SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar,Kattankulathur–603203

DEPARTMENT OF AGRICULTURAL ENGINEERING

QUESTION BANK

III Semester

AG3364 - Theory of Machines for Agricultural Engineering

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Prepared by

K.KARTHICK, Assistant Professor (Sr.G)

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SUBJECT CODE / NAME : AG3364 - Theory of Machines for Agricultural Engineering

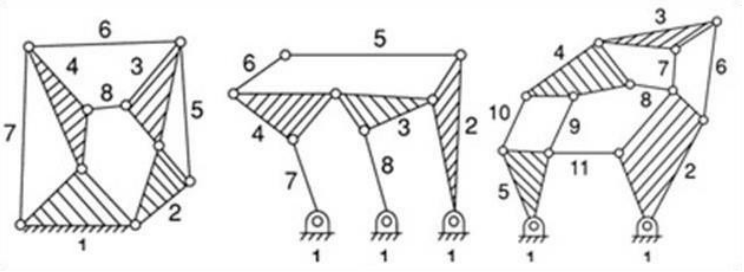
Semester &Year : III / II year

UNIT I - BASICS OF MECHANISMS			
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.			
PART – A (2 MARKS)			
Sl.No	**QUESTIONS**	**LEVEL**	**COMPETENCE**
1	Define “kinematic link”.	BTL1	Remember
2	Compare Machine and Structure.	BTL4	Analyze
3	Classify the types of links.	BTL1	Remember
4	What is meant by successfully constrained motion?	BTL2	Understand
5	Compare lower and higher pair of joints.	BTL4	Analyze
6	What are some important inversions of four chain mechanism?	BTL1	Remember
7	What is meant by toggle position?	BTL2	Understand
8	What is the use of pantograph?	BTL2	Understand
9	Give the applications of single slider crank mechanism.	BTL1	Remember
10	Write down Kutzbach criterion to find the mobility of a planar mechanism.	BTL1	Remember
11	List the purpose of Elliptical trammel.	BTL2	Understand
12	Define kinematic pair.	BTL1	Remember
13	Define mechanical advantage with suitable sketch.	BTL1	Remember
14	What is meant by transmission angle?	BTL2	Understand
15	What is the mechanism used in Ackermann steering?	BTL2	Understand

16	State the Grashof's Law for a four bar mechanism.	BTL1	Remember
17	State the working principle of bicycle bells.	BTL1	Remember
18	What is meant by motion adjustment mechanism?	BTL2	Understand
19	Whether a cycle chain is kinematic chain or not?	BTL2	Understand
20	State the purpose of using offset slider crank mechanism.	BTL2	Understand
21	Under what conditions a kinematic chain become a mechanism?	BTL2	Understand
22	Differentiate between machine and mechanism.	BTL4	Analyze
23	Name some straight line generating mechanisms.	BTL1	Remember
24	Define mechanical advantage.	BTL1	Remember
25	Name the inversions of 4 bar mechanism.	BTL1	Remember

PART – B (16 MARKS)

S. NO	QUESTIONS	MARKS	LEVEL	COMPETENCE
1	a) Describe different types of constrained motions.	(8)	BTL2	Understand
	b) Describe the various types of Kinematic pair.	(8)	BTL2	Understand
2	With the help of sketch, describe inversions of four bar chain.	(16)	BTL2	Understand
3	Explain the inversion of Single Slider Crank Chain with neat sketch.	(16)	BTL1	Remember
4	Explain the inversion of Double Slider crank chain with neat sketch.	(16)	BTL1	Remember
5	a) Explain the offset slider crank mechanism.	(8)	BTL1	Remember
	b) Explain Straight line mechanism with neat sketch.	(8)	BTL1	Remember
6	Describe the working of Oldham's coupling with a neat sketch and state its application.	(16)	BTL2	Understand
7	Discuss the steering gear mechanism with neat sketch.	(16)	BTL2	Understand
8	Explain the working of Whitworth quick return mechanism with a neat sketch.	(16)	BTL2	Understand
9	Explain the working of crank and slotted lever quick return motion mechanism with a neat sketch.	(16)	BTL2	Understand
10	What is straight line mechanism? Sketch the peaucellier straight line motion mechanism and prove that the	(16)	BTL6	Create

	generating points moves in a straight line.			
11	 For the kinematic linkages shown below calculate: (i) Number of binary links (Nb) (ii) Number of ternarylinks (Nt) (iii) Number of other links (No) (iv) Number of total links (N) (v) Number of joints or pairs (P1) (vi) Number of degrees of freedom (F)	(16)	BTL5	Evaluate
12	a) Classify kinematic pairs based on degrees of freedom.	(8)	BTL2	Understand
	b) Explain mechanical advantage and transmission angle related to four bar mechanism.	(8)	BTL2	Understand
13	Draw the sketch of a mechanism in which a point traces an exact straight line. The mechanism must be made of only revolute pairs. Prove that the point traces an exact straight line motion.	(16)	BTL2	Understand
14	Formulate the types of lower pair with neat sketch, and tabulate the pair variable, symbol and degree of freedom for each pair	(16)	BTL2	Understand
15	Write notes on complete and incomplete constraints in lower and higher pairs, illustrating your answer with neat sketches.	(16)	BTL2	Understand
16	Sketch and describe the working of two different types of quick return mechanism. Give examples of their application. Derive an expression for the ratio of time taken in forward and return stoke for one of this mechanism.	(16)	BTL2	Understand
17	Explain the four bar chain mechanism with neat diagram.	(16)	BTL2	Understand
18	Explain the Slider crank mechanism with neat diagram	(16)	BTL2	Understand

UNIT II - KINEMATICS OF CAM MECHANISMS			
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 .			
PART – A (2 MARKS)			
S. No	**QUESTIONS**	**LEVEL**	**COMPETENCE**
1.	What is a cam?	BTL2	Understand
2.	Give some examples of cam.	BTL1	Remember
3.	Define tangent cam.	BTL1	Remember
4.	What are the different motions of the follower?	BTL2	Understand
5.	How can high surface stress in flat follower be minimized?	BTL1	Remember
6.	Where are the roller followers extensively used?	BTL1	Remember
7.	Define dwell period.	BTL1	Remember
8.	What is meant by offset follower?	BTL2	Understand
9.	Define trace point.	BTL1	Remember
10.	Describe pressure angle with respect to cams.	BTL2	Understand
11.	What is meant by lift or stroke in cam?	BTL2	Understand
12.	How undercutting occurs in cam?	BTL2	Understand
13.	What do you know about nomogram?	BTL2	Understand
14.	Define the basic requirements for high speed cam.	BTL1	Remember
15.	What do you know about gravity cam?	BTL2	Understand
16.	Write the different types of follower.	BTL1	Remember
17.	What are the uses of cam profile?	BTL2	Understand
18.	Define base circle.	BTL1	Remember
19.	Write the formula to find the maximum velocity of simple harmonic motion.	BTL2	Understand
20.	What is meant by pitch curve?	BTL2	Understand
21.	What is meant by pitch circle in cams?	BTL1	Remember
22.	Classify the follower types based on surface in contact.	BTL1	Remember
23.	Define pitch point.	BTL1	Remember
24.	Which type of cam follower is used in automobile engines?	BTL2	Understand
25.	Cycloidal motion followers is applied in which type of engines?	BTL2	Understand

PART – B (16 MARKS)

S. NO	QUESTIONS	MARKS	LEVEL	COMPETENCE
1	A cam is to give the following motion to a knife edged follower: a. Outstroke during 60° of cam rotation. b. Dwell for the next 30° of cam rotation. c. Return stroke during next 60° of cam rotation and d. Dwell for the remaining of cam rotation. The stroke of the follower is 40 mm and the minimum radius of the cam is 50 mm. The follower moves with uniform velocity during both the outstroke and return strokes. Draw the profile of the cam when the axis of the follower passes through the axis of the cam shaft.	(16)	BTL5	Evaluate
2	Draw the profile of a cam operating a Knife-edged follower from the following data: (a) Follower to move outward through 40 mm during 60° of a cam rotation; (b) Follower to dwell for the next 45° (c) Follower to return its original position during next 90° (d) Follower to dwell for the rest of cam rotation. The displacement of the follower is to take place with simple harmonic motion during both the outward and return strokes. The least radius of the cam is 50 mm. If the cam rotates at 300 rpm. Determine the maximum velocity and acceleration of the follower during the outward stroke and return stroke.	(16)	BTL3	Apply
3	A cam, with a minimum radius of 50 mm, rotating clockwise at a uniform speed, is required to give a knife- edged follower the motion as described below: (a) To move outwards through 40 mm during 100° rotation of the cam; (b) to dwell for next 80° (c)	(16)	BTL5	Evaluate

	To return to its starting position during next 90° and (d) To dwell for the rest period of revolution. Draw the profile of the cam (i) When the line of stroke of the follower passes through the centre of the cam shaft and (ii) When the line of stroke of the follower is to take place with Uniform acceleration and uniform retardation. Determine the maximum velocity and acceleration of the follower when the cam shaft rotates at 900 r.p.m.			
4	Draw the profile of a cam operating a roller reciprocating follower and with the following data: Minimum radius of cam = 25 mm; lift = 30 mm; Roller diameter = 15 mm. The cam lifts the follower for 120° with SHM, followed by a dwell period of 30°. Then the follower lowers down during 150° of cam rotation with uniform acceleration and retardation followed by a dwell period. If the cam rotates at a uniform speed of 150 rpm. Calculate the maximum velocity and acceleration of follower during the descent period.	(16)	BTL3	Apply
5	It is required to set out the profile of a cam to give the following motion to the reciprocating follower with a flat mushroom contact surface: (i) Follower to have a stroke of 20 mm during 120° of cam rotation, (ii) Follower to dwell for 50° of cam rotation, (iii) Follower to return to its initial position during 90° of cam rotation, (iv) Follower to dwell for remaining period of cam rotation. The minimum radius of the cam is 25 mm. The out stroke of the follower is performed with SHM and return stroke with equal uniform acceleration and retardation	(16)	BTL5	Evaluate
6	A tangent cam to drive a roller follower through a total lift of 12.5 mm for a cam rotation of 75°. The cam speed is 600 rpm. The distance between cam centre and follower centre at full lift is 45 mm and the roller is	(16)	BTL3	Apply

	20 mm in diameter. Find the cam proportions and plot displacement, velocity and acceleration for one full cycle.			
7	Construct a tangent cam and mention the important terminologies on it. Also derive the expression for displacement, velocity, acceleration of a reciprocating roller follower when the roller has contact with the nose.	(16)	BTL6	Create
8	Layout the profile of a cam operating a roller reciprocating follower for the following data. Lift of follower = 30mm; Angle during the follower rise period =120°; angle during the follower after rise = 30°; angle during the follower return period = 150°. Angle during which follower dwell after return= 60° ; minimum radius of cam = 25mm; Roller diameter =10mm. The motion of follower is uniform acceleration and deceleration during the rise and return period.	(16)	BTL5	Evaluate
9	Design a cam to raise a valve with simple harmonic motion through 15mm is 1/3rd of a revolution, keep it fully raised through 1/12th of a revolution and to lower it with SHM in 1/6th of a revolution. The valve remain closed during the rest of the revolution. The diameter of the roller is 20mm and the minimum radius of the cam is 25mm. The axis of the valve rod passes through the axis of the cam shaft. If the cam shaft rotates at uniform speed of 100 rpm; find the maximum velocity and acceleration of the valve during raising and lowering. Also draw the profile of the cam.	(16)	BTL3	Apply
10	a) Classify with neat sketches the cam follower according to their shape, location and motion. State also their advantages, if any, with respect to other followers	(8)	BTL4	Analyze

	b) Sketch neatly the displacement, velocity and acceleration curves of a cycloidal motion follower. Why is it superior over other motion curves?	(8)	BTL4	Analyze
11	The following particular relate to symmetric circular cam operating a flat faced follower: least radius = 25 mm nodes radius = 8 mm, lift of the valve = 10 mm, angle of the action = 120° ,cam shaft speed = 1000 rpm. Determine the flank radius abs the maximum velocity, acceleration and retardation of the follower. If the mass of follower and the value with which it is in contact is 4 kg, find the minimum force to be exerted by the spring to overcome inertia of the valve parts.	(16)	BTL5	Evaluate
12	A cam, with a minimum radius of 25 mm, rotating clockwise at a uniform speed, is to designed to give motion to a roller follower. At the end of valve rod as described below (i) to rise the valve through 50 mm during 120° rotation of the cam. (ii) To keep the valve fully raised through next 30° (iii) To lower the valve during next 60° (iv) to keep the valve closed during rest of the revolution The dia of the roller is 20mm and the dia of the cam shaft is 25 mm. the line of stroke is offset by 15 mm from the axis of the cam shaft. The displacement of the valve while being raised and lowered is to take place with SHM. draw the displacement diagram. Sketch roughly the space of velocity and acceleration diagrams, draw the profile of cam.	(16)	BTL3	Apply
13	In a system tangent cam operating a roller follower. The radius of the cam is 30mm 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 is 600rpm. assume that there is no dwell between ascent and decent.(i) calculate the principal dimension of the cam (ii) find the acceleration of follower at the	(16)	BTL5	Evaluate

	beginning of the lift (iii) draw the profile of the cam.			
14	a) Draw the displacement, velocity and acceleration curves, when the follower moves with simple harmonic motion and deriver the expression for maximum velocity and maximum acceleration	(8)	BTL2	Understand
	b) Depict the type of cam	(8)	BTL2	Understand
15	A cam is to be designed for a knife edge follower with the following data : 1. Cam lift = 40 mm during 90° of cam rotation with simple harmonic motion. 2. Dwell for the next 30°. 3. During the next 60° of cam rotation, the follower returns to its original position with simple harmonic motion. 4. Dwell during the remaining 180°. Draw the profile of the cam when (a) the line of stroke of the follower passes through the axis of the cam shaft, and (b) the line of stroke is offset 20 mm from the axis of the cam shaft. The radius of the base circle of the cam is 40 mm. Determine the maximum velocity and acceleration of the follower during its ascent and descent, if the cam rotates at 240 r.p.m.	(16)	BTL5	Evaluate
16	A cam drives a flat reciprocating follower in the following manner : During first 120° rotation of the cam, follower moves outwards through a distance of 20 mm with simple harmonic motion. The follower dwells during next 30° of cam rotation. During next 120° of cam rotation, the follower moves inwards with simple harmonic motion. The follower dwells for the next 90° of cam rotation. The minimum radius of the cam is 25 mm. Draw the	(16)	BTL5	Evaluate

	profile of the cam.			
17	Draw the profile of the cam when the roller follower moves with cycloidal motion during out stroke and return stroke, as given below : 1. Out stroke with maximum displacement of 31.4 mm during 180° of cam rotation, 2. Return stroke for the next 150° of cam rotation, 3. Dwell for the remaining 30° of cam rotation. The minimum radius of the cam is 15 mm and the roller diameter of the follower is 10 mm. The axis of the roller follower is offset by 10 mm towards right from the axis of cam shaft.	(16)	BTL5	Evaluate
18	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.	(16)	BTL5	Evaluate

UNIT III - GEARS AND GEARTRAINS			
Law of toothed gearing – Involutes and cycloidal tooth profiles –Spur Gear terminology and definitions –Gear tooth action – contact ratio – Interference and undercutting. Gear trains – Speed ratio, train value – Parallel axis gear trains – Epicyclic Gear Trains- Compound gear trains- reverted gear trains-cyclometer- differential gear.			
PART – A (2 MARKS)			
Sl.No	**QUESTIONS**	**LEVEL**	**COMPETENCE**
1.	What is an angle of obliquity in gear?	BTL2	Understand
2.	Classify the gears.	BTL1	Remember
3.	Define arc of approach.	BTL1	Remember
4.	What is meant by arc of recess?	BTL2	Understand
5.	What is the purpose of using gears?	BTL2	Understand
6.	State law of gearing.	BTL1	Remember
7.	Define normal and axial pitch in helical gears.	BTL1	Remember
8.	What are the methods to avoid interference?	BTL2	Understand
9.	What is the advantage when arc of recess is equal to arc of approach in a meshing gears?	BTL2	Understand
10.	Define contact ratio.	BTL1	Remember
11.	Where will the interference occur in an involute pinion and gear are in mesh having same size of addendum?	BTL2	Understand
12.	What is meant by interference?	BTL2	Understand
13.	Define cycloidal tooth profile and involute tooth profile.	BTL1	Remember
14.	Mention the drawbacks of Backlash.	BTL2	Understand
15.	Compare gear and gear train.	BTL4	Analyze
16.	Give the types of gear trains.	BTL1	Remember
17.	Where the epicyclic gear trains are used?	BTL2	Understand
18.	Write about the uses of differential gear trains.	BTL1	Remember
19.	What is meant compound gear train?	BTL2	Understand
20.	Write the advantages of co-axial gearbox.	BTL2	Understand
21.	What is toothed wheel?	BTL1	Remember

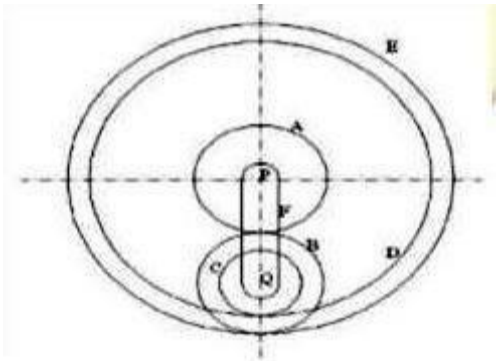
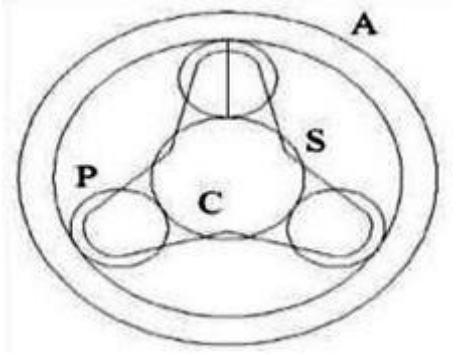
22.	Write the advantages of gear drive.	BTL2	Understand
23.	What is addendum circle?	BTL1	Remember
24.	Define clearance in gear terminology.	BTL2	Understand
25.	What is module?	BTL1	Remember

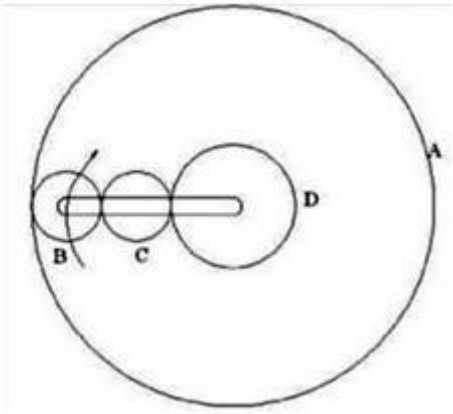
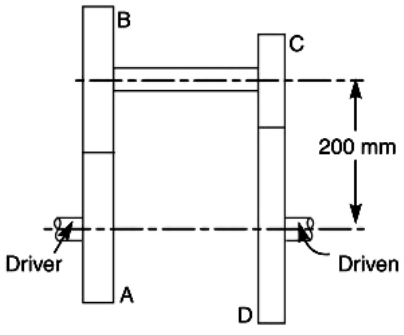
PART – B (16 MARKS)

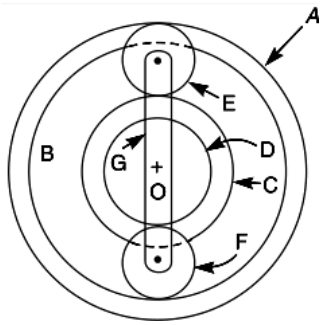
S.NO	QUESTIONS	MARKS	LEVEL	COMPETENCE
1	A pinion having 30 teeth drives a gear having 80 teeth. The profile of the gear is involute with 20 degree pressure angle 12 mm module and 10 mm addendum. Find the length of path of contact, arc of contact and the contact ratio.	(16)	BT4	Analyze
2	Two involute gears of 20 degree pressure angle are in mesh. The number of teeth on pinion is 20 and the gear ratio is 2. If the pitch expressed in module is 5 mm and the pitch line speed is 1.2 m/s, assuming addendum as standard and equal to one module. Find a).The angle turned through by pinion when one pair of teeth is in mesh and b).The maximum velocity of sliding.	(16)	BT4	Analyze
3	A pair of gears having 40 and 20 teeth respectively are rotating in mesh, the speed of the smaller being 2000 rpm. Determine the velocity of sliding between the gear teeth faces at the point of engagement, at the pitch point and at the point of disengagement if the smaller gear is the driver. Assume that the gear teeth are 20 degree involute form, addendum length is 5 mm and the module is 5 mm. Also find the angle through which the pinion turns while any pairs of teeth are in contact.	(16)	BT3	Apply
4	The following data relate to a pair of 20 degree involute gears in mesh. Module = 6 mm, Number of teeth on pinion =17, Number of teeth on gear =	(16)	BT4	Analyze

	49, Addendum on pinion and gear wheel = 1 module. Find the number of pairs of teeth in contact, the angle turned through by the pinion and the 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 larger wheel (i) is just making contact(ii)is just leaving contact with its mating tooth and is (iii) at the pitch point.			
5	Two mating spur gear with module pitch of 6.5 mm have 19 and 47 teeth of 20° pressure angle and 6.5 mm addendum. Determine the number of pair of teeth and angle turned through by the larger wheel for one pair of teeth in contact. Determine also the sliding velocity at the instant (i) engagement commences (ii) engagement terminates. When the pitch line velocity is 1.2 m/s.	(16)	BT4	Analyze
6	a) Two 20° involute spur gears have a module of 10 mm. The addendum is one module. The larger gear has 50 teeth and pinions 13 teeth. Does the interference occur? If it occurs, to what value should the pressure angle be changed to eliminate interference? b) Two mating involute spur gears 16° pressure angle have a gear ratio of 2. The number of teeth on the pinion is 15 and its speed is 240 rpm. The module pitch of the teeth is 5 mm. if the addendum on each wheel recess on each side are half the maximum possible length each, find (1) the addendum for pinion and gear wheel (2) the length of arc of contact (3) the maximum velocity of sliding during approach and recess. Assume pinion to be driver.	(16)	BT4	Analyze
7	a) A pair of spur gear with involute teeth is to give a gear ratio of 4:1. The arc of approach is not be less than the circular pitch and the smaller wheel is the driver. The angle of pressure is 14.5 What is the least number	(16)	BT4	Analyze

	of teeth that can be used on each wheel? What is the addendum of the wheel in terms of circular pitch? b) A pair 20° full depth involute spur gear having 30 and 50 teeth respectively module 4 mm arc in mesh, the smaller gear rotates at 1000 rpm. Determine (a) Sliding velocities at engagement and disengagement of a pair of teeth and (b) Contact ratio.			
8	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 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.(4) Maximum velocity of sliding.	(16)	BT3	Apply
9	The arm of an epicyclic gear train rotates at 100 rpm in the anticlock wise direction. The arm carries two wheels A and B having 36 and 45 teeth respectively. The wheel A is fixed and the arm rotates about the centre of wheel A. Find the speed of wheel B. What will be the speed of B, if the wheel A instead of being fixed, makes 200 rpm (clockwise).	(16)	BT3	Apply
10	In a reverted epicyclic train, the arm A carries two gear B and C and a compound gear D-E. Wheel B meshes with gear E and gear C meshes with gear D. The number of teeth on gear B, C and D are 75, 30, and 90. Find the speed and direction of gear C , when gear B is fixed and arm A makes 100 rpm clockwise.	(16)	BT3	Apply
11	A compound epicyclic gear is shown in Fig.1 The gears A, D and E are free to rotate on axis P. The compound gears B and C rotate together on the axis Q at the end of arm F. All the gears have equal pitch. The number of external teeth on gears, A B and C are	(16)	BT4	Analyze

	18, 45 and 21 respectively. The gears D and E are annulus gears. The gear A rotates at 100 rpm in anticlockwise direction and the gear D rotates at 450 rpm clockwise. Find the speed and direction of the arm and the gear E.  Fig.1			
12	The sun planet gear of an epicyclic gear train, the annular D has 100 internal teeth, the sun gear A has 50 external teeth and planet gear B has 25 external teeth. The gear B meshes with gear D and gear A. The gear B is carried on arm E, which rotates about the centre of annular gear D. If the gear D is fixed and arm rotates at 20 rpm, then find the speeds of gear A and B.	(16)	BT4	Analyze
13	An epicyclic gear train for an electric motor, is shown in Fig.2 The wheel S has 15 teeth and is fixed to motor shaft rotating at 1450 rpm. The planet P has 45 teeth, gears with fixed annular A and rotates on a spindle carried by an arm which fixed to output shaft. The planet P also gears with the sun when S. Find the speed of output shaft. If motor is transmitting 2 KW find the torque required to fix the annular.  Fig.2	(16)	BT3	Apply
14	An epicyclic gear train as shown in fig.3 is composed of a fixed annular wheel A having 150 teeth. The wheel A is meshing with wheel B which drives wheel D through an idle wheel C, D being concentric with A. The wheels	(16)	BT4	Analyze

	B and C are carried on an arm which revolves clockwise at 100 rpm about the axis of A and D. If the wheels B and D have 25 and 40 teeth respectively, determine the number of teeth on C and speed and sense of rotation of wheel C.  Fig.3			
15	The number of teeth on each of the two spur gears in mesh is 40. The teeth have 20° involute profile and the module is 6mm. If the arc of contact is 1.75 times the circular pitch. Find the addendum.	(16)	BT3	Apply
16	A single reduction gear of 120 kW with a pinion 250 mm pitch circle diameter and speed 650 r.p.m. is supported in bearings on either side. Calculate the total load due to the power transmitted, the pressure angle being 20°.	(16)	BT3	Apply
17	The speed ratio of the reverted gear train, as shown in Fig., is to be 12. The module pitch of gears A and B is 3.125 mm and of gears C and D is 2.5 mm. Calculate the suitable numbers of teeth for the gears. No gear is to have less than 24 teeth.  	(16)	BT3	Apply
18	In an epicyclic gear train, the internal wheels A and B and compound wheels C and D rotate independently about axis O. The wheels E and F rotate on pins fixed to the arm G. E gears with A and C and F gears with B and D. All the wheels have the same module and the number of teeth are : TC = 28; TD = 26; TE = TF = 18. 1. Sketch	(16)	BT3	Apply

	the arrangement ; 2. Find the number of teeth on A and B ; 3. If the arm G makes 100 r.p.m. clockwise and A is fixed, find the speed of B ; and 4. If the arm G makes 100 r.p.m. clockwise and wheel A makes 10 r.p.m. counter clockwise ; find the speed of wheel B. 			

UNIT IV - FORCE ANALYSIS

Dynamic force analysis – Inertia force and Inertia torque– D Alembert's principle –Dynamic Analysis in reciprocating engines – Gas forces – Inertia effect of connecting rod– Bearing loads – Crank shaft torque – Turning moment diagrams –Fly Wheels.

PART – A (2 MARKS)

Sl.No	QUESTIONS	LEVEL	COMPETENCE
1.	Define static force analysis.	BT-1	Remember
2.	Define dynamic force analysis.	BT-1	Remember
3.	List the sufficient conditions of static equilibrium of a body.	BT-2	Understand
4.	Mention some examples of applied forces.	BT-2	Understand
5.	Differentiate between active force and reactive force.	BT-2	Understand
6.	Define constraint forces.	BT-1	Remember
7.	Point out the methods used for static force analysis of mechanisms.	BT-2	Understand
8.	State the principle of superposition.	BT-1	Remember
9.	Compare inertia force and inertia torque.	BT-2	Understand
10.	State D'Alembert's principle.	BT-1	Remember
11.	Write the expression for acceleration of the piston at the inner dead centre position.	BT-1	Remember
12.	Write the expression for piston effort for a vertical engine by considering the weight of the engine and frictional resistance.	BT-1	Remember
13.	Determine the thrust on the sides of the cylinder walls having the piston effort as 400 N and angle made by the connecting rod as 30˚.	BT-5	Evaluate
14.	Define crank effort.	BT-1	Remember
15.	A force of 4000 N is applied on a piston along the line of stroke of a horizontal steam engine. When the crank is at 60˚ to IDC, Calculate the torque on the crank shaft, when the length of the connecting rod is 0.8 m and the length of the stroke is 0.4 m.	BT-1	Remember
16.	Define obliquity ratio.	BT-2	Understand
17.	Sketch the turning moment diagram for a single cylinder double acting steam engine.	BT-2	Understand
18.	Sketch the turning moment diagram for a single cylinder four stroke IC engine.	BT-2	Understand
19.	List the significance of turning moment diagram.	BT-1	Remember
20.	Multi cylinder engines have less fluctuation in turning moment diagram. Justify	BT-2	Understand
21.	Mention the significance of flywheels used in engines.	BT-1	Remember
22.	Write the expression for maximum fluctuation of energy stored in a flywheel.	BT-2	Understand
23.	Define coefficient of steadiness.	BT-1	Remember
24.	List the reasons for windup in the camshaft.	BT-1	Remember
25.	Point out the objectives of analyzing the dynamics of any cam system.	BT1	Remember

PART – B (16 MARKS)

SL. NO	QUESTIONS	MARKS	LEVEL	COMPETENCE
1	Derive the expression for the velocity and acceleration of the piston and connecting rod in a reciprocating engine.	(16)	BT-4	Analyze
2	The length of crank and connecting rod of a horizontal reciprocating engine are 100 mm and 500 mm respectively. The crank is rotating at 400 rpm when the crank has turned 30˚ from the inner dead centre, find analytically (i) acceleration of the piston (ii) velocity of the piston (iii) angular velocity of the connecting rod (iv) angular acceleration of the connecting rod.	(16)	BT-5	Evaluate
3	The length of the crank and connecting rod of a vertical reciprocating engine are 300 mm and 1.5 m respectively. The crank is rotating at 200 rpm clockwise. Determine analytically (i) acceleration of the piston (ii) velocity of the piston (iii) angular acceleration of the connecting rod when the crank has turned through 40˚ from the top dead centre and the piston is moving downwards.	(16)	BT-5	Evaluate
4	The crank and connecting rod of a reciprocating engine are 150 mm and 600 mm respectively. The crank makes an angle of 60˚ with the inner dead centre and revolves at a uniform speed of 300 rpm. By using Klien's construction determine (i) velocity and acceleration of the piston (ii) velocity and acceleration of the midpoint of the connecting rod (iii) Angular velocity and angular acceleration of the connecting rod.	(16)	BT-5	Evaluate
5	Derive the expression for the forces acting in the reciprocating parts of an engine neglecting the weight of the connecting rod.	(16)	BT-4	Analyze
6.	During a trial on a steam engine, it is found that the acceleration of the piston is 36 m/s^2 when the crank has moved 30˚ from the inner dead centre position. The net effective steampressure on the piston is 0.5 MPa and the frictional resistance is equivalent is equivalent to a force of 600 N. The diameter of the piston is 300 mm and the mass of the reciprocating parts is180 kg. If the length of the crank is 300 mm and the ratio of the connecting rod length to the crank length is 4.5. Determine (i) Reaction on the guide bars (2) Thrust on the crank	(16)	BT-5	Evaluate

	shaft bearings (3) Turning moment on the crankshaft.			
7.	A horizontal steam engine running at 120 rpm has a bore of 250 mm and a stroke of 400 mm. The connecting rod is 0.6 m and mass of the reciprocating parts is 60 kg. When the crank has turned through an angle of 45˚ from the inner dead centre,the steam pressure on the cover end side is 550 kN/mm2 and that on the crank end side is 70 kN/mm2. Considering the diameter of the piston rod equal to 50 mm. Determine (i) Turning moment on the crank shaft (ii) Thrust on the bearings (iii) Acceleration of the flywheel, if the power of the engine is 20 kW, mass of the flywheel is 60 kg and radius of the gyrationis 0.6 m.	(16)	BT-5	Evaluate
8	A petrol engine 90 mm in diameter and 120 mm stroke has a connecting rod of 240 mm length. The piston has a mass of 1 kg and the speed is 1800 rpm. On the expansion stroke with thecrank at 30˚ from top dead centre, the gas pressure is 0.5 N/mm^2. Determine (i) The resultant load on the gudgeon pin (ii) The thrust on the cylinder walls (iii) The speed above which other things remains the same, the gudgeon pin load would be reversed in direction. Also calculate the crank effort at the given position of the crank.	(16)	BT-5	Evaluate
9	A vertical single cylinder diesel engine running at 300 rpm hasa cylinder diameter 250 mm and stoke 400 mm. The mass of the reciprocating parts is 200 kg. The length of the connecting rod is 0.8 m. The ratio of the compression ratio is 14 and the pressure remains constant during the injection of the oil for 1/10 th of the stroke. If the index of the law of expansion and compression is 1.35, Estimate the torque on the crankshaft when it makes an angle of 60˚ with the top dead centre during the expansion stroke. The suction pressure may be taken as 0.1 N/mm^2.	(16)	BT-3	Apply
10	(i) Derive the expression for the energy stored in a flywheel.	(8)	BT-4	Analyze

	(ii) A vertical double-acting steam engine develops 75 kW at 250 r.p.m. The maximum fluctuation of energy is 30% of the work done per cycle. The maximum and minimum speeds are not to vary more than 1% on either side of the mean speed. Find the mass of the flywheel required if the radius of gyration is 0.6metres.	(8)	BT-5	Evaluate
11	The areas above and below the mean torque line for an IC engine are -25,+200, -100, +150, -300, +150 and -75 mm^2 taken in order. The scale for the turning moment diagram is 1mm vertical scale = 10 Nm and 1 mm of the horizontal scale = 1.5˚. The mass of the rotating parts are 45 kg with a radius of gyration of 150 mm. If the engine speed is 1500 rpm. Find the coefficient of the fluctuation of speed.	(16)	BT-3	Apply
12	The turning moment diagram for a petrol engine is drawn to a scale of 1mm to 6 N-m and the horizontal scale of 1mm to 1°.The turning moment repeat itself after every half revolution of the engine. The area above and below the mean torque line are 305, 710, 50, 350, 980and 275 mm^2. The mass of rotating parts is 40kg at a radius of gyration of 140 mm. calculate the coefficient of fluctuation of speed if the mean speed is 1500 rpm.	(16)	BT-3	Apply
13	(i) In an engine, the speed varies from 98 rpm to 102 rpm. It has a flywheel of mass 5000 kg and the radius of gyration is 900 mm. Determine (i) The mean speed of the flywheel (ii) Coefficient of fluctuation of speed (iii) Maximum fluctuation of energy.	(8)	BT-5	Evaluate
	(ii) Determine the coefficient of fluctuation of speed and the limiting speeds of a flywheel of mass 4000 kg having a radius of gyration of 1.4 m. The mean speed of the engine is 200 rpm and the fluctuation of energy is 90 kNm.	(8)	BT-5	Evaluate

14	The turning moment diagram for a four stroke gas engine maybe assumed for simplicity to be represented by four triangles, the areas of which from the line of zero pressure are as follows : Suction stroke = 0.45×10^{-3} m^2; Compression stroke = 1.7×10^{-3} m^2; Expansion stroke = 6.8×10^{-3} m^2; Exhaust stroke = 0.65×10^{-3} m^2. Each m^2 of area represents 3 MN-m of energy. Assuming the resisting torque to be uniform, find the mass of the rim of a flywheel required to keep the speed between 202 and 198 r.p.m. The mean radius of the rim is 1.2 m.	(16)	BT-3	Apply
15	A shaft fitted with a flywheel rotates at 250 r.p.m. and drives amachine. The torque of machine varies in a cyclic manner overa period of 3 revolutions. The torque rises from 750 N-m to 3000 Nm uniformly during 1/2 revolution and remains constant for the following revolution. It then falls uniformly to 750 N-m during the next 1/2 revolution and remains constant for one revolution, the cycle being repeated thereafter. Determine the power required to drive the machine and percentage fluctuation in speed, if the driving torque applied to the shaft is constant and the mass of the flywheel is 500 kg with radius of gyration of 600mm	(16)	BT-5	Evaluate
16	A punching press is driven by a constant torque electric motor. The press is provided with a flywheel that rotates at maximumspeed of 225 rpm. The radius of gyration of the flywheel is 0.5 m. The press punches 720 holes per hour, each punchingoperation takes 2 seconds and requires 15 kNm of energy. Determine the power of the motor and the minimum mass of the flywheel if speed of the same is not to fall below 200 rpm.	(16)	BT-4	Analyze

17	A constant torque 4 kW motor drives a riveting machine. A flywheel of mass 130 kg and radius of gyration 0.5 m is fitted to the riveting machine. Each riveting operation takes 1 second and requires 9000 Nm of energy. If the speed of the flywheel is 420 rpm before riveting. Estimate (i) The fall in speed of the flywheel after riveting (ii) The number of rivets fitted per hour.	(16)	BT-5	Evaluate
18	A single cylinder single acting 4 stroke cycle gas engine develops 22 kW at 300 r.p.m. The flywheel mass is 100 kg. Hoop stress developed is 5MPa. Density of material of rim of flywheel is 8000 kg/m^3. The speed variation on either side is 1% of mean speed. Determine ratio of work done during expansion and compression strokes. Work done in suction and exhaust stroke is negligible.	(16)	BT-5	Evaluate

UNIT V - BALANCING

Balancing of rotating masses – Balancing of several masses rotating in same plane - Balancing of several masses rotating in different planes. Balancing of reciprocating masses – Swaying couple - Hammer blow – Partial balancing of unbalanced primary force in a reciprocating engine

PART – A (2 MARKS)

Sl.No	QUESTIONS	LEVEL	COMPETENCE
1.	Define Balancing.	BT-1	Remember
2.	List the types of balancing.	BT-1	Remember
3.	Point out the necessity of balancing.	BT-2	Understand
4.	Define centrifugal force.	BT-1	Remember
5.	Write the expression for the centrifugal disturbing force.	BT-1	Remember
6.	Define static balancing.	BT-1	Remember
7.	Define dynamic balancing.	BT-1	Remember
8.	State the conditions for static balancing.	BT-2	Understand
9.	State the conditions for dynamic balancing.	BT-2	Understand
10.	Differentiate between static balancing and dynamic Balancing.	BT-2	Understand
11.	Mention the conditions for complete balancing.	BT-2	Understand
12.	State the effect of centrifugal force on the rotating system.	BT-2	Understand
13.	List the important cases used for balancing of the rotating mass.	BT-1	Remember
14.	Point out the methods used for balancing several masses rotating in a same plane.	BT-2	Understand
15.	Define the term reference plane.	BT-1	Remember
16.	Indicate the significance of the reference plane in balancing.	BT-2	Understand
17.	Define shaking force.	BT-1	Remember
18.	Mention the purpose of balancing the reciprocating mass.	BT-2	Understand
19.	Write the expression for primary unbalanced force and secondary unbalanced force.	BT-1	Remember
20.	Differentiate between inside cylinder locomotive and outside cylinder locomotive.	BT-2	Understand
21.	Differentiate between single locomotive and coupled locomotive.	BT-2	Understand
22.	Mention the effect of partial balancing of reciprocating parts of the two- cylinder locomotives.	BT-2	Understand
23.	Define hammer blow.	BT-1	Remember
24.	Define tractive force.	BT-1	Remember
25.	Write the expression for swaying couple.	BT-1	Remember

PART – B (16 MARKS)

SL. NO	QUESTIONS	MARKS	LEVEL	COMPETENCE
1	Four masses M1, M2, M3, and M4 are 200 kg, 300 kg, 240 kgand 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the anglebetween successive masses 45°, 75°, and135°.Find the positionand magnitude of balance mass required if its radius of rotation is 0.2 m.	(16)	BT-5	Evaluate
2	A rigid rotor has all its unbalance in one plane and can be considered to consist of three masses m_1 = 5 kg, m_2 = 3 kg at an angle 165˚ counter clockwise from m1 and m_3 = 8 kg at angle 85˚ clockwise from m_1. The radii r_1= 20 cm, r_2=8 cm, r_3=14 cm. Determine the balancing mass required at a radius of 10 cm. Specify the location of this mass with respect to m_1.	(16)	BT-5	Evaluate
3	A rotating shaft carries four unbalanced masses 18 kg, 14 kg, 16 kg and 12 kg at radii 5 cm, 6 cm, 7 cm and 6 cm respectively. The 2nd, 3rd and 4th masses revolve in planes 8 cm, 16 cm and 28 cm respectively measured from the plane ofthe first mass and are angularly located at 60°, 135° and 270° respectively measured clockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, both located at 5 cm radii and revolving in planes mid-way between those of 1s and 2nd masses and mid-way between those of 3rd and 4th masses. Determine graphically or otherwise, the magnitudes of the masses and their respective angular positions	(16)	BT-5	Evaluate
4	A shaft caries four rotating masses A, B, C and D which are completely balanced. The masses B, C and D are 50 kg, 80 kg and 70 kg respectively. The masses C and D make angles of 90° and 195° respectively with mass B in the same sense. The masses A, B, C and D are concentrated at radius 75 mm, 100 mm, 50 mm and 90 mm respectively. The plane of rotationof masses B and C are 250 mm apart. Determine (i) the magnitude of mass A and its angular position (ii) the position of planes A and D.	(16)	BT-5	Evaluate
5.	A, B, C and D are four masses carried by a rotating shaft at radii 100 mm,150 mm, 150 mm and 200 mm respectively. Theplanes in which the masses revolve are	(16)	BT-5	Evaluate

	spaced 500 mm apart and the masses of B, C and D are 9 kg, 5 kg and 4 kgrespectively. Find the required mass A and relative angular setting of the four masses so that the shaft be in complete balance.			
6.	Four masses A, B, C and D revolves at equal radii and are equally spaced along a shaft. The mass B is 7 kg and the radii of C and D make angles of 90° and 240° respectively with the radius of B. Find the magnitude of masses A, C and D andangular position of A so that the system may be completely balanced.	(16)	BT-5	Evaluate
7.	A shaft has three eccentrics, each 75 mm diameter and 25 mmthick, machined in one piece with the shaft. The central planes of the eccentric are 60 mm apart. The distance of the centres from the axis of rotation are 12 mm, 18 mm and 12 mm and their angular positions are 120° apart. The density of metal is 7000 kg/m3. Find the amount of out-of-balance force and couple at 600 r.p.m. If the shaft is balanced by additional two masses at a radius 75 mm and at a distance of 100 mm from the central plane of the middle eccentric, find the amount of the masses and their angular positions.	(16)	BT-5	Evaluate
8.	A, B, C and D are four masses carried by a rotating shaft at radii 100, 125, 200 and 150 mm respectively. The planes inwhich the masses revolve are spaced 600 mm apart and the mass of B, C and D are 10 kg, 5 kg, and 4 kg respectively. Find the required mass A and the relative angular settings of the four masses so that the shaft shall be in complete balance.	(16)	BT-5	Evaluate
9.	(i) A single cylinder horizontal engine runs at 120 rpm. The length of the stroke is 400 mm. The mass of the revolving parts assumed concentrated at the crank pin is 100 kg and mass of the reciprocating parts is 150 kg. Determine the magnitude of the balancing mass required to be placed opposite to the crankat a radius of 150 mm which is equivalent to all the revolving and 2/3rd of the reciprocating masses. If the crank turns 30˚ from the inner dead centre, find the magnitude of the unbalanced force due to the balancing mass.	(8)	BT-5	Evaluate

	(ii) Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotatingmasses i.e, when c = 1/2.	(8)	BT-4	Analyze
10.	An inside cylinder locomotive has its cylinder centre lines 0.7 m apart and has a stroke of 0.6 m. The rotating masses per cylinder are equivalent to 150 kg at the crank pin and the reciprocating masses per cylinder to 180 kg. The wheel centrelines are 1.5 m apart. The cranks are at right angles. The whole of the rotating and 2/3 of the reciprocating masses are to be balanced by masses placed at a radius of 0.6 m. Find the magnitude and direction of the balancing masses. Find the fluctuation in rail pressure under one wheel, variation of tractive effort and the magnitude of swaying couple at a crank speed of 300 r.p.m.	(16)	BT-5	Evaluate
11.	The three cranks of a three cylinder locomotive are all on the same axle and are set at 120°. The pitch of the cylinders is 1 metre and the stroke of each piston is 0.6 m. The reciprocating masses are 300 kg for inside cylinder and 260 kg for each outside cylinder and the planes of rotation of the balance masses are 0.8 m from the inside crank. If 40% of the reciprocating parts are to be balanced, find the magnitude and the position of the balancing masses required at a radius of 0.6 m and the hammer blow per wheel when the axle makes 6 r.p.s.	(16)	BT-5	Evaluate
12.	The following data refer to two cylinder locomotive with cranks at 90° : Reciprocating mass per cylinder = 300 kg ; Crank radius = 0.3 m ; Driving wheel diameter = 1.8 m ; Distance between cylinder centre lines = 0.65 m ; Distance between the driving wheel central planes = 1.55 m. Determine : 1. the fraction of the reciprocating masses to be balanced, if the hammer blow is not to exceed 46 kN at 96.5 km.p.h. ; 2. the variation in tractive effort ; and 3. the maximum swaying couple.	(16)	BT-5	Evaluate
13.	The following data apply to an outside cylinder uncoupled locomotive :	(16)	BT-5	Evaluate

	Mass of rotating parts per cylinder = 360 kg ; Mass of reciprocating parts per cylinder = 300 kg ; Angle between cranks = 90° ; Crank radius = 0.3 m ; Cylinder centres =1.75 m ; Radius of balance masses = 0.75 m ; Wheel centres = 1.45 m. If whole of the rotating and two-thirds of reciprocating parts are to be balanced in planes of the driving wheels, find : 1. Magnitude and angular positions of balance masses, 2. Speed in kilometres per hour at which the wheel will lift off the rails when the load on each driving wheel is 30 kN and the diameter of tread of driving wheels is 1.8 m, and 3. Swaying couple at speed arrived at in (2) above.			
14.	The following particulars relate to a two-cylinder locomotive with two coupled wheels on each side : Stroke = 650mm,Mass of reciprocating parts per cylinder = 240 kg, Mass of revolving parts per cylinder = 200 kg, Mass of each coupling rod = 250 kg, Radius of centre of coupling rod pin = 250 mm, Distances between cylinders = 0.6 m, Distance between wheels = 1.5 m, Distance between coupling rods = 1.8 m, The main cranks are at right angles and the coupling rod pins are at 180° to their respective main cranks. The balance masses are to be placed in the wheels at a mean radius of 675 mm in order to balance whole of the revolving and 3/4th of the reciprocating masses. The balance mass for the reciprocating masses is to be divided equally between the driving wheels and the coupled wheels. Find : 1. The magnitudes and angular positions of the masses required for the driving and trailing wheels, and 2. The hammer blow at 120 km/h, if the wheels are 1.8 meter diameter.	(16)	BT-5	Evaluate
15.	Derive the expression for primary and secondary unbalanced forces of reciprocating masses.	(16)	BT-4	Analyze
16.	Write short notes on partial balancing of unbalanced primary forces in a reciprocating engine.	(16)	BT-4	Analyze
17.	Enumerate on the effect of partial balancing of reciprocating parts of two cylinder locomotives.	(16)	BT-4	Analyze
18.	Explain the various methods of balancing the rotating masses.	(16)	BT-4	Analyze