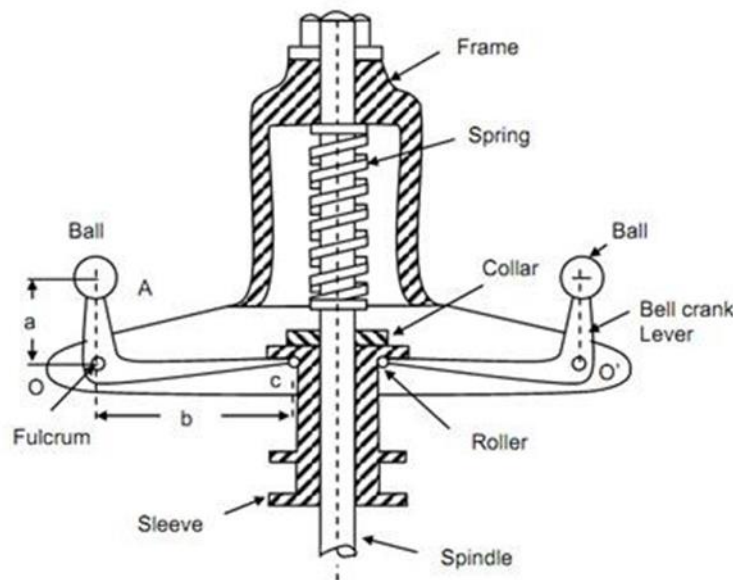**Apparatus used: - H**artnell governor.

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

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

The centrifugal governors may further be classified as follows:

(1) **Dead weight**: Watt, Porter governor and Proell governor
(2) **Spring controlled governors**: Hartnell governor, Hartung governor, Wilson-Hartnellgovernor and Pickering governor

Hartnell Governor :-A Hartnell governor is a spring loaded governor as shown in fig.-. It consists of two bell crank levers pivoted at the points A and D to the frame. The frame is attached to the governor spindle and therefore rotates with it. Each lever carries a ball at the end of the vertical arm and a roller at the end of the horizontal arm. A helical spring in compression provides equal downward forces on

the two rollers through a collar on the sleeve. The spring force be adjusted by screwing at nut up or down on the sleeve.

$$\therefore \qquad (F_C)_2 - (F_C)_1 = \left(\frac{b}{a}\right)^2 \frac{(r_2 - r_1)}{2} s$$

or stiffness of spring 's' $= 2\left(\frac{a}{b}\right)^2 \frac{(F_C)_2 - (F_C)_1}{(r_2 - r_1)}$

For ball radius 'r'

$$s = 2\left(\frac{a}{b}\right)^2 \frac{F_C - (F_C)_1}{r - r_1} = 2\left(\frac{a}{b}\right)^2 \left\{\frac{(F_C)_2 - (F_C)_1}{(r_2 - r_1)}\right\}$$

$$F_C = (F_C)_1 + \frac{(r - r_1)}{(r_2 - r_1)} \{(F_C)_2 - (F_C)_1\}$$

Calculation:-

For Hartnell Governor

Radius of rotation r = ro + x.a/b
Where a, b are length pof bell crank lever

Observation:-
Mass of the each ball (m) = 0.6 kg. Length of vertical arm (a) = 77 mm Length of vertical arm (b) = 122 mm Initial radius of rotation (ro) = 177.5 mm Weight of sleeve (M) = 0.6 kg
Free Height of spring =102 mm, Spring stiffnes s = 5 and 10 kg/cm Initial compression of spring =..

S. No.	Sleeve displacement(X) ,mm	Avg. Speed(RPM)	Radius of rotation r = ro + x.a/b	Force F = $m\omega^2.r$
1	5			
2	10			
3	15			
4	20			
5	25			

Performance Characteristic Curve: speed vs height of governor
Force vs radius of rotation

Precautions:-

- DO NOT KEEP THE MAINS ON when trial is complete
- Increase the speed gradually.
- Take the sleeve displacement reading when the pointer remain steady.
- See that at higher speed the load on sleeve does not hit the upper sleeve of the governor.
- While closing the test bring the dimmer to zero position and then switch OFF the hartnell governor

VIVA – QUESTIONS:

1. What is the function of a governor ?
2. How does it differ from that of a flywheel?
3. State the different types of governors.
4. What is the difference between centrifugal and inertia type governors?
5. Explain the term height of the governor.
6. What are the limitations of a Watt governor?
7. What is the stability of a governor?
8. Define the Sensitiveness of governor.
9. Which of the governor is used to drive a gramophone?10.
10. The power of a governor is equal to⸺⸺⸺⸺
11. What is hunting?

EXPERIMENT NO. 7

Object: To study the gyroscopic effects through model.

Apparatus:

The motorized gyroscope with freedom of rotation about three perpendicular axis. Angular scale and pointer fitted to frame helps to measure precession rate. In steady position, frame no.1 is balanced by providing a weight pan on the opposite side of the motor.

Theory:

The credit of the mathematical foundation of the principles of gyroscopic motion goes to Euler who derived a set of dynamic equation related to applied mechanics between moment inertia, angular acceleration and angular velocity in many machines. The rotary components are forced to turn about their axis other than their own axis of rotation and gyroscopic effects are thus setup. The gyroscopes are used in ships to minimize the rolling & pitching effects of water.

Gyroscope:

Gyroscope is a body while spinning about an axis is free to rotate in other directions under the action of external forces. For example locomotive, automobile and aero plane making a turn. In certain cases the gyroscopic effect may be utilized in developing desirable forces. Balloons use Gyroscope for controlling direction.

Let, ω is the angular velocity of disk about OX,
$d\Theta/dt = \omega p$, the angular velocity of the precession of yoke, which is uniform and is about axis OZ
Thus, we get Gyroscopic couple (C) = Iω.ωp

The direction of the *couple applied* on the body is anticlockwise when looking in the direction YY' and in the limit this is perpendicular to the axis of ω and ωp.
In the supplied apparatus, the reaction couple exerted by the body on its frame is *equal*
in magnitude to that, but *opposite* in the direction.

Observation:

Weight of rotor, kg   :

Rotor diameter, mm   :
Rotor thickness, mm   :
Moment of inertia of
disc, coupling and motor rotor about the central axis, I, kg cm sec
Distance of the bolt of :
Weight pan from disc centre, L, cm

S.No.	Weight,W (kg)	Time required for precession, (sec)	Speed, N(rpm)	Angle of precession, dΘ (degree)	Gyroscopic Couple(C)	
1						
2						
3						

Critical data of experiment

Weight of rotor, kg   :   6.7
Rotor diameter, mm   :   300
Rotor thickness, mm   :   10.0
Moment of inertia of   :   m X r^2

Disc, coupling and motor rotor about the central axis,

I, kg cm^2 Distance of the bolt of :   19.0
Weight pan from disc centre, L, cm

Motor: Fractional H.P. single phase. 6000 rpm-AC/DC Type
Autotransformer provided for speed regulation.

Sample Experimental data

S.No.	Weight, W(kg)	Time requiredfor precession, dt (sec)	Speed, N (rpm)	Angle of precession, dΘ (degree)
1.	0.5	14	1730	45

APPENDIX-3:Data Analysis Angular velocity

of disc in rad/sec

$$\omega = \frac{2\pi \times 1730}{60}$$

$= 181.17$ rad/sec

Angular velocity of precession of yoke in ωp rad/sec

$$\omega p = \frac{d\theta}{dt}$$

Where dΘ is in radian $= 45 \times \pi/180$

$= 0.785$ rad

$\omega p = 0.785/14$

$= 0.0561$ rad/sec

Experimental justification of the equation:$C = I\omega.\omega p$

Cactual $=$ W x L

$$\% \text{ error} = \frac{\text{Cactual} - \text{C}}{\text{C}} \times 100\%$$

1. ωp is to be calculate 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 ωp goeson 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.

FRONT VIEW OF GYROSCOPE
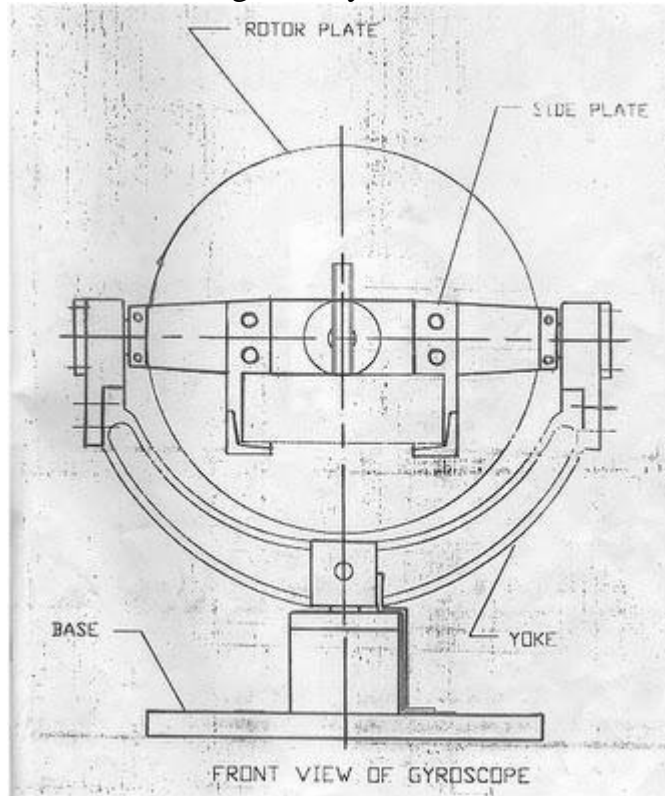
VIVA – QUESTIONS:

1. Write a short note on gyroscope.
2. What do you understand by gyroscopic couple? Derive a formula for its magnitude.
3. Explain the application of gyroscopic principles to aircrafts.
4. Discuss the effect of the gyroscopic couple on a two wheeled vehicle when taking aturn.
5. When the pitching of a ship is upward, the effect of gyroscopic couple acting on itwill be to move the ship towards port side or to move the ship towards star-board.

EXPERIMENT NO. 8

Object: To determine the whirling speed of shaft theoretically and experimentally.

Apparatus: Tachometer, shaft, End fixing arrangement etc.

Theory: This apparatus is developed for the demonstration of a whirling phenomenon.The shaft can be tested for different end conditions. The apparatus consists of a frame tosupport its driving motor, end fixing and sliding blocks etc. A special design is providedto clear out the testing of bearing of motor spindle from these testing shafts. The specialdesign features of this equipment are as follow:

a. Coupling
A flexible shaft is used to drive the test shaft from motor.

b. Ball bearing fixing ends.
The end fixes the shaft while it rotates. This can be replaced within a short time with the help of this unit. The fixing ends provide change of end fixing condition of the rotatingshaft as per the requirement.

Shaft supplied with the equipment
Polished steel shaft is supplied with the machine. The dimensions being as under:

Shaft no.	Diameter (approx)	Length(approx)
1.	4.0 mm	900 mm
2.	4.7 mm	900 mm

End fixing arrangement

At motor end as well as tail end different end conditions can be developed by making use of different fixing blocks.

1. Supported end conditions - make use of end block with single self-aligning bearings.
2. Fixed end condition - make use of end block with double bearing.

Guard's d1 and d2 and d3:
The guard's d1, d2 and d3 can be fixed at any position on the supporting bar frame which fits on side supports. Rotating shafts are to be fitted in blocks in a and b stands.

Speed control of driving motor:
The driving motor is 230v, dc 1/6 hp, 3000 rpm, universal motor and speed control unit is a dimmer state of 240v, 2 amps, 50 c/s.

Measurement of speed:
To measure the speed of the rotating shaft a simple tachometer may be used on the opposite side of the shaft extension of the motor

Whirling of Elastic Shaft:

if L = length of the shaft in cm.
E = young's module kg/cm^2 =
2.060 x 10^6 I = 2nd moment of
inertia of the shaft cm^4
w = weight of the shaft per unit length
kg/cm. g = acceleration due to gravity of
cm/sec^2 = 981

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

equation:$f = k \times \sqrt{(EIG/wL^4)}$

End condition	value of k	
	1st mode	2nd mode
fixed , supported fixed , fixed	1.47 1.57	2.56 2.46

Data:

shaft dia	$i = cm^4$	w = kg/cm
4.0 mm 4.7 mm	x 10^{-4} x 10^{-4}	0.15 x 10^{-2} 0.19 x 10^{-2}

Calculations:

a) Both ends of shafts free (supported) 1st and 2nd mode of vibration can be observed ofshafts with both rods.

b) One end of shaft fixed and the other free; 1st and 2nd mode of vibration can be observedon shaft with 4.0 mm rod.

c) Both ends of shaft fixed- 2nd mode of vibration cannot be observed on any of the shafts asthe speeds are very high and hence beyond the range of the apparatus.

Fixed – fixed
Diameter of rod = 0.4 cm
Weight = 150 grams =0.0015
kg/cmYoung modulus e =
2.06 x 10^6

S.No.	Speed rpm 1stmode	value of k	i=$(\pi d^4)/64$	weight in kg/cm	fth = $\sqrt{(EIG/wL^4)}$	fact = rpm/time
1						
2						

Diameter of rod = 0.47 cm
Weight = 190 gram =
kg/cm = 0.0019 Young
modulus e = 2.06 x 10^6

S.no.	Speed rpm 2nd mode	Value of k	I=$(\pi d^4)/64$	weight in kg/cm	Fth = $\sqrt{(EIG/wL^4)}$	fact = rpm/time
1						
2						

Supported – fixed
Diameter of rod = 0.4 cm
Weight = 150 gram =
kg/cm = 0.0015 Young
modulus e = 2.06 x 10^6

S.no.	Speed rpm 1st mode	Value of k	I=$(\pi d^4)/64$	weight in kg/cm	Fth = $\sqrt{(EIG/wL^4)}$	fact = rpm/time
1						
2						

Diameter of brass rod = 0.47 cm
Weight = 190 gram =
kg/cm = 0.0019 Young
modulus e = 2.06 x 10^6

S.no.	Speed rpm 2nd mode	Value of k	I=$(\pi d^4)/64$	weight in kg/cm	Fth = $\sqrt{(EIG/wL^4)}$	fact = rpm/time
1						
2						

Result : % Error

Preacautions:

WHIRLING OF SHAFT APPARATUS

F – Side supports   D – Guards
G – Bushes of the shaft ends   AB – Stand for fixing
C – Flexible shaft   M – Motor side free block
MN-Ball bearing shaft   N – Tail side free block
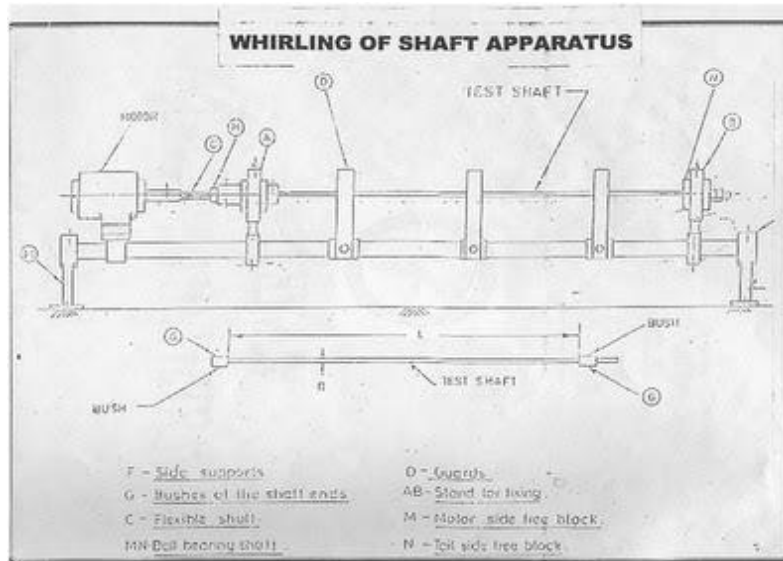
EXPERIMENT 9

Object: -To perform experiment on brake.

Theory

It goes without saying that brakes are one of the most important control components of vehicle. They are required to stop the vehicle within the smallest possible distance and this is done by converting the kinetic energy of the vehicle into the heat energy which is dissipated into the atmosphere.

Braking requirements:

1 The brakes must be strong enough to stop the vehicle within a minimum distance inan emergency. But this should also be consistent with safety. The driver must haveproper control over the vehicle during emergency braking and the vehicle must not skid.2 The brakes must have well anti fade characteristics i.e. their effectiveness should notdecrease with   constant   prolonged   application   e.g.   whi
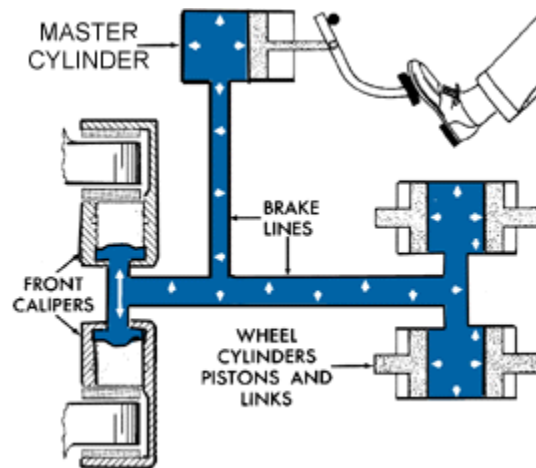
Types of Brakes:

A) Hydraulic and pneumatic brake systems
B) Drum brake system
C) Disc brake system

Hydraulic brakes

Most of the cars today use hydraulically operated foot brakes on all the four wheels with an additional hand brake mechanically operated on the rear wheels. An outline of the hydraulic braking system is shown in fig. The main component in this is the master cylinder which contains reservoir for the brake fluid. Master cylinder is operated by the brake pedal and is further connected to the wheel cylinders in each wheel through steel pipe lines, unions and flexible hoses. In case of hindustan ambassador car, on front wheels each brake shoe is operated by separate wheel cylinder (thus making the brake two shoe leading) whereas in case of rear wheels there is only one cylinder on each wheel which operates both the shoes (thus giving one leading and one training shoe brakes.) As the rear wheel cylinders are also operated mechanically with the hand brake, they are made floating. Further, all the shoes in the ambassador car are of the floating anchor type.
The system is so designed that even when the brakes are in the released position, a small pressure of about 50 kpa is maintained in the pipe lines to ensure that the cups of the wheel cylinder are kept expanded. This prevents the air from entering the wheel cylinders when the brakes are released. Besides, this pressure also serves the following purposes.
(i) It keeps the free travel of the pedal minimum by opposing the brake shoe retraction
    springs.
(ii) During bleeding, it does not allow the fluid pumped into the line to return, thus
    quickly purging air from the system.

Drum brakes

In this type of brakes, a brake drum is attached concentric to the axle hub whereas on the axle casing is mounted a back plate. In case of front axle, the back plate is bolted to the steering knuckle. The back plate is made of pressed steel sheet and is ribed to increase rigidity and to provide support for the expander, anchor and brake shoes. It also protects the drum and shoe assembly from mud and dust. Moreover, it absorbs the complete torque reaction of the shoes due to which reason it is sometimes also called torque plate. Two brake shoes are anchored on the back plate as shown in fig. Friction linings are mounted on the brake shoes. One or two retractor springs are used which serve to keep the brake shoes away from the drum when the brakes are
Not applied. The brake shoes are anchored at one end, whereas on the other ends force f is applied by means of some brake actuating mechanism which forces the brake shoe against the revolving drum, thereby applying the brakes. An adjuster is also provided to compensate for wear of friction lining with use. The relative braking torque obtained at the shoes for the same force applied at the pedal varies depending upon whether the expander (cam or toggle lever) is fixed to the back plate or it is floating, whether the anchor is fixed or floating and whether the shoes are leading or trailing.
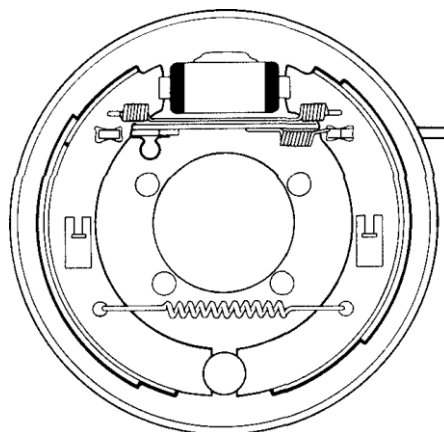
Disc brakes
As shown in fig. a disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle, like the axle casing or the sub axle and is cast in

two parts, each part containing a piston. In between each piston and disc, there is friction pad held in position by retaining pins, spring plates etc. Passages are drilled in the caliper for the fluid to enter or leave each housing. These passages are also connected to another one for bleeding. Each cylinder and contains a rubber sealing ring between the cylinder and the piston.

When the brakes are applied, hydraulically actuated pistons move the friction pads into contact with the disc, applying equal and opposite forces on the later. On releasing the brakes, the rubber sealing rings act as return springs and retract the pistons and the friction pads away from the disc.

For a brake of this type $T = 2\mu par$ Where μ = coefficient of friction

P = fluid pressure

A = cross sectional area of one piston

R = distance of the longitudinal axis of the piston from the wheel axis
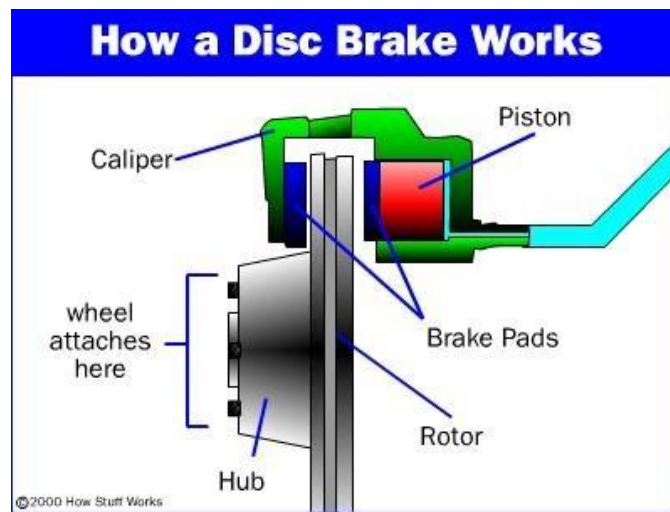
Brake system for maruti (suzuki) 800 car

The front wheel brakes are of the disc type, whereas for rear wheels drum type brakes (leading trailing shoes) are employed. Parking brake is mechanically operated by a wire and link system and works on the rear wheels only. Same brake shoes are used for service and parking brakes. The layout of the system is shown in fig.

A tandem master cylinder is employed. The hydraulic pressure produced there is applied to two independent circuits. One circuit is for front left and rear right brakes, whereas the other is for front right and rear left brakes. Due to this reason, the braking system in the maruti has greater safety because even if a pressure leak occurs in the brake line of one circuit, the other braking circuit works, due to which a certain degree of braking is still available to the vehicle.
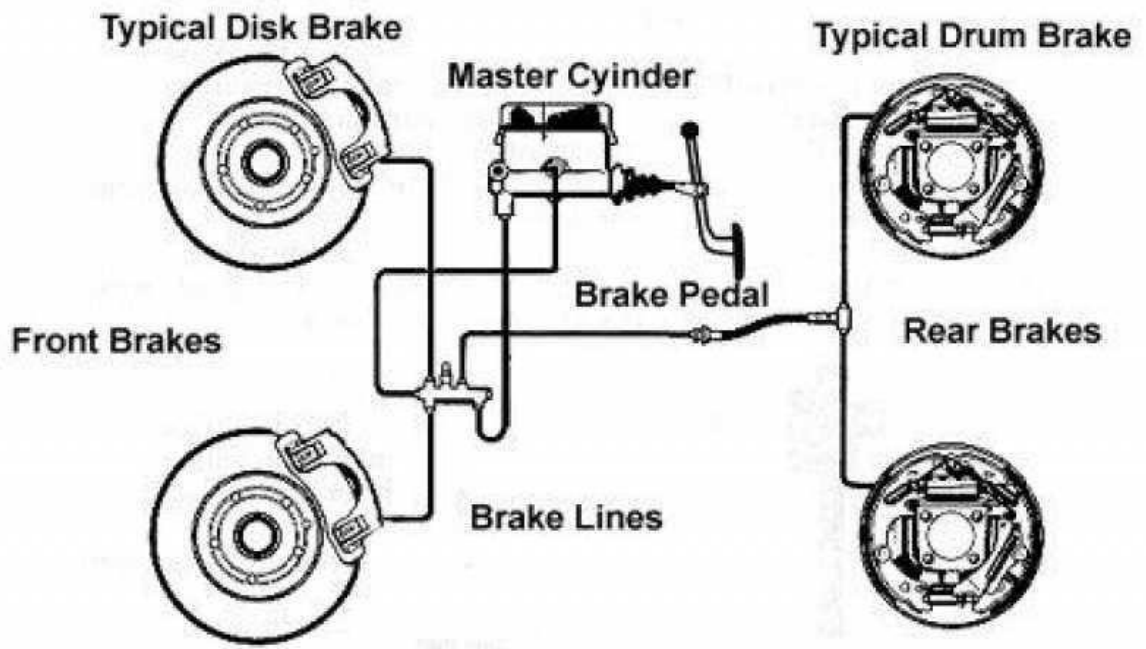
Typical Automotive Braking System

Mr. Vishnu Kuntal　　　　　　　　　**Dr. Shailesh Kumar Singh**

Lab IN-charge　　　　　　　　　　　**Head of Department (ME)**

Prof. (Dr.) Seema Shukla

Director