

SYED AMMAL ENGINEERING COLLEGE

(Approved by the AICTE, New Delhi, Govt. of Tamilnadu and Affiliated to Anna University, Chennai)

Established in 1998 - An ISO 9001:2000 Certified Institution

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Course Name: KINEMATICS OF MACHINERY

Course Code: ME6401

Semester: 4

UNIT I - BASICS OF MECHANISMS

1. What is Kinematics?

Kinematics is the study of motion (position, velocity, acceleration). A major goal of Understanding kinematics is to develop the ability to design a system that will satisfy Specified motion requirements. This will be the emphasis of this class.

2. What is Kinetics?

Kinetics is the study of effect of forces on moving bodies. Good kinematic design should produce good kinetics.

3. Define Link.

A link is defined as a member or a combination of members of a mechanism connecting other members and having relative motion between them. The link may consist of one or more resistant bodies. A link may be called as kinematic link or element. Eg: Reciprocating steam engine.

4. Define Kinematic Chain

When the kinematic pairs are coupled in such a way that the last link is joined to the first link to transmit definite motion it is called a kinematic chain.

Eg: The crank shaft of an engine forms a kinematic pair with the bearings which are fixed in a pair, the connecting rod with the crank forms a second kinematic pair, the piston with the connecting rod forms a third pair and the piston with the cylinder forms

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the fourth pair. The total combination of these links is a kinematic chain. Eg: Lawn mower.

5. Define Degrees of Freedom.

It is defined as the number of input parameters which must be independently controlled in order to bring the mechanism in to useful engineering purposes.

It is also defined as the number of independent relative motions, both translational and rotational, a pair can have.

6. Define Pantograph.

Pantograph is used to copy the curves in reduced or enlarged scales. Hence this mechanism finds its use in copying devices such as engraving or profiling machines.

7. What is meant by spatial mechanism?

Spatial mechanism have a geometric characteristics in that all revolute axes are parallel and perpendicular to the plane of motion and all prism lie in the plane of motion.

8. Classify the Constrained motion?

Constrained motions are classified into three types

1. Completely constrained motion.
2. Incompletely constrained motion.
3. Successfully constrained motion.

9. What is Toggle position?

It is the position of a mechanism at which the mechanical advantage is infinite and the sine of angle between the coupler and driving link is zero.

10. What are the important applications of a single slider crank mechanism?

1. Rotary or Gnome engine.
2. Crank and slotted lever mechanism.
3. Oscillating cylinder engine.
4. Bull engine and
5. Hand pump.

11. Give some examples for kinematic pairs.

1. Crank and connecting rod,
2. Connecting rod and piston rod, and
3. Piston and engine cylinder.

12. What is meant by transmission angle?

In a four bar chain mechanism, the angle between the coupler and the follower (driven) link is called as the transmission angle.

13. What are the applications of inversion of double slider crank chain mechanism?

It consists of two sliding pairs and two turning pairs. There are three important inversions of double slider crank chain. 1) Elliptical trammel. 2) Scotch yoke mechanism. 3) Oldham's coupling. Give some examples for kinematic pairs.

14. Write down the Grashof's law for a four bar mechanism?

Grashof's law states that the sum of the shortest and longest links cannot be greater than the sum of the remaining two links lengths, if there is to be continuous relative motion between two members.

UNIT II - KINEMATICS OF LINKAGE MECHANISMS

1. What are the important concepts in velocity analysis?

A. The absolute velocity of any point on a mechanism is the velocity of that point with reference to ground.

B. Relative velocity describes how one point on a mechanism moves relative to another point on the mechanism.

2. Define Instantaneous centre.

Instantaneous centre of a moving body may be defined as that centre which goes on changing from one instant to another.

3. Define Instantaneous centre

Instantaneous axis is a line drawn through an instantaneous centre and perpendicular to the plane of motion.

4. How to represent the direction of linear velocity of any point on a link with respect to another point on the same link?

The direction of linear velocity of any point on a link with respect to another point on the same link is perpendicular to the line joining the points.

5. Define Kennedy's theorem.

The Kennedy's theorem states that if three bodies move relatively to each other, they have three instantaneous centers and lie on a straight line.

6. Define displacement.

It may be defined as the distance moved by a body with respect to a fixed certain fixed point. When there is no displacement in a body it is said to be at rest and when it is being displaced, it is said to be in motion.

7. What are the types of motions?

1. Rectilinear motion.
2. Curvilinear motion.

3. Circular motion.

8. What are the methods for determining the velocity of a body?

Important methods for determining the velocity of a body are:

- i) Relative velocity method
- ii) Graphical method
- iii) Instantaneous centre method
- iv) Analytical method.

9. Define velocity.

Velocity may be defined as the rate of change of displacement of a body with respect to the time. Since the velocity has both magnitude and direction, therefore it is a vector quantity.

10. Define speed.

Speed may be defined as the rate of change of linear displacement of a body with respect to the time. Since the speed is irrespective of its direction, therefore it is a scalar quantity.

11. What is deceleration?

The negative acceleration is also known as deceleration or retardation.

12. Define Acceleration.

The rate of change of velocity with respect to time is known as acceleration.

13. Define coincident points.

When a point on one link is sliding along another rotating link, then the point is known as coincident point.

14. Define centrode.

The locus of all instantaneous centre's (i.e., I_1, I_2, \dots) is known as centrode.

15. Define Axode.

The locus of all instantaneous axis is known as axode.

16. Define Body centrede.

The locus of all instantaneous centre relative to the body itself is called the body centrede

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UNIT III - KINEMATICS OF CAM MECHANISMS

1. What is cam?

A cam is a rotating machine element which gives reciprocating (or) oscillating motion to another element known as follower

2. Define tangent cam?

When the flanks of the cam are straight and tangential to the base circle and nose circle, the cam is known as tangent cam.

3. Distinguish radial and cylindrical cams.

Radial cam	Cylindrical cam
In this cam, the follower reciprocates (or) oscillates in a direction perpendicular to the axis.	In this the follower reciprocates (or) oscillates in a direction parallel to the cam axis.

4. What are the different motions of the follower?

- Uniform motion,
- Simple harmonic motion,
- Uniform acceleration and retardation, and
- Cycloidal motion.

5. Compare Roller and mushroom follower of a cam.

S.No	Roller Follower	Mushroom Follower
1	Roller followers are extensively used where more space is available.	The mushroom followers are generally used where space is limited.
2	It is used in stationary gas engines, oil engines and aircraft valves in engines.	It is used in cams which operate the valves in automobile engines.

6. Explain offset follower.

When the motion of the follower is along an axis away from the axis of the cam centre, it is called offset follower.

7. Define trace point in the study of cams.

It is a reference point on the follower and is used to generate the pitch curve. In case of knife edge follower the knife edge represents the trace point and the pitch curve corresponds to the cam profile. In a roller follower the centre of the roller represents the trace point.

8. Define pressure angle with respect to cams.

It is the angle between the direction of the follower motion and a normal to the pitch curve. This angle is very important in designing a cam profile. If the pressure angle is too large, a reciprocating follower will jam in its bearings.

9. Define Lift (or) Stroke in cam.

It is the maximum travel of the follower from its lowest position to the topmost position.

10. Define undercutting in cam. How is occurs?

The cam profile must be continuous curve without any loop. If the curvature of the pitch curve is too sharp, then the part of the cam shape would be lost and thereafter the intended cam motion would not be achieved. Such a cam is said to be undercut. Undercutting occurs in the cam because of attempting to achieve too great a follower lift with very small cam rotation with a smaller cam.

11. What do you know about Nomogram?

In Nomogram, by knowing the values of total lift of the follower (L) and the cam rotation angle (β) for each segment of the displacement diagram, we can read directly the maximum pressure angle occurring in the segment for a particular choice of prime circle radius (R_0).

12. What are the classifications of cam based on the follower movement?

1) Rise-Return-Rise (R-R-R) cams,

- 2) Dwell-Rise-Return-Dwell (D-R-R-D) cams,
- 3) Dwell-Rise-Dwell-Return-Dwell (D-R-D-R-D) cams,
Dwell-Rise-Dwell (D-R-D) cams.

13. What are the different types of cams?

1. Wedge (or) flat cams
2. Radial (or) Disc cams
3. Spiral cams
4. Cylindrical (or) Barrel (or) Drum Cams
5. Conjugate cams
6. Globoidal cams
7. Spherical cams

14. What do you know about gravity cam?

In this type, the rise of the cam is achieved by the rising surface of the cam and the return by the force of gravity of due to the weight of the cam.

15. Define Trace point.

It is a reference point on the follower to trace the cam profile. In case of a knife edge follower, the knife edge itself is a tracing point and in roller follower, the centre of the roller is the tracing point.

16. Define pressure angle.

It is the angle between the direction of the follower motion and a normal to the pitch curve. This is very important in cam design as it represents steepness of the cam profile. If the pressure angle is too large, a reciprocating follower will jam in its bearings.

17. Define Prime circle.

The smallest circle drawn tangent to the pitch curve is known as the prime circle.

18. Define Angle of Ascent.

The angle of rotation of cam from the position when the follower begins to rise till it reaches its highest position is known as angle of ascent. It is also known as out stroke and is denoted by θ_0 .

19. What is meant by Simple Harmonic Motion?

When a body rotates on a circular path with uniform angular velocity, its projection on the diameter will have simple harmonic motion. The velocity of the projection will be maximum at the centre of and zero at the ends of the diameter. In case of acceleration and retardation, the values will be zero at the centre and maximum at the ends of diameter.

20. What are the different shapes of high speed cams?

1. Circular Arc cam with flat faced follower
2. Tangent cam with reciprocating roller follower

21. Define cam angle.

It is the angle of rotation of the cam for a definite displacement of the follower.

22. What are the classifications of follower based on the follower movement?

- i) Reciprocating (or) translating follower.
- ii) Oscillating (or) rotating follower.

23. Define Pitch curve.

The locus of the tracing point is known as the pitch curve. For the purpose of laying out the cam profiles, it is assumed that the cam is fixed and the follower rotates around it.

24. What are the classifications of the follower based on the path of motion of the follower?

- a) Radial follower.
- b) Offset follower.

25. What are the classifications of cam base on the constraint of the follower? a)

- a) Pre-loaded spring cams.
- b) Positive drive cams.
- c) Gravity cams.

UNIT IV - GEARS AND GEAR TRAINS

1. State law of Gearing.

The law of gearing states that for obtaining a constant velocity ratio, at any instant of teeth the common normal at each point of contact should always pass through a pitch point, situated on the line joining the centre of rotation of the pair of mating gears.

2. Define normal and axial pitch in helical gears.

Normal pitch is the distance between similar face of adjacent teeth, along a helix on the pitch cylinder normal to the teeth.

Axial pitch is the distance measured parallel to the axis between similar faces of a adjacent teeth.

3. What is the maximum efficiency in worm and worm gear?

$$\eta_{\max} = \frac{1 - \sin\phi}{1 + \sin\phi}$$

4. What are the advantages and limitations of gear drive? Write any two.

Advantages:

1. Since there is no slip, so exact velocity ratio is obtained.
2. It is more efficient and effective means of power transmission.

Limitations:

1. Manufacture of gear is complicated.
2. The error in cutting teeth may cause vibration and noise during operation.

5. Define interference.

The phenomenon when the tip of tooth undercuts the roots on its mating gear is known as interference.

6. Define cycloidal tooth profile and involute tooth profile.

A cycloid is the curve traced by a point on the circumference of a circle which rolls without slipping on a fixed straight line.

Involute profile is defined as the locus of a point on a straight line which rolls without slipping on the circumference of a circle.

7. Define circular pitch and diametral pitch in spur gears.

Circular pitch (p_c) : It is the distance measured along the circumference of the pitch circle from a point on one teeth to the corresponding point on the adjacent tooth.

$$p_c = \pi D / T$$

Diametral pitch (p_D) : It is the ratio of number of teeth to the pitch circle diameter.

$$p_D = T / D = \pi / p_c$$

8. Define Backlash.

It is the difference between the tooth space and the tooth thickness along the pitch circle.

$$\text{Backlash} = \text{Tooth space} - \text{Tooth thickness}$$

9. What is gear train of train of wheels?

Two or more gears re made to mesh with each other to transmit power from one shaft to another. Such a combination is called a gear train or train of wheels.

10. Write velocity ratio in compound train of wheels?

$$\frac{\text{Speed of last follower}}{\text{Speed of first driver}} = \frac{\text{Product of teeth on drivers}}{\text{Product of teeth on followers}}$$

11. Define simple gear train.

When there is only one gear on each shaft, it is known as simple gear train.

12. What is reverted gear train?

When the axes of the first and last wheels are co-axial, the train is known as reverted gear train.

13. Where the epicyclic gear trains are used?

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

14. Write down the difference between involute and cycloidal tooth profile.

S.No	Involute Tooth Profile	Cycloidal Tooth Profile
1	Variation in centre distance does not affect the velocity ratio.	The centre distance should not vary.
2	Pressure angle remains constant throughout the teeth.	Pressure angle varies. It is zero at the pitch point and maximum at the start and end of engagement.
3	Interference occurs.	No interference occurs.
4	Weaker teeth.	Stronger teeth.

15. Define Contact Ratio.

It is the ratio of the length of arc contact to the circular pitch is known as contact ratio. The value gives the number of pairs of teeth in contact.

16. What is an angle of obliquity in gears?

It is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point. It is called as pressure angle.

17. What is bevel gearing? Mention its types.

When the non-parallel (or) intersecting but coplanar shafts connected by gears, they are called bevel gears and the arrangement is bevel gearing. It is of two types namely skew bevel gearing and spiral gearing.

18. What are the methods to avoid interference?

1. The height of the teeth may be reduced.
2. The pressure angle may be increased.
3. The radial flank of the pinion may be cut back (undercutting).

19. What is the advantage when arc of recess is equal to arc of approach in meshing gears?

When arc of recess equal to arc of approach, the work wasted by friction is minimum and efficiency of drive is maximum.

20. What do you know about tumbler gear?

Tumbler gears are those which are used in lathes for reversing the direction of rotation of driven gears.

21. What you meant by non-standard gear teeth?

The gear tooth obtained by modifying the standard proportions of gear teeth parameters is known as non- standard gear teeth.

22. What is meant by compound gear train?

When there are more than one gear on shaft, it is called a compound gear train.

23. What is the advantage of a compound gear train over a simple gear train?

The advantage of a compound gear train over a simple gear train is that a much larger speed reduction from the first shaft to the last shaft can be obtained with small gears.

24. State the methods to find the velocity ratio of epicyclic gear train.

Two methods are:

- 1) Tabulation method.
- 2) Algebraic method.

25. What is the externally applied torques used to keep the gear train in equilibrium?

- 1) Impart torque on the driving member.
- 2) Resisting or holding torque on the driven member.
- 3) Holding or braking torque on the fixed member.

UNIT V - FRICTION IN MACHINE ELEMENTS .

1 .What is meant by slope of a thread?

It is the inclination of the thread with horizontal.

$$\text{Slope of thread} = \tan^{-1} \left[\frac{\text{Lead screw}}{\text{Circumference of screw}} \right]$$

2. What are the effects of limiting angle of friction?

1. If limiting angle of friction (ϕ) is equal to $\tan^{-1} \mu$, then the body will move over the plane irrespective of the magnitude of the force (F) (Limiting force of friction).

2. If $\phi < \tan^{-1} \mu$, then no motion of body on plane is possible irrespective of how large the magnitude of F may be.

3. Define co-efficient of friction (μ).

It is defined as the ratio of the limiting friction (F) to the normal reaction (RN) between the two bodies.

$$\mu = \frac{\text{Limiting force of friction}}{\text{Normal reaction}} = \frac{F}{RN}$$

5. Differentiate coefficient of friction in square thread and V-thread.

(a) In square thread, $\mu = F/RN$

(b) In V thread, $\mu_1 = \mu / \cos \beta$

Where F = Limiting force of friction,

RN = Normal reaction, and

2β = Angle of 'V' in a 'V' thread.

5. What is the efficiency of inclined plane?

The efficiency of an inclined plane is defined as the ratio between effort without friction (P0) and the effort with friction (P).

6. Why self- locking screws have lesser efficiency?

Self locking needs some friction on the thread surface of the screw and nut hence it needs higher effort to lift a body and hence automatically the efficiency decreases.

7. What are the functions of clutches?

1. It supplies power to the transmission system.
2. It stops the vehicle by disconnecting the engine from transmission system.
3. It is used to change the gear and idling the engine.
4. It gives gradual increment of speed to the wheels.

8. What is the difference between cone clutch and centrifugal clutch?

Cone clutch works on the principle of friction alone. But centrifugal clutch uses principle of centrifugal force in addition with it.

9. Why friction is called as 'necessary evil'?

Friction is the important factor in engineering and physical applications such as belt and ropes, jibs, clutches and brakes, nut and bolts, so it is the necessary one. If the friction exceeds certain value it will cause heat, damage and wear when applied. So it is called 'necessary evil'.

10. What are the belt materials?

1. Leather,
2. Cotton or fabric,
3. Rubber,
4. Balata, and
5. Nylon.

11. State the law of belting?

Law of belting states that the centre line of the belt as it approaches the pulley must lie in a plane perpendicular to the axis of the pulley or must lie in the plane of the pulley, otherwise the belt will runoff the pulley.

12. What you meant by 'Crowing in pulley'?

The process of increasing the frictional resistance on the pulley surface is known as crowing. It is done in order to avoid slipping of the belt.

13. What is meant by initial tension in belts?

In order to increase the frictional grip between the belt and pulleys, the belts is tightened up. Due to this the belt gets subjected to some tension even when the pulleys are stationary. This tension in the belts is called initial tension (T_0).

14. List out the commonly used breaks.

1. Hydraulic brakes: e.g., Pumps or hydrodynamic brake and fluid agitator.
2. Electric brakes: e.g., Eddy current brakes.
3. Mechanical brakes: e.g., Radial brakes and axial brakes

15. What do you mean by a brake?

Brake is a device by means of which motion of a body is retarded for slowing down (or) to bring it to rest which works on the principle of frictional force, it acts against the driving force.

16. Explain velocity ratio.

It is defined as the ratio between velocity of the driver and the follower (or) driven.

17. What is the centrifugal effect on belts?

During operation, as the belt passes over a pulley the centrifugal effect due to its weight tends to lift the belt from the pulley surface. This reduces the normal reaction and hence the frictional resistance. The centrifugal force produces additional tension in the belt.

18. Write down the disadvantage of V-belt drive over flat belt?

1. V belt cannot be used in large distance.
2. It is not as durable as flat belt.
3. Since the V belt subjected to certain amount of creep therefore it is not suitable for constant speed applications such as synchronous machines, and timing devices.
4. It is a costlier system.

21. When is the cross belt used instead of open belt?

1. Cross belt is used where the direction of rotation of driven pulley is opposite to driving pulley.
2. Where we need more power transmission there we can use cross belt drive.

21. Why lubrication reduces friction?

In practical all the mating surfaces are having roughness with it. It causes friction. If the surfaces are smooth then friction is very less. Lubrication smoothens the mating surface by introducing oil film between it. The fluids are having high smoothness than solids and thus lubrication reduces friction.

22. What is meant by initial tension in belts?

In order to increase the frictional grip between the belt and pulleys, the belt is tightened up. Due to this belt gets subjected to some tension even when the pulleys are stationary. This tension in the belt is called initial tension (T_0).

23. Where does the P.I.V. drive system used?

P.I.V. (Positive Infinitely variable) drive is used in an infinitely varying speed system.

24. When the intensity of pressure acting brake shoe is assumed to uniform?

The intensity of pressure is assumed to be constant when the brake shoe has small angle of contact. For large angle of contact, it is assumed that the rate of wear of the shoe remains constant.