KNOWLEDGE INSTITUTE OF TECHNOLOGY,SALEM.

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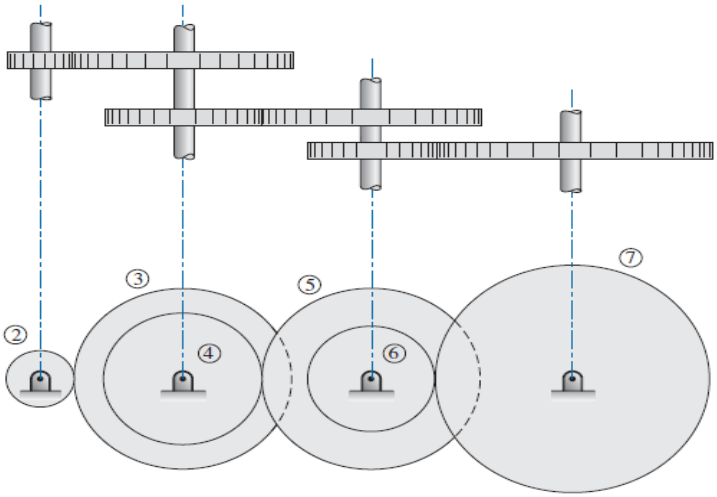
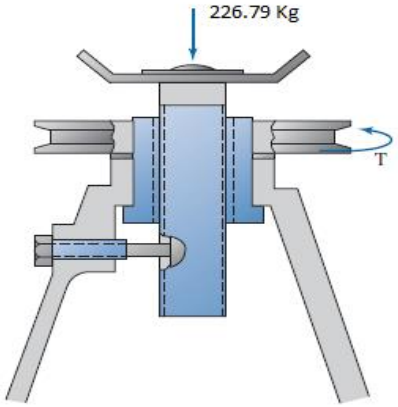
Question Bank

KINEMATICS OF MACHINERY

Department of Mechanical Engineering



7. A screw jack mechanism is shown in Figure. A belt/sheave is used to rotate a nut, mating with a single-thread, 1–5 ACME screw, to raise the jack. Notice that a pin is used in a groove on the screw to prevent the screw from rotating. The nut rotates at 300 rpm. Determine the lifting speed of the jack, the torque required, and the efficiency of the jack.



TWO MARKS QUESTIONS & ANSWERS

UNIT 1 -BASICS OF MECHANISMS

PART- A

1. Differentiate between analysis of mechanisms and synthesis of mechanisms.

Analysis of mechanisms	Synthesis of mechanisms
Analysis involves the study of motion and forces concerning different parts of the mechanism. In the analysis, the kinematic quantities, i.e., displacement, velocity and acceleration of the parts are determined.	Synthesis involves the design of various parts of machine concerning(I) its shape and size, (ii) materials to be so that the resulting machine can perform the desired tasks

2. Differentiate between rigid body and resistant body.

Rigid Body	Resistant Body
Rigid body means a body with no deformation when the required force is transmitted.	A body is said to be a resistant if it is capable of transmitting the required force with negligible deformation.

3. Define kinematic link (or element).

A kinematic link, also known as an element, is defined as a single part (or an assembly of rigidly connected parts) of a machine which has motion relative to some other part of the machine.

4. What are the different types of links?

Rigid link

Flexible link

Fluid link

5. A spring used in a machine/mechanism is not treated as a kinematic link. Why?

Because a kinematic link must be a resistant body. As spring deforms in the direction of applied force, it is not a resistant body and hence it is not treated as a link.

6. Differentiate between a machine and a structure.

S.No	Machine	Structure
1	The part of machine move relative to one another.	The member of structure does not move relative to one other.
2	Machine transform available energy into useful work	Structure does not transform energy in to the useful work.
3	The link of m/c made transmit both power relative motion and forces.	The members of structure transmit forces only.
4	Machine can have one or more mechanism	It does not have mechanism.
5	E,g: Washing machine, Grinding machine, Shaper.	E,g: Railway Bridge, truss, Machine frames.

7. Classify the constrained motions.

Completely constrained motion

Incompletely constrained motion

Successfully constrained motion

8. Define kinematic pair.

When any two links are connected in such a way that their relative motion is completely or successfully constrained, they form a kinematic pair.

9. Classify kinematic pairs

I. Based on the nature of contact between the pairing elements
   - Lower Pair
   - Higher Pair

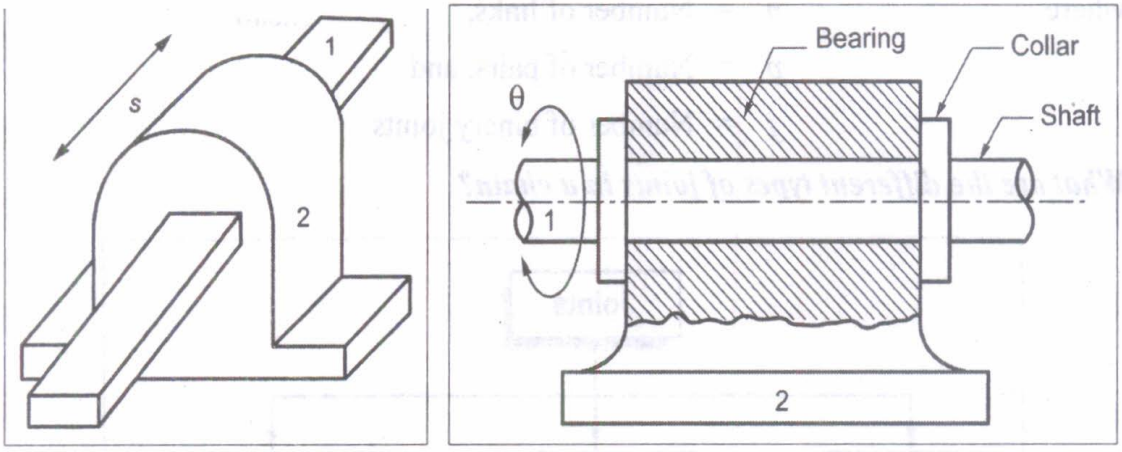
II. Based on the type of mechanical constraint (or mechanical contact)
   - Self-Closed Pair
   - Force Closed Pair

III. Based on the type of relative motion between the elements of the pair
   - Sliding Pair
   - Rolling Pair
   - Turning Pair
   - Screw Pair (or Helical Pair)
   - Cylindrical Pair
   - Spherical Pair

10. Differentiate between lower pair and higher pair with examples.

Lower Pair	Higher Pair
If a kinematic pair has a surface or area of contact between the two links.	If a kinematic pair in motion has a line or point contact between the two links.
E.g: Nut and Bolt, Ball and Socket Joint, Shaft rotating in bearings.	E.g: Cam and follower, roller bearings, ball bearings.

11. Illustrate any two types of constrained pair.



a. Sliding pair b. Turning pair

12. Identify the possible motion and flame of the following combinations:
(a) Members of a scissor.
(b) A two pin plug inserted in a two pin socket.

(a) Members of a scissor:
Types of motion: Incompletely constrained motion.
Types of pair: Lower pair (and also closed pair)
(b) A two pin plug inserted in a two pin socket:
Types of motion: Completely constrained motion.
Types of pair: Lower pair (and also unclosed pair)

13. State atleast one similarity and one difference between a helical pair and a cylindrical pair.

Similarity: Both are lower pairs.
Difference: Helical pair has one degree of freedom, whereas the cylindrical pair has two degrees of freedom.

14. Define kinematic chain.

A kinematic chain is defined as the combination of kinematic pairs in which each link forms a part of two kinematic pairs and the relative motion between the links is either completely constrained or successfully constrained.

15. What are the different types of joints in a chain?

Binary joint, Ternary joint & Quaternary joint.

16. Write the difference between a mechanism and a machine.

S.No	Mechanism	Machine
1	Mechanism transmits and modifies the motion.	Machine changes the mechanical work.
2	A mechanism is an outline of the machine to produce define motion between various links or joints.	Machine will have many mechanisms for transmitting the mechanical work or power.
3	Where kinematic chain is analyzed as a mechanism, no special consideration need to be given to the formed cross-section of the links.	In a machine, cross-section and proportions are to be considered to give stiffness, strength, and clearance to the paths of the machine.
4	Examples of mechanisms are clocks, typewriter, steering mechanism in a car, etc.	Examples of the machine are slotting, lathe, shaper in the workshop, (Shaper receives mechanical power which is

		suitably converted to do the work of cutting the metal), etc.

17. Define degrees of freedom of a mechanism.

The degree of freedom of a mechanism is the number of independent parameters required to specify the location of every link within the mechanism.

18. Define mobility of a mechanism.

The mobility of a mechanism is defined as the number of inputs required to produce the constrained motion of the mechanism.

19. Give the DOF for a shaft in a circular hole.

Since a circular shaft moving in a circular hole have both rotations and sliding, it has 2 degrees of freedom.

20. What is Kutzbach criterion for planar mechanism?

The Kutzbach criterion for planar mechanisms is given by

DOF = 3 (n - 1) – 2l - h

n = Number of links,

l = Number of lower pairs, and

h = Number of higher pairs.

21. What do you mean by inversion of mechanism?

The process of obtaining different mechanisms by fixing different links in a kinematic chain is known as inversion of the mechanism.

22. State Grashof's law for a four-bar linkage.

Grashof's law states that for a planar four-bar mechanism, the sum of the shortest and longest links must be less than or equal to the sum of the lengths of two other links, if there is to be continuous relative rotation between two members.

23. What is the significance of Grashof's law for a four-bar mechanism?

For four-bar chain, Grashof's law is used to test whether any of the links in the chain can be a crank.

24. Write down the different types of kinematic chain.

i). Four bar chain

ii). Single slider crank chain

iii). Double slider crank chain

25. What are the conditions to obtain a four-bar crank-rocker mechanism?

When (i). $s+l \leq p+q$ and (ii) the shortest link is fixed.

26. State Grubler's criterion for planar mechanisms.

Grubler's criterion for planar mechanisms is given by

$3n-2l-4=0$

Where n=Number of links

l= Number of lower pairs

27. What is Kutzbach criterion for planar mechanism?

The Kutzbach criterion for planar mechanisms is given by

DOF = 3 (n - 1) - 2 l - h

n = Number of links,

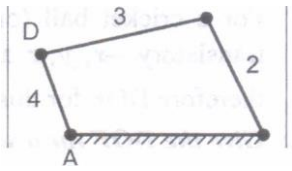
l = Number oflower pairs, and

h = h=Number of higher pairs.

28. Draw a four-bar mechanism and show that it has one degree of freedom.

The four-bar mechanism is shown in Fig. It has four links and four binary joints. i.e., n = 4; j = 1= 4; h = 0

DOF:
We know that
DOF= 3(n-1)-2l-h
=3 (4 - 1) - 2 (4) - 0 = 1



29. How many inversions are possible from a four-bar kinematic chain? Name them based on their input-output motions.

Theoretically, four inversions are possible from a four-bar mechanism.
First and second inversions form crank-rocker mechanism.
Third inversion forms double-crank mechanism.
Fourth inversion forms double-rocker mechanism.

30. Give any four inversions of four-bar chain.

Beam engine.
All rotary oscillating converters
Coupled wheels of a locomotive
Watt's indicator mechanism

31. Give any four inversions of a single slider chain.

Internal combustion engine
Reciprocation compressor/pump
Whitworth quick return mechanism
Oscillating cylinder engine
Pendulum pump

32. Give any two inversions of a double slider crank chain.

Elliptical trammel
Scotch yoke mechanism
Oldham's coupling

33. Name any four common mechanisms with specific applications.

S.No	Mechanism	Application
l.	Crank-lever mechanism	Beam engine
2.	Double-crank mechanism	Coupled wheels of a locomotive
3.	Double-rocker mechanism	Watt's indicator diagram
4.	Whitworth quick return mechanism	Shaping and slotting machines

34. Define sliding connectors.

Sliding connectors are used when one slider (the input) is to drive another slider (the output). Usually the two sliders operate in the same plane but in different directions.

35. What is the use of elliptical trammel?

Elliptical trammel is an instrument used for drawing ellipses.

36. What is the purpose of scotch yoke mechanism?

The scotch yoke mechanism is used for converting rotary motion into reciprocating motion.

37. When do you use Oldham's coupling?

Oldham's coupling is used for transmitting motion between two shafts when (i) the shafts are parallel, but not coaxial; and (ii) the centre distance between their centre lines is small.

38. Define mechanical advantage of a mechanism.

The mechanical advantage of a mechanism is defined as the ratio of the output torque exerted by the driven link to the required input torque at the driver link.

39. Define transmission angle of a four-bar mechanism. What is the worst value of transmission angle?

The angle between the coupler link and the driven link (or follower) is known as transmission angle (γ). The worst value of transmission angle is less than 45°.

40. What is toggle position?

Toggle position is the position of a mechanism at which the mechanical advantage is infinite and the sine of angle between the coupler and the driving link is zero or 180°

41. What is the use of offset slider-crank mechanism?

The offset slider crank mechanism is essentially used as a quick return mechanism, in which return stroke is executed quickly as compared to the working stroke.

42. What is pantograph?

Pantograph is a mechanism used to reproduce path described by a exactly on an enlarged or reduced scale.

43. What are the applications of pantograph?

Pantographs are:

i). Used in drawing offices for duplicating the drawings, maps, plans, complicated drawings, etc., on an enlarged or reduced scale.

ii). Used in profile grinding, in engraving machine.

iii). Used in guiding cutting torch to generate contour similar to that of a template.

44. How can you classify the straight line motion mechanisms?

i). Exact straight line motion mechanism- The Peaucellier mechanism, The Hart mechanism & The Scott-Russel mechanism.

ii). Approximate straight line motion mechanism- The Watt mechanism, The Grass Hopper's mechanism, The Tchebicheft mechanism & The Roberts mechanism.

45. List out the applications of straight line motion mechanisms.

(i) Used to machine straight and flat surfaces.

(ii) Used in self-recording instruments in indicator mechanism.

(iii) Used in level lifting crane to achieve horizontal straight line movement.

(iv) Used in a mechanism used for advancing film of a movie camera.

46. What is the condition of correct steering of an automobile?

The condition of correct steering is that the relative motion between the wheels and the road surface should be that of pure rolling while taking a turn, avoiding any lateral slip (skidding).

47. What are indexing mechanisms?

Indexing mechanisms are generally used to convert a rotary or oscillating motion to a series of step movements (i.e., intermittent motion) of the output link or shaft.

48. What are ratchets and escapements?

i). Ratchets are used to ensure that the motion of the output device is allowed in only one direction.

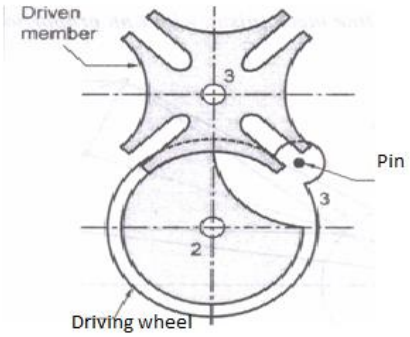
ii). Escapements are used to control continuous motion to produce a highly controlled step motion (i.e., intermittent motion) at a fixed rate.

49. List any two applications of Hooke's joints.

i). In automobiles, Hooke's joints are used for power transmission from the gear box to the back axle.

ii). In multi-spindle drilling machines, Hooke's joints are used for the transmission of power to different spindles.

50. Sketch the Geneva wheel indexing mechanism and state its applications.



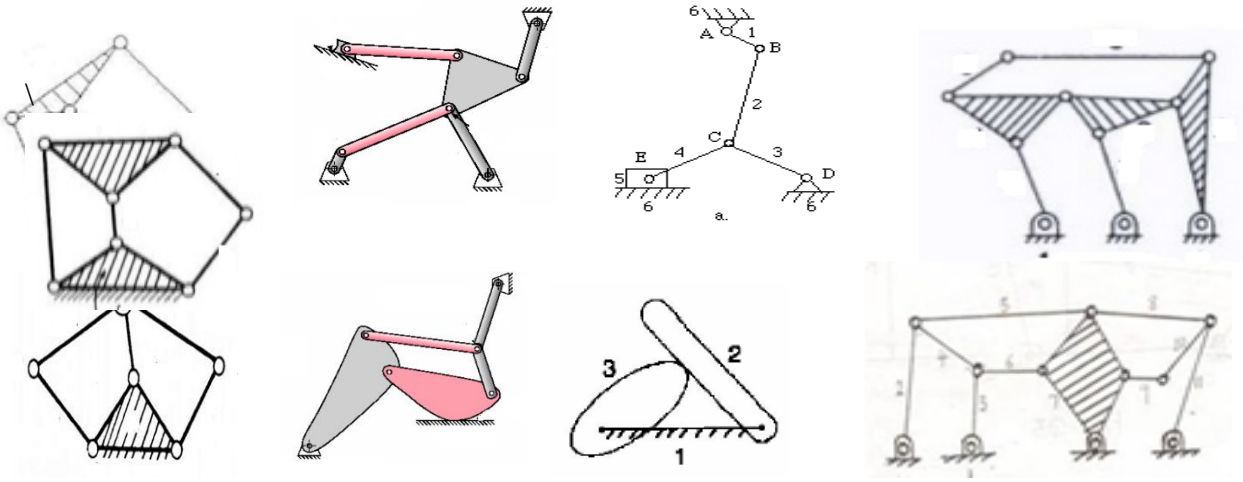
Application: Geneva mechanisms are used in machine tools for indexing the turret or work table.

51. What is low degree of complexity?

In a complex mechanism, if only one radius of path curvature of one motion transfer point is not known, such a mechanism is called a mechanism with low degree of complexity.

PART B & C

1. Sketch and explain inversions of a single slider crank chain.
2. Sketch and explain inversions of a double slider crank chain.
3. Define and explain inversion of four-bar mechanisms.
4. Explain Classification of Kinematic pair with neat diagrams.
5. Explain types of Kinematic pair with neat diagrams
6. Explain maximum and minimum transmission angle.
7. Sketch and explain about quick return motion mechanism.
8. Find number of Degrees of Freedom for the following figures.



9. Explain the following mechanisms with neat diagram (1) Approximate Straight line mechanism (2). Watt's straight line mechanism (3). Peaucellier Mechanism. (4). Hart's Mechanism. (5). Pantograph. (6). Offset slider crank mechanism (7). Ratchet and Pawl mechanism (8). Geneva wheel (9) universal joint (10). Indexing mechanism.

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UNIT: II KINEMATICS OF LINKAGE MECHANISM

PART- A

1. Differentiate between rotation and translation.

i). Translation is defined as a state of motion of body for which the displacement difference between any two points is zero.

ii). Rotation is a state of motion of the body for which different points of the body are equal.

2. 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.

3. What is a configuration diagram? What is its use?

i). Configuration diagram is a line sketch of a given mechanism drawn to a suitable scale.

ii). The configuration diagram forms the basis for the construction of both velocity and acceleration diagrams.

4. Define rubbing velocity at a pin joint. What will be the rubbing velocity at pin joint when the two links move in the same and opposite directions?

Definition: The rubbing velocity is defined as the algebraic sum between the angular velocities of the two links which are connected by pin joints, multiplied by the radius of the pin.

Rubbing velocity at pin joint when the two links move in opposite direction = $(\omega_1 + \omega_2)\, r$

Rubbing velocity at pin joint when the two links move in opposite direction = $(\omega_1 - \omega_2)\, r$

Where ω_1 and ω_2 =Angular velocities of two links, and

r = Radius of the pin.

5. How the direction of the angular velocity is found out during velocity analysis of a mechanism by graphical method?

By using right hand screw rule.

6. Explain normal component of acceleration.

Normal or radial component of acceleration IS perpendicular to the velocity of the particle at the given instant. The magnitude is given by $a^r_{BA} = \omega^2 . AB = v^2_{BA} / AB$.

7. Distinguish normal component of acceleration and tangential component of acceleration.

Normal (or radial or centripetal) component is perpendicular to the velocity of the particle at the given instant. In other words, the normal component acts parallel to the link.

$a^r_{link} = \omega^2$ x Length of link = v^2_{link} / Length of link

Tangential component is parallel to the velocity of the particle at the given instant. In other words, it acts perpendicular to the link,

$a^t_{link} = \alpha$ x Length of link

8. What type of link will have only centripetal component of acceleration and what types of link will have only linear acceleration?

i). The link which rotates at a constant velocity will have only centripetal i.e., radial component of acceleration.

ii). The link which moves in a linear direction will have only linear i.e., tangential component of acceleration.

9. How will you determine the total acceleration of a point on a link, when the normal component of acceleration and the tangential component of acceleration are known?

The total acceleration of a point on a link is the vector sum of their components of the radial acceleration and tangential acceleration.

10. What is a coincident point?

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

11. State Coriolis law.

Whenever a point on one link is sliding along another rotating link, then the total acceleration will have one additional acceleration component known as Coriolis component.

12. What is Coriolis component of acceleration?

Coriolis component of acceleration occurs when a point on one link is sliding along another rotating link, such as in quick return mechanism.

13. When Coriolis component of acceleration occur?

Coriolis component of acceleration occurs when a point on one link is sliding along another rotating link, such as in quick return mechanism.

14. Name two mechanisms: one where Coriolis acceleration is encountered and another where Coriolis acceleration is not encountered.

i). In the mechanisms such as crank and slotted lever mechanism, Whitworth quick return mechanism and oscillating cylinder mechanism, Coriolis acceleration is encountered .

ii). In the mechanisms such as four-bar chain, slider-crank mechanism and toggle mechanisms, Coriolis is not encountered.

15. State the condition for a link to experience Coriolis acceleration (or for what kind of relative motion, the Coriolis component of acceleration occurs?

Coriolis acceleration occurs when a point on one link is sliding along another rotating link, such as in quick return mechanism.

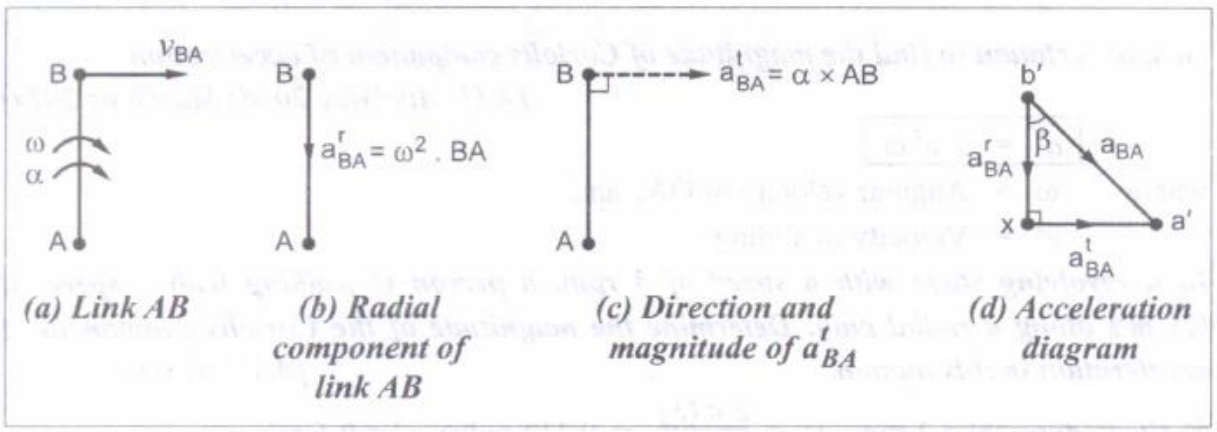
16. Give the relation to find the magnitude of Coriolis component of acceleration.

$a^c = 2 v^s \omega$

where, ω= Angular velocity

v^s = Velocity of sliding

17. Draw an acceleration polygon for a crank rotating at an angular speed of 'OJ' rad/s and angular acceleration of 'a' rad/s^2 .



(a) Link AB *(b) Radial component of link AB* *(c) Direction and magnitude of a^t_{BA}* *(d) Acceleration diagram*

18. In a revolving stage with a speed of 3 rpm, a person is walking with a speed of 0.5 m/s along a radial path. Determine the magnitude of the Coriolis component of acceleration in this motion.

☹ ***Given data:*** N = 3 rpm; $\omega = \frac{2\pi(3)}{60} = 0.314$ rad/s; $v^s = 0.5$ m/s.

☺ ***Solution:*** Coriolis acceleration, $a^c = 2 v^s \omega$

$= 2 \times 0.5 \times 0.314 =$ **0.314 m/s^2 Ans.**

19. A slider sliding at 100 mm/s on link, which is rotating at 60 rpm is subjected to Coriolis acceleration. Find its magnitude.

Given Data: $v^s = 100$ mm/s $= 0.1$ m/s; N $= 60$ rpm on $\omega = 2\pi\,(60)/60 = 6.28$ rad/s

☺ ***Solution:*** Coriolis acceleration, $a^c = 2\,v^s\,\omega$

$= 2 \times 0.1 \times 6.28 =$ **1.256 m/s^2** **Ans.** ☜

20. How the direction of Coriolis component of acceleration is determined?

The direction of Coriolis component is the direction of relative velocity vector for the two coincident points rotated at 90° in the direction of angular velocity of rotation of link.

21. On rotating link with a speed of 15 rpm, a slider is moving with a linear velocity, v. The linear velocity vector is acting in north-east direction and the Coriolis acceleration vector of magnitude 125.67 mm/s^2 acts in south-east direction. Sketch the vectors, and determine the sense of rotation of the rotating link, and the magnitude of linear velocity vector, v.

☹ ***Given data:*** N $= 15$ rpm; $a^c = 125.67$ mm/s^2 $= 0.12567$ m/s^2

☺ ***Solution:*** $\omega = \dfrac{2\pi N}{60} = \dfrac{2\pi\,(15)}{60} = 1.571$ rad/s

We know that the Coriolis component of acceleration,

$$a^c = 2\,v^s\,\omega$$

$$0.12567 = 2\,v^s\,(1.571)$$

or Magnitude of linear velocity, $v^s =$ **0.04 m/s** **Ans.** ☜

The directions of v^s and a^c are given and are shown in Fig.5. Therefore the sense of rotation of the rotating link is ***clockwise direction.*** **Ans.** ☜

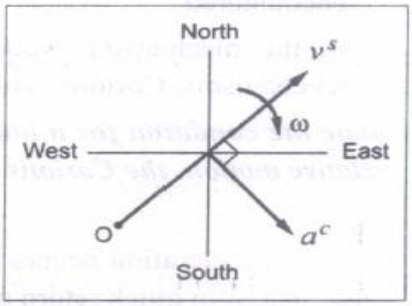


Fig. 5.

22. What is meant by virtual centre or instantaneous centre?

The combined motion of rotation and translation of the link may be assumed to be a motion of pure rotation about some centre known as virtual centre or instantaneous centre.

23. Write the equation to determine the number of instantaneous centres of a mechanism.

Number of instantaneous centres, N=(n(n-1))/2

Where, n= Number of links

24. How many instantaneous centres are possible in a four bar chain mechanism?

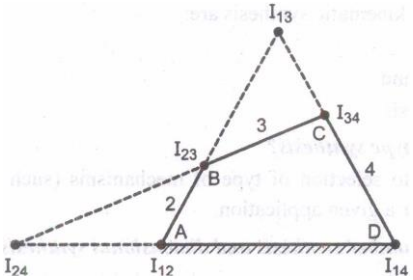
Number of instantaneous centres, N=(n(n-1))/2

Where, n= Number of links

In four bar chain mechanism, n=4

N=(4(4-1))/2= 6 centres are possible.

25. Illustrate the instantaneous centres of a typical four bar.



26. How many instantaneous centres are in a single slider crank mechanism?

In a single slider crank mechanism, there are four links.

Number of instantaneous centres, $N = \frac{n(n-1)}{2} = \frac{4(4-1)}{2} = 6$

27. What are the types of instantaneous centres?

i). Fixed instantaneous centres

ii). Permanent instantaneous centres, and

iii). Neither fixed nor permanent centres.

28. Define Aronhold-Kennedy's theorem.

The Kennedy's theorem states that if three bodies have relative motion with each other, then their relative instantaneous centres lie on a straight line.

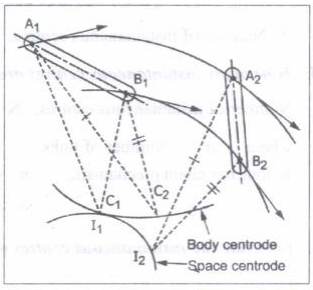
29. Define angular velocity ratio theorem.

The angular velocity ratio theorem states that the angular velocity ratio of two links relative to a third link is inversely proportional to the distances of their common instantaneous centre from their respective centres of rotation.

30. Explain with a neat sketch, the space centrode and body centrode .

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

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



31. What the stages of kinematic synthesis?

The three stages of the kinematic synthesis are:

i). Type synthesis,

ii). Number synthesis, and

iii). Dimensional synthesis.

32. What do you mean by type synthesis?

Type synthesis refers to selection of type of mechanisms (such as gears, cams, belts, etc.) to be employed for a given application.

33. Distinguish between number synthesis and dimensional synthesis.

i). Number synthesis refers to the determination of the number and order of links and joints required for a specified motion.

ii). Dimensional synthesis refers to the determination of the dimensions of parts (i.e., lengths and angles) so as to accomplish specified task and desired motion characteristics.

34. What are the tasks of kinematic synthesis?

i). Function generation,

ii). Path generation, and

iii). Motion generation

35. Differentiate between path generation and motion generation.

i). In path generation, a point on the coupler link is constrained to describe a path with reference to a fixed frame.

ii). In motion generation, a mechanism is designed to guide a rigid body in a specified path.

36. What do you mean by coupler curve?

When the linkage is put into motion, any point attached to the plane of coupler generates some path/curve with respect to frame link. This path or curve is called coupler curve.

37. State the Freudenstein's equation for a four-bar mechanism.

Freudenstein's equation is given by

$k_1 \cos \phi + k_2 \cos \theta + k_3 = (\cos (\theta - \phi)$

where $k_1 = d/a$, $k_2 = -d/c$ and $k_3 = (a^2 – b^2 + c^2 + d^2) / 2ac$

a,b, c and d are magnitudes of four links.

θ and ϕ are the angles made with horizontal by the input and follower links respectively.

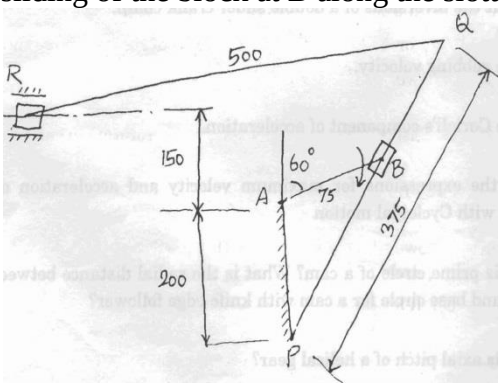
38. State the relationship between crank angle (θ) and connecting rod angle Φ of single slider-crank mechanism.

$\sin \phi = r/l$, $\sin \theta = \sin \theta / n$

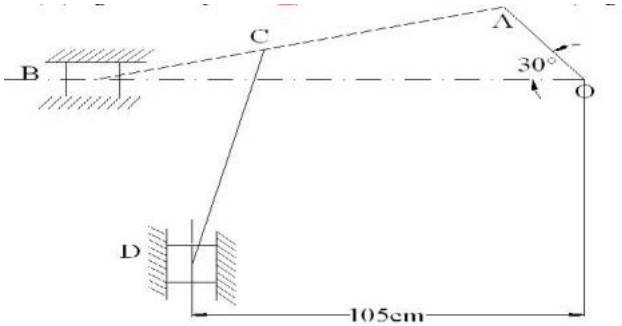
PART B & C

1. In a four bar mechanism, the crank rotates at 36 rad/s. The lengths of the links are AB = 200 mm; BC = 400 mm; CD = 450 mm and AD = 60 mm. AD is the fixed link. At the instant when is at right angle to AD, determine the velocity of (i) the mid-point of the link BC (ii) a point on link CD, 100 mm from the pin connecting the links CD and AD.
2. In a four bar chain ABCD ,AD is fixed 150mm long. The crank AB is 40mm long and rotates at 120 rpm clockwise. While the link CD = 80mm oscillates about D .BC and AD are of equal length Find the angular velocity of link CD when angle BAD = 60degree.
3. PQRS is four bar chain with link PS fixed. The lengths of the link are PQ = 62.5mm, QR = 175mm; and RS = 112.5mm; and PS = 200mm. The crank PQ rotates at 10 rad/s clockwise. Draw the velocity and acceleration diagram when angle QPS = 60 degree and Q and R lie on the same side of PS, Find the angular velocity and angular acceleration of links QR and RS.
4. A slider crank mechanism has crank CB = 100mm and the connecting road BA = 300mm with Centre of gravity G 100mm from B as shown in fig (3) below. The crankshaft has a speed of 75 rad/s and an angular acceleration of 1200 rads/s2. Find 1.velocity of G and angular velocity of AB and 2.accleleration of G and angular acceleration of AB.
5. The Crank of a slider crank mechanisms rotates clockwise at a Constant speed of 300 r.p.m. The crank is 150 mm and connecting rod is 600 mm long. Determine 1. Linear velocity and acceleration of the mid-Point of the connecting rod, and 2. Angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead centre position.
6. Locate all instantaneous centers of the slider crank mechanism; the length of crank OB and connecting rod AB are 125 mm and 500 mm respectively. The crank speed is 600 rpm clockwise. When the crank has turned 45° from the IDC. Determine (i) velocity of slider' A' (ii)Angular velocity of connecting rod 'AB'.
7. A four bar linkage has following dimensions: Crank AO2 = 150 mm; Link AB = 450 mm; Link BO4 = 300 mm; Link O2O4 = 200 mm. Link O2O4 is fixed. Find the angular acceleration of links AB and BO4 when the crank is rotating with a constant angular velocity of 200 rad/s counter clockwise and also positioned of 45° to horizontal.
8. The driving crank AD of the quick-return mechanism, as shown in figure, revolves at a uniform speed of 200 r.p.m. Find the velocity and acceleration of the tool-box R, in the

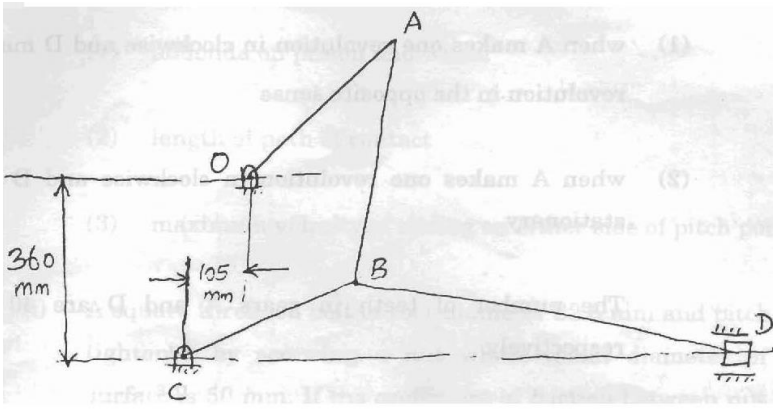
position shown, when the crank makes an angle of 60°with the vertical line of centers PA. What is the acceleration of sliding of the block at B along the slotted lever PQ?



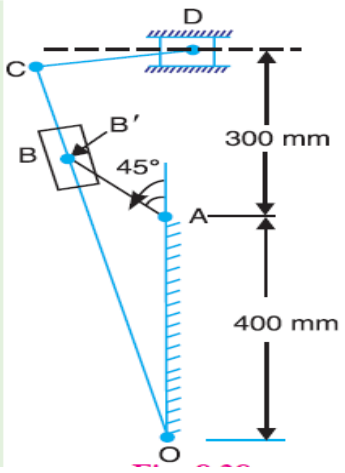
9. In the mechanism shown in figure , the crank OA rotates at 20 rpm anticlockwise and gives motion of sliding blocks B and D. The dimensions of various links are OA = 300mm, AB = 1200 mm, BC = 450 mm and CD = 450 mm. For the given configuration determine i) velocities of sliding at B and D, ii) angular velocity of CD iii) Linear acceleration of D and iv) angular acceleration of CD



10. For the toggle mechanism as shown in figure, the slider D is constrained to move along horizontal direction. The crank rotates at 180 rpm. The dimensions of various links are as follows. OA = 180 mm ; CB = 240 mm; AB = 360 mm; BD = 540 mm. For the given configuration determine the velocity of the slider and angular velocities of links AB, BC and BD. Also determine the linear acceleration of the slider D.



11. A mechanism of a crank and slotted lever quick return motion is shown in Fig. If the crank rotates counter clockwise at 120 r.p.m., determine for the configuration shown, the velocity and acceleration of the ram D. Also determine the angular acceleration of the slotted lever. Crank, AB = 150 mm; Slotted arm, OC = 700 mm and link CD = 200 mm.



UNIT: III KINEMATICS OF CAM MECHANISMS

PART- A

1. **What is a cam?**

A cam is a rotating mechanical member used for transmitting desired motion to a follower by direct contact.

2. **What are the three necessary elements of a cam mechanism?**

Cam: The driving member is known as the cam.
Follower: The driven member is known as the follower.
Frame: It supports the cam and guides the follower.

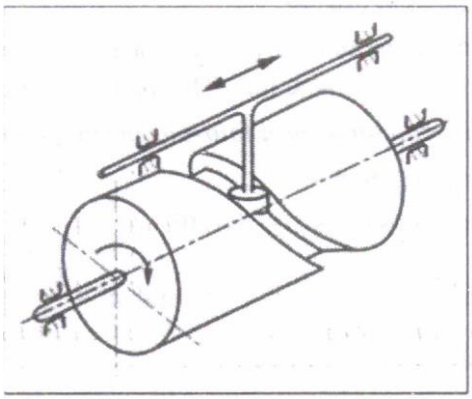
3. **State the advantages of cam mechanisms over linkage mechanisms**.

The cam mechanisms are preferred over linkage mechanisms in applications that require complex or irregular motion and work function requirements.

4. **What are the classifications of cams based on contact surfaces?**

i). Radial (or disc or plate) cams ii). Wedge (or flat) cams iii). Cylindrical (or barrel) cams, iv). Conical cams v). Globoidal cams, and vi). End (or face) cams.

5. **Sketch a cylindrical cam with the follower reciprocates in a direction parallel to the cam axis**.



6. **List any four types of cam followers**.

(i) Knife-edge follower (ii) Roller follower (iii) Flat-faced (or mushroom) follower and (iv) Spherical-faced follower.

7. **Classify followers according to the follower shape or surface in contact.**

(i) Knife-edge follower (ii) Roller follower (iii) Flat-faced (or mushroom) follower; and (iv) Spherical-faced follower.

8. **Classify followers according to the motion of the follower.**

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

9. **Classify followers according to the path of motion of the follower.**

i). Radial follower ii). Offset follower

10. **Why is a roller follower preferred to knife-edge follower?**

In roller followers, the wear rate is considerably reduced because of rolling motion between contacting surfaces.

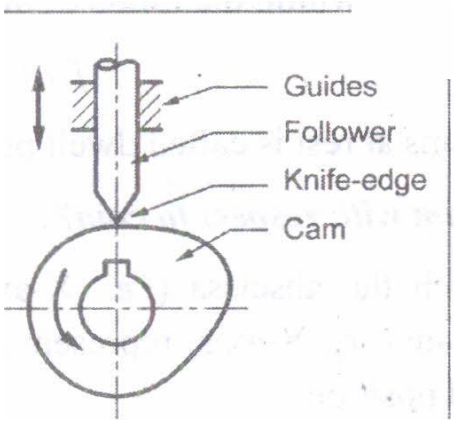
11. **State, at least, one advantage and one disadvantage of flat-faced follower over roller follower in a cam mechanism.**

Advantage: The thrust at the bearing is less as compared roller followers.
Disadvantage: It causes high surface stresses.

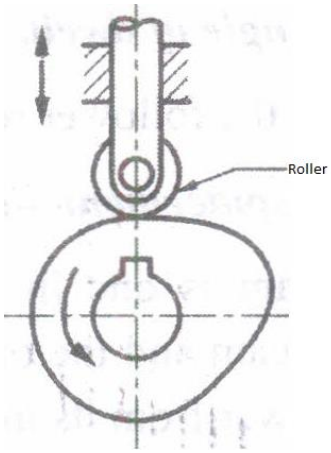
12. **Why sometimes the axes of translating roller followers in cam follower mechanisms are offset from the axis of rotation of cam?**

An offset is usually provided on a side so as to decrease pressure angle at the point of maximum velocity during outstroke in order to reduce the side thrust in guides of followers.

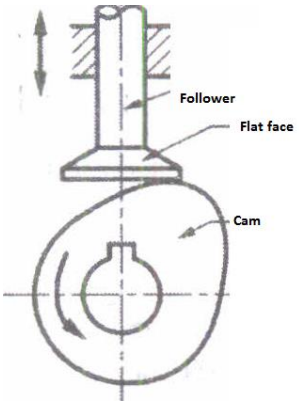
13. Sketch any four types of follower with cam arrangement.



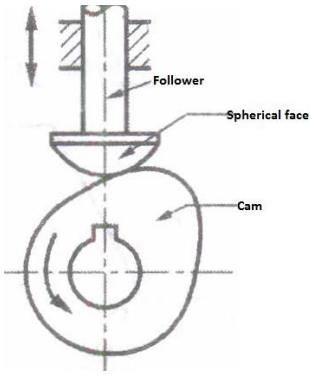
a). Knife Edge Follower



b). Roller Follower



c).Flat faced follower



d). Spherical faced follower

14. Define pitch curve of the cam.

The locus or path of the tracing point is known as the pitch curve.

15. What is prime circle of a cam? What is the radial distance between the prime circle and base circle for a cam with knife-edge follower?

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

ii). The radial distance between the prime circle and base circle for a cam with knife- edge follower is zero.

16. Define pressure angle of a cam mechanism and state the best value of the pressure angle.

i). Pressure angle is the angle between the line of action of the follower and corresponding normal to the pitch curve through trace point.

ii). The maximum pressure angle should be less than 30° for cams with reciprocating followers.

17. What is the significance of pressure angle in cam? (or why large pressure angle is not preferred in cam curves?)

i). The pressure angle is very important in cam design as it measures the effectiveness of cam to transfer driving force to the follower.

ii). Higher value of pressure angle results in higher value of side thrust at the guides and hence higher the chances of jamming the translating follower in its guide ways. The pressure angle should be as small as possible within the limits of design.

18. Define dwell period or angle of dwell.

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

19. What do you mean by displacement diagram with respect to cam?

The displacement diagram is one in which the abscissa (i.e., X-axis) represents the angular displacement of earn and the ordinate (i.e., Y-axis) represents the corresponding displacement of the follower from its initial position.

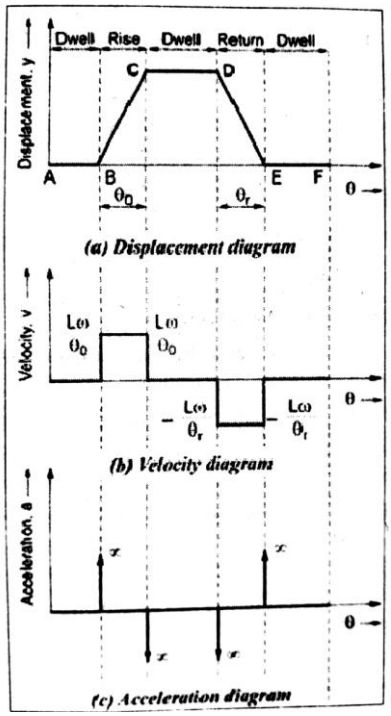
20. What are the different types of motion with which a follower can move?

i). Uniform velocity motion (or uniform motion),
ii). Simple harmonic motion (SHM),
iii). Uniform acceleration and retardation motion (UARM) (or Parabolic motion),
iv). Cycloidal motion.

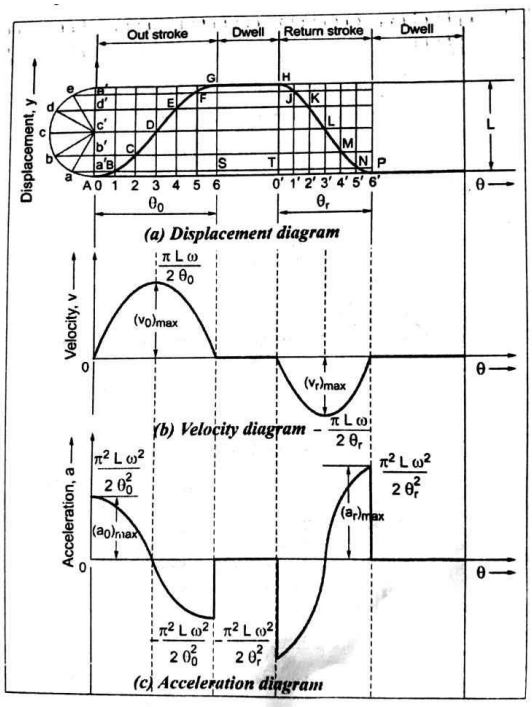
21. Why cams with specified contours are used?

In actual practice, in order to achieve ease of manufacturing and cheaper cost of production of cams, the cams with specified contours are used.

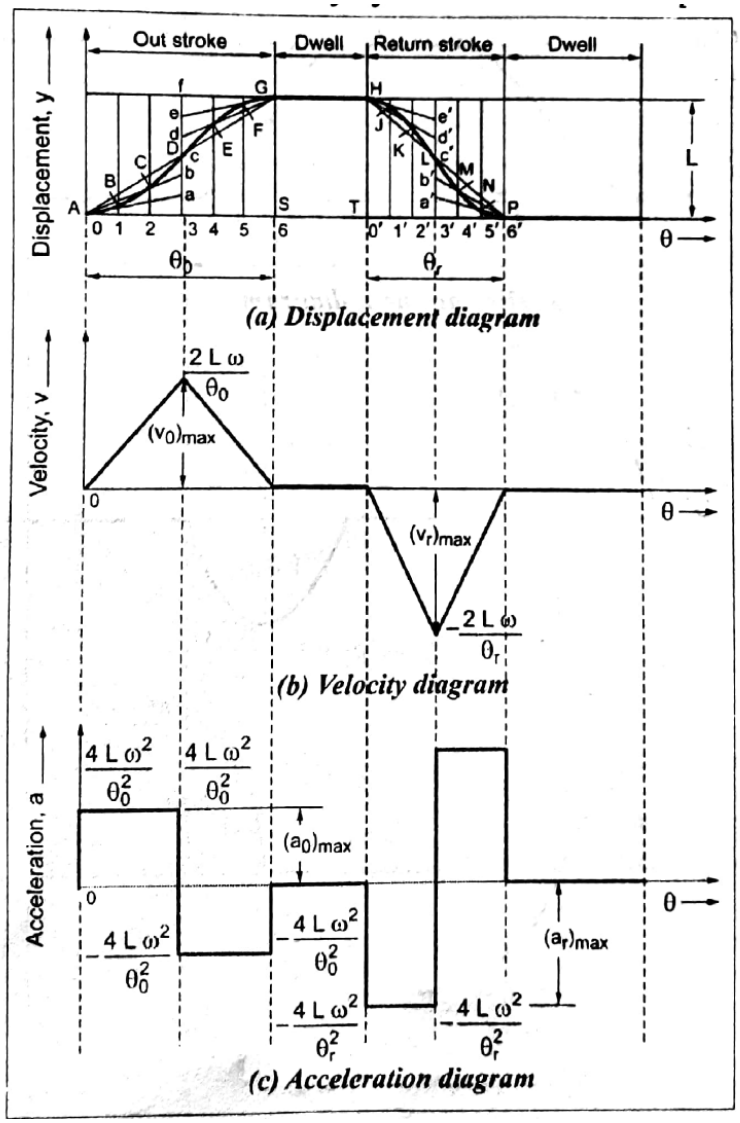
22. Sketch the displacement, velocity and acceleration diagram when a follower moves with uniform velocity.



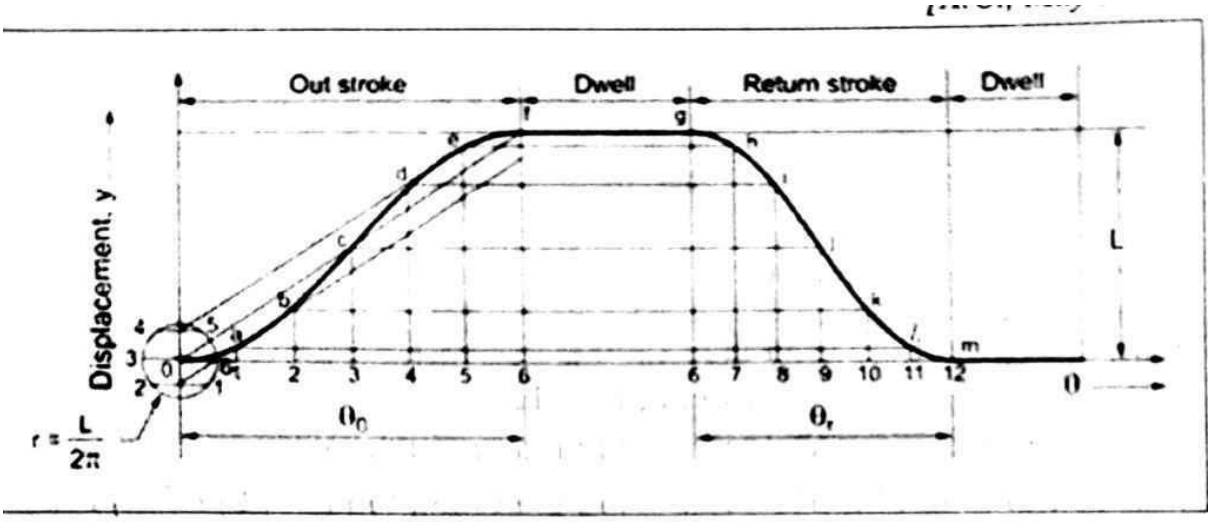
23. Sketch displacement, velocity and acceleration diagram of a follower which moves with simple harmonic motion and indicate the, maximum: velocity and maximum acceleration position.



24. Sketch the shapes of displacement, velocity and acceleration diagrams for uniform acceleration and retardation motion of a follower.



25. Construct the displacement diagram for the follower motion to be cycloidal.



26. State the expressions for maximum velocity and acceleration of a follower moves with cycloidal motion.

$$(v_o)_{max} = \frac{2 L \omega}{\theta_o} \qquad (v_r)_{max} = \frac{2 L \omega}{\theta_r}$$

$$(a_o)_{max} = \frac{2\pi L \omega^2}{\theta_o^2} \qquad (a_r)_{max} = \frac{2\pi L \omega^2}{\theta_r^2}$$

where L = Stroke of the follower,
ω = Angular velocity of the cam in rad/s, and
θ_0 and θ_r = Angle of ascent and angle of descent.

27. State the equations to determine the maximum velocity and the maximum acceleration when the follower has simple harmonic motion.

$$(v_o)_{max} = \frac{\pi L \omega}{2 \theta_o} \qquad (v_r)_{max} = \frac{\pi L \omega}{2 \theta_r}$$

$$(a_o)_{max} = \pm \frac{\pi^2 L \omega^2}{2 \theta_o^2} \qquad (a_r)_{max} = \mp \frac{\pi^2 L \omega^2}{2 \theta_r^2}$$

where L = Stroke of the follower,
ω = Angular velocity of the cam in rad/s, and
θ_0 and θ_r = Angle of ascent and angle of descent.

28. What is the follower motion used for high speed cams? Why?

The cams with cycloidal motion for followers are recommended for higher speeds. Because

the acceleration curve is continuous and the value of jerk is not infinite anywhere.

29. Name the types of cams with specified contours.

i). Tangent cams, and ii). Circular arc cams.

30. Define tangent cam.

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

31. What is a circular arc cam?

When, the flanks of the cam connecting the base circle and nose are of convex circular arcs, then the cam is known as circular arc cam.

32. List any four methods to reduce pressure angle of a cam.

The pressure angle can be reduced by using anyone or combination of the following ways:

(i) By increasing the earn size (i.e., by increasing the prime circle radius),

(ii) By adjusting the offset of the follower,

(iii) By changing the follower motion type, and

(iv) By reducing the follower total rise.

33. What do you mean by undercutting in cams?

If the curvature of the pitch curve is too sharp, then the part of the earn shape would be lost and thereafter the intended earn motion would not be achieved. Such a cam is said to be undercut.

34. List the various methods to eliminate undercutting.

The undercutting in the earn profile can be avoided:

i). By decreasing the desired follower lift,

ii). By increasing the earn rotation angle, and

iii). By increasing the cam size (i.e., the prime circle radius of the cam).

35. State the basic requirements for high speed cams.

For any high speed earn application it is extremely important that not only the displacement and velocity curves but also the acceleration curve be made continuous for the entire motion cycle. No discontinuities should be allowed at the boundaries of different sections of the cam.

36. State the advantages of tangent cam.

The tangent cams are usually symmetrical about the centre line of camshaft. The tangent cams with roller followers are used for operating inlet and exhaust values of I.C. engines.

PART B & C

1. Draw the profile of a cam operating a Knife-edged follower from the following data: (a) Follower to move outward through 40 mm during 60° of a cam rotation; (b) Follower to dwell for the next 45° (c) Follower to return its original position during next 90° (d)Follower to dwell for the rest of cam rotation. The displacement of the follower is to take place with simple harmonic motion during both the outward and return strokes. The least radius of the

cam is 50mm. If the cam rotates at 300 r.p.m., determine the maximum velocity and acceleration of the follower during the outward stroke and return stroke.

2. A cam with a minimum radius of 25mm, rotating clockwise at a uniform speed is to be designed to give a roller follower, at the end of a valve rod, motion described below.
   (1) To raise the valve through 50mm during 120degree rotation of the cam;
   (2) To keep the valve fully raised through next 30 degree
   (3) To lower the valve during next 60 degree and
   (4) To keep the valve closed during the rest of the revolution;
3. The diameter of the roller is 20mm and diameter of the cam shaft is 25mm. Draw the profile of the cam when the line of stroke is offset 15 mm from the axis of the cam shaft. The displacement of the valve, while being raised and lowered, is to take place with simple harmonic motion. Determine the maximum acceleration of the valve rod when the cam shaft rotates at 100 rpm. Draw displacement, the velocity and acceleration diagram for one complete revolution of the cam.
4. A cam with minimum radius of 50mm , rotating clockwise at a uniform speed is required to give a knife edge follower the motion has described below,
   To move outward through 40mm during 100 degree rotation of the cam;
   To dwell for next 80 degree ;
   To return to its rotating position during next 90 degree and
   To dwell for the next period of a revolution
5. Draw the profile of the cam when the line of stroke of the follower passes through the center of the cam shaft.The displacement of the follower is to take place with uniform acceleration and uniform retardation. Determine the maximum velocity and acceleration of the follower when the cam shaft rotates at 900rpm.Draw the displacement , velocity and acceleration diagram for one complete revolution of the cam.
6. It is required to set out the profile of the cam to give the following motion to the reciprocating follower with a flat follower;
   (a)The follower to have a stroke of 20mm during 120 degree of cam rotation.
   (b)Follower to a dwell for 30 degree
   (c)Follower to return to its ignition position during 120 degree of cam rotation ;
   (d)And follower to dwell for remaining rotation
   The minimum radius of the cam is 25mm , the outstroke of the follower is performed with SHM and the return stroke with equal uniform acceleration and retardation.
7. Construct the profile of the cam to suite the following specifications
   Cam shaft diameter = 40mm, least radius of the cam = 25mm, diameter of the roller =25mm, angle of lift =120 degree; angle of fall=150 degree; lift of the follower =40mm; number of pauses are two of equal interval between motions.During the lift, the motion is SHM. During fall off, the motion is uniform acceleration and retardation. The speed of the cam shaft is uniform. The line of stroke the follower is off set 12.5mm from the center of the cam.
8. Draw the profile of a cam operating a roller reciprocating follower and with the following data: Minimum radius of cam =25 mm; lift=30mm; Roller diameter= 15mm. The cam lifts the follower for 120° with SHM, followed by a dwell period of 30°. Then the follower lowers down during 150° of cam rotation with uniform acceleration and retardation followed by a dwell period. If the cam rotates at a uniform speed of 150 RPM. Calculate the maximum velocity and acceleration of follower during the descent period.
9. A cam drives a flat reciprocating follower in the following manner: (i) Follower moves outwards through a distance of 20 mm with simple harmonic motion during the first 120° rotation of the cam. (ii) Follower dwells during next 30° of cam rotation. (iii) Follower

moves inwards with UAAR for the next 120° of cam rotation. (iv) The follower dwells for the remaining period. Draw the profile of the cam, when the minimum radius of cam is 25 mm. Also calculate the maximum velocity and acceleration during outward and inward motion of the follower when the cam rotates with 200 rpm.

10. Layout the profile of a cam operating a roller reciprocating follower for the following data. Lift of follower = 30mm; Angle during the follower rise period =1200; angle during the follower after rise = 300; angle during the follower return period = 1500. Angle during which follower dwell after return = 600; minimum radius of cam = 25mm; Roller diameter =10mm. The motion of follower is uniform acceleration and deceleration during the rise and cycloid motion during return period
11. Classify with neat sketches the cam follower according to their shape, location and motion. State also their advantages.

UNIT:IV GEARS AND GEAR TRAINS

PART- A

1. **What are the advantages of gear drive over other drives?**

(i) Since there is no slip, so gear drive obtains exact velocity ratio.
(ii) It is capable of transmitting larger power (than that of the belt and chain drives).
(iii) It is more efficient and effective means of power transmission.
(iv) It requires less space (as compared to belt and rope drives).

2. **Under what situations, (a) spur gears, (b) bevel gears, and (c) worm gears, are used?**

(a) Spur gears are used when the power and motion are to be transmitted between two parallel shafts.
(b) Bevel gears are used when the power and motion are to be transmitted between two intersecting shafts.
(c) Worm and worm wheel are used when the power and motion are to be transmitted between two non-parallel and non-intersecting shafts.

3. State the advantages of helical gears over spur gears.

(i) Helical gears operate smoother and quieter than spur gears.
(ii) Helical gears have a greater load carrying capacity.

4. Define: (a) normal pitch and (b) axial pitch relating to helical gears.

i). Normal pitch is the distance between similar faces of adjacent teeth, along a helix on the pitch cylinder normal to the teeth.
ii). Axial pitch is the distance measured parallel to the axis, between similar faces of adjacent teeth.

5. **What are herringbone gears? State its advantage.**

i). Herringbone gears, also known as double-helical gears, consists of teeth having a right and a left handed helix cut on the same blank .
ii). In Herringbone gears, the problem of axial thrust is eliminated.

6. **What is the use of rack and pinion arrangement?**

The rack and pinion is used to convert rotary motion into translatory motion or vice versa.

7. **Differentiate between a straight bevel gear and a spiral bevel gear.**

i). If the teeth on the bevel gears are parallel to the lines generating the pitch cones, then they are called straight bevel gears.
ii). When the teeth of a bevel gear are inclined at an angle to the face of the bevel gears, they are known as spiral bevel gears.

8. What is a worm gear drive?

A worm gear drive is used to transmit power from one shaft to another which is non- intersecting and their axes are normally right angles to each other.

9. State the advantages of worm gear drive over other gear drives.

(i) The worm gears can be used for high speed reductions up to 400: 1.
(ii) The operation is smooth and quite.
(iii) The worm gear drives are irreversible.

10. Which type of gear pair is to be used to get very large speed reduction in a stage? State the reason.

i). The worm and worm wheel are used for large speed reduction in a stage up to 400: I

ii). As the worm (similar to screw) drives the larger worm wheel, it is used in a very large speed reduction applications.

11. Define the following terms used in gears: (a) Pitch circle, (b) Circular pitch, (c) Diametral pitch and (d) Module.

(a) Pitch circle: Pitch circle is an imaginary circle on gear, by which pure rolling action would give the same motion as the actual gear.

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

(c) Diametral pitch: Diametral pitch is the number of teeth per unit pitch circle diameter of the gear.

(d) Module: Module is the ratio of the pitch circle diameter to the number of teeth on the gear.

12. Differentiate diametral pitch and circular pitch of a friction wheel.

i). Diametral pitch: Diametral pitch is the number of teeth per unit pitch circle diameter of the gear .

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

13. Define module of gears and its relation to circular pitch.

i). Module is the ratio of the pitch circle diameter to the number of teeth on the gear.

ii). Relation between circular pitch and module:

Circular pitch, $p_c = \pi$ x Module

14. Define the following terms used in gears: (a) Pressure angle, (b) Module.

(a) Pressure angle is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point.

(b) Module is defined as the ratio of pitch circle diameter to the number of teeth on the gear.

15. Define the term 'arc of contact' in gears.

The arc of contact is the path traced by a point on the pitch circle from the beginning to the end of engagement of two meshing teeth.

16. What do you mean by backlash?

Backlash is the difference between the tooth thickness of one gear and the tooth space of the mating gear.

17. State the law of gearing.

The law of gearing states that for maintaining constant velocity ratio between two meshing gears, the common normal of the tooth profiles, at all contact points with in mesh, must always pass through a fixed point on the lines of centres, called pitch point.

18. Prove or disprove that pure rolling is possible at one point only, on the line of action between two meshing gear teeth profiles.

We know that in a spur gear pair, at the pitch point there is no sliding. The action is pure rolling. We also know that the path of contact should always pass through the pitch point. Thus the pure rolling occurs only at one point along the path of contact.

19. State the condition for constant velocity ratio of toothed wheels.

i). The condition for constant velocity ratio of toothed wheels is nothing but the law of gearing.

ii). The law of gearing states that for maintaining constant velocity ratio between two meshing gears, the common normal of the tooth profiles, at all contact points with in mesh, must always pass through a fixed point on the lines of centres, called pitch point.

20. Define the terms velocity ratio and sliding velocity in a spur gear pair.

i).Velocity ratio: Velocity ratio is the ratio of speed of driving gear to the speed of the driven gear.

ii). Sliding velocity: Sliding velocity or velocity of sliding is the velocity of one tooth relative to its mating tooth along the common tangent at the point of contact.

21. Name two curves for use as gear profile, which satisfy the law of gearing (or) List down the common forms of gear teeth.

i). Involute curve ii). Cycloidal curve

22. What are the advantages and disadvantages of in volute gear tooth profile?

i). Advantages: Variable centre distance; Constant pressure angle; Easy manufacturing. .
ii). Disadvantages: Interference occurs; Weaker teeth; More wear and tear.

23. What are the standard interchangeable tooth profiles commonly used?

i). 14 1/2° composite system ii).14 1/2° full depth involute system iii). 20° full depth involute system iv).20° stub involute system v). 25° full depth involute system, and
vi). 25° stub involute system.

24. Define pressure angle in gears and explain the effect of different pressure angle.

Pressure angle is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point.

Effect of pressure angle:

i). The gears with smaller pressure angles efficiently transfer torque and apply lower radial loads onto the shaft and supporting bearings. However as the pressure angles are reduced, a greater tendency exists for gear tooth to interfere as they engage.

ii). The larger pressure angle makes teeth with a much larger base, which makes these teeth much stronger and also allows the production of gears with fewer teeth.

25. What is meant by contact ratio in gear? And write the equation to determine this value.

The contact ratio in gear refers to the average number of teeth that are in contact at any instant.

Mathematically, Contact ratio= Length of arc of contact / Circular pitch

26. What is the significance of contact ratio in gears?

i).The greater contact ratio values result in smoother action because another gear tooth shares the load for a longer duration during the engaging/disengaging process.

ii).The contact ratio should exceed I because contact between gears must not be lost.

27. Explain the term interference as applied to gears.

The phenomenon when the tip of tooth will dig out or interfere with the flank portion of the tooth portion of the mating gear is known as interference.

28. Define undercutting in gears.

When the tip of the gear tooth undercuts the root (flank) of the mating gear tooth, some portion of the flank will be removed. This process of removal of material due to interference phenomenon is called undercutting.

29. Explain any two methods of reducing or eliminating interference in gears.

i). By modifying addendum of gear teeth.
ii). By increasing the pressure angle.
iii). By modifying tooth profile or profile shifting.
iv). By increasing the centre distance.

30. Determine the minimum number of teeth to avoid interference in worst case of meshing with 14 1/2° pressure angle.

Solution: Assuming the pinion and gear wheel have equal teeth i.e., G = 1, the minimum number of teeth on the gear wheel is given by

$T_{G(min)} = 2A_n / \sqrt{((1+3 \sin^2 ø) - 1)}$

$= 2x1 / \sqrt{((1+3 \sin^2 14.5) - 1)}$

$T_{p(min)} = T_G / G = 23/1 = 23$

31. **What are non-standard gears?**

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

32. What are the principal reasons for the use of non-standard gears?

The principal reasons for employing non-standard gears are: (i) to prevent interference, (ii) to maintain reasonable contact ratio, and (iii) to attain predetermined centre distance.

33. What do you mean by tumbler gears?

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

34. What is a gear train?

A gear train is a combination of gears that is used for transmitting motion from one shaft to another.

35. Define the term train value of gear train.

Train value is the ratio of the speed of the driven gear to the speed of the driving gear.

36. What are the types of gear trains?

(i) Simple gear train. '
(ii) Compound gear train,
(iii) Reverted gear train, and
(iv) Epicyclic gear train.

37. Define simple gear train.

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

38. What is meant by compound gear train?

When a gear train having one 0,' more compound gears is known as compound gear train.

39. 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 it can provide higher speed reductions, for the given centre distance between the input and output shafts, using smaller gears.

40. Mention two methods to transmit power between two wheels when the distance between them is more.

(i) By providing the large sized wheels, or
(ii) By providing one or more intermediate wheels.

41. How to change the direction of rotation of the output gear in simple gear train without changing the direction of rotation of input gear?

By using intermediate idle gears.

42. What are the roles of idlers ill gear trains? lor what are the uses of intermediate gears in a gear train?

Intermediate gears, also known as idler gears, are necessary:
i). to change the direction of rotation of the driven gear without changing its angular velocity, and
(ii) to bridge the gap between first and last gears, when the centre distance is large.

43. What is the effect of intermediate gears on train value in a gear train?

The intermediate gears do not affect the train value of the gear train.

44. 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 it can provide higher speed reductions, for the given centre distance between the input and output shafts.

45. In a compound gear train, the drivers have 25,50, 75 and 100 teeth and the followers have 15, 30,40 and 65 teeth. What is the velocity ratio of the compound gear train?

Solution: We know that velocity ratio of compound gear train,
Velocity ratio= Product of number of teeth on drivers / Product of number of teeth on followers
= 25x50x75x100 / 15x30x40x65 = 8

46. What are the applications of reverted gear trains?

The reverted gear trains are used in automobile gear boxes, lathe back gears, clocks, etc.

47. What is meant by an epicyclic gear train? Give a practical example.

When the axis of rotation of one or more gears is allowed to rotate about another axis, then the gear train is known as epicyclic gear train.
Examples: Automobile differentials, machine tools, hoists, pulley blocks, etc

48. Distinguish between simple gear train and epicyclic gear train.

i). When there is only one gear on each shaft, it is known as simple gear train.
ii). When the axis of rotation of one or more gears is allowed to rotate about another axis, then the gear train is known as epicyclic gear train .
iii). If the arm is fixed then the epicyclic gear train becomes simple gear train.

49. How epicyclic gear train differs from the other types of gear trains?

In epicyclic gear trains, the axes of the shafts on which the gears are mounted may have the relative motion between them. But in other types, the axes on which the gears are mounted are fixed relative to each other.

50. List out the applications of epicyclic gear train.

The epicyclic gear trains find many applications in automobile differentials, machine tools, hoists, pulley blocks, wrist watches, aircraft propeller reduction drives, automatic transmissions, etc.

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

Two methods are: I. Tabulation method, and 2. Algebraic method.

52. What are the various types of torques in an epicyclic gear train? [or what are the externally applied torques used to keep the gear train in equilibrium?]

i). Input torque on the driving member.

ii). Output or resisting or load torque on the driven member.

iii). Holding or braking or fixing torque on the fixed gear.

53. Explain briefly the use of differential in an automobile.

The function of a differential gear in an automobile is to:

(i) transmit motion from engine to rear wheels, and

(ii) rotate the rear wheels at different speeds while the automobile is taking a turn.

54. What are the advantages of epicyclic (or planetary) gear trains?

The advantage of epicyclic gear trains over simple or compound gear trains is that it can achieve high speed reductions within a very limited space.

57. What is the degree of freedom of a differential mechanism?

DOF of a differential mechanism = 2

PART B & C

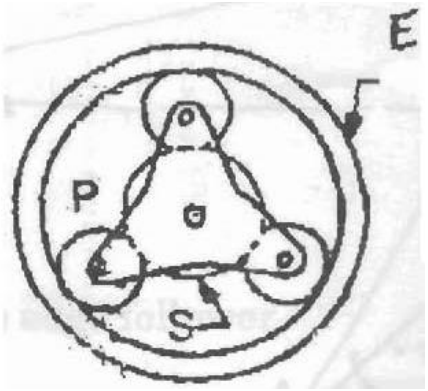
1. Two mating spur gear with module pitch of 6.5 mm have 19 ad 47 teeth of 20° pressure angle and 6.5 mm addendum. Determine the number of pair of teeth and angle turned through by the larger wheel for one pair of teeth in contact. Determine also the sliding velocity at the instant (i) engagement commences (ii) engagement terminates. When the pitch line velocity is 1.2 m/s.
2. Two mating gears have 20 and 40 involute teeth of module 10 mm and 20° pressure angle. The addendum on each wheel is to be made of such a length that the line of contact on each side of the pitch point has half the maximum possible length. Determine the addendum height for each gear wheel, length of the path of contact, arc of contact and contact ratio.
3. Two 20° involute spur gears have a module of 10 mm. The addendum is one module. The larger gear has 50 teeth and pinions 13 teeth. Does the interference occur? If it occurs, to what value should the pressure angle be changed to eliminate interference?
4. Two gear wheels mesh externally and are to give a velocity ratio of 3 to 1. The teeth are of involute form; module=6mm, addendum=one module, pressure angle= 20°. The pinion rotates at 90 rpm. Determine (1) the number of teeth on the pinion to avoid interference on it and the corresponding number of teeth on the wheel, (2) The length of path and arc of contact, (3) the number of pairs of teeth in contact
5. In an epicyclic gear train the internal wheels A and B and compound wheels C and D rotate independently about axis O. The wheels E and F rotate on pins fixed to the arm G. E gears with A and C . Wheel F gear with B and D. All the wheels have the same module and the number of teeth are: TC =28 TD=26; TE = TF=18. (1) Sketch the arrangement, (2) Find the number of teeth on A and B, (3)If the arm G makes 100 rpm clockwise and A is fixed, find

the speed of B , and (4) If the arm G makes 100 rpm clockwise and wheel A makes 10 rpm counter clockwise; Find the speed of wheel B.

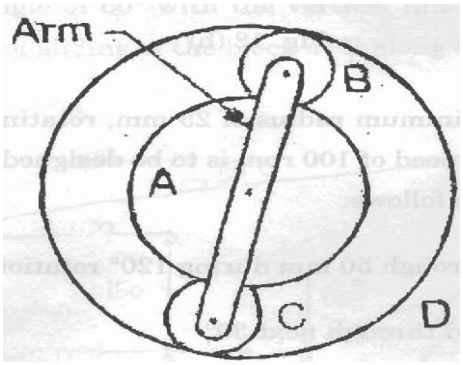
6. In a reverted epicyclic train, the arm F carries two wheels A and D and a compound wheel B-C. Wheel A meshes with wheel B and Wheel D meshes with wheel C. Ther number of teeth on wheel A, D and C are 80, 48, and 72. Find the speed and direction of wheel D , when wheel A is fixed and arm F makes 200 rpm clockwise.
7. In an epicyclic gear train, an arm carries two gears A and B having 36:eeth and 45 teeth respectively. If the arm rotates at 50 rpm in the antic lodwise about the centre of the gear A which is fixed, find the speed of geal B. f the gear A instead of being fixed, makes 300 rpm in the clockwise jirec:tion, what is the speed of B?
8. A pinion having 30 teeth drives a gear having 80 teeth. The profile of the gears is involute with 20° pressure angle, 12 mm module and 10 mm addendum. Find the length of path of contact, arc of contact and contact ratio.
9. An epicyclic train has a pinion A having 15 teeth, centrally located and rigidly connected to shaft of driving motor. Another gear B having 20 teeth is gearing with A and also with annular fixed wheel D. Gear C is integral with B and meshes with another annular wheel E which is keyed to the shaft of driven unit. The arm rotates about driving shaft and carries compound gear B, C. Sketch the arrangement and determine speed of machine for a motor speed of 1000 rpm. Also determine torque on machine shaft for a motor torque of 100 N-
10. Two gears in mesh have a module of 10mm and a pressure angle of 25°. The pinion has 20 teeth and the gear has 52. The addendum on both the gears is equal to one module. Determine

    1. The number of pairs of teeth in contact,
    2. The angles of action of the pinion and the wheel

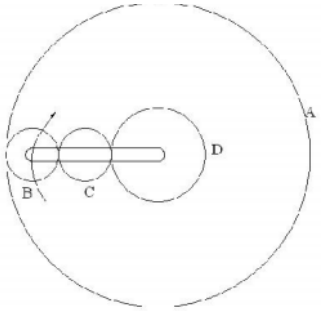
    The ratio of the sliding velocity to the rolling velocity at the pitch point and at the beginning and end of engagement.
11. The sun planet gear of an epicyclic gear train, the annular D has 100 internal teeth, the sun gear A has 50 external teeth and planet gear B has 25 external teeth. The gear B meshes with gear D and gear A. The gear B is carried on arm E, which rotates about the centre of annular gear D. If the gear D is fixed and arm rotates at 20 rpm, then find the speeds of gear A and B.
12. An epicyclic gear train for electric motor is shown in figure. The wheel S has 15 teeth and is fixed to the motor shaft running at 1450 rpm. The planet P has 45 teeth, gears with fixed annulus E and rotates on a spindle carried by an arm **A** which is fixed to the output shaft. If the motor transmits 1.5 kW, determine the torque required to fix the annulus.



13. An epicyclic gear train is shown in the figure. How many revolutions does the arm makes, (1) when **A** makes one revolution in clockwise and D makes ½ a revolution in the opposite sense (2) when **A** makes one revolution in clockwise and D remains stationary. The number of teeth in gears A and D are 40 and 90 respectively



14. An epicyclic gear train as shown in figure is composed of a fixed annular wheel A having 150 teeth. The wheel A is meshing with wheel B which drives wheel D through an idle wheel C, D being concentric with A. The wheels B and C are carried on an arm which revolves clockwise at 100 rpm about the axis of A and D. If the wheels B and D have 25 and 40 teeth respectively, determine the number of teeth on C and speed and sense of rotation of wheel C.



UNIT: V FRICTION IN MACHINE ELEMENTS

Part- A

1. **What are the advantages of gear drive over other drives?**

(i) Since there is no slip, so gear drive obtains exact velocity ratio.
(ii) It is capable of transmitting larger power (than that of the belt and chain drives).
(iii) It is more efficient and effective means of power transmission.
(iv) It requires less space (as compared to belt and rope drives).

2. **Under what situations, (a) spur gears, (b) bevel gears, and (c) worm gears, are used?**

(a) Spur gears are used when the power and motion are to be transmitted between two parallel shafts.
(b) Bevel gears are used when the power and motion are to be transmitted between two intersecting shafts.
(c) Worm and worm wheel are used when the power and motion are to be transmitted between two non-parallel and non-intersecting shafts.

3. State the advantages of helical gears over spur gears.

(i) Helical gears operate smoother and quieter than spur gears.
(ii) Helical gears have a greater load carrying capacity.

4. Define: (a) normal pitch and (b) axial pitch relating to helical gears.

i). Normal pitch is the distance between similar faces of adjacent teeth, along a helix on the pitch cylinder normal to the teeth.
ii). Axial pitch is the distance measured parallel to the axis, between similar faces of adjacent teeth.

5. **What are herringbone gears? State its advantage.**

i). Herringbone gears, also known as double-helical gears, consists of teeth having a right and a left handed helix cut on the same blank .
ii). In Herringbone gears, the problem of axial thrust is eliminated.

6. **What is the use of rack and pinion arrangement?**

The rack and pinion is used to convert rotary motion into translatory motion or vice versa.

7. **Differentiate between a straight bevel gear and a spiral bevel gear.**

i). If the teeth on the bevel gears are parallel to the lines generating the pitch cones, then they are called straight bevel gears.
ii). When the teeth of a bevel gear are inclined at an angle to the face of the bevel gears, they are known as spiral bevel gears.

8. What is a worm gear drive?

A worm gear drive is used to transmit power from one shaft to another which is non- intersecting and their axes are normally right angles to each other.

9. State the advantages of worm gear drive over other gear drives.

(i) The worm gears can be used for high speed reductions up to 400: 1.
(ii) The operation is smooth and quite.
(iii) The worm gear drives are irreversible.

10. Which type of gear pair is to be used to get very large speed reduction in a stage? State the reason.

i). The worm and worm wheel are used for large speed reduction in a stage up to 400: I
ii). As the worm (similar to screw) drives the larger worm wheel, it is used in a very large speed reduction applications.

11. Define the following terms used in gears: (a) Pitch circle, (b) Circular pitch, (c) Diametral pitch and (d) Module.

(a) Pitch circle: Pitch circle is an imaginary circle on gear, by which pure rolling action would give the same motion as the actual gear.
(b) Circular pitch: Circular pitch is the distance measured along the circumference of the pitch circle from a point on one tooth to the corresponding point on the adjacent tooth.
(c) Diametral pitch: Diametral pitch is the number of teeth per unit pitch circle diameter of the gear.
(d) Module: Module is the ratio of the pitch circle diameter to the number of teeth on the gear.

12. Differentiate diametral pitch and circular pitch of a friction wheel.

i). Diametral pitch: Diametral pitch is the number of teeth per unit pitch circle diameter of the gear .
ii). Circular pitch: Circular pitch is the distance measured along the circumference of the pitch circle from a point on one tooth to the corresponding point on the adjacent tooth.

13. Define module of gears and its relation to circular pitch.

i). Module is the ratio of the pitch circle diameter to the number of teeth on the gear.
ii). Relation between circular pitch and module:
Circular pitch, $p_c = \pi$ x Module

14. Define the following terms used in gears: (a) Pressure angle, (b) Module.

(a) Pressure angle is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point.
(b) Module is defined as the ratio of pitch circle diameter to the number of teeth on the gear.

15. Define the term 'arc of contact' in gears.

The arc of contact is the path traced by a point on the pitch circle from the beginning to the end of engagement of two meshing teeth.

16. What do you mean by backlash?

Backlash is the difference between the tooth thickness of one gear and the tooth space of the mating gear.

17. State the law of gearing.

The law of gearing states that for maintaining constant velocity ratio between two meshing gears, the common normal of the tooth profiles, at all contact points with in mesh, must always pass through a fixed point on the lines of centres, called pitch point.

18. Prove or disprove that pure rolling is possible at one point only, on the line of action between two meshing gear teeth profiles.

We know that in a spur gear pair, at the pitch point there is no sliding. The action is pure rolling. We also know that the path of contact should always pass through the pitch point. Thus the pure rolling occurs only at one point along the path of contact.

19. State the condition for constant velocity ratio of toothed wheels.

i). The condition for constant velocity ratio of toothed wheels is nothing but the law of gearing.

ii). The law of gearing states that for maintaining constant velocity ratio between two meshing gears, the common normal of the tooth profiles, at all contact points with in mesh, must always pass through a fixed point on the lines of centres, called pitch point.

20. Define the terms velocity ratio and sliding velocity in a spur gear pair.

i).Velocity ratio: Velocity ratio is the ratio of speed of driving gear to the speed of the driven gear.

ii). Sliding velocity: Sliding velocity or velocity of sliding is the velocity of one tooth relative to its mating tooth along the common tangent at the point of contact.

21. Name two curves for use as gear profile, which satisfy the law of gearing (or) List down the common forms of gear teeth.

i). Involute curve ii). Cycloidal curve

22. What are the advantages and disadvantages of in volute gear tooth profile?

i). Advantages: Variable centre distance; Constant pressure angle; Easy manufacturing. .

ii). Disadvantages: Interference occurs; Weaker teeth; More wear and tear.

23. What are the standard interchangeable tooth profiles commonly used?

i). 14 1/2° composite system ii).14 1/2° full depth involute system iii). 20° full depth involute system iv).20° stub involute system v). 25° full depth involute system, and

vi). 25° stub involute system.

24. Define pressure angle in gears and explain the effect of different pressure angle.

Pressure angle is the angle between the common normal to two gear teeth at the point of contact and the common tangent at the pitch point.

Effect of pressure angle:

i). The gears with smaller pressure angles efficiently transfer torque and apply lower radial loads onto the shaft and supporting bearings. However as the pressure angles are reduced, a greater tendency exists for gear tooth to interfere as they engage.

ii). The larger pressure angle makes teeth with a much larger base, which makes these teeth much stronger and also allows the production of gears with fewer teeth.

25. What is meant by contact ratio in gear? And write the equation to determine this value.

The contact ratio in gear refers to the average number of teeth that are in contact at any instant.

Mathematically, Contact ratio= Length of arc of contact / Circular pitch

26. What is the significance of contact ratio in gears?

i).The greater contact ratio values result in smoother action because another gear tooth shares the load for a longer duration during the engaging/disengaging process.

ii).The contact ratio should exceed I because contact between gears must not be lost.

27. Explain the term interference as applied to gears.

The phenomenon when the tip of tooth will dig out or interfere with the flank portion of the tooth portion of the mating gear is known as interference.

28. Define undercutting in gears.

When the tip of the gear tooth undercuts the root (flank) of the mating gear tooth, some portion of the flank will be removed. This process of removal of material due to interference phenomenon is called undercutting.

29. Explain any two methods of reducing or eliminating interference in gears.

i). By modifying addendum of gear teeth.

ii). By increasing the pressure angle.

iii). By modifying tooth profile or profile shifting.

iv). By increasing the centre distance.

30. Determine the minimum number of teeth to avoid interference in worst case of meshing with 14 1/2° pressure angle.

Solution: Assuming the pinion and gear wheel have equal teeth i.e., G = 1, the minimum number of teeth on the gear wheel is given by

$T_{G(min)} = 2A_n / \sqrt{((1+3 \sin^2 ø) - 1)}$

$= 2x1 / \sqrt{((1+3 \sin^2 14.5) - 1)}$

$T_{p(min)} = T_G / G = 23/1 = 23$

31. **What are non-standard gears?**

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

32. What are the principal reasons for the use of non-standard gears?

The principal reasons for employing non-standard gears are: (i) to prevent interference, (ii) to maintain reasonable contact ratio, and (iii) to attain predetermined centre distance.

33. What do you mean by tumbler gears?

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

34. What is a gear train?

A gear train is a combination of gears that is used for transmitting motion from one shaft to another.

35. Define the term train value of gear train.

Train value is the ratio of the speed of the driven gear to the speed of the driving gear.

36. What are the types of gear trains?

(i) Simple gear train. '
(ii) Compound gear train,
(iii) Reverted gear train, and
(iv) Epicyclic gear train.

37. Define simple gear train.

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

38. What is meant by compound gear train?

When a gear train having one 0,' more compound gears is known as compound gear train.

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The advantage of a compound gear train over a simple gear train is that it can provide higher speed reductions, for the given centre distance between the input and output shafts, using smaller gears.

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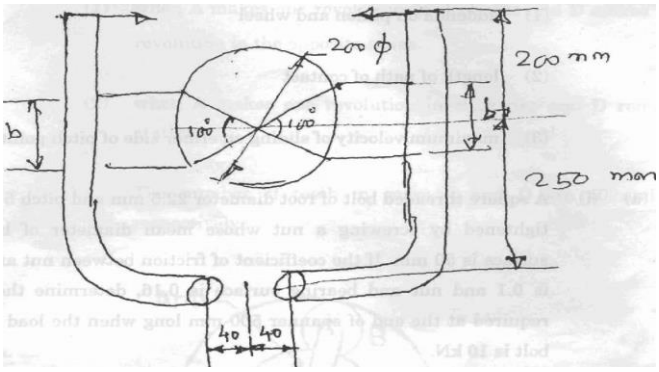
DOF of a differential mechanism = 2

PART B & C

1. Derive from first principles an expression for the effort required to raise a load with a screw jack taking friction into consideration.
2. Derive from first principles an expression for the friction moment of a conical pivot assuming (i) Uniform pressure, and (ii) Uniform wear.
3. Describe with a neat sketch the working of a single plate friction clutch
4. An open belt running over two pulley of 1.5 m and 1.0 m diameters connects two parallel shafts 4.8 m apart. The initial ten in the belt is 3000 N. The smaller pulley is rotating at 600 rpm. The mass of belt is 0.6703 kg/m length. The coefficient of friction between the belt and pulleys is 0.3. Find (1) the exact length of the belt required (2) the power transmitted taking C.F tension into account.
5. A rope drive is required to transmit 230 KW from a pulley of 1m diameter running at 450 rpm. The safe pull in each rope is 800 N and the mass of the rope is 0.4 kg per meter length. The angle of lap and groove angle 1600 and 450 respectively. If coefficient of friction is 0.3, find the number of ropes required

6. A single plate clutch is required to transmit 8 KW at 1000 rpm. The axis pressure is limited to 70 KN/m2. The mean radius of the plate is 4.5 times the radial width of the friction surface. If both the sides of the plate are effective and the coefficient of friction is 0.25. find a) the inner and the outer radius of the plate and the mean radius, b) the width of the friction lining.
7. A shaft has a number of collars integral with it. The external diameter of the collars is 400mm and the shaft diameter is 250mm. If the uniform intensity of pressure is 0.35N/mm2 and its coefficient of friction is 0.05, estimate i) power absorbed in overcoming friction when the shaft runs at 105 rpm and carries a load of 150KN and ii) number of collars required.
8. An open flat belt drive connects two parallel shafts 1.2 meters apart. The driving and the driven shafts rotate at 350 rpm. and 140 rpm respecively and the driven pulley is 400 mm in diameter. The belt is 5mm thicK ard 80 mm wide. The coefficient of friction between the belt and pulley i= 0.3 and the maximum permissible tension in the belting is 1.4 MN/m2. Determine: 'i. diameter of the driving pulley 2. maximum power that may be transmitted by the belting.
9. A single plate clutch, effective on both sides, is required to transmit ~5 I<W at 3000 rpm. Find the outer and inner radii of frictional surface if the nefficient of friction is 0.255, the ratio of radii is 1.25 and the maximum pressure i5 not to exceed 0.1 N/mm2. Also find the axial thrust to be provided by thE, springs. Assume the theory of uniform wear.
10. A single block brake is operated by a lever of length 500 mm. The brake drum has a diameter of 500 mm and the brake band embraces *5/8* of the circumference. One end of the band is attached to the fulcrum of the lever while the other end is attached to a pin on the lever 100mm from the fulcrum. If the effort applied to the end of the lever is 2 kN and the coefficient of friction is 0.25, find the maximum braking torque on the drum.
11. . An open belt drive connects two pulleys 120 cm and 50 cm diameters on parallel shafts 4 m apart. The maximum tension in the belt is 1855 N. The coefficient of friction is 0.3. The driver pulley of diameter 120 cm runs at 200 rpm. Calculate: (i) the power transmitted (ii) the torque on each of the two shafts.
12. The brake whose dimensions are shown in figure has a co-efficient of friction of 0.3 and is to have a maximum pressure of 1000 kPa against the friction material. (1) Using an actuating force of 1750 N, determine the face width of the Shoes (both shoes have same width) and (2) What torque will the brake absorb?



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Question Paper Code : 27357

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2015.

Fourth Semester

Mechanical Engineering

ME 6401 — KINEMATICS OF MACHINERY

(Common to Third Semester Mechanical Engineering (Sandwich), Mechatronics Engineering)

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Define Grubler's criteria for a mechanism.
2. Name any two inversions of the 4-bar chain.
3. What is the total number of instantaneous centers that are possible for a mechanism consisting 'n' links?
4. Name the mechanism in which Corolis component of acceleration is taken into account.
5. Define the following with respect to cam and follower mechanism
   (a) Pressure angle
   (b) Pitch circle.
6. State the reasons for providing offset in a cam follower mechanism.
7. State the law of gearing.
8. How is the epicyclic gear train works?
9. Write the mathematical expression for the maximum efficiency of a screw jack.
10. Write mathematical expression for the length of the belt required for two pulleys of diameters d_1 and d_2 and at distance x apart are connected by means of an open belt drive.

PART B — (5 × 16 = 80 marks)

11. (a) Describe with neat sketch, the mechanisms obtained by the inversions of 4-bar chain. (16)

Or

(b) In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres is 240 mm and the length of the driving crank is 120 mm. Find the inclination of the slotted bar with the vertical in the extreme position and the time ratio of cutting stroke to the return stroke.

If the length of the slotted bar is 450 mm, find the length of the stroke if the line of stroke passes through the extreme positions of the free end of the lever. (16)

12. (a) In a four bar chain ABCD, AD is fixed and is 15 cm long. The crank AB is 4 cm long and rotates at 120 rpm clockwise, while the link CD (whose length is 8 cm) oscillates about D. BC and AD are of equal length. Find the angular velocity of link CD when angle BAD = 60°. (16)

Or

(b) The crank of a slider crank mechanism is 15 cm and the connecting rod is 60 cm long. The crank makes 300 rpm in the clockwise direction. When it has turned 45° from the inner dead centre position, determine (i) acceleration of the mid-point of the connecting rod and (ii) angular acceleration of the connecting rod. (16)

13. (a) Draw the profile of a cam operating a knife-edge follower when the axis of the follower passes through the axis of cam shaft from the following data:

(i) Follower to move outwards through 40 mm during 60° of cam rotation,

(ii) Follower to dwell for the next 45°,

(iii) Follower to return to its original position during next 90°,

(iv) Follower to dwell for the rest of the cam rotation.

The displacement of the follower is to take place with simple harmonic motion during both the outward and return strokes. The least radius of cam is 50 mm. (16)

Or

(b) Draw the profile of a cam operating a knife-edge follower (when the axis of the follower passes through the axis of cam shaft) from the following data:

(i) Follower to move outward through 30 mm with Simple Harmonic motion during 120° of cam rotation,

(ii) Follower to dwell for the next 60°,

(iii) Follower to return to its original position with uniform velocity during 90° of cam rotation

(iv) Follower to dwell for the rest of the cam rotation. The least radius of cam is 20 mm and the cam rotates at 240 rpm. (16)

14. (a) Calculate (i) the length of path of contact, (ii) arc of contact and (iii) the contact ratio when a pinion having 23 teeth drives a gear having teeth 57. The profile of the gears is involute with pressure angle 20°, module 8 mm and addendum equal to one module.

Or

(b) The arm of an epicyclic gear train rotates at 100 rpm in the anti-clockwise direction. The arm carries two wheels A and B having 36 and 45 teeth respectively. The wheel A is fixed and the arm rotates about the centre of wheel A. Find the speed of wheel B. What will be the speed of B, if the wheel A instead of being fixed, makes 200 rpm clockwise. (16)

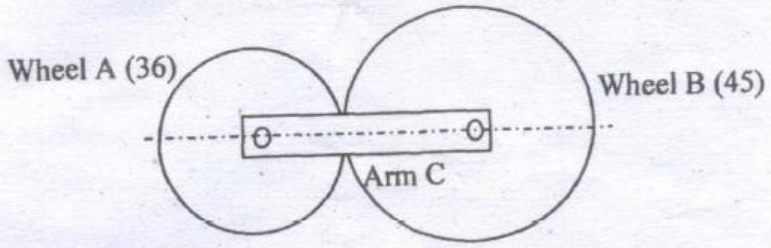


Fig 14(b)

15. (a) The external and internal radii of a friction plate of a single clutch are 120 mm and 60 mm respectively. The total axial thrust with which the friction surfaces are held together is 1500 N. For uniform wear, find the maximum, minimum and average pressure on the contact surfaces. (16)

Or

(b) Determine the maximum power that can be transmitted using a belt of 100 mm × 10 mm with an angle of lap of 160°. The density of the belt is 1000 kg/m^3 and the co-efficient of friction may taken as 0.25. The tension in the belt should not exceed 1.5 N/mm^2. (16)

Question Paper Code : 57547

Question Paper Code : 57547

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2016

Fourth Semester

Mechanical Engineering

ME 6401 – KINEMATICS OF MACHINERY

(Common to Third Semester Mechanical Engineering (Sandwich), Mechatronics Engineering)

(Regulations 2013)

Time : Three Hours **Maximum : 100 Marks**

Answer ALL questions.

PART – A (10 × 2 = 20 Marks)

1. Classify kinematic pairs based on nature of contact. Give examples.
2. When a linkage becomes mechanism ?
3. What is a relative pole, with respect to velocity analysis ?
4. What are the different methods used for finding the velocity ?
5. Define trace point of a cam.
6. Define tangent cam.
7. Define normal and axial pitch in helical gears.
8. What is the advantage when arc of recess is equal to arc of approach in meshing gears ?
9. What are self energizing brakes ?
10. Why self locking screws have lesser efficiency ?

PART – B (5 × 16 = 80 Marks)

11. (a) (i) Classify kinematic pairs based on degrees of freedom. **(10)**

(ii) What is inversion and list its properties. **(2 + 4)**

OR

(b) (i) Find the degrees of freedom of the mechanisms shownin fig. 11 (b). **(10)**

(ii) State the inconsistancies of Grubler's criterion. **(6)**

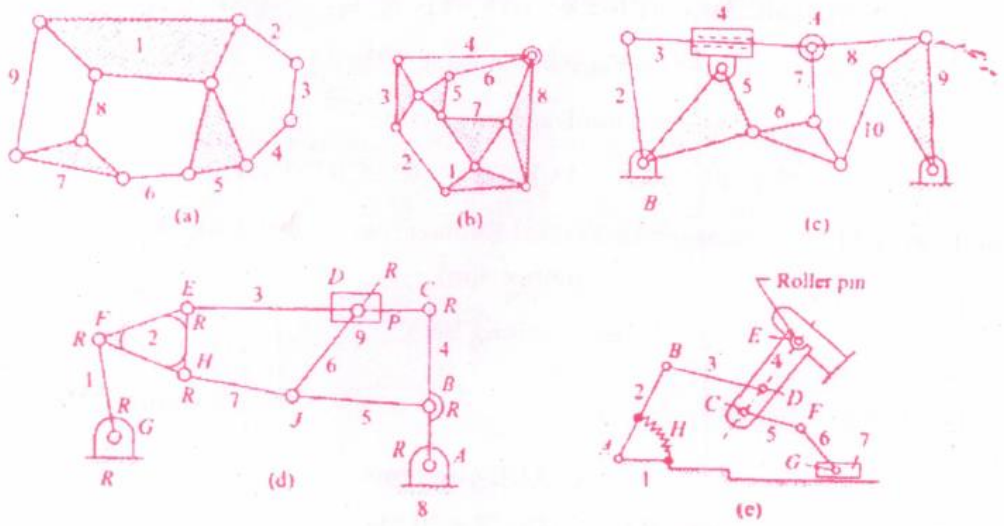


Fig 11 (b)

12. (a)

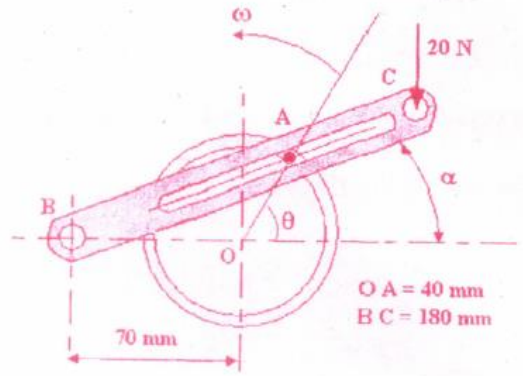


Figure 12 (a)

The diagram shows part of a quick return mechanism. The pin A slides in the slot when the disc is rotated. Calculate the angular velocity and acceleration of link BC when θ = 60° and ω = 100 rad/s. **(16)**

OR

(b) Derive the expression for Coriolis component of acceleration with neat sketch and give its direction for various conditions. **(16)**

13. (a) (i) Draw the displacement, velocity and acceleration curves, when the follower moves with simple harmonic motion and derive the expression for maximum velocity and maximum acceleration. **(10)**

(ii) Depict the types of cams. **(6)**

OR

(b) Follower type = roller follower, lift = 25 mm; base circle radius = 20 mm; roller radius = 5 mm; out stroke with UARM, for 120° cam rotation; dwell for 60° cam rotation; return stroke with UARM, for 90° cam rotation; dwell for the remaining period. Determine max. velocity and acceleration during out stroke and return stroke if the cam rotates at 1200 rpm in counter clockwise direction.

Draw the cam profile for conditions with follower off set to right of cam center by 5 mm. **(16)**

14. (a) The cutter of a broaching machine is pulled by square threaded screw of 55 mm external diameter and 10 mm pitch. The operating nut takes the axial load of 400 N on a flat surface of 60 mm internal diameter and 90 mm external diameter. If the coefficient of friction is 0.15 for all contact surfaces on the nut, determine the power required to rotate the operating nut, when the cutting speed is 6 m/min. **(16)**

OR

(b) Following data is given for a rope pulley transmitting 23.628 kW.

Dia of pulley = 40 cm; speed = 110 rpm, angle of groove = 45°; angle of lap = 60°, co efficient of friction = 0.28, No. of ropes = 10. Mass in kg/m length of ropes = $0.0053 \times C^2$ and working tension is limited $12.2\ C^2$ N where C = girth of rope in cm. Find (i) initial tension, and (ii) diameter of each rope. **(16)**

15. (a) Explain gear nomenclature with neat diagram and define all salient terms pertaining to the gear. **(16)**

OR

(b) Fig. shows a differential gear used in a motor car. The pinion A on the propeller shaft has 12 teeth and gears with the crown gear B which has 60 teeth. The shafts P and Q form the rear axles to which the road wheels are attached. If the propeller shaft rotates at 1000 r.p.m. and the road wheel attached to axle Q has a speed of 210 r.p.m. while taking a turn, find the speed of road wheel attached to axle P. **(16)**

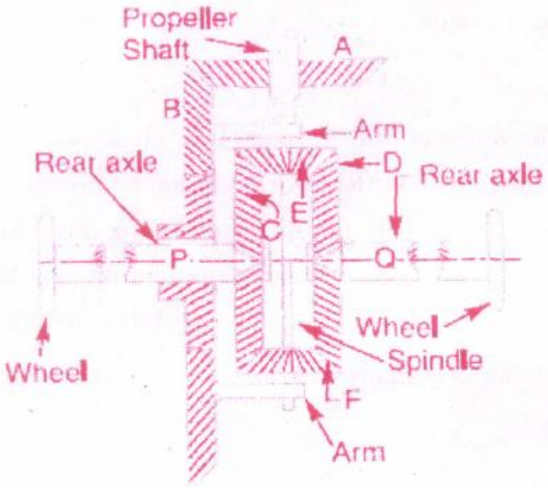


Fig. 15 (b)

Question Paper Code : 72140

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Third/Fourth Semester

Mechanical Engineering

ME 6401 — KINEMATICS OF MACHINERY

(Common to Mechanical Engineering (Sandwich)/Mechatronics Engineering)

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What type of kinematic pair exists between human shoulder and arm based on nature of contact and nature of relative motion?

2. Sketch and define Transmission angle of a four bar mechanism.

3. Find the resultant acceleration of an 80mm radius crank rotating at a constant angular velocity of 10 rad/s, at the crank – pin position.

4. Illustrate the instantaneous centres of a typical four bar mechanism.

5. Which type of cam follower motion is preferred for high speed engines? Why?

6. Give any two applications of cam mechanism in IC engines.

7. State law of gearing.

8. What type of gear arrangement is used to traverse the carriage in lathe machine?

9. What kind of friction acts between the tyre and road in an automobile?

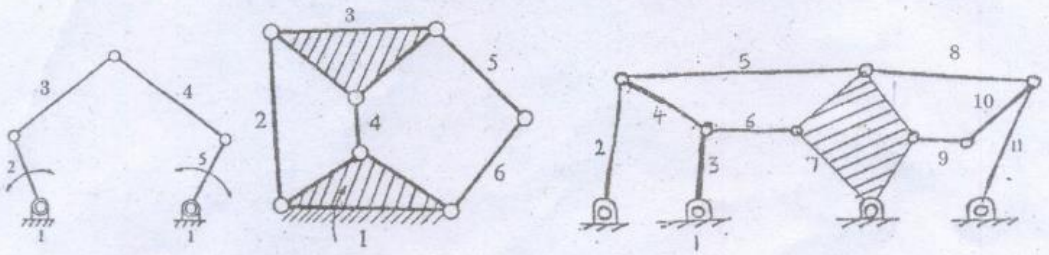
10. State the functional difference between a clutch and a brake.

PART B — (5 × 13 = 65 marks)

11. (a) What is a kinematic inversion? Discuss any three applications of inversions of slider crank mechanism with suitable sketches. (13)

Or

(b) (i) Find the degrees of freedom for the mechanisms shown in Fig 11(b) (i). (7)



(1) (2) (3)

Fig. 11 (b) (i)

(ii) Explain mechanical advantage and transmission angle related to four bar mechanism. (6)

12. (a) An engine mechanism is shown in Fig. 12 (a). The crank CB = 200 mm and the connecting rod BA = 600 mm. In the position shown, the crankshaft has a speed of 50 rad/s and an angular acceleration of 800 rad/s². Find: (i) angular velocity of AB and (ii) angular acceleration of AB. (13)

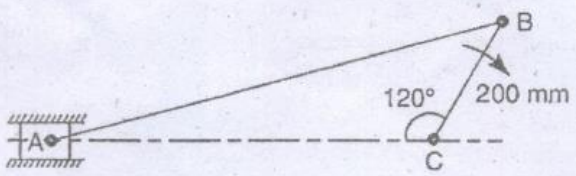


Fig. 12(a)

Or

(b) Locate all the instantaneous centres of the slider crank mechanism as shown in Fig. 12 (b). The lengths of crank OB and connecting rod AB are 100 mm and 400 mm respectively. If the crank rotates clockwise with an angular velocity of 10 rad/s, find: (i) Velocity of the slider A, and (ii) Angular velocity of the connecting rod AB. (13)

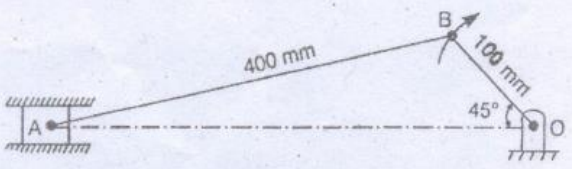


Fig. 12(b)

13. (a) Draw the profile of a cam operating a knife edge follower having a lift of 30 mm. The cam raises the follower with SHM for 150° of the rotation followed by a period of dwell for 60°. The follower descends for the next 100° rotation of the cam with uniform velocity, again followed by a dwell period. The cam rotates at a uniform velocity of 120 rpm and has a least radius of 20 mm. What will be the maximum velocity and acceleration of the follower during the lift and the return? (13)

Or

(b) In a symmetrical tangent cam operating a roller follower, the least radius of the cam is 30 mm and roller radius is 17.5 mm. The angle of ascent is 75° and the total lift is 17.5 mm. The speed of the cam shaft is 600 r.p.m. Calculate: (i) The principal dimensions of the cam; (ii) the accelerations of the follower at the beginning of the lift, where straight flank merges into the circular nose and at the apex of the circular nose; (iii) Draw the profile of the cam. Assume that there is no dwell between ascent and descent. (13)

14. (a) The following data relate to a pair of 20° involute gears in mesh:

Module = 6 mm, Number of teeth on pinion = 17, Number of teeth on gear = 49; Addenda on pinion and gear wheel = 1 module.

Find: (i) The number of pairs of teeth in contact (ii) The angle turned through by the pinion and the gear wheel when one pair of teeth is in contact, and (iii) The ratio of sliding to rolling motion when the tip of a tooth on the larger wheel (1) is just making contact, (2) is just leaving contact with its mating tooth, and (3) is at the pitch point. (13)

Or

(b) An epicyclic gear consists of three gears A, B and C as shown in Fig. 14 (b). The gear A has 72 internal teeth and gear C has 32 external teeth. The gear B meshes with both A and C and is carried on an arm EF which rotates about the centre of A at 18 r.p.m.. If the gear A is fixed, determine the speed of gears B and C. (13)

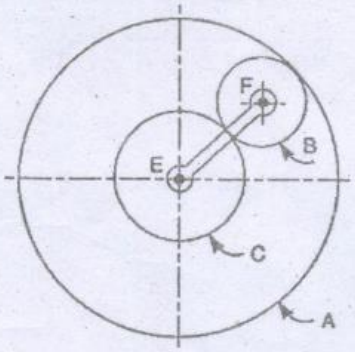


Fig. 14(b)

15. (a) The following data relate to a screw jack:
Pitch of the threaded screw = 8 mm
Diameter of the threaded screw = 40 mm
Coefficient of friction between screw and nut = 0.1
Load = 20kN

Assuming that the load rotates with the screw, determine the
(i) Ratio of torques required to raise and lower the load
(ii) Efficiency of the machine. (13)

Or

(b) A single plate clutch transmits 25 kw at 900 rpm. The maximum pressure intensity between the plates is $85\,kN/m^2$. The outer diameter of the plate is 360 mm. Both the sides of the plate are effective and the coeffieient of friction is 0.25. Determine the
(i) Inner radius of the plate (ii) Axial force to engage the clutch. (13)

PART C — (1 × 15 = 15 marks)

16. (a) Figure 16 (a) shows a mechanical press used to exert large forces to insert a small part into a larger one. Draw a kinematic diagram, using the end of the handle as a point of interest. Also compute the degrees of freedom.

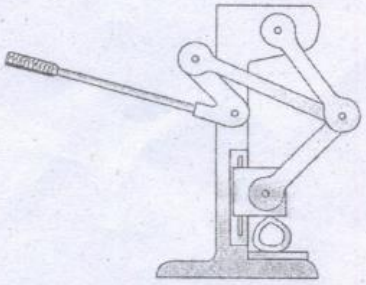


Figure 16(a)

Or

(b) A cam is to be used for a platform that will repeatedly lift boxes from a lower conveyor to an upper conveyor. This machine is shown in Figure 16(b). Plot a displacement diagram and determine the required speed of the cam when the follower motion sequence is as follows:
(i) Rise 40mm in 1.2 s. (ii) Dwell for 0.3 s. (iii) Fall 20 mm in 0.9 s. (iv) Dwell 0.6 s. (v) Fall 20 mm in 0.9 s.

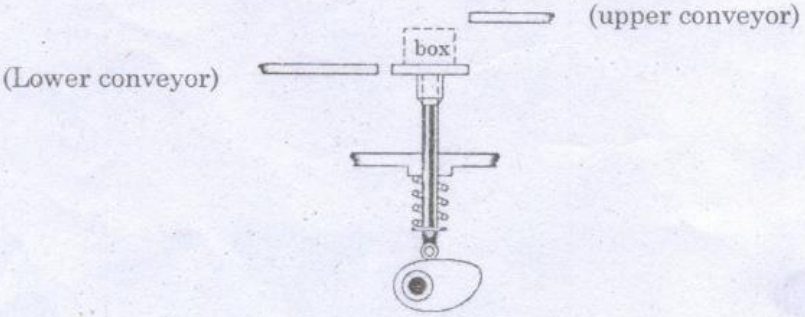


Fig. 16(b)

Question Paper Code : 50859

Question Paper Code : 50859

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Third/Fourth Semester

Mechanical Engineering

ME 6401 – KINEMATICS OF MACHINERY

(Regulations 2013)

(Common to : B.E. Mechnical Engineering (Sandwich)/Mechatronics Engineering)

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Time : Three Hours Maximum : 100 Marks

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. Define the Grubler's criterion for plane mechanism with mathematical expression.
2. Name any two inversions of single slider crank chain.
3. Define Coriolis component of acceleration.
4. State the Arnold Kennedy theorem.
5. Differentiate between radial cam and cylindrical cam.
6. Name the cam follower extensively used in air-craft engines.
7. What is meant by crossed belt drive ?
8. Write the conditions for the maximum power transmission by a belt from one pulley to another.
9. Give the classification of gears based on position of teeth on the wheel.
10. Draw the compound gear train and write its speed ratio.

PART – B (5×13=65 Marks)

11. a) Write in detail with neat sketch, any three inversions of double slider crank chain.

(OR)

b) Describe with neat sketch, the mechanisms obtained by the inversions of four-bar chain.

12. a) In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres is 240 mm and the length of the driving crank is 120 mm. Find the inclination of the slotted bar with the vertical in the extreme position and the time ratio of cutting stroke to the return stroke. If the length of the slotted bar is 450 mm, find the length of the stroke if the line of stroke passes through the extreme positions of the free end of the lever.

b) Locate all the instantaneous centres of the slider crank mechanism. The crank (OA) is 160 mm and the connecting rod (AB) is 470 mm long. If the crank rotates clockwise with an angular velocity of 12 rad/s, Determine 1. Linear velocity of slider (B) 2. Angular velocity of the connecting rod (AB), at a crank angle of 30° from inner dead centre position using instantaneous centre method.

13. a) A symmetrical cam with convex flanks operates a flat-footed follower. The lift is 10 mm, base circle radius 20 mm. The total angle of the cam action is 162°. Find the radius of convex flanks and nose and determine the maximum acceleration and retardation during lift when the cam shaft rotates at 1200 rpm. Period of acceleration is half the period of retardation during the lift.

(OR)

b) Design a cam for operating the exhaust valve of an oil engine. It is required to give equal uniform acceleration and retardation during opening and closing of the valve each of which corresponds to 60° of cam rotation. The valve must remain in the fully open position for 20° of cam rotation. The lift of the valve is 37.5 mm and the least radius of the cam is 40 mm. The follower is provided with a roller of radius 20 mm and its line of stroke passes through the axis of the cam.

14. a) A pinion having 24 teeth drives a gear having 60 teeth. The profile of the gears is involute with 20° pressure angle, 10 mm module and 10 mm addendum. Find the length of path of contact, arc of contact and the contact ratio.

(OR)

b) An epicyclic train of gears is arranged as shown in Fig. 14 (b). How many revolutions does the arm, to which the pinions P are attached, when S makes 300 rpm counter clockwise and A is stationary. The number of teeth on the gears S and A are 30 and 130 respectively.

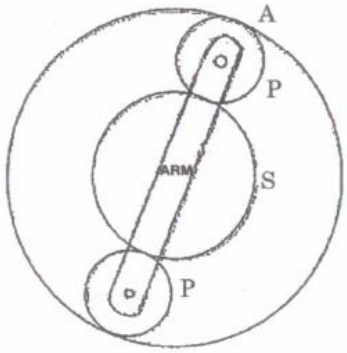

Fig. 14 (b)

15. a) A cross belt running over two pulleys 600 mm and 300 mm diameter connects two parallel shafts 4 meters apart and transmits 7.5 kW from the larger pulley that rotates at 225 rpm. Coefficient of friction between the belt and the pulley is 0.35 and the safe working tension is 25 N per mm width. Determine 1. Minimum width of the belt 2. Initial belt tension and 3. Length of the belt required.

(OR)

b) An electric motor driven power screw moves a nut in a horizontal plane against a force of 75 kN at a speed of 300 mm/min. The screw has a single square thread of 6 mm pitch on a major diameter of 40 mm. The coefficient of friction at the screw threads is 0.1. Estimate power of the motor.

PART – C (1×15=15 Marks)

16. a) ABCD is a four bar chain with link AD fixed. The length of the links are AB = 190 mm, BC = 280 mm, CD = 280 mm, and AD = 500 mm. The crank AB has an angular velocity of 10 rad/s clockwise. Draw the velocity and acceleration diagram when angle BAD = 55° and B and C lie on same side of AD. Find the acceleration and angular acceleration of links BC and CD.

(OR)

b) Design a cam for operating exhaust valve of an oil engine. It is required to give simple harmonic motion during opening of valve with 120° of cam rotation and simple harmonic motion during closing of the valve with 60° of cam rotation. The valve must remain in the fully open position for 30° of cam rotation. The lift of the valve is 50 mm and the least radius of the cam is 25 mm. The follower is provided with a roller of radius 10 mm and its line of stroke passes through the axis of the cam.

Question Paper Code : 41390

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018
Third/Fourth Semester

Question Paper Code : 41390

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018
Third/Fourth Semester
Mechanical Engineering
ME6401 – KINEMATICS OF MACHINERY
(Common to Mechanical Engineering (Sandwich)/Mechatronics Engineering)
(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions
Missing data, if any, may be suitably assumed and stated clearly.

PART – A **(10×2=20 Marks)**

1. Define kinematic pair and classify it according to the types of contact.
2. Sketch a crank-rocker mechanism and a slider crank mechanism indicating their input and output motions.
3. How will you find out the total acceleration from its normal and tangential components ?
4. Mention any two motives for doing acceleration analysis of mechanisms or machines.
5. Classify and sketch the translating cam followers based on their position.
6. Sketch and name a specified contour cam, stating its advantage.
7. State the two important similarities of a spur gear pair and helical gear pair.
8. Sketch an ordinary gear train and an epicyclic gear train stating their important difference.
9. In an open belt drive of horizontal type, the slack side of belt should be kept on the top side of pulleys. Why ?
10. What are the advantages of using friction clutches ?

PART – B **(5×13=65 Marks)**

11. a) i) State and brief the Kutzbach criterion for planar mechanisms and using this criterion, determine the arrangement shown in Fig. 11 (a) as a structure or a constrained mechanism or an unconstrained mechanism. **(6)**

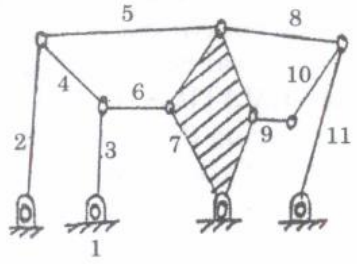

Fig. 11(a)

ii) Define transmission angle of a four bar mechanism and explain its significance. Also, neatly sketch a Crank-Rocker mechanism in its minimum and maximum transmission angle positions. **(7)**

(OR)

b) i) Define kinematic inversion and neatly sketch an elliptic trammel, i.e., one of the inversion of a double slider crank chain. Also, prove or disprove that all the points on the revolving link of the elliptic trammel will trace ellipses only. **(8)**

ii) Sketch and brief Peaucellier exact straight line mechanism. **(5)**

12. a) i) A four-bar mechanism AoABBo has the following lengths :

Fixed link, AoBo – 60 mm; Input link, AoA – 30 mm; Coupler, AB – 45 mm Output link, BBo – 50mm.

Pivot Ao is left of pivot Bo and both pin joints A and B are above the horizontal fixed link. A point C is on the straight extension of the coupler, such that BC = 25 mm. Input link rotates at a constant speed of 20 rpm clockwise. Determine the linear velocities of points B and C separately, and angular velocities of the coupler and the output link, when the input link is 60° counter clockwise from the fixed link. **(9)**

ii) What is Kinematic Synthesis ? Name the three phases of kinematic synthesis and classify the linkage synthesis problems. **(4)**

(OR)

b) i) State and prove the Aronhold-Kennedy theorem related to instantaneous centres. **(6)**

ii) Explain in detail, the concept of Coriolis component of acceleration with neat sketches and equations. **(7)**

13. a) i) Neatly sketch a cam mechanism with roller follower and indicate the following in the sketch and brief them : Cam profile, Base circle, Prime circle and Pressure angle. **(6)**

ii) In a cam follower mechanism, 40 mm lift of the follower has to be made in the first 120° rotation of the cam. Draw the displacement diagrams for the following types of motions, separately for each, taking atleast 8 equal divisions of 120° :

a) Simple harmonic motion

b) Cycloidal motion. **(7)**

(OR)

b) Draw the cam profile of an offset knife edge follower cam, which rotates in clockwise direction, with both rise and return have Uniform Acceleration and retardation motions, for the following data :

Base circle Diameter of the cam = 50 mm,

Lift of the follower = 48 mm

Offset of follower = 10 mm to the right of cam rotation centre

Cam rotation angles for the follower motions are :

Rise = 80°, First Dwell = 100°, Return = 120° and Second dwell = 60°. Assume the length of the displacement diagram as 180 mm (x-axis) and divide the rise and return rectangles into at least 8 equal divisions each. **(13)**

14. a) i) State the fundamental law of gearing. Prove this law, by considering and neatly sketching two moving curved surfaces in contact. **(10)**

ii) Name the two types of tooth profiles satisfying the law of gearing and brief any one of them. **(3)**

(OR)

b) i) Explain with neat sketches various classifications of gear trains. **(7)**

ii) Neatly sketch the gear train called as Fergusson's Paradox. Explain and prove why is it called Paradox, by assuming suitable number of teeth for the gears of this train. **(6)**

15. a) i) State and prove the relationship between angle of friction and co-efficient of friction with suitable sketches. **(5)**

ii) An open belt running over two pulleys of diameters 600 mm and 200 mm connects two parallel shafts which are 2.5 m apart. The smaller pulley transmits 7.5 kW at 300 rpm. The co-efficient of friction between the pulley and the belt is 0.3. Determine the ratio of tension on tight side, T1 with tension on slack side, T2 and the initial tension on the belt. **(8)**

(OR)

b) i) Neatly sketch a Simple Band Brake and derive the equations for braking torque for both directions of rotation separately and compare them. **(8)**

ii) The outer and inner radii of a flat collar thrust bearing are 120 mm and 72 mm respectively. The total axial thrust is 60 kN and the intensity of uniform pressure is 0.25 MPa. If the coefficient of friction is 0.05 and the shaft rotates at 600 rpm, determine the power lost in overcoming the friction and the number of collars required to withstand the axial thrust. **(5)**

PART – C **(1×15=15 Marks)**

16. a) i) In a four-bar crank-rocker mechanism, the forward motion of the rocker takes place during the 225° constant speed rotation of the crank. Determine the time-ratio and prove that this mechanism can be used as a quick-return mechanism. **(3)**

ii) For a high speed application using cam mechanism, the motion of the follower should be with gradually changing smooth acceleration and with constant pressure angle for whole cycle of rotation of the cam. Suggest a suitable type of motion and a suitable follower, for this application stating the reasons. **(3)**

iii) Number of teeth on spur gears A, B, C, D and E are 30, 15 45 20 and 75 respectively. The shaft with Gear A is input and the shaft with gear E is output and the gears have to mesh with the same order as mentioned above. Neatly sketch them as a) a Simple Gear Train and b) a Non-reverted Gear Train with gears C and D on a single shaft and find the output speeds of each gear train with sense of rotation when the input shaft rotates 100 rpm in counter clockwise direction. **(9)**

(OR)

b) i) In order to form a four-bar kinematic chain, state and prove the assembly condition of link lengths by selecting suitable link lengths which are within the range of 35 mm to 175 mm and also, satisfying Grashof's law. **(7)**

ii) Data related to a Square Threaded Screw Jack are : Pitch diameter = 60 mm, Pitch of the thread = 16 mm, Load = 30 kN, Co-efficient of friction between screw and nut is 0.2. Determine the ratio of torque required to lower and to raise the load. Also, find the efficiency of the screw jack when the load is raised. **(8)**

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Question Paper Code : 20807

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

Fourth Semester

Mechanical Engineering

ME 6401 — KINEMATICS OF MACHINERY

(Regulations 2013)

(Common to Mechanical Engineering (Sandwich), Mechatronics Engineering)

(Also common to PTME 6401 – Kinematics of Machinery for B.E. (Part-Time) Third Semester- Mechanical Engineering – Regulations 2014)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Name the inversions of a double slider crank mechanism.

2. What is a pantograph?

3. Define Instantaneous centre.

4. What is meant by Coriolis component of acceleration?

5. Define prime circle of cam.

6. What is meant by Tangent cam? What are its applications?

7. What are the advantages of cycloidal gears?

8. Define Train value of a gear train.

9. What are the characteristics of Brake lining material?

10. Define slip and Creep in a belt drive.

PART B — (5 × 13 = 65 marks)

11. (a) Sketch and describe the working of crank and slotted lever quick return mechanism. Derive an expression to find the length of the stroke for the quick return mechanism. (13)

Or

(b) Describe the watts parallel mechanism for straight line motion and derive the condition under which the straight line is traced. (13)

12. (a) PQRS is a four bar chain with link PS fixed. The lengths of the links are PQ = 62.5 mm, QR = 175 mm, RS = 112.5 mm and PS = 200 mm. The crank PQ rotates at 10 rad/s clockwise. Draw the velocity and acceleration diagram when angle QPS = 60° and Q and R lie on the same side of PS. Find the angular velocity and angular acceleration of links QR and RS. (13)

Or

(b) In a pin jointed four bar mechanism ABCD, length of links AB = 300 mm, BC = CD = 360 mm and AD = 600 mm. The angle BAD = 60°. The crank AB rotates uniformly at 100 rpm. Locate all the instantaneous centre and find the angular velocity of link BC. (13)

13. (a) Draw the profile of a cam for operating the exhaust valve of an oil engine. It is required to give equal uniform acceleration and retardation during opening and closing of the valve each of which corresponds to 60° of cam rotation. The valve must remain in the fully open position for 20° of cam rotation.

The lift of the valve is 37.5 mm and the least radius of cam is 40 mm. The follower provided with a roller radius of 20 mm and its line of stroke passes through the axis of the cam. (13)

Or

(b) In a symmetrical tangent earn operating a roller follower, the least radius of the cam is 30 mm and roller radius is 17.5 mm. The angle of ascent is 75° and the total lift is 17.5 mm. The speed of the cam shaft is 600 rpm. Calculate

(i) The principal dimensions of the cam

(ii) The acceleration of the follower at the beginning of the lift, where straight flank merges into the circular nose and at the apex of the circular nose. Assume that there is no dwell between ascent and descent. (13)

14. (a) Derive an expression to find the minimum number of teeth on the pinion to avoid interference of gears. (13)

Or

(b) An internal wheel B with 80 teeth is keyed to a shaft F. A fixed internal wheel C with 82 teeth is concentric with B. A compound wheel D-E gears with the two internal wheels. D has 28 teeth and gears with C while E gears with B. The compound wheels revolve freely on a pin which projects from a disc keyed to a shaft A co-axial with F. If the wheels have the same pitch and the shaft A makes 800 rpm. What is the speed of the shaft F? (13)

15. (a) A multi disc clutch has three discs on the driving shaft and two on the driven shaft. The outside diameter of the contact surface is 240 mm and the inside diameter is 120 mm. Assuming uniform wear and coefficient of friction as 0.3. Find the maximum axial intensity of pressure between discs for transmitting 25 KW at 1575 rpm.

Or

(b) Derive an expression to find the length of a belt in an open belt drive. (13)

PART C — ($1 \times 15 = 15$ marks)

16. (a) A simple band brake operates on a drum of 600 mm in diameter that is running at 200 rpm. The coefficient of friction is 0.25. The brake band has a contact of 270°, one end is fastened to a fixed pin and the other end to the brake arm 125 mm from the fixed pin. The straight brake arm is 750 mm long and placed perpendicular to the diameter that bisects the angle of contact

(i) What is the pull necessary on the end of the brake arm to stop the wheel if 35 KW is being absorbed? What is the direction for minimum pull?

(ii) What width of steel band of 2.5 mm thick is required for this brake if the maximum tensile stress is not to exceed 50 N/mm^2? (15)

Or

(b) The mean diameter of the screw jack having pitch of 10 mm is 50 mm. A load of 20 KN is lifted through a distance of 170 mm. Find the work done in lifting the load and efficiency of screw jack when

(i) the load rotates with the screw and

(ii) the load rests on the loose head which does not rotate with the screw the external and internal diameters of the bearing surface of the loose head are 60 mm and 10 mm respectively. The coefficient of friction for the screw as well as the bearing surface may be taken as 0.08. (15)

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