

## Kinematics of Machinery

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**MAHENDRA ENGINEERING COLLEGE  
MALLASAMUDRAM**

**ME 2203 KINEMATICS OF MACHINERY  
(PART –A) 2 marks**

**Unit 1: BASICS OF MECHANISMS**

1. Define 'degrees of freedom'.

It is defined as the number of input parameters which must be controlled independently in order to bring the device into a particular position.

The degrees of freedom of a mechanism (n) is given by

$$n = 3(L-1)-2j-h$$

L = Number of links

j = Number of joints

h = Number of higher pairs.

2. What is meant by spatial mechanism?

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

3. Classify the constrained motion.

There are three types.

- 1) Completely constrained motion (eg. Square bar moving in a square hole)
- 2) In completely constrained motion ( eg. Circular shaft in a hole)
- 3) Successfully constrained motion (eg. Piston and cylinder)

4. What is meant by number synthesis?

Expressing mobility or degree of freedom of a mechanism in terms of the number of links and the number of pair connections of a given type is known as number synthesis.

5. What are the some important inversions of four chain mechanism?

- 1) Crank-rocker mechanism.
- 2) Crank-crank mechanism.
- 3) Rocker-rocker mechanism.

6. 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.

7. What is pantograph?

Pantograph is a device which is used to reproduce a displacement exactly in an enlarged or reduced scale. It is used in drawing offices, for duplicating the drawings, maps, plans, etc. It works on the principle of 4 bar chain mechanism.

8. What are the applications of single slider crank mechanism?

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

9. Give some examples for kinematics pairs.

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

10. Discuss Elliptical trammel

Elliptical trammel is an instrument used for drawing ellipses. It is the best example for first inversion of double slider crank chain.

11. What is movability?

It includes the 6 degree of freedom of the device as a whole, as though the ground link were not fixed, and this applies to a kinematic chain.

12. What is mobility?

It neglects these and considers only the internal relative motions, thus applying a mechanism.

13. What is meant by transmission angle?

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

14. What is meant by Ackermann steering?

Ackermann steering is the one of the mechanism used in vehicles. It is obtained by inversion of four bar chain.

15. 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.

16. Explain the working principle of bicycle bells.

Bicycle bells are working on the principle of snap action mechanism or toggle mechanism or flip flop mechanism.

17. What is meant by motion adjustment mechanism?

The mechanism used to adjust or modify the motion of the link are known as motion adjustment mechanism. Motion adjustment is obtained by wedges, levers and rack and pinion.

18. Whether a cycle chain is kinematic chain or not?

A cycle chain is a combination of several links with turning pair. Hence it is not a kinematic chain.

19. Define instantaneous centre.

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

20. What is instantaneous axis?

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

21. What is resistant body?

A body is said to be resistant if it is capable of transmitting the required force with negligible deformation. A link need not necessarily be a rigid body, but it must be a resistant body.

22. What is link?

A link or an element is defined as that part of a machine which has motion relative to some other part. A link need not to be a single unit, but it may consist of several parts which are manufactured as separate units.

23. What are the different types of links?

- 1) Rigid link.
- 2) Flexible link.
- 3) Fluid link.

24. What is meant by spatial mechanism?

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

25. What is the use of oldham's coupling?

It is used for transmitting motion between two shafts which are parallel but not coaxial.

## Unit 2: KINEMATIC ANALYSIS

1. What is kinematic analysis?

The objective of the kinematics analysis is to determine the kinematic quantities such as displacements, velocities and accelerations of the elements in a mechanism.

2. What is displacement?

It is defined as the distance moved by a body with respect to a certain fixed point.

3. What is vector?

A vector is a straight line of a certain length possessing a starting point and a terminal point at which it carries an arrow head.

4. Write down the different types of motion.

- 1) Rectilinear motion.
- 2) Curvilinear motion.
- 3) Circular motion.

5. What is Rectilinear motion?

In this motion, the particles of a body move in straight parallel paths. Such a motion is also known as Translatory motion or straight line motion.

6. What is Curvilinear motion?

In this motion, the particles of a body move along parallel circular arcs or curved paths.

7. What is Circular motion?

When all the particles of a body travel in concentric circles then the motion is said to be circular motion.

8. What is the difference between velocity and speed?

Velocity is defined as the rate of change of displacement of a body with respect to the time.

Speed is defined as the rate of change of linear displacement of a body with respect to the time.

9. What are the different methods are used for finding the velocity?

- 1) Graphical method.
- 2) Analytical method.

10. Write the different types of graphical method.

- 1) Relative velocity method.
- 2) Instantaneous centre method.

11. What is configuration diagram?

It is a skeleton or a line diagram which represents a machine or a mechanism. To study the velocity and acceleration of any mechanisms, first we have to draw the configuration diagram. It is also known as space diagram.

12. What is acceleration?

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

13. What is deceleration?

The negative acceleration is known as deceleration or retardation.

14. What is meant by coincident points?

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

15. What is centrode?

The locus of all instantaneous centre is known as centrode.

16. What is space centrode?

The locus of the instantaneous centre in space during a definite motion of the body is called the space centrode.

17. What is Body centrode?

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

18. What is Instantaneous axis?

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

19. What is axode?

The locus of Instantaneous axis is known as axode.

20. Write down the different types of Instantaneous centres.

- 1) Fixed Instantaneous centres.
- 2) Permanent Instantaneous centres.
- 3) Neither fixed nor permanent Instantaneous centres.

21. Define Kennedy's theorem.

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

22. What are properties of instantaneous centre?

1) A rigid link rotates instantaneously relative to another link at the instantaneous centre for the configurations of the mechanism.

2) The two rigid links have no linear velocity relative to each other at the instantaneous centre. At this point the two rigid links have the same linear velocity relative to the rigid link.

23. What is angular velocity ratio theorem?

The angular velocity ratio theorem states that the angular velocity ratio of any two bodies in planar relative to a third body is inversely proportional to the segments into which the common instantaneous centre cuts the line of centres.

24. Explain any two methods of reducing interference in gears.

1. The height of the teeth may be reduced.
2. The pressure angle may be increased.
3. The face of gear tooth may be relieved.

25. What is the effects of centrifugal tension in belt drives?

1. Centrifugal tension will increase the tension on both tight and slack sides.
2. Centrifugal tension has no effect on the power transmitted by the belt drive.

### Unit 3: KINEMATICS OF CAMS

1. What is a cam?

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

2. Give some examples of cam.

- 1) Radial or disc cams.
- 2) Cylindrical or barrel cams.
- 3) End or face cams.
- 4) Wedge cams.

3. 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.

4. What are the different motions of the follower?

- 1) Uniform motion.
- 2) Simple harmonic motion.
- 3) Uniform acceleration and retardation.
- 4) Cycloidal motion.

5. How can high surface stress in flat faced follower be minimized?

High surface stress in the follower is minimized by machining the flat end of the follower to a spherical shape.

6. Where are the roller follower extensively used?

Roller followers are extensively used where more space is available such as in stationary gas oil engines, and aircraft engines.

7. Define dwell period?

The period during which the follower remains at rest is called dwell period.

8. 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.

9. Define trace point.

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.



10. 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.

11. Define lift or stroke in cam.

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

12. Define undercutting in cam. How it 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.

13. What do you know about nomogram?

In nomogram, by knowing the values of total lift of the follower and the cam rotation angle 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.

14. How can you prevent undercutting in cam?

- 1) By decreasing the follower lift.
- 2) By increasing cam rotation angle.
- 3) By increasing the cam size.

15. 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 or due to the weight of the cam.

16. Write the different types of follower.

- 1) Knife edge follower
- 2) Roller follower
- 3) Mushroom or flat faced follower
- 4) Spherical faced or curved shoe follower.

17. What is cam profile?

The surface of cam which comes into contact with follower, is known as cam profile.

18. What is base circle?

It is the smallest circle that can be drawn to the cam profile. The radius of the base circle is called the least radius of the cam.

19. What is 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.

20. What is pitch curve?

The locus or path 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.

21. What is prime circle?

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

22. What is pressure angle?

It is the angle between the direction of the follower motion and a normal to the pitch curve. This angle is very important in cam design as it represents steepness of the cam profile.

23. What is pitch point?

It is the point on the pitch curve at which the pressure angle is maximum.

24. What is pitch circle?

It is the circle passing through the pitch point and concentric with the base circle.

25. What is cam angle?

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

#### Unit 4: GEARS

1. What is an angle of obliquity in gear?

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 also called as pressure angle.

2. 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.

Types.

- 1) Skew bevel gearing
- 2) Spiral gearing.

3. What is meant by arc of approach?

It is the portion of the path of contact from the beginning of the engagement to the pitch point.

4. What is meant by arc of recess?

It is the position of the path of contact from pitch point to the end of the engagement to the pitch point.

5. What is meant by Arc of contact?

It is the path traced by a point on the pitch circle from the beginning to the end of engagement of a pair of teeth.

6. 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.

7. Define normal and axial pitch in helical gears.

Normal pitch is the distance between similar faces 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 adjacent teeth.

8. 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.

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

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

10. 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.

11. Define contact ratio.

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

12. Where will the interference occur in an involute pinion and gear are in mesh having same size of addendum?

There will be an interference between the tip of pinion and flank of gear.

13. Define interference.

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

14. What you meant by non standard gear teeth?

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

15. 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.

16. Define Backlash.

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

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

17. What is gear train?

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

18. What are the types of gear trains?

1. Simple gear train.
2. Compound gear train.
3. Reverted gear train.
4. Epicyclic gear train.

19. Write velocity ratio in compound train of wheels?

Speed of last follower- Product of teeth on drives.

Speed of first driver- Product of teeth on followers.

20. Define simple gear train.

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

21. What is meant compound gear train?

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

22. 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.

23. 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.

24. What are 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.

25. 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.

## Unit 5: **FRICTION**

### 1. What is dry friction?

The friction that exists between two unlubricated surfaces is known as dry friction.

### 2. What is greasy friction?

When the two surfaces in contact have a minute thin layer of lubricant between them, then it is called as greasy friction.

### 3. What is fluid friction?

When the two surfaces in contact are completely separated by a lubricant, then it is called as fluid friction.

### 4. State the laws of dry friction.

1. The frictional force is directly proportional to the normal reaction between the surfaces.
2. The frictional force opposes the motion.
3. The frictional force is independent of the area and the shape of the contacting surfaces.

### 5. State the laws of fluid friction.

1. The frictional force is almost independent of load.
2. The frictional force is independent of the substances of the bearing surfaces and opposing tendency is less.
3. The frictional force reduces with increase in temperature of the lubricant.

### 6. What is angle of repose?

The angle of repose is defined as the maximum inclination of a plane at which a body remains in equilibrium over the inclined plane by the assistance of friction only.

### 7. What is limiting angle of friction?

The limiting angle of friction is defined as the angle at which the resultant reaction R makes with the normal reaction.

### 8. Define Co-efficient of friction.

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

$$\mu = F / R_n$$

### 9. What is the efficiency of the inclined plane?

The efficiency of inclined plane is defined as the ratio between effort without friction and the effort with friction.

10. Why self locking screws have lesser efficiency?

Self locking screws need 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.

11. 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.

12. 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.

13. 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, 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.

14. What are the belt materials?

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

15. Explain velocity ratio.

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

16. 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.

17. What is slip?

The relative motion between belt and pulley due to insufficient friction is called slip.

18. What is creep?

The phenomenon of sudden contraction and expansions of belt when it passes from slack side to tight side is called as creep.

19. What is centrifugal effect on belts?

During operation, as the belt passes over a pulley the centrifugal effect due to its self weight to lift the belt from the pulley surface. This reduces the normal reaction and hence the frictional resistance.

20. What 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. What is whipping?

If the centre distance between two pulleys are too long then the belt begins to vibrate in a direction perpendicular to the direction of motion of belt. This phenomenon is called whipping. It can be avoided by idler pulleys.

22. 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.

23. What you meant by crowning in pulley?

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

24. What is 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.

25. Explain self energizing.

When moments of efforts applied on the break drum and frictional force are in the same direction, the breaking torque becomes maximum. In such a case the brake is said to be partially self actuating or self energizing.