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(AUTONOMOUS)
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PERAMBALUR-621212, TAMILNADU, INDIA.
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COURSE MATERIALS

Course Code/Name	U23MET41/ Kinematics of Machinery			
Year/Department	II / MECHANICAL ENGINEERING			
Credits Details	L:3	T: 0	P: 0	C:3
Total Contact Hours Required	45			

Syllabus:

UNIT I/BASICS OF MECHANISMS	**No.of Periods : 9**
Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, Mobility – Kutzbach criterion, Gruebler's criterion – Grashof's Law – Kinematic inversions of four-bar chain and slider crank chains – Limit positions – Mechanical advantage – Transmission Angle – Description of some common mechanisms – Quick return mechanisms, Straight line generators, Universal Joint – rocker mechanisms.	
UNIT II/KINEMATICS OF LINKAGE MECHANISMS	**No.of Periods : 9**
Displacement, velocity and acceleration analysis of simple mechanisms - Graphical method- Velocity and acceleration polygons - Velocity analysis using instantaneous centres - kinematic analysis of simple mechanisms - Coincident points - Coriolis component of Acceleration - Introduction to linkage synthesis problem.	
UNIT III/KINEMATICS OF CAM MECHANISMS	**No.of Periods : 9**
Classification of cams and followers - Terminology and definitions - Displacement diagrams - Uniform velocity, parabolic, simple harmonic and cycloidal motions - Derivatives of follower motions - Layout of plate cam profiles - Specified contour cams - Circular arc and tangent cams - Pressure angle and undercutting - sizing of cams.	
UNIT IV/GEARS AND GEAR TRAINS	**No.of Periods : 9**
Law of toothed gearing - Involutes and cycloidal tooth profiles -Spur Gear terminology and definitions -Gear tooth action - contact ratio - Interference and undercutting. Helical, Bevel, Worm, Rack and Pinion gears [Basics only]. Gear trains - Speed ratio, train value - Parallel axis gear trains - Epicyclic Gear Trains.	
UNIT V/FRICTION IN MACHINE ELEMENTS	**No.of Periods : 9**
Surface contacts - Sliding and Rolling friction - Friction drives - Friction in screw threads -Bearings	

and lubrication - Friction clutches - Belt and rope drives - Friction in brakes- Band and Block brakes.

Objective:

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

Text Book:

T1:Uicker, J.J., Pennock G.R and Shigley, J.E., "Theory of Machines and Mechanisms" 3rd Edition, Oxford University Press, 2014.
T2:2. Rattan, S.S, "Theory of Machines", 4th Edition, Tata McGraw-Hill, 2019.

Reference Book:

R1. Thomas Bevan, "Theory of Machines", 3rd Edition, CBS Publishers and Distributors, 2005.
R2. Cleghorn. W. L, "Mechanisms of Machines", Oxford University Press, 2014
R3. Robert L. Norton, "Kinematics and Dynamics of Machinery", Tata McGraw-Hill, 2009.
R4. Allen S. Hall Jr., "Kinematics and Linkage Design", Prentice Hall, 1961
R5. Ghosh. A and Mallick, A.K., "Theory of Mechanisms and Machines", Affiliated East-West Pvt.Ltd., New Delhi, 2008.
R6. Rao.J.S. and Dukkipati.R.V. "Mechanisms and Machine Theory", Wiley-Eastern Ltd., New Delhi, 1992.

Website:

W1 : http://www.me.ncku.edu.tw/~mechanism/mechanisms/download/erdman_ma.pdf
W2 :http://www.brainkart.com/article/Description-of-common-mechanisms-Single--Double-and-offset-slider- mechanisms---Quick-return-mechanisms_6276.
W3 : http://mechdesigner.support/index.htm?kinematic-analysis-of-cams.htm
W4 : http://community.wvu.edu/~bpbettig/MAE342/Lecture_2_gear_trains_b.pdf
W5 : http://sounak4u.weebly.com/block-and-band-brake.html

Online Mode of Study(if Any):

http://nptel.ac.in/courses/112101096/download/lecture-6.pdf:
https://nptel.ac.in/courses/112101096/Mod%206/Lec1/6.1_4.html
http://nptel.ac.in/courses/112101096/download/lecture-8.pdf
http://nptel.ac.in/courses/112107088/module1/lecture2/lecture2.pdf

DEPARTMENT OF MECHANICAL ENGINEERING
U23MET41 KINEMATICS OF MACHINERY
TWO MARK QUESTION
UNIT 1 – BASICS OF MECHANISM
PART-A

1. Differentiate between Machine and Mechanism.

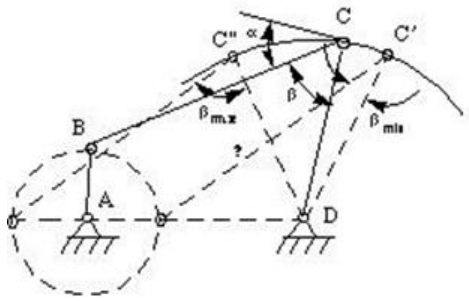
Machine	Mechanism
Machine is a mechanism or collection of mechanism which transmits force from the source of power to the resistance (load) to overcome and thus performs useful mechanical work.	Combination of rigid or resistant bodies connected that they move upon each other with definite relative motion,
Eg. Lathe, Shaping Machine etc.	Eg. Single slider mechanism in IC engine
All machines are mechanism	All mechanism are not machine

2. Write down Kutzbach criterion to find the mobility of a planar mechanism.

The Kutzbach criteria which calculates the mobility. **F = 3(n – 1) – 2j – h** ; Where, F- Degrees of freedom, n – number of links, J – number of joints, h – no of higher pairs

3. Define transmission angle and its significance.

The acute angle between the coupler and the driven link. In Figure, if AB is the input link, the force applied to the output link, CD, is transmitted through the coupler link BC. (That is, pushing on the link CD imposes a force on the link AB, which is transmitted through the link BC.) For sufficiently slow motions (negligible inertia forces), the force in the coupler link is pure tension or compression (negligible bending action) and is directed along BC.



For a given force in the coupler link, the torque transmitted to the output bar (about point D) is maximum when the angle βbetween coupler bar BC and output bar CD is $\pi/2$.Therefore, angle BCD is called **transmission angle**.When the transmission angle deviates significantly from $\pi/2$, the torque on the output bar decreases and may not be sufficient to overcome the friction in the system. For this reason, the **deviation angle** $\alpha=|\pi/2-\beta|$ should not be too great. In practice, there is no definite upper limit for α, because the existence of the inertia forces may eliminate the undesirable force relationships that is present under static conditions. Nevertheless, the following criterion can be followed.

$$\alpha_{max} = |90^\circ - \beta|_{min} < 50^\circ$$

4. Enumerate the difference between a Machine and a Structure. [JUNE2014]

Machine	Structure
Machine is a mechanism or collection of mechanism which transmits force from the source of power to the resistance (load) to overcome and	Structure is the assemblage of resistant bodies without any relative motion between the links.
Eg. I C Engine	Eg. Bridges & Dams

4. Listout the inversions of a double slider crank chain.

Inversions of Double Slider Mechanism - First Inversion – Scotch Yoke mechanism, Second Inversion – Oldhams Coupling , Third Inversion – Elliptical trammel, Fourth Inversion – Hand Pump

6. State Grashof's law for a four bar linkage. [DEC2012]

It states that for a planar four bar linkage, sum of the shortest and longest link – lengths must be less than or equal to the sum of the remaining two link-lengths, is there is to be a continuous relative motion between two members - $S + L \leq P + Q$; Where, S – Length of shortest link, L – length of longest link, P and Q – remaining two link lengths.

i. If $L + S < P + Q$, then we call this a Grashof Mechanism G.1 = crank-rocker if S is the crank and either of the adjacent link is the fixed link G.2 = double-crank if S is the fixed link G.3 = double-rocker if the link opposite S is the fixed link
ii. If $L + S > P + Q$, then we call it non-Grashof's mechanism only double-rocker: no link is capable of making a complete revolution

ii) If $L + S = P + Q$, it can have G.1~G.3 and parallelogram form (collinear)

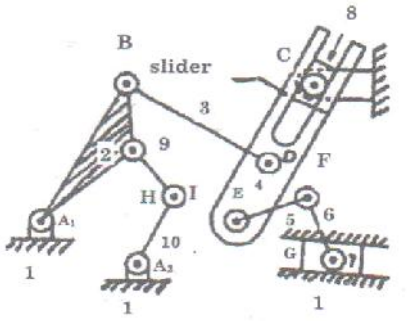
7. Define degree of freedom (or) mobility and give the DOF for a shaft in a circular hole.

It is defined as the minimum number of input parameters which must be independently controlled, in-order to bring the mechanism into a useful engineering purpose.
DOF for a shaft in circular hole is 2. It will have sliding motion and rotational motion. If the shaft end is fixed to a collar, sliding motion will be arrested and DOF is 1.

8. Define kinematic pair and illustrate any two types of constrained pair. [MAY2018]

When two kinematic links are connected in such a way that their motion is either completely or successfully constrained, these two links are said to form a kinematic pair. E.g foot step bearing, circular shaft in the circular slot.

9. Determine the number of degrees of freedom of the mechanism shown in the figure below.
[APRIL2015]



No of links l = 10
No of joints j = 9
The joints formed in closed loop (at link 2) will be considered as one joint.
[Eg Joints at (1,2), (9,2) & (3,2) forms a joint].
Deg of freedom n = 3(l-1) – 2j – h
Since h=0 (no higher pair),
n = 3 (10-1) – 2(9) = 9
Degrees of freedom n = 9

10. Define Link and List the various type of link.
Link is a resistant body is one which is capable of transmitting the required motion and force with negligible deformation in the direction of force transmission.

Types of links: 1) Rigid Link 2) Flexible link 3) Fluid link

11. Define the kinematic chain.
Kinematic chain is defined as the combination of kinematic pairs in which each link forms a pair of two kinematic pairs and the relative motion between the links is either completely constrained or successfully constrained. When a number of links connected in space make relative motion of any point on a link with respect to any other point on the other link follow a definite law it is known as kinematic chain.

12. Name the inversions of four bar mechanisms. [NOV2015]
Inversions of four bar mechanisms - First Inversion – Coupled wheels of locomotive – double crank, Second Inversion – Beam Engine - Crank and lever mechanism, Third Inversion – Watt's Engine Indicator – Double lever mechanism.

13. Name the inversions of single slider mechanism. [NOV2017]
Inversions of Single Slider Mechanism - First Inversion – Reciprocating engine mechanism, Second Inversion – Gnome Engine or Rotary Engine – Whitworth quick return mechanism, Third Inversion – Quick return mechanism – Crank and slotted lever – Oscillating cylinder engine, Fourth Inversion – Hand Pump.

14. Name some straight line generating mechanism.

Straight line generating Mechanism – Peaucellier mechanism, Scott Russel mechanism and Hart's mechanism, Robert's Mechanism & Tchibicheff Mechanism.

15. Write down the Grubler's criteria for planar mechanism. [NOV2015/NOV2017]

The following equation is used to describe mobility in 2D or planar systems: M = 3(N-1) – 2 f1 – f2, Where, N = total number of links, M = DOF, f1 = number of 1 DOF joints, f 2 = number of 2 DOF joints. This is known as **GRUBLER'S EQUATION** and is for mobility of planar systems.

16. Define Kinematic Pair.

When two links are in contact with each other it is known as a pair. If the pair makes constrain motion it is known as kinematic pair.

17. Classify the kinematic pair based on the various characteristics. Define Higher and lower pair. Classify kinematic pair based on nature of contact [MAY2016/MAY2018]

Kinematic pairs are classified on the basis of the following characteristics – 1) Type of relative motion between contacting elements, 2) Type of contact between contacting elements, 3) Number of degrees of freedom and 3) Type of closure. Kinematic pairs in which there is a surface (area) contact between the contacting elements. All revolute pairs, sliding pairs, screw pairs, globular pairs, cylindrical pairs and flat pairs are Lower Pairs. Kinematic pairs in which there is a point or line contact between the contacting elements are called as higher pair. Meshing gear teeth, cam and follower pair, wheel rolling on a surface, a ball and roller bearings and pawl and ratchet are higher pair.

18. When a linkage becomes Mechanism. [MAY 2016]

A mechanism is formed by fixing one of the links of a chain. The process of choosing different links of a kinematic chain for making different kind of mechanism is called Kinematic Inversion.

19. Define Mechanical Advantage.

It is defined as the ratio of the output force or torque, supplied by the driven link, to the input force or torque, required to be supplied to the driver link.

21. Differentiate between rigid and resistant bodies [NOV2014]

A rigid body is an idealization of a solid body in which deformation is neglected. In other words, the distance between any two given points of a rigid body remains constant in time regardless of external forces exerted on it.

A body is said to be a resistant body, if it does not deform for the purpose for which it is made. For example the chair, it does not deform if a person sits on it, but it will break if you put a load of 1000 kg on it. So a resistant body is rigid for the purpose for which it is used.

22. What is meant by spatial mechanism?

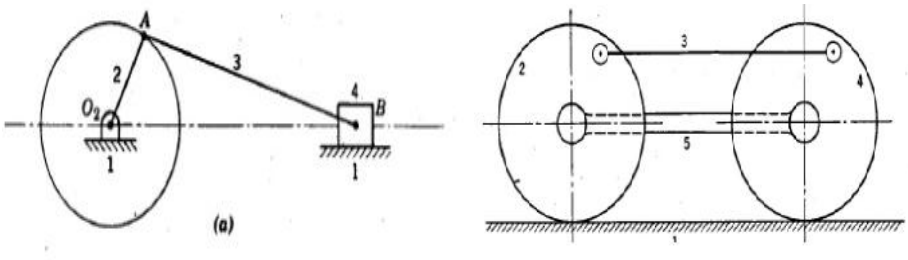
If there is any relative motion that is not in the same plane or in parallel planes, the mechanism is called **spatial mechanism. S**patial mechanisms are three dimensional.

23. Define Sliding Connectors [NOV2013]

When the two elements of a pair are connected in such a way that one can only slide relative to the other, then the connector is called Sliding connector. The piston and cylinder, cross-head and guides of a reciprocating steam engine, ram and its guides in shaper, tail stock on the lathe bed are examples of Sliding Connectors.

24. Differentiate Rotation and Translation [NOV2013]

Translation: A body has translation if it moves so that all straight lines in the body move to parallel positions. **Rectilinear translation** is a motion where in all points of the body move in straight line paths [Eg. The slider in slider cranks mechanism]. **Curvilinear translation** is translation in which points in a body move along curved paths. [Eg. Tie rod connecting the wheels of a steam locomotive]
Rotation: In rotation, all points in a body remain at fixed distances from a line which is perpendicular to the plane of rotation. The line is the axis of rotation and points in the body describes the circular paths about it



[Link 4 – Rectilinear translation] [Link 3–Curvilinear translation & Links 2, 4 – Rotation]

25. Classify Constrained Motion.[JUNE2014] (or) Write short notes on complete & incomplete constraints in lower & higher pair. [APRIL2015]

When the motion of a kinematic link/pair is restricted to a particular direction/path, it is called constrained motion. It can be classified as: **(i) Completely Constrained Motion**: If the movement of the link is restricted to move in one particular path only, it is completely constrained**.**

(ii) Incompletely Constrained Motion: If the movement of the link is restricted to move in more than one path, it is incompletely constrained motion. **(iii) Successfully constrained motion:** If the movement of the link is restricted to one particular path and made it to stop at particular length of the movement it is successfully constrained motion

26. What type of kinematic pair exists between human shoulder and arm based on nature of contact and nature of relative motion? [APRIL2017]

Type of kinematic pair exists between human shoulder and arm: *Nature of contact- Lower Pair
*Nature of relative motion-Spherical Pair

UNIT – II KINEMATICS OF LINKAGE MECHANISMS
PART-A

1. What are the various methods used to find the velocity. [MAY2016]

1. Instantaneous centre method and 2. Relative velocity method.

2. Explain normal component of acceleration.

The acceleration of a particle at any instant moving along a circular path in a direction normal to the tangent at that instant and directed towards the centre of circular path [direction from A to O] is called normal component of acceleration or normal acceleration. It is also called as radial or centripetal

acceleration.

3. Explain normal component of acceleration.

The acceleration of a particle at any instant moving along a circular path in a direction normal to the tangent at that instant and directed towards the centre of circular path [direction from A to O] is called normal component of acceleration or normal acceleration. It is also called as radial or centripetal acceleration.

4. Define rubbing velocity. [DEC2012]

The links in a mechanism are mostly connected by means of pin joints. The rubbing velocity (V_r) is defined as the algebraic sum between the angular velocities (ω) of the two links which are connected by pin joints, multiplied by the radius(r) of the pin. $V_r = \omega r$.

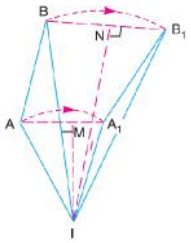
5. Define Corioli's component of acceleration. [NOV2017]

When a point on one link is sliding along another rotating link, such as in quick return motion mechanism, then the coriolis component of the acceleration must be calculated to determine the direction of acceleration component. It can be calculated by:

$$a_{BC}^{c} = a_{BC}^{t} = 2\omega v$$

6. Define Instantaneous centre of rotation. [JUNE2014/APRIL2017]

The combined motion of rotation and translation of the link may be assumed to be a motion of pure rotation about some centre I, known as the Instantaneous Centre of rotation. [Also called as Centro or Virtual centre]. In the figure, the link AB has a translatory (curvilinear) motion as well as rotary motion and moves to the position of A_1B_1 as shown. In instantaneous centre method it will be considered as a pure rotation about the centre I which is called Instantaneous centre.



7. Illustrate the space centrode and body centrode.

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

8. Name any two mechanisms having coriolis component. [NOV2014]

Crank and Slotted lever quick return mechanism and Whitworth quick return mechanism.

9. What is relative pole, with respect to velocity analysis? [MAY2016]

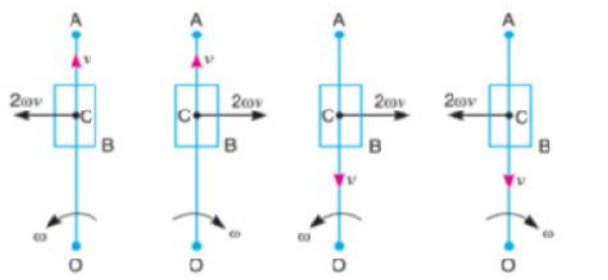
The relative pole is the centre of rotation of the connecting rod relative to the crank rotation and the corresponding slider displacement.

10. State the properties of instantaneous centre method.

An Instantaneous centre of rotation is a point common to two links having relative motion. I_C is a point about which one body can be assumed to rotate with respect to the other. It is an imaginary point at which the two bodies have same absolute velocity. It follows that the two bodies have zero relative velocity at the coincident points I. I_C is in general not a stationary point, because the mechanism moves from one position to another, the velocities of points like A and B keep on changing.

10. How will you determine the direction of Coriolis component of acceleration? [APRIL2015]

The direction of coriolis component of acceleration can be determined by rotating the velocity of sliding vector v_s through 90˚ in the direction of rotating angular velocity ω.



11. State and explain the Kennedy's theorem

It states that if three bodies are in relative motion with respect to one another, the three relative instantaneous centres of velocity are collinear.

12. List the various types of instantaneous centres. What is total no of instantaneous centres in mechanism? [NOV2015]

The various types of instantaneous centres are 1. Fixed Instantaneous Centre 2. Permanent Instantaneous Centre and 3.Neither fixed or permanent Instantaneous Centre

To determine the number of instantaneous centre in a mechanism, the formula used is **N (N-1) / 2**, where, N – no of links. E.g., For 4 bar mechanism, No of links = 4,

No of Instantaneous centre = 6

13. What are the expressions for radial and tangential component of acceleration?[MAY18]

If OB is the link and has a fixed centre at O and OB is the turning pair then, Radial **component** a^r_{OB} = μ_{OB}*$_{OB}$ where, μ_{OB}=Angular velocity of link OB, ~$_{OB}$=Angular acceleration of link OB, **OB**=Length of link OB. **Tangential component** a^t_{OB} =~$_{OB}$***OB**, where ~$_{OB}$=Angular acceleration of link OB, OB=Length of link OB.

14. For what type of mechanism Coriolis component of acceleration is taken into account. [NOV2015]

The mechanism containing the turning pair and sliding pair in the same point needs to determine coriolis component. Whitworth Quick return mechanism and Crank and slotted level mechanism are examples of such mechanism.

15. What is meant by coincident points?

In quick return motion mechanism, like Crank & Slotted lever mechanism and Whitworth quick return motion mechanism, the end point of the crank and point on the slotted lever are the same point. In crank, it will be turning pair. In Slotted lever, it will be sliding pair. The same point will act as a turning pair and sliding pair in such mechanism. Such type of point is called Coincident points. In coincident point, in one pair, the point will be turning and in another pair it will be sliding.

16. What is meant by Instantaneous axis, Axode and Centrode?

A line drawn through an instantaneous centre and perpendicular to the plane of motion. The locus of the instantaneous axis is known as axode. The locus of all instantaneous centres is called as Centrode.

17. What is meant by configuration diagram? Where do we use it? [DEC2012]

The diagram which is drawn with the actual scale at the positions shown in the mechanism. By using it, velocity and acceleration of the links can be calculated for this position.

18. Define low degree of Complexity. [NOV2013]

When a complex mechanism can be rendered simple by a change of input link, it is called mechanism having low degree of complexity. For example in a 6 bar mechanism as shown in figure, If the input link is 2, the velocity at point B cannot be determined from velocity at point A as the radius of path of curvature of B is unknown. But if the input link is changed as link 5 or 6, velocity of point at B can be determined. Hence it is called mechanism having low degree of complexity.

19. Define high degree of Complexity.

When a complex mechanism cannot be rendered simple by a change of input link, it is called mechanism having high degree of complexity. In such mechanism, the radii of paths of curvature of two or more transfer points of a floating link are not known.

20. Define Freudenstein's equation in Computer Aided analysis for 4 bar mechanism.

Computer Aided Analysis for four bar mechanism is developed by taking components of links in 2 dimensional spaces of X-axis and Y-axis as shown. The expressions for displacement, velocity and acceleration are derived from it. Freudenstein's equation is derived from displacement analysis to simplify the velocity & acceleration analysis. This expression is called **Freudenstein's Equation.**

21. What is the need for finding acceleration of linkage in a mechanism? [NOV2014]

Acceleration of linkages are determined to get the output acceleration of the various linkages to utilize the mechanism for suitable application.

22. What is the expression for Corioli's component of acceleration? [JUNE2014]

When a point on one link is sliding along another rotating link, such as in quick return motion mechanism, then the coriolis component of the acceleration must be calculated to determine the direction of acceleration component. It can be calculated by:

$$a^c_{BC} = a^t_{BC} = 2\omega.v$$

23. What is Virtual Centre?

The combined motion of rotation and translation of the link may be assumed to be a motion of pure rotation about some centre I, known as the Instantaneous Centre of rotation. [Also called as Centro or Virtual centre].

24. What is the formulation to calculate the no of instantaneous centres are in a mechanism?

To determine the number of instantaneous centre in a mechanism, the formula used is **N (N-1) / 2**, where, N – no of links. E.g., For 4 bar mechanism, No of links = 4, No of Instantaneous centre = 6

25. Define number of instantaneous centre [NOV2013/APRIL2015]

The various types of instantaneous centres are 1.Fixed Instantaneous Centre, 2. Permanent Instantaneous Centre and 3.Neither fixed or permanent Instantaneous Centre

26. State the Arnhold Kennedy Theorem. [NOV2017]

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

27. Find the resultant acceleration of an 80mm radius crank rotating at a constant angular velocity of 10rad/s, at the crank-pin position. [APRIL2017]

Given: Crank Radius=0.08m; Angular Velocity ω=10rad/s

Resulatnat Acceleration $a=\omega^2$*Crank Radius=8rad/s^2

UNIT – III KINEMATICS OF CAMS

PART-A

1. List the classifications of cam followers based on shape.

Cam followers are classified based on shape as follows

1. Knife edge follower; 2.Roller follower; 3.Flat faced follower; and 4.Spherical follower

2. What are the various types of motions of follower motion? [JUN2014/NOV2014]

The cam rotates at a uniform angular velocity; the follower may have the following motions, 1. Uniform Velocity; 2.Simple Harmonic Motion; 3.Uniform velocity & acceleration and 4. Cycloidal motion.

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

Cylindrical cam and Radial or Disc cam

4. State the basic requirements for high speed cams.

An acceleration curve with abrupt changes exerts abrupt stresses on the cam surfaces and at the bearings accompanied by detrimental effects such as surface wear and noise. This may lead to early failure of the cam system. Hence, the high speed cam requires smooth acceleration curves. At very high speeds, even the jerk (related to rate of change of acceleration) is made continuous as well.

5. What are the necessary elements of a cam mechanism?

Cam- The driving member is known as the cam, Follower-The driven member is known as the follower and Frame-It supports the cam and guider the follower.

6. State the expressions for maximum velocity and acceleration of a follower moves with Cycloidal motion.

$V = 2\omega S/\theta_o$; $a = 2\pi\omega^2 S/\theta_o^2$, ω – Angular velocity (rad/sec), S – Stroke length or Lift (mm) and θ_o – Angle of ascent

7. 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?

Prime circle is the smallest circle drawn to the pitch curve from the centre of rotation of cam. For knife edge follower, prime circle and base circle are aligned. Hence, radial distance between them is zero.

8. Define Radial follower

When the motion of the follower is along an axis passing through the centre of the cam it is known as radial follower.

9. Define Cam

A **cam** may be defined as a machine element having a curved outline or a curved groove, which, by its oscillation or rotation motion, gives a predetermined specified motion to another element called the **follower** The cam has a very important function in the operation of many classes of machines, especially those of the automatic type, such as printing presses, shoe machinery, textile machinery, gear-cutting machines, and screw machines

10. Define pitch curve of the cam.

The path generated by the trace point at the follower is rotated about a stationary cam. i.e., BY holding

the cam fixed and rotating the follower in a direction opposite to that of cam, then the curve generated by the locus of the trace point is called the pitch curve.

11. Define offset follower. [NOV2015]

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

12. Define the term jump speed of a cam. [NOV2014]

The speed at which the follower will not be in contact during the rotation of the cam and it occurs at high speeds. It is not advisable to run the cam with jumping phenomenon.

13. Why roller follower is preferred to knife edge follower. [APRIL2015]

Excessive wear of the knife edge follower is reduced by roller follower

14. Define pressure angle and Pitch Circle. [NOV2013/NOV2015]

Pressure angle represents the included angle at any point on the pitch curve between the line of motion of follower and normal to that point on the cam profile. This angle is of great importance in designing the cam profiles. It is a circle drawn from the centre of the cam through the pitch points.

15. Define undercutting in cam. How it occurs?

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

16. Define tangent cam? [Jun 2014/May 2016]

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

17. Define trace point in the study of cams. [DEC 2012/MAY2016]

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

18. Where are the roller follower extensively used? [NOV2017]

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

19. How can you prevent undercutting in cam?

By decreasing the follower lift, by increasing cam rotation angle, by increasing the cam size (i.e., Base circle).

20. What do you know about gravity cam?

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

21. Define Lift (or) Stroke in cam.

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

22. How can high surface stress in flat faced follower be minimised?

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

23. What is meant by Circular arc cam? [DEC2012]

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.

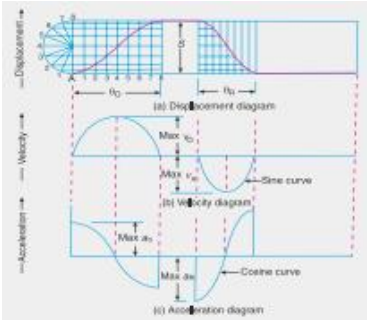
24. What is the procedure to draw the cam profile? [NOV2013]

(i) Construct the displacement diagram as per the given type of follower motion (Simple

harmonic/Uniform Acceleration and Retardation/Uniform Velocity/Cycloidal)

(ii) Draw the base circle and prime circle (if roller follower is used) and divide the circle into Angle of ascent, Dwell and Angle of descent.

(iii) Transfer the lengths of displacement diagram and trace the profile of the cam.



25. Draw the Displacement, Acceleration and Velocity Diagrams for a follower when it moves with simple harmonic motion. [APRIL2015]

26. Differentiate between radial cam and cylindrical cam. [NOV2017]

*In radial cams, the follower reciprocates or oscillates in a direction perpendicular to the cam axis.

*In cylindrical cams, the follower reciprocates or oscillates in a direction parallel to the cam axis. The follower rides in a groove at its cylindrical surface.

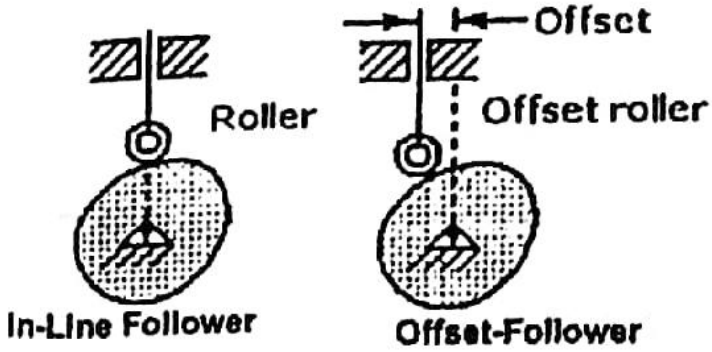
27.Which type of cam follower motion is preferred for high speed engines? Why? [APRL2017]

For high speed engines, the cam follower should move with cycloidal motion because all the other motions have infinite acceleration at the starting of the motion. So this induces thrust which damages the cam so to avoid this we use cycloidal motion.

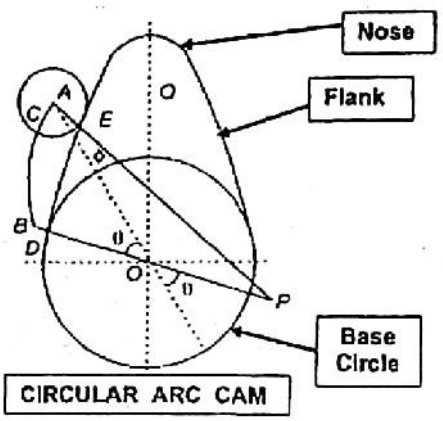
28. Give any two applications of cam mechanism in IC engines [APRL2017]

*Valve actuation *Control of valve timing

29. Classify & Sketch the translating cam followers based on their position. [MAY2018]



30. Sketch & name a specified contour cam, stating its advantage. [MAY2018]



The profile shapes are with circular arcs and tangents [i.e. straight lines], which are easy to manufacture, whereas the complicated shape profiles which are obtained from general displacement diagrams are very difficult to manufacture.

UNIT – IV GEARS & GEAR TRAINS

PART-A -

1. Define (a) Module (b) Diametrical Pitch of gears.

Module (m): is the ratio of pitch diameter to the number of teeth on the gear. m = D/T, where D- pitch circle diameter, T – no of teeth. **Diametrical Pitch**: It is the number of teeth per unit pitch circle. = T/D

2. What is axial pitch of a helical gear? [APRIL/MAY2016]

It is the distance, parallel to the axis, between similar faces of adjacent teeth. It is same as circular pitch and is therefore denoted by p_c. The axial pitch may also be defined as the circular pitch in the plane of rotation or the diametrical plane.

3. What are the special advantages of epicyclic gear trains? [APRIL2015]

The epicyclic gear train are useful for transmitting high velocity ratios with gears of moderate size in a comparatively lesser space.

4. Define velocity ratio.

Velocity ratio of a simple gear train is defined as the ratio of the angular velocity of the first gear in the train to the angular velocity of the last gear.

5. Define gear train.

A combination of gears that is used for transmitting motion from one shaft to another shaft is known as gear train. E.g. spur gear, spiral gear.

6. When involute interference occurs?

If the teeth are of such proportion that the beginning of contact occurs before the interference point is met then the involute proportion of the driven gear will mate a non in volute portion of the driving gear and involute interference is said to occur.

7. Define cycloid.

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

8. Define Arc of Approach and Arc of Recess. [APRIL/MAY2016]

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

It is the portion of the path of contact from the pitch point to the end of engagement of a pair of teeth.

9. What are the conditions to be satisfied for interchangeability of all gears?

For interchangeability of all gears, the set must have the same circular pitch, module, diameter pitch, pressure, angle, addendum and dedendum and tooth thickness must be one half of the circular pitch.

10. Define i) path of contact. ii) Length of path of contact. iii) Arc of contact [DEC2012]

Path of contact: It is the path traced by the point of contact of two teeth from the beginning to the end of engagement. Length of path of contact: It is the length of common normal cut- off by the addendum circles of the wheel and pinion. Arc of contact: The distance travelled by a point on either pitch circle of the two wheels during the period of contact of a pair of teeth.

11. Define circular pitch.

It is the distance measured on the circumference of the pitch circle from a point of one tooth to the corresponding point on the next tooth. It is denoted by $P_{c.}$ Circular pitch $P_c = \pi/DT$, Where D = Diameter of pitch circle, T = Number of teeth on the wheel.

12. What is reverted gear train? [DEC2012]

A reverted gear train is a compound gear train in which, the first and last gears are coaxial with each other. E.g In clocks and simple lathes where back gear is used to impart slow speed to the chuck

13. Define undercutting in Gears.

The under cutting concept in gearing is, when the two gears mates, pinions whose base circle is more than the dedendum circle, therefore the profile of tooth below the base circle is non– involute. In this case the profile of wheel and pinion will not be tangent to each other and the tip of the wheel will dig out or interfere with the flank of the pinion and remove the part of material called under cut and the process of removal of material is under cutting of gears. The teeth of pinion will become weak due to undercutting.

14. What are the properties of involute tooth profile?

a) A normal drawn to an involute at pitch point is a tangent to the base circle.
b) Pressure angle remains constant during the mesh of an involute gears.
c) The involute tooth form of gears is insensitive to the centre distance and depends only on the dimensions of the base circle.
d) The radius of curvature of an involute is equal to the length of tangent to the base circle.
e) Basic rack for involute tooth profile has straight line form.

15. Define pressure angle and explain the effect of different pressure angle.

The pressure angle is the angle which the common normal to the contacting tooth profiles, at the point of contact, makes with the common tangent to the two pitch circles at the pitch point.

16. Discuss the advantages of involute gear tooth profile.

It is easy to manufacture and the center distance between a pair of involute gears can be varied without changing the velocity ratio. Thus close tolerances between shaft locations are not required. The most commonly used conjugate tooth curve is the involute curve.

In involute gears, the pressure angle, remains constant between the point of tooth engagement and disengagement. It is necessary for smooth running and less wear of gears.

The face and flank of involute teeth are generated by a single curve where as in cycloidal gears, double curves (i.e. epi-cycloid and hypo-cycloid) are required for the face and flank respectively. Thus the involute teeth are easy to manufacture than cycloidal teeth.

17. Describe the advantages and applications of helical gears

Applications: These are highly used in transmission because they are quieter even at higher speed and are durable. The other possible applications of helical gears are in textile industry, blowers, feeders, rubber and plastic industry, sugar industry, rolling mills, food industry, elevators, conveyors, cutters, clay working machinery, compressors and in oil industry.

18. State law of gearing. [JUNE2014/NOV 2015]

The common normal at the point of contact between a pair of teeth must always pass through the pitch point for all positions of the mating gears.

19. How is the epicyclic gear train works? [NOV2015]

An epicyclic gear train consists of two gears mounted so that the center of one gear revolves around the center of the other. A carrier connects the centres of the two gears and rotates to carry one gear, called the planet gear, around the other, called the sun gear. The planet and sun gears mesh so that their pitch circles roll without slip. A point on the pitch circle of the planet gear traces an epicycloid curve. In this simplified case, the sun gear is fixed and the planetary gear(s) roll around the sun gear.

20. What is meant by interference of Gears and how it can be avoided? What are the methods to avoid it?

Gear profile usually starts from base circle and ends with tip circle gear teeth and made in such a way that their contact is along the profile. Since the top surface of teeth is made flat the tip of the teeth of one gear tends to dig into the bottom flank of mating gears. This action is called interference.

Interference of gear tooth can be over comed by (i) undercutting the tooth of gears i.e. to remove some of the material in the root of the gear teeth (ii) using the minimum number of teeth on mating gears.

21. What are the advantages of helical gears over Spur Gears?

a) Noise less operation, b) High power transmission c) Fully engaged d) High speed operation

22. Why helical gear tooth is stronger than spur gear?

The teeth of helical gear are inclined to axis of gear. During meshing the helical gears are made to contact in point whereas spur gears are in line contact. Therefore helical gear tooth are stronger than spur gear tooth.

23. Define gear ratio. [NOV2013]

It is the ratio of number of teeth on the gear [T] to the number of teeth on the pinion. [t]. Gear ratio = T/t

24. Write short notes on Differentials. [NOV2013]

Differential gears are a kind of epicyclic gear train having two pairs of bevel gears attached in carrier with a bevel gear setup which is used to compensate the speed of the rear wheel of an automobile when the vehicle is negotiating a curve.

25. Differentiate between involute profile and cycloidal profile. [NOV2014]

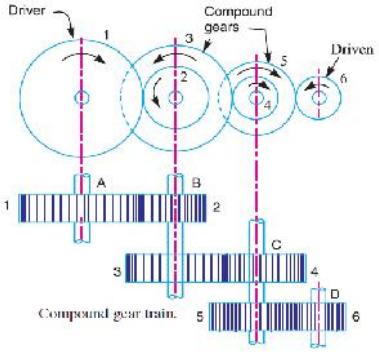
Involute Profile	Cycloidal profile

1. It can be formed by a locus of point traced by a string unwound from the circle.	1.It is formed from a point on circumference of a circle and locus of the point formed when rolling the circle without slipping
2.They are widely used in gears due to ease of manufacturing and will not affect the gearing action if any changes in centre distance	2. If the circle rolls on concave or convex surface it forms epicycloid or hypocycloid and it is normally given as gear tooth profile. Cycloidal gears are limited in use due to difficulty in manufacturing.

26. Give the classification of gears based on position of teeth on the wheel. [NOV2017]

According to position of teeth on the gear surface. The teeth on the gear surface may (a) straight, (b) inclined, and (c) curved.

27. Draw the compound gear train and write its speed ratio. [NOV2017]



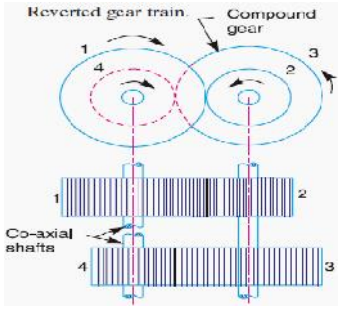
$$\frac{N_1}{N_6} = \frac{T_2 \times T_4 \times T_6}{T_1 \times T_3 \times T_5}$$

Speed ratio = Speed of the first driver / Speed of the last driven or follower = Product of the number of teeth on the drivens / Product of the number of teeth on the drivers

28. List down the common forms of gear teeth. [MAY2017]

Following are the two types of teeth commonly used: 1. Cycloidal teeth and 2. Involute teeth.

29. Sketch the configuration of a reverted gear train. [MAY2017]



30. State the two important similarities of a spur gear pair and helical gear pair. [MAY2018]

a] Both are used to transmit motion between parallel shafts.

b] In both the cases, teeth are cut on the curved surface of a cylinder.

UNIT – V FRICTION IN MACHINE ELEMENTS

PART-A

1. Distinguish between sliding and rolling friction. [DEC2012]

Sliding Friction – When two dry surfaces have a sliding motion relative to each other, then it is called as

sliding friction e.g friction between nut and bolt.

Rolling friction – When two dry surfaces have a rolling motion relative to each other, then it is called as rolling friction E.g – friction in ball and roller bearings.

2. State the condition for transmission of maximum power in belt drives.

The velocity of the belt $\mathbf{v = \sqrt{(T_{max} / 3m)}}$

3. What are the functions of clutch?

Functions: (i) To engage or disengage the rest of transmission as required, (ii) To transmit the engine power to rear wheels when the rear wheels without shock. (iii) To enable the gear to get engaged when the vehicle is in motion.

4. Define Velocity Ratio.

It is the ratio of the speed of driving pulley to the driven pulley in a belt drive. It can be expressed as VR $= N_2/N_1 = [D_1+t] / [D_2+t]$, N_1, N2 – Speed of driving and driven pulley, D_1, D2 – Diameter, t - thickness

5. Distinguish between Brakes and Dynamometer.

A brake is a mechanical device that inhibits motion, slowing or stopping a moving object or preventing its motion. Most brakes commonly use friction between two surfaces pressed together to convert the kinetic energy of the moving object into heat.

A dynamometer or "dyno" for short is a device for measuring force, torque, or power. For example, the power produced by an engine, motor or other rotating prime mover can be calculated by simultaneously measuring torque and rotational speed.

6. List out any four desirable characteristics of brake lining material.

a) It should have low wear rate, b) High heat resistant, c) It should have high coefficient of friction with minimum fading d) It should have adequate mechanical strength and high heat dissipation capacity and e) E.g materials – bronze, steel, wood on cast iron and fiber, asbestos, leather, cork on metal.

7. What are laws of solid dry friction? [NOV2014]

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

8. What is meant by self-locking & over hauling screw. [DEC2012/MAY2016]

If $\Phi < \alpha$, then the torque required to lower the load will be negative i.e load will start moving downward without applying any torque. It is known as overhauling of screws.

If $\Phi > \alpha$, the torque required to lower the load will be positive i.e some of torque is required to lower the load such a screw is known as self-locking screw [Φ – Limiting angle of friction & α – Angle of inclination of screw thread / Helix angle]

9. Name the various types of pivot bearing.

Based on the shape of the end of shaft and the shape of bearing surface, (i) Flat pivot bearing, (ii) Flat collar bearing, (iii) Conical pivot bearing, (iv) Truncated conical or trapezoidal bearing

10. Define brake and name its various types.

The frictional force is used to absorb the energy possessed by a moving member. Various types of brake 1. Block or shoe brake, 2.Band and block brake 3. Band brake, 4. Internal expanding shoe brake

11. Define centrifugal clutch.

It works on the principle of centrifugal force i.e the centrifugal force is increases with the increase in speed. It is used when it is required to engage the driven member automatically after the driving member has attained certain speed.

12. Explain. Self-energising brakes. **[MAY2016]**

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

13. Why lubrication reduces friction?

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

14. What you meant by 'Crowning in pulley'? [NOV2014]

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

15. What is meant by initial tension in belts?

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

16. State the law of belting?

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

17. What is meant by angle of contact or Lap angle?

It is the angle made by a common normal drawn to the tangent line at the point of engagement and at the point of disengagement of the belt on a pulley, at its centre.

18. What is the centrifugal effect on belts? [APRIL2015]

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

19. 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 belt drive. [NOV2015]

$$L = \frac{\pi}{2}(d_1 + d_2) + 2x + \frac{(d_1 - d_2)^2}{4x}$$

20. What is wipping? How it can be avoided in belt drives?

If the centre distances between two pulleys are long then the belt begins to vibrate in a direction perpendicular to the direction of motion of belt. This phenomenon is called as wipping. Wipping can be avoided by using idler pulleys.

21. What will be the effect on the limiting ratio of tensions of a belt if the coefficient of friction between the belt and rim of pulley is doubled while angle of lap remains same?

The ratio of tension will be squared.

22. Compare Plate clutch and cone clutch /Differentiate multi plate clutches & cone clutches. [NOV2013]

S.No	Plate clutches	Cone clutches
1.	Works on the principle of friction.	Works on the principle of friction
2.	Friction lined flat plates are used.	Friction lined frustum of cone is used.
3	Single plate and multi-plate clutch is possible depending on load condition	It is not possible.
4.	It uses uniform wear & uniform	It also uses the uniform wear & pressure

	pressure principle	principle

23. Define anti-friction bearing. [NOV2013]

Anti-friction bearings minimize friction by removing any possible sliding between bearing surfaces and replacing all contacts with rolling interfaces. They substitute ball or rollers for hydrodynamic or hydrostatic film to carry loads with reduced friction.

24. What is the maximum efficiency of screw jack? (or) [JUNE2014]

Write the expression for maximum efficiency of Screw jack. [NOV2015]

The maximum efficiency for a screw is defined by the following equations

$$\eta_{max} = \frac{1 - \sin\phi}{1 + \sin\phi} \qquad \alpha = 45^o - \frac{\phi}{2}$$

Where α is the helix angle, ϕ is the friction angle, and η_{max} is the maximum efficiency. The friction value is dependent on the materials of the screw and interacting nut, but ultimately the efficiency is controlled by the helix angle.

25. What is Creep in the case of belt drives?

The relative motion between belt and pulley surface due to unequal stretching of the two sides of drive. The effect of creep slow down the speed of the belt on the driving pulley than the peripheral velocity of pulley.

26. What is meant by crossed belt drive? [NOV2017] lt is a looped strip of flexible material, used to mechanically link two or more rotating shafts. They may be used as a source of motion, to efficiently transmit power, or to track relative movement. Belts are looped over pulleys. In a two pulley system, the belt drives the pulleys may be crossed, so that the direction of the shafts is opposite.

27. Write the conditions for the maximum power transmission by a belt from one pulley to another. [NOV2017]

$$\text{(i)}T_c = \frac{1}{3}T_{max} \text{ and } \text{(ii)}T_1 = \frac{2}{3}T_{max}$$

T_c=Centrifugal Tension in N; T_1=Tight side tension in N; T_{max}=Maximum tension in drive system in N

28. What kind of friction acts between the tyre and road in an automobile? [APRIL2017]

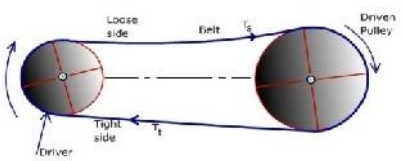
*Static friction (when tyre rolls without slipping) *Kinetic friction

29. State the functional difference between a clutch and a brake. [APRIL2017]

* A clutch is a transmission & control device that provides for energy transfer from driver to driven shaft.* A brake is a transmission & control device that stops a moving road, regulates movement or holds a road at rest by transforming by kinetic energy into heat.

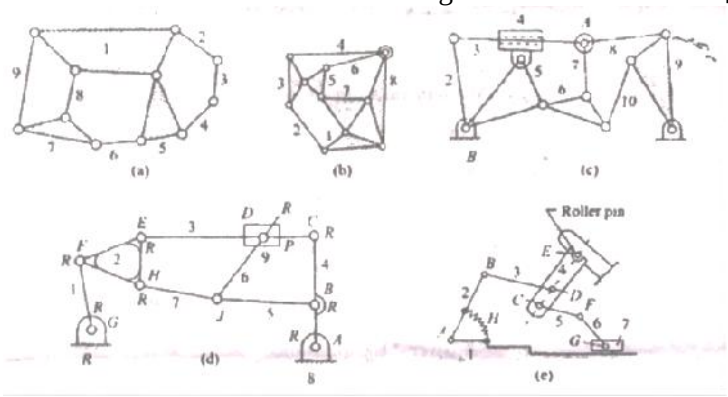
30. In an open belt drive of horizontal type, the slack side of belt should be kept on the top side of pulleys. Why? [MAY2018]

While the belt is running, the belt tension is such that 'sag' or 'droop' is visible on one side of the driving pulley. This is shown in Fig. for flat belt drive. The positions of input and output pulleys are such that the tight side of the belt must be on the bottom and slack side on the top of the pulleys.



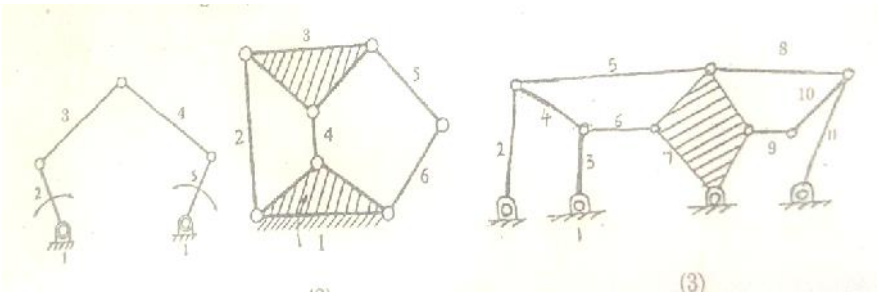
DEPARTMENT OF MECHANICAL ENGINEERING
U23MET41 KINEMATICS OF MACHINERY
16 MARK QUESTION
UNIT 1 – BASICS OF MECHANISM

1. **(i)** Classify Kinematic Pairs based on degrees of freedom
   (ii) What is Inversion and list its properties **[MAY2016]**
2. Define inversion of mechanism. Explain the inversions of four bar mechanism with neat sketch with suitable example. (or) Sketch & explain any three kinematic inversion of 4 bar chain. **[JUNE 2014/APRIL 2015/NOV 2015/APRIL2017]**
3. Explain the various inversions of double slider crank mechanism with neat sketch. **[APR2017/18]**
4. Design a four-bar crank rocker quick return mechanism to give a time ratio of 1.25 with rocker swing angle as 75° clockwise. Assume the output link (rocker) length as 50 mm and in the right extreme position it is vertical.
5. **(i)** Find the degrees of freedom of mechanism as shown in figure. [**MAY2016]**



   (ii) State the inconsistencies in Grubler's criterion **[MAY2016]**
6. **(i)** Find the maximum and minimum transmission angles for the mechanisms shown in fig.2. The figure indicates the dimension in standard units of lengths.
   (ii) Write short notes on toggle mechanism **[NOV2013/MAY2018]**
7. 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. **[NOV2015/APRIL2017]**
8. Sketch & describe the working of two different types of quick return mechanisms. Derive an expression for the ratio of time taken in forward & return stroke of these mechanisms**.**
   [JUNE2014/APRIL2015]
9. Sketch and explain any various types of straight-line motion generating mechanism.**[APR18]**

10. What is a kinematic inversion? Discuss any 3 application of inversion of slider crank mechanism with suitable sketches. **[APRIL2017]**
11. Find the degrees of freedom for the mechanisms shown in figure. **[APRIL2017/2018]**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UNIT – II KINEMATICS OF LINKAGE MECHANISMS

PART-B

1. 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 8cm) oscillates about D. Be and AD are of equal length. Find the angular velocity of link CD when angle BAD=60°. **[NOV2015]**

2. The crank of a slider crank mechanism is 15 cm and the connecting rod is 60 cm long. The crank makes 300rpm 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. **[NOV2015]**

3. Locate all the instantaneous center of the mechanism as shown in figure 1 shown below. The lengths of various links are: AB = 150mm; BC = 300mm; CD = 225mm; and CE = 500mm. When the crank AB rotates in anticlockwise direction at uniform speed of 240rpm, find (i) Velocity of Slider E, and (ii) Angular Velocity of the links BC and CE. **[APRIL2015]**

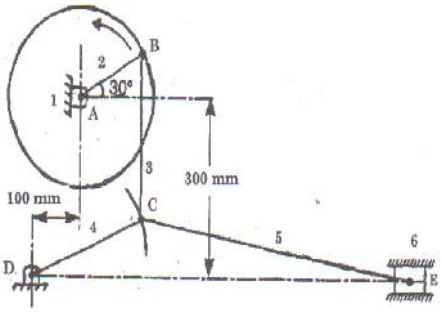


Fig.1

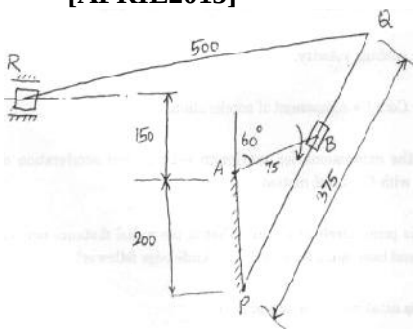


Fig.2

4. (i) In a slider crank mechanism, the length of the crank OB and connecting rod AB are 125 and 500 mm respectively. The center of gravity G of the connecting rod is 275 mm from the slider A. The crank speed is 600 rpm clockwise. When the crank has turned 45° from the IDC, determine 1.Velocity of the slider A, 2. Velocity of point G, 3. Angular velocity of the AB.
(ii) Derive an expression for angular velocity of link in a 4 bar linkage **[JUNE2014]**

5. For the toggle mechanism as shown in figure 3, 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.

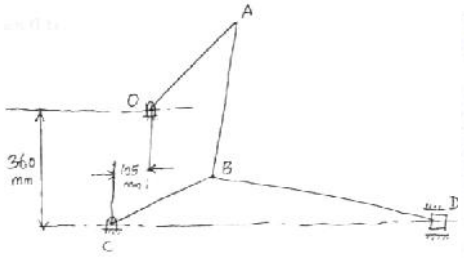


Fig.3

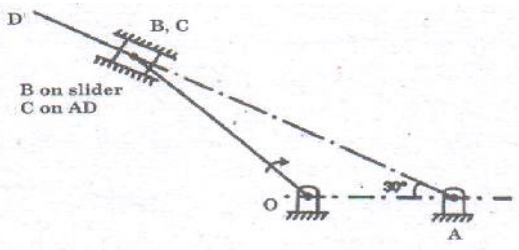


Fig.4

6. A Single cylinder rotary engine is shown in figure 4 below. OA is fixed link, 200mm long. OB is the connecting rod and is 520 mm long. The line of stroke is stroke is along AD and at the instant is inclined at 30˚ to the horizontal. The body of the engine consists of cylinders rotates at a uniform speed of 400 rpm about fixed centre A. Determine the acceleration of slider B and angular acceleration of the connecting rod. **[Apr 2015]**

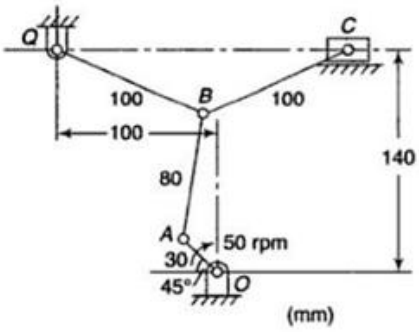


Fig.5

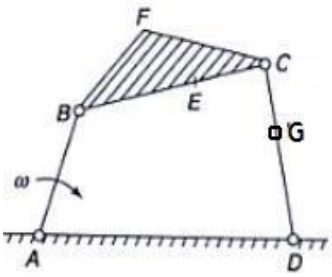


Fig.6

7. A four bar chain ABCD as shown in figure 6. In which the link AD is fixed, the length of the links AB =65mm, BC=75mm, CD=88mm, AD=120mm BF = 45mm CF = 35mm and If the crank AB rotates at 18 rad/sec in clockwise direction. Draw the configuration and velocity diagram when angle DAB=65^0 and the point E in the link BC at a distance of 25mm from C and the point G in the link CD at a distance of 28mm. Find the absolute velocity of point F,E and G and angular velocity of links BC and CD.

8. Derive an expression for Coriolis Component of acceleration with neat sketch and give its directions for various conditions. **[MAY2016]**

9. (i) Fig 7, shows the configuration of whitworth quick return mechanism. The length of the fixed link OA and the crank OP are 200mm and 300mm respectively. Other lengths are AR = 200mm and RS = 400mm. Find the velocity of ram using instantaneous center method when the crank angle makes a angle of 120˚ with the fixed link and rotates at 10 rad/s. **[NOV2013]**

(ii) Differentiate low degree of complexity with high degree of complexity with suitable sketch.

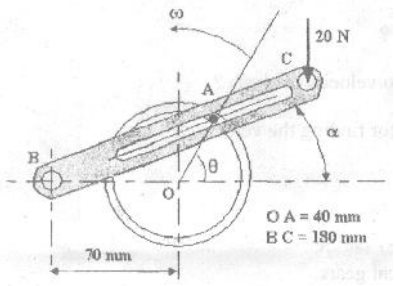


Fig.7

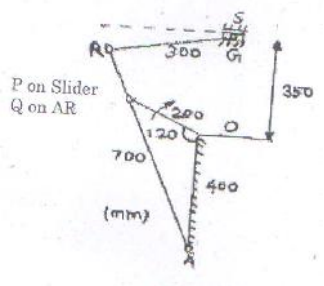
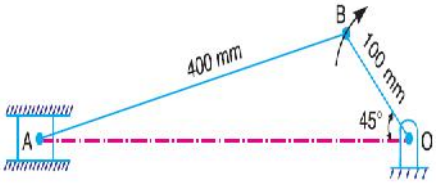


Fig.8

10. Locate all the instantaneous centres of the slider crank mechanism as shown in Fig. 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: 1. Velocity of the slider A, and 2. Angular velocity of the connecting rod AB. **[MAY2017]**



UNIT – III KINEMATICS OF CAMS

PART-B

1. **(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. **(ii)**Depict the types of cams **[MAY2016]**
2. A cam with 30 mm as minimum diameter is rotating clockwise at a uniform speed of 1200 r.p.m. and has to give the following motion to a roller follower 10mm in diameter: (i)Follower to complete the outward stroke of 25 mm during 120^o of cam rotation with uniform acceleration and retardation ; (ii) Follower to dwell for 60^o of cam rotation; (iii) Follower to return its original position during 90^o of cam rotation with uniform acceleration and retardation ; (iv) Follower to dwell for the remaining 90^o of cam rotation. Draw the cam profile if the axis of the follower follower passes through the axis of

the cam. Determine the maximum velocity of the follower during outstroke and return stroke and also the uniform acceleration of the follower on the out stroke and return stroke. **[APR 2015/NOV2014]**

3. Follower type - roller follower, lift=25mm, base circle radius =25mm Roller radius=5mm, out stroke with UARM, for 20° cam rotation, dwell for 60° cam rotation, return stroke with UARM, for 90° cam rotation, dwell for remaining cam period. Determine maximum velocity and acceleration during out stroke and return stroke if the cam rotates at 200rpm in counter clockwise direction. Draw the cam profile for the conditions with follower offset to the right of cam center by 5mm**. [MAY2016/2018]**

4. The following particulars relate to a symmetrical circular cam operating a flat faced follower: Least radius = 16mm, nose radius = 3.2 mm, distance between cam shaft centre and nose centre = 25mm, angle of action of cam = 150^{o}, and cam shaft speed = 600 r.p.m. Assuming that there no dwell between ascent or descent, determine the lift of the valve, the flank radius and the acceleration and retardation of the follower at a point where circular nose merges in to circular flank. **[APR2015]**

5. 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: **[NOV2015/MAY2018]**

(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

6. Draw the profile of a cam in which the follower moves with SHM during ascent while it moves with uniformly accelerated and decelerated motion during descent. Least radius of the cam = 60 mm; Angle of ascent = 58°; Angle of dwell= 32°; Angle of descent= 70°; Lift of the follower= 30 mm; Diameter of the roller= 25 mm. If the cam rotates at 560 rpm anticlockwise find the maximum velocity and acceleration of the follower during descent. **[APRIL2017]**

7. A Cam is designed for a knife edge follower with following data: (i) Cam Lift = 40mm during 90˚ of cam rotation with SHM, (ii) Dwell for next 30˚. (iii) During next 60˚ of cam rotation, follower returns to original position with SHM, (iv) Dwell for the remaining 180˚. Draw the profile of Cam when the line of stroke is offset 20mm from the axis of the cam shaft. (Assume suitable base circle radius) **[JUN2014]**

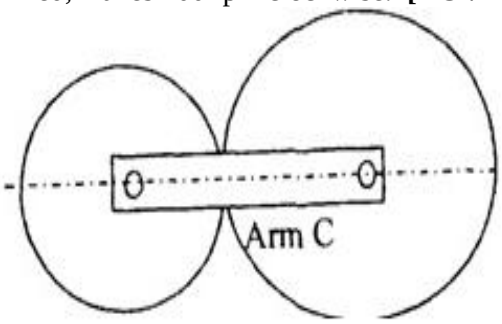
8. A cam operates an offset follower. The least radius of the cam is 50mm, roller diameter is 30mm, and offset is 20mm, the cam rotates at 360rpm. The angle of ascent is 48˚, angle of dwell is 42˚, and the angle of descent is 60˚. The motion is to be SHM during ascent and uniform acceleration and deceleration during descent. Draw the cam profile[Assume suitable cam lift] **[NOV2013]**

10. 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. **[NOV2017]**

11. 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: 1. The principal dimensions of the cam; 2. 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. Assume that there is no dwell between ascent and descent. **[APRIL2017]**

UNIT – IV GEARS & GEAR TRAINS
PART – B

1. Calculate: (i) 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^o, and module 8mm and addendum equal to one module. **[APRIL2015]**
2. Calculate (i) the length of path of contact (ii) arc of contact and (iii) contact ratio when a pinion having 23 teeth drives a gear having 57 teeth. The profile of the gear involute with pressure angle 20°, module 8mm and addendum equal to one module. **[NOV/DEC 2015]**
3. 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, and (4) the maximum velocity of sliding. **[JUNE2014]**
4. 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. **[NOV 2015]**



5. The following data relate to a pair of 20° involute gear in module=6 mm, Number of teeth on pinion=17, Number of teeth on gear=49; Addenda on pinion and gear wheel=1 module. Find (1) the number of Pairs of teeth in contact (2) the angle turned through by the pinion and gear wheel when one pair of teeth is in contact, and (3) The ratio of sliding to rolling motion when the tip of a tooth on the large wheel (a) just making contact (b) Just leaving contact with its mating tooth, and (c) at the pitch point. **[NOV2014]**
6. The cutter of a broaching machine is pulled by square threaded screw of 55mm external diameter and 10mm pitch, the operating nut takes the axial load of 400N on a flat surface of 60mm internal diameter and 90mm external diameter. If 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 6m/min. **[APRIL/MAY 2016]**
7. A Compound gear train using spur gear is required to give a total reduction ratio of 250 to 1 in 4 steps. The modules of the gears are 5mm for the first step, 7mm for the second step, 10mm for the third and 16mm for the fourth. (i) Arrive at the individual speed ratios if a tolerance of +/-0.2% is allowed in the total reduction ratio.(4), (ii) Find the number of teeth on all gears if minimum no of teeth on any pinion is 20. (4), (iii) Find the pitch diameters of all gears and centre distance. (4) (iv) Sketch a line diagram showing the gear train. (4) **[NOV2012]**
8. (i) In an epicyclic gear train, the sun gear A and the planet gear B are having 36 and 45 teeth respectively. If the arm rotates at 150 rpm counter clockwise about center of A which is fixed, determine speed of gear B. If the arm is locked and gear A rotates at 300 rpm what is the speed of gear B? (6)

   (ii) An epicyclic gear train is shown in the figure 1. 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. (10)

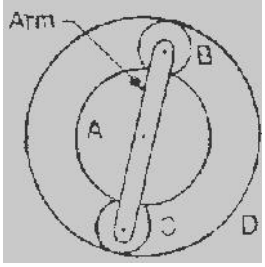


Fig.1

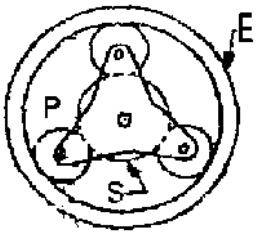
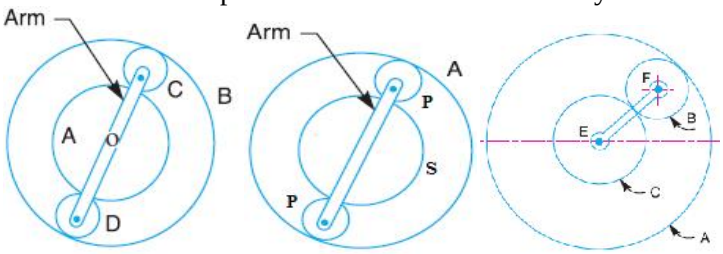


Fig.2

9. In an epicyclic gear train a gear C is keyed to the driving shaft A which rotates at 900 rpm. Gears D and E are fixed together and rotate freely on a pin carried by the arm M which is keyed to the driven shaft B. Gear D is in mesh with gear C while the gear E is in mesh with fixed annular wheel F. The annular wheel is concentric with the driven shaft B. If the shaft A and B are collinear and number of teeth on gears C, D, E and F are respectively 21, 28, 14 and 84. Determine the speed and sense of rotation of the driven shaft B. **[APRIL 2015]**

10. An epicyclic gear train shown in figure 4. The number of teeth on A & B are 80 and 200 respectively. Determine the speed of the arm 'A': (i) If A rotates at 100rpm clockwise and B at 50rpm anticlockwise (ii) If A rotates at 100rpm clockwise and B is stationary.



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UNIT – V FRICTION IN MACHINE ELEMENTS

PART-B – C402.5

1. The external and internal radii of a friction plate of a single clutch are 120mm and 60mm respectively. The total axial thrust with which the friction surfaces are held together is 1500N. For uniform wear, find the maximum, minimum and average pressure on the contact surfaces. **[NOV2015]**

2. 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**.** **[MAY2016]**

3. (i) In a screw jack, the diameter of the threaded screw 40 mm and the pitch is 8 mm.The total load is 20 KN and it does not rotate with the screw but is carried on a swivel head having a bearing diameter of 70mm. The coefficient of friction between swivel head and spindle is 0.08 and between the screw and nut is 0.1. Determine the total torque required to raise the load and efficiency.

(ii) A single plate clutch transmits 20 kW at 900 rpm. The maximum pressure intensity between 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 coefficient of friction is 0.25. Determine the inner radius of the plate and axial force to engage the clutch. **[NOV2014]**

4. Determine the maximum power that can be transmitted using a belt of 100 mm x 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 be taken as 0.25. The tension in the belt should not exceed 1.5 N/mm^2 **[NOV2015]**

5. A flat belt, 8 mm thick and 100 wide transmits power between two pulleys, running at 1600 m/min. The mass of the belt is 0.9 kg/m length. The angle of lap in the smaller pulley is 165^o and the coefficient of friction between the belt and pulley is 0.3. If the maximum permissible stress in the belt is 2 MN/m^2. Find: (i) Maximum power transmitted and; (ii) Initial tension in the belt.**[APR2015]**

6. (i) A vertical shaft 140mm diameter rotating at 120 rpm rests on a flat end foot step bearing. The shaft carries a vertical load of 30kN and the coefficient of friction is 0.06. Estimate the power lost in friction

assuming uniform pressure and uniform wear.

(ii) A multi-plate disc clutch transmits 55 KW of power at 1800 rpm. Coefficient of friction for the friction surfaces is 0.1. Axial intensity at pressure is not to exceed 160 KN/m^2. The internal radius is 80 mm and is 0.7 times the external radius. Find the number of plates needed to transmit the required torque. **[NOV2013]**

7. Following data is given for a rope pulley transmitting 23.628 kW. Diameter 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 x C2 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. [**May2016]**

8. (i) Derive the force analysis of a body resting on an inclined plane with force inclined to the plane
(ii) Lis**t** the various types of friction. (4) **[NOV2013]**

9. A cross belt running over two pulleys 60mm and 300mm diameter connects two parallel shafts 4meters apart and transmits 7.5kW from the larger pulley that rotates at 225rpm. Coefficient of friction between the belt and the pulley is 0.35 and the safe working tension is 25N per mm width. Determine 1.Minimum width of the belt 2.Initial belt tension and 3.Length of the belt required. **[NOV2017]**

10. An electric motor driven power screw moves a nut in a horizontal plane against a force of 75kN at a speed of 300mm/min. The screw has a single square thread of 6mm pitch on a major diameter of 40mm. The coefficient of friction at the screw threads is 0.1, estimate power of the motor.[**NOV2017]**

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