DEPARTMENT OF MECHANICAL ENGINEERING
KINEMATICS OF MACHINES
QUESTION BANK
SEMESTER:- IV

1 What is a machine ? Giving example, differentiate between a machine and astructure.
2 Explain and Give the classification of the terms kinematic link, Pairs, Chain and Mechanisms
3 Explain with neat sketches the different types of Constrained motions.
4 What is the significance of degrees of freedom of a kinematic chain when it functions as a mechanism? Give examples.
5 Explain Grubler's criterion for plane mechanisms.
6 Explain Kutzbach's criterion for plane mechanisms.
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.
8 Sketch a pantograph, explain its working and show that it can be used to reproduce to An Enlargedscale a given figure.
9 What are straight line mechanisms ? Describe all types of exact straight line motion Mechanism with the help of a sketch
10 What is the condition for correct steering ? Sketch and show the two main types of steering Gears and discuss their relative advantages.
11 What do you understand by the instantaneous centre of rotation (centro) in kinematic of machines? Answer briefly.
12 In a pin jointed four bar mechanism, as shown in Fig. AB = 300 mm, BC = CD = 360 mm, and AD = 600 mm. The angle BAD = 60°. The crankAB rotates uniformly at 100 r.p.m. Locate all the instantaneouscentres and find the angular velocity of the link BC
*13 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.*
14 In a four bar chain ABCD, AD is fixed and is 150 mm long. The crank AB is 40mm longand rotates at 120 r.p.m. clockwise, while the link CD = 80 mm oscillates about D. BC andAD are of equal length. Find the angular velocity of link CD when angle BAD = 60°.

*15 The crank of a slider crank mechanism rotates clockwise at a constant speedof 300 r.p.m.The crank is 150 mm and the connecting rod is 600 mm long. Determine :**1.** Linearvelocity and acceleration of the midpoint of the connecting rod, and **2.** angular velocityand angularacceleration of the connecting rod, at a crank angle of 45° from inner deadcentre position.*

16 Explain and Give the classification with examples of Toothed Gears.

17 State and prove the law of gearing. Show that involute profile satisfies the conditions forCorrectgearing.

18 What do you understand by the term 'interference' as applied to gears? Derive an expression for the minimum number of teeth required on the pinion in order to avoid interference in involute gear teeth when it meshes with wheel.

19 What do you understand by the term 'interference' as applied to gears? Derive an expression for minimum number of teeth required on a pinion to avoid interference when itgears with a rack

20 Derive an expression for the length of the Path of contact,,length of the arc of contact and contact Ratio in apair of meshed spur gears.

21 Derive an expression for the maximum length of the Path of contact,,length of the arc of contact and contact Ratio in apair of meshed spur gears in order to avoid interference.

22 What do you understand by the term 'interference' as applied to gears? Derive an expression for the minimum number of teeth required on the gear in order to avoidinterference in involute gear teeth when it meshes with pinion.

23 A pinion of 20 involute teeth and 125 mm pitch circle diameter drives arack. The addendum of both pinion and rack is 6.25 mm. What is the least pressure angle which can be used to avoid interference ? With this pressure angle, find the length of the arc of ontact and theminimum number of teeth in contact at a time.

*24 Two gear wheels mesh externally and are to give a velocity ratio of 3 to 1.The teeth are of involute form ; module = 6 mm, addendum = one module, pressure angle = 20°. The pinion rotates at 90 r.p.m. Determine : **1.** The number of teeth on the pinion to avoidinterference onit and the corresponding number of teeth on the wheel, **2.** The length ofpath and arc of contact,**3.**The number of pairs of teeth in contact, and **4.** The maximumvelocity of sliding.*

*25 A pair of 20° full depth involute spur gears having 30 and 50 teeth respectivelyof module4 mm are in mesh. The smaller gear rotates at 1000 r.p.m. Determine :**1.** Slidingvelocitiesat engagement and at disengagement of pair of a teeth, and **2.** contact ratio.*

26 A pair of involute spur gears with 16° pressure angle and pitch of module6 mm is inmesh. The number of teeth on pinion is 16 and its rotational speed is 240 r.p.m. When thegear ratio is 1.75, find in order that the interference is just avoided

*; **1.** the addenda onpinion andgear wheel ; **2.** the length of path of contact ; and **3.** the maximum velocity ofsliding of teeth on eitherside of the pitch point.*
27 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 contactoneach side of the pitch point has half the maximum possible length. Determine the ddendumheight for each gear wheel, length of the path of contact, arc of contact and contact ratio.
28 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 ; Addendaon pinion and gear wheel = 1 module.
Find :***1.** The number of pairs of teeth in contact ; **2.** The angle turned through by thePinionand the gear wheel when one pair of teeth is in contact, and **3.** The ratio of slidingto rolling motionwhen the tip of a tooth on the larger wheel **(i)** is just making contact, **(ii)**is just leaving contact withits mating tooth, and **(iii)** is at the pitch point.*
29A pair of gears, having 40 and 20 teeth respectively, are rotating in mesh,the speed of thesmaller being 2000 r.p.m. Determine the velocity of sliding between the gear teethfaces atthe point of engagement, at the pitch point, and at the point of disengagement if thesmallergear is the driver. Assume that the gear teeth are 20° involute form, addendumlength is 5 mand themodule is 5 mm.Also find the angle through which the pinion turnswhile any pairs of teeth are in contact.
30 What do you understand by ‘gear train’? Discuss the various types of gear trains.
31 Explain briefly the differences between simple, compound, and epicyclic gear trains. What
are thespecial advantages of epicyclic gear trains ?
32 How the velocity ratio of epicyclic gear train is obtained by tabular method?
33 Explain with a neat sketch the ‘sun and planet wheel’.
34 What are the various types of the torques in an epicyclic gear train ?
35 An epicyclic gear consists of three gears A, B and C as shown in Fig. The gear A has 72internal teeth and gear C has 32 external teeth. The gear B meshes with both Aand C andis carried on an arm EF which rotates about the centre of A at 18 r.p.m.. If the gear A isfixed, determine the speed of gears B and C
*36 An epicyclic train of gears is arranged as shown inFigHow many revolutions does thearm, to which the pinions B andC are attached, make :**1.** when A makes one revolutionclockwise and D makes half arevolution anticlockwise, and**2.** when A makes onerevolution clockwise and D is stationary ?The number of teeth on the gears A and D are40 and 90respectively.*
37 In an epicyclic gear train, the internal wheels A and B and compound wheelsC and Drotate independently about axis O. The wheels E and F rotate on pins fixed

*to the arm G. Egears with A and C and F gears with B and D. All the wheels havethe same module andthe number of teeth are : TC = 28; TD = 26;TE = TF = 18.**1.** Sketch the arrangement*
***2.** Find the number of teeth onA and B ;**3.** If the arm G makes 100 r.p.m. clockwise and Aisfixed,find the speed of B ; and **4.** If the arm G makes 100 r.p.m. clockwiseand wheel Amakes 10 r.p.m. counter clockwise ; find the speed ofwheel B*
38 In an epicyclic gear of the 'sun and planet' type shown in Fig. the pitch circle diameter ofthe internally toothed ring is to be224 mm and the module 4 mm. When the ring D isstationary, the spider A,which carries three planet wheels C of equal size, is to make onerevolution inthe same sense as the sunwheel B for every five revolutions of the drivingspindle carrying the sunwheel B. Determine suitable numbers of teeth for allthe wheels.
*39 An epicyclic gear train consists of a sun wheelS, a stationary internal gear E and threeidentical planet wheels Pcarried on a star- shaped planet carrier C. The size of differenttoothedwheels are such that the planet carrier C rotates at 1/5th of the speedof thesunwheel S. The minimum number of teeth on any wheel is 16.The driving torque on thesun wheel is 100 N-m. Determine :**1.** Numberof teeth on different wheels of the train, and**2.** torque necessary tokeep the internal gear stationary.*
40 Write short notes on cams and followers.
41 Explain with sketches the different types of cams and followers.
42 Why a roller follower is preferred to that of a knife-edged follower ?
43 Define the following terms as applied to cam with a neat sketch
(*a*) Base circle, (*b*) Pitch circle, (*c*) Pressure angle, and (*d*) Stroke of the follower.
44 What are the different types of motion with which a follower can move ?
45 Draw the displacement, velocity and acceleration diagrams for a follower when it moves with simpleharmonic motion. Derive the expression for velocity and acceleration duringoutstroke and returnstroke of the follower.
46 Draw the displacement, velocity and acceleration diagrams for a follower when it moveswith uniformacceleration and retardation. Derive the expression for velocity andacceleration during outstrokeand return stroke of the follower.
47 Draw the displacement, velocity and acceleration diagrams for a follower when it moveswithuniform velocity. Derive the expression for velocity and acceleration duringoutstroke and returnstroke of the follower.
48 A cam operating a knife-edged follower has the following data :
(*a*) Follower moves outwards through 40 mm during 60° of cam rotation.
(*b*) Follower dwells for the next 45°.
(*c*) Follower returns to its original position during next 90°.
(*d*) Follower dwells for the rest of the rotation.

The displacement of the follower is to take place with simple harmonic motion during both
Theoutward and return strokes. The least radius of the cam is 50 mm. Draw the profile ofthe cam when1. the axis of the follower passes through the cam axis, and 2. the axis of thefollower is offset 20mm towards right from the cam axis. If the cam rotates at 300 r.p.m.,determine maximum velocityand acceleration of the follower during the outward strokeand the return stroke.

49 A disc cam rotating in a clockwise direction is used to move a reciprocating roller with
Simpleharmonic motion in a radial path, as given below :
(*i*) Outstroke with maximum displacement of 25 mm during 120° of cam rotation,(*ii*) Dwell for 60° of cam rotation,
(*iii*) Return stroke with maximum displacement of 25 mm during 90° of cam rotation, and(*iv*) Dwell during remaining 90° of cam rotation.The line of reciprocation of follower passes through the camshaft axis. The maximumradius of camis 20 mm. If the cam rotates at a uniform speed of 300 r.p.m. find themaximum velocity andacceleration during outstroke and return stroke. The roller diameteris 8 mm. Draw the profile of the cam when the line of reciprocation of the follower isoffset by 20 mmtowards right from the cam shaft axis.

50 A cam rotating clockwise at a uniform speed of 100 r.p.m. is required to give motion to knife-edgefollower as below :
(*a*) Follower to move outwards through 25 mm during 120° of cam rotation,
(*b*) Follower to dwell for the next 60° of cam rotation,
(*c*) Follower to return to its starting position during next 90° of cam rotation, and
(*d*) Follower to dwell for the rest of the cam rotation.
The minimum radius of the cam is 50 mm and the line of stroke of the follower passesthrough theaxis of the cam shaft. If the displacement of the follower takes place withuniform and equal accelerationand retardation on both the outward and return strokes, findthe maximum velocity andacceleration during outstroke and return stroke.

51 ExplainFreudenstein's method of three point synthesis of mechanisms.

52 Explain synthesis of mechanism with examples.

53 What do you understand by
(a) Type synthesis ; (*b*) Number synthesis ; and (*c*) dimensional synthesis.

54 Write an expression for determining the precision points using Chebyshev's spacing.

55 What do you understand by coupler curves ? Describe the method of obtaining the coordinatesofa coupler point in a slider crank mechanism.

56 Synthesize a slider crank mechanism so that the displacement of the slideris proportionalto the square of the crank rotation in the interval 45° ≤ θ ≤135° . Use three precisionpoints with Chebyshev's spacing.
57 Synthesize a four-bar mechanism to generate a function y = sin x for0≤x≤90°. The rangeof the output crank may be chosen as 60° while that of inut crank be 120°.Assume threeprecision points which are to be abtained from Chebyshev spacing. Assume fixedlink tobe 52.5 mm long and $\theta_1 = 105°$ *and* $\varphi_1 = 66°$.
*58 A four bar mechanism is to be designed, by using three precision points, togenerate theFunctiony=x*1.5 *, for the range 1≤x≤4.Assuming 30° starting position and 120° finishingposition for the input link and 90°starting position and 180° finishing position for theoutput link, find the values of x, y,* θ *and* φ*corresponding to the three precision points.*
59 A four bar function generator is used to generate the function $y = 1/x$ for $1 \le x \le 3$ betweenTheinput angle of a crank and the angle the follower makes with the frame. Find the threePrecisionpoints from Chebyshev's spacing if the initial values of input angle (*i.e.* crankangle) and outputangle (*i.e.* follower angle) are 30° and 200° respectively. The differencebetween the final andinitial values of the crank and follower angles are each equal to 90°.
60 Discuss briefly the various types of belts used for the transmission of power.61 How does the velocity ratio of a belt drive effect, when some slip is taking place between
the belt andthe two pulleys ?
62 Obtain an expression for the length of a belt in 1. an open belt drive ; and 2. a cross beltdrive.
63 Explain the phenomena of 'slip' and 'creep' in a belt drive.
64 For a flat belt, prove that 1
where
T_1 = Tension in the tight side of the belt,
T_2 = Tension in the slack side of the belt,
μ = Coefficient of friction between the belt and the pulley, and
θ = Angle of contact between the belt and the pulley (in radians.)
65 What is centrifugal tension in a belt ? How does it affect the power transmitted.
66 Derive the condition for transmitting the maximum power in a flat belt drive.
67 Explain what do you understand by 'initial tension in a belt'.
68 Derive an expression for the ratio of the driving tensions in a rope drive assuming theangle of thegroove of the pulley to be as 2 β.
69 Discuss relative merits and demerits of belt, rope and chain drive for transmission ofpower.
70 What are different types of chains ? Explain, with neat sketches, the power transmissionchains.Obtain an expression for the length of a chain.

71 Find the width of the belt, necessary to transmit 7.5 kW to a pulley 300 mm diameter, ifthe pulleymakes 1600 r.p.m and the coefficient of friction between the belt and the pulleyis 0.22. Assume theangle of contact as 210° and the maximum tension in the belt is not toexceed 8 N/mm width.
72 An open belt 100 mm wide connects two pulleys mounted on parallel shafts with theircentres 2.4 mapart. The diameter of the larger pulley is 450 mm and that of the smallerpulley 300 mm. The coefficientof friction between the belt and the pulley is 0.3 and the maximum stress in the belt is limited to14 N/mm width. If the larger pulley rotates at 120r.p.m., find the maximum power that can be transmitted.
73 .A leather belt 125 mm wide and 6 mm thick, transmits power from a pulley 750 mm diameter whichruns at 500 r.p.m. The angle of lap is 150° and $\mu = 0.3$. If the mass of $1m^3$ of leather is 1 Mg and thestress in the belt is not to exceed 2.75 MPa, find the
maximum power that can be transmitted.
74 A flat belt is required to transmit 35 kW from a pulley of 1.5 m effective diameter runningat 300r.p.m. The angle of contact is spread over 11/24 of the circumference and thecoefficient of frictionbetween belt and pulley surface is 0.3. Determine, taking entrifugaltension into account, width ofthe belt required. It is given that the belt thickness is 9.5mm, density of its material is 1.1 Mg/m3 andthe related permissible working stress is 2.5MPa.
75 A blower is driven by an electric motor though a belt drive. The motor runs at 750 r.p.m.For thispower transmission, a flat belt of 8 mm thickness and 250 mm width is used. Thediameter of themotor pulley is 350 mm and that of the blower pulley 1350 mm. Thecentre distance between thesepulleys is 1350 mm and an open belt configuration isadopted. The pulleys are made out of cast iron.The frictional coefficient between the beltand pulley is 0.35 and the permissible stress for the beltmaterial can be taken as $2.5N/mm^2$ with sufficient factor of safety. The mass of a belt is 2 kg per metrelength. Findthe maximum power transmitted without belt slipping in any one of the pulleys.
76 An open belt drive connects two pulleys 1.2 m and 0.5 m diameter on parallel shafts 3.6 mapart. Thebelt has a mass of 1 kg/m length and the maximum tension in it is not to exceed2 kN. The 1.2 mpulley, which is the driver, runs at 200 r.p.m. Due to the belt slip on oneof the pulleys, the velocity ofthe driven shaft is only 450 r.p.m. If the coefficient offriction between the belt and the pulley is 0.3,find : 1. Torque on each of the two shafts,2. Power transmitted, 3. Power lost in friction, and 4.Efficiency of the drive.
77 The power transmitted between two shafts 3.5 metres apart by a cross belt drive round thetwo pulleys600 mm and 300 mm in diameters, is 6 kW. The speed of the larger pulley(driver) is 220 r.p.m. Thepermissible load on the belt is 25 N/mm width of the belt whichis 5 mm thick. The coefficient offriction between the

smaller pulley surface and the beltis 0.35. Determine : 1. necessary length of thebelt ; 2. width of the belt, and 3. necessaryinitial tension in the belt.

78 A flat belt, 8 mm thick and 100 mm wide transmits power between two pulleys, runningAt1600 m/min. The mass of the belt is 0.9 kg/m length. The angle of lap in the smallerpulley is 165° andthe coefficient of friction between the belt and pulley is 0.3. If the
Maximum permissible stress in thebelt is 2 MN/m2, find : 1. maximum power transmittedand 2. initial tension in the belt

79 An open belt connects two flat pulleys. The smaller pulley is 400 mm diameter and runsat 200 r.p.m.The angle of lap on this pulley is 160° and the coefficient of friction betweenthe belt and pulley faceis 0.25. The belt is on the point of slipping when 3 kW is beingtransmitted. Which of the followingtwo alternatives would be more effective in order to
increase the power :1. Increasing the initial tension in the belt by 10 per cent, and2. Increasing the coefficient of friction by 10 per cent by the application of a suitabledressing to thebelt?

80 A V-belt drive consists of three V-belts in parallel on grooved pulleys of the same size.The angle ofgroove is 30° and the coefficient of friction 0.12. The cross-sectional area of
each belt is 800 mm2 andthe permissible safe stress in the material is 3 MPa. Calculatethe power that can be transmittedbetween two pulleys 400 mm in diameter rotating at
960 r.p.m.

81 A rope drive is required to transmit 230 kW from a pulley of 1 metre diameter running at450 r.p.m.The safe pull in each rope is 800 N and the mass of the rope is 0.46 kg permetre length. The angle oflap and the groove angle is 160° and 45° respectively. If thecoefficient of friction between the ropeand the pulley is 0.3, find the number of ropesrequired.

82 A rope drive transmits 75 kW through a 1.5 m diameter, 45° grooved pulley rotating at200 r.p.m. Thecoefficient of friction between the ropes and the pulley grooves is 0.3 and
the angle of lap is 160°.Each rope has a mass of 0.6 kg/m and can safely take a pull of800 N. Taking centrifugal tension intoaccount determine : 1. the number of ropes required
for the drive, and 2. initial rope tension.

83 Discuss briefly the various types of friction experienced by a body.

84 State the laws of
(*i*) Static friction ; (*ii*) Dynamic friction ;(*iii*) Solid friction ; and (*iv*) Fluid friction.

85 Explain the following :
(*i*) Limiting friction, (*ii*) Angle of friction, and(*iii*) Coefficient of friction.

86 Write a short note on journal bearing.
87 What is meant by the expression 'friction circle'? Deduce an expression for the radius ofFrictioncircle in terms of the radius of the journal and the angle of friction.
88 From first principles, deduce an expression for the friction moment of a collar thrustbearing, statingclearly the assumptions made.
89 Derive an expression for the friction moment for a flat collar bearing in terms of the inner radius$r1$,outer radius $r2$, axial thrust W and coefficient of friction μ. Assume uniform
intensity of pressure.
90 Derive from first principles an expression for the friction moment of a conical pivotAssuming(*i*) Uniform pressure, and (*ii*) Uniform wear
91 A truncated conical pivot of cone angle φ rotating at speed N supports a load W. Thesmallest andlargest diameter of the pivot over the contact area are 'd' and 'D'respectively. Assuming uniformwear, derive the expression for the frictional torque.
92 Aconical pivot bearing 150 mm in diameter has a cone angle of 120º. If the shaft supportsan axialload of 20 kN and the coefficient of friction is 0.03, find the power lost in friction
when the shaftrotates at 200 r.p.m., assuming 1. Uniform pressure, and 2. uniform wear
93 A vertical shaft supports a load of 20 kN in a conical pivot bearing. The external radius ofthe cone is3 times the internal radius and the cone angle is 120º. Assuming uniformintensity of pressure as 0.35MN/m2, determine the dimensions of the bearing.
If the coefficient of friction between the shaft and bearing is 0.05 and the shaft rotates at120 r.p.m.,find the power absorbed in friction.
94 A plain collar type thrust bearing having inner and outer diameters of 200 mm and 450mm is subjectedto an axial thrust of 40 kN. Assuming coefficient of friction between thethrust surfaces as0.025, find the power absorbed in overcoming friction at a speed of 120r.p.m. The rate of wear isconsidered to be proportional to the pressure and rubbing speed.
95 The thrust of a propeller shaft in a marine engine is taken up by a numberof collarsintegral with the shaft which is 300 mm in diameter. The thrust on the shaft is200 kN andthe speed is 75 r.p.m. Taking μ constant and equal to 0.05 and assuming intensity ofpressure asuniform and equal to 0.3 N/mm2, find the external diameter of the collars andthe number of collarsrequired, if the power lost in friction is not to exceed 16 kW.
96 A shaft has a number of a collars integral with it. The external diameter ofthe collars is400 mm and the shaft diemater is 250 mm. If the intensity of pressure is 0.35 N/mm2(uniform) and the coefficient of friction is 0.05, estimate : ***1.*** *power*

absorbed when theshaft runs at105 r.p.m. carrying a load of 150 kN ; and ***2.*** *number of collars required.*

97 A conical pivot bearing supports a vertical shaft of 200 mm diameter. It issubjected to aload of 30 kN. The angle of the cone is 120º and the coefficient of friction is 0.025.Find the power lost in friction when the speed is 140 r.p.m., assuming ***1.*** *uniform pres and* ***2.*** *uniform wear.*

98 A conical pivot supports a load of 20 kN, the cone angle is 120º and theintensity of normalpressure is not to exceed 0.3 N/mm2. The external diameter is twice the internaldiameter.Find the outer and inner radii of the bearing surface. If the shaft rotates at 200 r.p.m. andthe coefficient of friction is 0.1, find the power absorbed in friction. Assume uniformpressure.

99 A vertical shaft 150 mm in diameter rotating at 100 r.p.m. rests on a flat endfootstepbearing. The shaft carries a vertical load of 20 kN. Assuming uniform pressure distributionand coefficient of friction equal to 0.05, estimate power lost in friction.

100 Explain the terms

a) Over-Hauling of Screws

b) Self- Locking of Screws