17BEME405 **KINEMATICS OF MACHINERY** 3 1 0 3 100

OBJECTIVES

1. To understand the basic components and layout of linkages in the assembly of a system / machine.
2. To understand the principles in analyzing the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism.
3. To understand the motion resulting from a specified set of linkages, design few linkage mechanisms and cam mechanisms for specified output motions.
4. To understand the basic concepts of toothed gearing and kinematics of gear trains and the effects of friction in motion transmission and in machine components.

INTENDED OUTCOME

1. Upon completion of this course, the students can able to apply fundamentals of mechanism for the design of new mechanisms and analyse them for optimum design.

UNIT I BASICS OF MECHANISMS 12

Terminology and Definitions–Degree of Freedom – Mobility–Kutzbach criterion–Grashoff's law–Kinematic Inversions of four bar chain and slider crank –Mechanical Advantage–Transmission angle —Single, double and offset slider mechanisms – Quick return mechanisms – Ratchets and escapements – Indexing Mechanisms – Straight line generators.

UNIT II KINEMATICS 12

Displacement, velocity and acceleration – analysis in simple mechanisms – Graphical Method –velocity and acceleration polygons – Kinematic analysis by Complex Algebra methods–Vector Approach, Instantaneous center – Coriolis Acceleration.

UNIT III KINEMATICS OF CAM 12

Classifications – Displacement diagrams–parabolic, Simple harmonic and Cycloidal motions – Layout of plate cam profiles – Derivatives of Follower motion – High speed cams – circular arc and tangent cams – Standard cam motion – Pressure angle and undercutting.

UNIT IV GEARS AND GEAR TRAINS 12

Spur gear - Terminology and definitions–Fundamental Law of toothed gearing and involute gearing–Interchangeable gears–gear tooth action – Terminology – Interference and undercutting–Non standard gear teeth– Helical, Bevel, Worm, Rack and Pinion gears (Basics only)–Gear trains–Parallel axis gear trains–Epicyclic gear trains.

UNIT V FRICTION IN DRIVES 12

Surface contacts–Sliding and Rolling friction – Friction drives – Friction in screw threads – Friction clutches – Belt and rope drives, Friction aspects in Brakes.

TOTAL 60

TEXT BOOKS

S. No.	Author(s) Name	Title of the book	Publisher	Year of Publication
1	Rattan S.S	Theory of Machines, 4e	Tata McGraw–Hill Publishing Company Ltd., New Delhi	2014
2	Shigley J.E, Uicker J.J	Theory of Machines and Mechanisms, 10e	McGraw–Hill, New York	2014

REFERENCES

S. No.	Author(s) Name	Title of the book	Publisher	Year of Publication
1	Thomas Bevan	Theory of Machines	CBS Publishers and Distributors, New Delhi	2011
2	Asok Kumar Mallik, Amitabha Ghosh	Theory of Mechanisms and Machines, 3e	Affiliated East–West Pvt. Ltd., New Delhi	2006
3	Rao J.S, Dukkipati R.V	Mechanism and Machine Theory	New Age International Ltd. publishers	2006

STANDARDS

IS 2458 : 2001, Vocabulary of Gear Terms – Definitions Related to Geometry
IS 3756 : 2002, Method of Gear correction – Addendum modification for External Cylindrical Gears with Parallel Axes.
IS 5267 : 2002 Vocabulary of Gear Terms – Definitions Related to Worm Gear Geometry.
IS 12328 : Part 1 : 1988 Bevel Gear Systems Part – 1 Straight Bevel Gears.
IS 12328 : Part 2 : 1988 Bevel Gear Systems Part – 2 Spiral Bevel Gears

KARPAGAM
ACADEMY OF HIGHER EDUCATION
(Deemed to be University)
(Established Under Section 3 of UGC Act, 1956)

KARPAGAM ACADEMY OF HIGHER EDUCATION

COIMBATORE – 21

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

LESSON PLAN

Subject Name	**: Kinematics Of Machinery**
Subject Code	**: 17BEME405 (Credits3)**
Name of the Faculty	**: Mr.M.Prakash**
Designation	**: Assistant Professor**
Year/Semester/Section	**: III / V /**
Branch	**: B.E. – Mechanical Engineering**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
		UNIT – I :Basics of Mechanism	
1.	1	Terminology and Definition	**T(1)**
2.	1	Degree of Freedom -Mobility-Kutzbach criterian-Grashoffs law	**T(1)**
3.	1	Kinematic Inversion of four bar chain	**T(1)**
4.	1	Slider Crank	**T(1)**
5.	1	Mechanical Advantage-Transmission Angle	**T(1)**
6.	1	Single,double and offset slider mechanism	**T(1)**
7.	1	Quick return mechanism	**T(1)**
8.	1	Ratchets and escapements	**T(1)**
9.	1	Indexing Mechanism	**T(1)**
10.	1	Straight line generators	**T(1)**
		Total No. of Periods Planned for Unit - I	**10**

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
		UNIT – II : Kinematics	
11.	1	Dispacement	**T(1) R(2)**
12.	1	Velocity	**T(1) R(2)**
13.	1	Acceleration	**T(1) R(2)**
14.	1	Analysis in simple Mechanism	**T(1) R(3)**
15.	1	Graphical Method	**T(1) R(3)**
16.	1	Velocity Polygons	**T(1) R(3)**
17.	1	Acceleration Polygons	**T(1) R(3)**
18.	1	Kinematic Analysis by Complex Algebra Method	**T(1) R(3)**
19.	1	Vector Approach-Instentaneous Center-coriolis	**T(1) R(3)**
20.	1	Acceleration	**T(1) R(3)**

Total No. of Periods Planned for Unit - II	10

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – III : Kinematics Of CAM			
21.	1	Classification-Dispacement diagrams	T(1)
22.	1	Parabolic,simpleharmonic and cycloidal motion	T(1)
23.	1	Layout of Plate cam profiles	T(1)
24.	1	Derivatives of follower motion	T(1)
25.	1	High speed cams	T(1)
26.	1	Circular arc cams	T(1) R(1)
27.	1	Tangent cams	T(1) R(1)
28.	1	Standard cam motion	T(1)
29.	1	Pressure angle	T(1)
30.	1	undercutting	T(1)
Total No. of Periods Planned for Unit - III			10

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – IV : Gears And Gear Trains			
31.	1	Spur Gear-Terminology And Definition	T(1)
32.	1	Fundamental law of toothed gearing	T(1)
33.	1	Involute gearing	T(1)
34.	1	Interchangeable gears	T(1)
35.	1	Gear tooth action-Terminology	T(1)
36.	1	Interference and Undercutting	T(1)
37.	1	Non standard gear tooth	T(1)
38.	1	Helical,bevel,worm,rack and pinion gears	T(1)
39.	1	Gear trains	T(1)
40.	1	Parallel axis gear train -Epicyclic gear train	T(1)
Total No. of Periods Planned for Unit - IV			10

Sl. No.	No. of Periods	Topics to be Covered	Support Materials
UNIT – V : Friction in Drives			
41.	1	Surface contacts	R(1) R(3)
42.	1	Sliding friction	R(1) R(3)
43.	1	Rolling friction	R(1) R(3)
44.	1	Friction Drives	R(1) R(3)
45.	1	Friction in screw threads	R(1) R(3)
46.	1	Friction clutches	R(1) R(3)
47.	1	Belt drives	R(1) R(3)
48.	1	Belt drives	R(1) R(3)

49.	1	Rope drives	**R(1) R(3)**
50.	1	Friction aspects in brakes	**R(1) R(3)**
51.	2	**Discussion on Competitive Examination related Questions / University previous year questions**	**GATE, ESE QP**
Total No. of Periods Planned for Unit - V			**12**

TOTAL PERIODS : 52

TEXT BOOKS

S. No.	Author(s) Name	Title of the book	Publisher	Year of Publication
1	Rattan ss	Theory of machine	Tata MC Graw Hill publishing company ltd New Delhi	2014

REFERENCES

S. No.	Author(s) Name	Title of the book	Publisher	Year of Publication
1.	Rao	Mechanism and Machine theory	New age international Ltd publishers	2006
2.	Ghosh	Theory of Mechanisms and machines	East est pvt ltd new delhi	2006
3.	Thomson Bevan	Theory Of Machines	CBS PUBLISHERSAND DISTRIBUTORS,New Delhi	2011

WEB REFERENCES

1. https://en.wikipedia.org/wiki/Kinematics
2. https://nptel.ac.in/courses/112/104/112104121/

Kinematics Of Machinery

UNIT	Total No. of Periods Planned	Lecture Periods	Tutorial Periods
I	10	10	0
II	10	10	0
III	10	10	0
IV	10	10	0
V	12	12	0
TOTAL	**52**	**52**	**0**

I. CONTINUOUS INTERNAL ASSESSMENT : 40 Marks

(Internal Assessment Tests: 30, Attendance: 5, Assignment/Seminar: 5)

II. END SEMESTER EXAMINATION : 60 Marks

TOTAL : 100 Marks

FACULTY **HOD / MECH** **DEAN / FOE**

UNIT 1 – Basics Of Mechanisms

1.1 Terminology and definition Degree of Freedom

Degrees of freedom (**DoF**) is related to the motion possibilities of rigid bodies. **Kinematic definition** for **DoF** of any system or its components would be "the number of independent variables or coordinates required to ascertain the position of the system or its components".

1.2 Mobility

Mobility is the ability to move freely. If your basketball injury causes you to lose **mobility** in your knee, that means you can't move it very well. **Mobility** often refers to whether you can move an injured body part, like a joint or a limb, but it can also describe movement in general.

1.3 Kutzbach Criterian

The number of degrees of freedom of a mechanism is also called the *mobility* of the device. The ***mobility*** is the number of input parameters (usually pair variables) that must be independently controlled to bring the device into a particular position. The ***Kutzbach criterion***, which is similar to Gruebler's equation, calculates the *mobility*.

In order to control a mechanism, the number of independent input motions must equal the number of degrees of freedom of the mechanism. For example, the transom has a single degree of freedom, so it needs one independent input motion to open or close the window. That is, you just push or pull rod 3 to operate the window.

To see another example, the mechan also has 1 degree of freedom. If an independent input is applied to link 1 (*e.g.*, a motor is mounted on joint A to drive link 1), the mechanism will have the a prescribed motion.

1.4 Grashoffs law

By **Grashof law**, for at least one link to be capable of making a full revolution, the sum of the lengths of the shortest link and the largest link is less than or equal to the sum of the lengths of the other two links.

1.5 Kinematic Inversion of four bar chain and slider crank

Inversions of mechanism: A mechanism is one in which one of the links of a kinematic chain is fixed. Different mechanisms can be obtained by fixing different links of the same kinematic chain. These are called as inversions of the mechanism. By changing the fixed link, the number of mechanisms which can be obtained is equal to the number of links. Excepting the original mechanism, all other mechanisms will be known as inversions of original mechanism. The inversion of a mechanism does not change the motion of its links relative to each other.

Four bar chain:

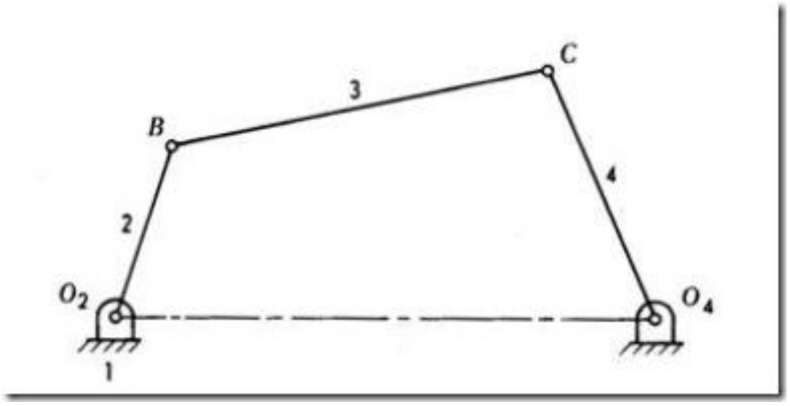


Fig 1.22 Four bar chain

One of the most useful and most common mechanisms is the four-bar linkage. In this mechanism, the link which can make complete rotation is known as crank (link 2). The link which oscillates is known as rocker or lever (link 4). And the link connecting these two is known as coupler (link 3). Link 1 is the frame.

Slider crank chain: This is a kinematic chain having four links. It has one sliding pair and three turning pairs. Link 2 has rotary motion and is called crank. Link 3 has got combined rotary and reciprocating motion and is called connecting rod. Link 4 has reciprocating motion and is called slider. Link 1 is frame (fixed). This mechanism is used to convert rotary motion to reciprocating and vice versa.

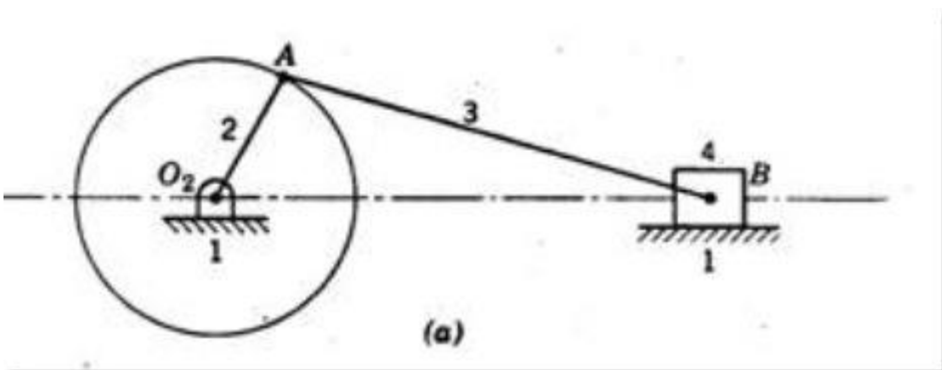


Fig1.27

1.6 Mechanical advantage Transmission Angle

Transmission angle is the **angle** between the coupling member and the output member in a mechanism. As this **angle** approaches ±90°, the **mechanical advantage** of the mechanism typically increases. Toggle positions occur when the input crank has near infinite **mechanical advantage**.

1.7 Single Double And Offset slider Mechanism

Many a times mechanisms are designed to perform repetitive operations. During these operations for a certain period the mechanisms will be under load known as working stroke and the remaining period is known as the return stroke, the mechanism returns to repeat the operation without load. The ratio of time of working stroke to that of the return stroke is known a time ratio. Quick return mechanisms are used in machine tools to give a slow cutting stroke and a quick return stroke. The various quick return mechanisms commonly used are i) Whitworth ii) Drag link. iii) Crank and slotted lever mechanism

1.8 Quick Return Mechanism

A **quick return mechanism** is an apparatus to produce a reciprocating **motion** in which the time taken for travel in **return** stroke is less than in the forward stroke. It is driven by a circular **motion** source (typically a motor of some sort) and uses a system of links with three turning pairs and a sliding pair.

1.9 Ratchets and escapements

A **ratchet** is a mechanical device that allows continuous linear or rotary motion in only one direction while preventing motion in the opposite direction.

Escapement, in mechanics, a device that permits controlled motion, usually in steps. In a watch or clock, it is the mechanism that controls the transfer of energy from the power source to the counting mechanism. The classic form for a timepiece, which made the mechanical clock possible, was the verge escapement, probably invented in 13th-century Europe. This consists of a crown wheel (i.e., a gearwheel shaped like a crown) driven by a weight and repeatedly checked by the action of a pair of metal pallets that alternately stop successive teeth. The pallets are mounted on a vertical shaft (the verge), and their speed of oscillating back and forth is controlled by a crossbar at the top (the foliot) with two small weights; moving the weights outward from the shaft slows the oscillations. The anchor escapement, an improvement invented in England in the 17th century, works with a pendulum and allows much smaller arcs of swing than the verge escapement with a pendulum. In the anchor escapement the pallets are in the shape of an inverted anchor, lying in the same plane as the wheel. Many improvements have since been made in escapements, most significantly the concept of detachment, where the escapement, while providing energy for the oscillator, is as detached from it as possible to allow the oscillator to swing as freely as possible.

1.10 Indexing Mechanisms

Indexing Mechanism is a **mechanism** that is used for dividing the periphery of a workpiece into any number of equal parts. The machine used for the **indexing mechanism** is called **indexing** head. **Indexing** head is also known as a dividing head or spiral head.

UNIT-II
KINEMATICS

2.1 Displacement

Displacement is defined as the change in position of an object. It is a vector quantity and has a direction and magnitude. It is represented as an arrow that points from the starting position to the final position. For example- If an object moves from A position to B, then the object's position changes.

2.2 Velocity And Acceleration

The acceleration of an object is given by the rate of change of the object's velocity. If an object moves with constant velocity, then its acceleration is zero. If an object changes its speed or the direction of its velocity, then it has a non-zero acceleration. It is important to recognize that the acceleration of an object only gives the rate of change of the velocity and is not correlated with the speed of an object. It is possible for an object to move very slowly, quickly, or not move at all, and have any variety of magnitudes of acceleration. Graphically, the acceleration represents the slope of the tangent to the velocity-time plot. The velocity could be very large and negative, with a very large and positive slope. In this case, the object would be moving quickly backward but slowing down and reversing direction in a short amount of time. A common misconception is that an acceleration always represents a change in speed. This is *not* correct. Because acceleration is a vector quantity, changes in the *direction* of velocities also constitute accelerations. Therefore, an object moving in a circle at constant speed is also constantly accelerating because the direction of the velocity vector is rotating at every instant in time.

2.3 Graphical method velocity and Acceleration

Graphical method includes drawing of position of links followed by the **velocity and acceleration** diagrams in vector-loop form yielding **velocity and acceleration** polygons. ... It has an interesting feature of animating the drawing of polygons in the way they are drawn by a teacher on the board of a classroom

2.4 Polygons

Polygons are many-sided figures, with sides that are line segments. **Polygons** are named according to the number of sides and angles they have. The most familiar **polygons** are the triangle, the rectangle, and the square. A regular **polygon** is one that has equal sides.

2.5 Kinematics Analysis by Complex algebra method

complex number is a number that can be expressed in the form a + b i, where a and b are real numbers, and i represents the “imaginary unit”, satisfying the equation. Because no real number satisfies this equation, i is called an imaginary number.

2.6 Vector Approach

The common **vector approach** (CVA) is a subspace **method** that eliminates unwanted information, such as environmental effects, personal and phase differences, and temporal variations from a spoken word.

2.7 Instantaneous Center

Instantaneous centre of a moving body may be defined as that centre which goes on changing from one instant to another. • The locus of all such instantaneous centres is known as centrode. • A line drawn through an **instantaneous centre** and perpendicular to the plane of motion is called instantaneous axis.

2.8 Coriolis Acceleration

Coriolis acceleration is the **acceleration** due to the rotation of the earth, experienced by particles (water parcels, for example) moving along the earth's surface. ... **Coriolis acceleration** is generated by the eastward rotation of the earth around the N-S axis. Figure 1: Definition of x,y,z axes on the rotating earth.

UNIT-III
KINEMATICS OF CAM

3.1 Displacement Diagrams

A Displacement Diagram is essentially a graph which plots the movement of a cam follower against time. Since the cam's movement is usually constant then equal time intervals can be represented by equal distances along the **horizontal axis** and the resulting follower movement (or 'displacement') along the **vertical axis**.

3.2 Simple Harmonic Motion

Simple harmonic motion, in physics, repetitive movement back and forth through an equilibrium, or central, position, so that the maximum displacement on one side of this position is equal to the maximum displacement on the other side. The time interval of each complete vibration is the same.

A specific example of a simple harmonic oscillator is the vibration of a mass attached to a vertical spring, the other end of which is fixed in a ceiling. At the maximum displacement $-x$, the spring is under its greatest tension, which forces the mass upward. At the maximum displacement $+x$, the spring reaches its greatest compression, which forces the mass back downward again. At either position of maximum displacement, the force is greatest and is directed toward the equilibrium position, the velocity (v) of the mass is zero, its acceleration is at a maximum, and the mass changes direction. At the equilibrium position, the velocity is at its maximum and the acceleration (a) has fallen to zero. Simple harmonic motion is characterized by this changing acceleration that always is directed toward the equilibrium position and is proportional to the displacement from the equilibrium position. Furthermore, the interval of time for each complete vibration is constant and does not depend on the size of the maximum displacement. In some form, therefore, simple harmonic motion is at the heart of timekeeping.

To express how the displacement of the mass changes with time, one can use Newton's second law, $F = ma$, and set $ma = -kx$. The acceleration a is the second derivative of x with respect to time t, and one can solve the resulting differential equation with $x = A \cos \omega t$, where A is the maximum displacement and ω is the angular frequency in radians per second. The time it takes the mass to move from A to $-A$ and back again is the time it takes for ωt to advance by 2π. Therefore, the period T it takes for the mass to move from A to $-A$ and back again is $\omega T = 2\pi$, or $T = 2\pi/\omega$. The frequency of the vibration in cycles per second is $1/T$ or $\omega/2\pi$.

3.3 Cycloidal Motion

In geometry, a **cycloid** is the curve traced by a point on a circle as it rolls along a straight line without slipping. A **cycloid** is a specific form of trochoid and is an example of a roulette, a curve generated by a curve rolling on another curve.

3.4 Layout of Plate CAM Profiles

Drawing the displacement diagrams for the different kinds of the motions and the plate cam profiles for these different motions and different followers. SHM, Uniform velocity, Uniform acceleration and retardation and Cycloidal motions Knife-edge, Roller, Flat-faced and Mushroom followers

3.5 Derivatives of Follower Motion

Velocity and acceleration of the followers for various types of motions.
Calculation of Velocity and acceleration of the followers for various types of motions.

3.6 Circular Arc CAM and Tangent CAMS

When the flanks between the nose and base circles are of straight and tangential to both the circles, then, the cams are called tangent cams

When the flanks of the cam connecting the nose and base circles are of convex circular arc, such cams are referred as circular arc cams.

These are usually symmetric about the centre line of the cam. Generally, the following combinations of cam and follower are used. (a) Circular arc cam with flat faced follower (b) Tangent cam with reciprocating roller follower

3.7 Pressure Angle

Pressure angle in relation to gear teeth, also known as the **angle** of obliquity, is the **angle** between the tooth face and the gear wheel tangent. It is more precisely the **angle** at a pitch point between the line of **pressure** (which is normal to the tooth surface) and the plane tangent to the pitch surface.

UNIT -IV
Gears And Gear Trains

4.1 Spur Gear

A **spur gear** is one of the simplest and most common types of cylindrical **gears**. **Spur gears** have straight teeth that run parallel to the shaft. These **gears** are easy to manufacture and can be used in a variety of applications.

4.2 Fundamental law of toothed gearing

The velocity ratio is equal to the inverse ratio of the diameters of pitch circles. This is the **fundamental law** of **gear-tooth** action. ... The common normal to the **tooth** profiles at the point of contact must always pass through a fixed point (the pitch point) on the line of centers (to get a constant velocity ration).

4.3 Involute gearing

An **involute gear** has the profiles of its teeth in the shape of an **involute** of a circle. This structure helps to reduce torque variation and allow greater assembly flexibility, helping to make **involute gears** one of the most popular power transmission devices.

4.4 Interchangeble gears

For **interchangeability** of all **gears**, the set must have the same circular pitch, module,diameter pitch, pressure, angle, addendum and dedendum and tooth thickness must be one half of the circular pitch. ... **gear** is called clearance. in volute interference occurs.

4.5 Gear Tooth Action

The velocity ratio is equal to the inverse ratio of the diameters of pitch circles. This is the fundamental law of **gear-tooth action**. ... The common normal to the **tooth** profiles at the point of contact must always pass through a fixed point (the pitch point) on the line of centers (to get a constant velocity ration).

4.6 Non standard Gear teeth

Non-standard gear is defined as one whose tooth thickness at the pitch circle is not equal to 0.5πm

4.7 Helical,Bevel,Worm,Rack And Pinion

Helical gears are one type of cylindrical **gears** with slanted tooth trace. Compared to spur **gears**, they have the larger contact ratio and excel in quietness and less vibration and able to transmit large force. A pair of **helical gears** has the same **helix** angle but the **helix** hand is opposite.

Bevel gears are **used in** differential drives, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile. **Bevel** gears are **used as** the main mechanism for a hand drill.

The applications for **worm** gears include **gear** boxes, fishing pole reels, guitar string tuning pegs, and where a delicate speed adjustment by utilizing a large speed reduction is needed. While you can rotate the **worm gear** by **worm**, it is usually not possible to rotate **worm** by using the **worm gear**.

Gear racks are utilized to convert rotating movement into linear motion. A **gear rack** has straight teeth cut into one surface of a square or round section of rod and operates with a pinion, which is a small cylindrical **gear** meshing with the **gear rack**. ... There are many ways to use **gears**

A **pinion** is a round **gear**—usually the smaller of two meshed **gears**—used in several applications, including drivetrain and rack and **pinion** systems.

4.8 Gear trains

The main purpose of a **gear** train is to increase torque or speed. The arrangement of the driver and driven **gears** determine if the **gear** train will increase torque or speed. To increase output torque using a **gear** train, a power source should be directly connected to a smaller **gear** and **used to** drive a larger **gear**.

4.9 Parallel Axis gear train

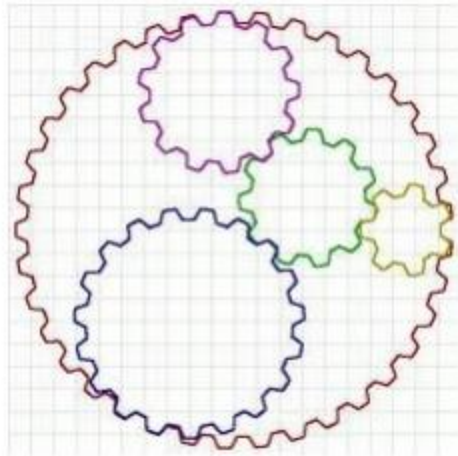
Simple Gear Trains – A simple gear train is a collection of meshing gears where each gear is on its own axis. The train ratio for a simple gear train is the ratio of the number of teeth on the input gear to the number of teeth on the output gear. A simple gear train will typically have 2 or 3 gears and a gear ratio of 10:1 or less. If the train has 3 gears, the intermediate gear has no numerical effect on the train ratio except to change the direction of the output gear.

Compound Gear Trains – A compound gear train is a train where at least one shaft carries more than one gear. The train ratio is given by the ratio mV = (product of number of teeth on driver gears)/(product of number of teeth on driven gears). A common approach to the design of compound gear trains is to first determine the number of gear reduction steps needed (each step is typically smaller than 10:1 for size purposes). Once this is done, determine the desired ratio for each step, select a pinion size, and then calculate the gear size.

Reverted Gear Trains – A reverted gear train is a special case of a compound gear train. A reverted gear train has the input and output shafts in –line with one another. Assuming no idler gears are used, a reverted gear train can be realized only if the number of teeth on the input side of the train adds up to the same as the number of teeth on the output side of the train

4.10 Epicyclic Gear trains

- If the axis of the shafts over which the gears are mounted are moving relative to a fixed axis , the gear train is called the epicyclic gear train.
- Problems in epicyclic gear trains.



Differentials:

- Used in the rear axle of an automobile.
- To enable the rear wheels to revolve at different speeds when negotiating a curve.
- To enable the rear wheels to revolve at the same speeds when going straight.

Unit-V

Friction In Drives

5.1 Surface Contacts

When the two elements of a pair have **surface contact** when relative motion takes place and the **surface** of one element slides over the **surface** of another element, the pair formed as lower pair. Example: All sliding, Turning and Screw pairs are lower pair.

5.2 Sliding Friction

The term **sliding friction** refers to the resistance created by two objects **sliding** against each other. This can also be called kinetic **friction**. **Sliding friction** is intended to stop an object from moving

5.3 Rolling Friction

Rolling friction takes place when an object rolls on the surface. Sliding **friction** takes place when two surfaces are rubbed against each other. **Rolling friction** takes place due to the deformation of surfaces. Sliding **friction** takes place due to interlocking between microscopic surfaces.

5.4 Friction Drives

Kinematics of Machines **Friction Drives** Unit-V Yatin Kumar Singh Page 2 belts need little adjustment and transmit more power, without slip, as compared to flat belts. ... Also, a multiple V-belt system, using more than one belt in the two pulleys, can be used to increase the power transmitting capacity

5.5 Friction in screw threads

The greater the **thread** angle, the greater the angle between the load vector and the surface normal, so the larger the normal force between the **threads** required to support a given load. Therefore, increasing the **thread** angle increases the **friction** and wear of a **screw**.

5.6 Friction Clutches

Friction clutches are by far the most well-known type of **clutches**. A **friction clutch** is a **clutch** in which the drive is transmitted by the **friction** between surfaces attached to the driving and driven shafts. These surfaces are lined with cork, asbestos, or other fibrous material.

5.7 Belt and Rope drives

A **belt** is a flexible power transmission element that runs tightly on a set of pulleys. A **chain drive** consists of a series of pin-connected links that run on a set of sprockets. ... **Belt drives** can be used to simply transmit power between one and another with the speed of the driving and driven shaft equal

5.8 Friction Aspects in brakes

Friction braking is the most commonly **used braking** method in modern **vehicles**. It involves the conversion of kinetic energy to thermal energy by applying **friction** to the moving parts of a system. The **friction** force resists motion and in turn generates heat, eventually bringing the velocity to zero.