SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur – 603203.

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTION BANK

IV SEMESTER

ME3464 THEORY OF MACHINES

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Prepared by

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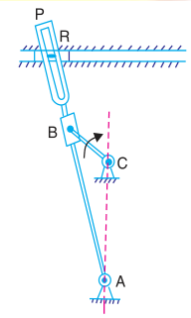
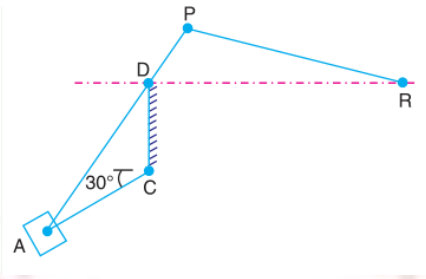
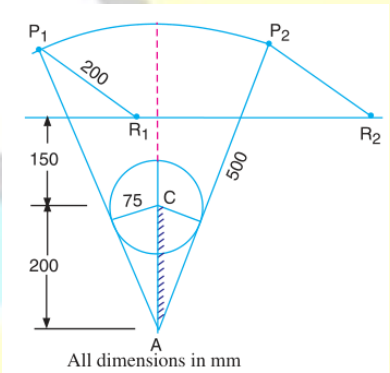
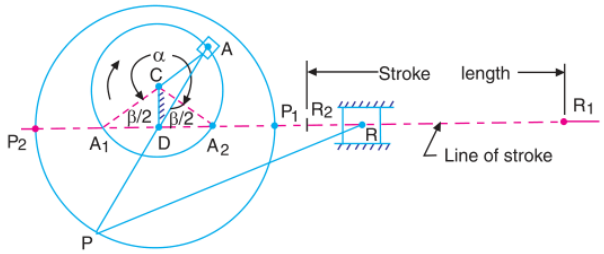
QUESTION BANK

SUBJECT / SUBJECT CODE : THEORY OF MACHINES
SEM / YEAR : IV SEM / 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)			
S. No.	**Questions**	**Level**	**Competence**
1.	Define Kinematic Link.	1	Remember
2.	Mention the characteristics of kinematic link.	2	Understand
3.	Define Structure.	1	Remember
4.	Distinguish between machine and structure.	2	Understand
5.	Distinguish between machine and mechanism.	2	Understand
6.	Define kinematic pair.	1	Remember
7.	Write a note on classification of kinematic pairs.	2	Understand
8.	What are the three types of constrained motions?	1	Remember
9.	Define kinematic chain.	1	Remember
10.	What the different types of joints?	2	Understand
11.	Define degree of freedom.	1	Remember
12.	What is the difference between kutzhbach equation and grubler's equation?	2	Understand
13.	What is meant by inversion of mechanism?	2	Understand
14.	State Grashoff's law.	1	Remember
15.	What are the different types of kinematic chain?	1	Remember
16.	Differentiate completely constrained motion and incompletely constrained motion.	2	Understand
17.	Define successfully constrained motion.	1	Remember
18.	What are the types of kinematic pairs based on relative motion between elements?	1	Remember
19.	What is meant by lower pair ?	2	Understand
20.	What are the types of kinematic pairs based on the type of closure?	1	Remember
21.	What is the use of Oldham's coupling?	2	Understand
22.	What is meant by higher pair?	2	Understand
23.	What is meant by simple mechanism?	2	Understand
24.	What is meant by compound mechanism?	2	Understand

25.	What is meant by locked chain?		2	Understand
Part – B (16 Marks)				
S. No.	**Questions**	**Marks**	**Level**	**Competence**
1.	Describe different types of constrained motions.	16	4	Analyze
2.	Describe the various types of Kinematic pair.	16	4	Analyze
3.	With the help of sketch, describe inversions of four bar chain.	16	4	Analyze
4.	Explain the inversion of Single Slider Crank Chain with neat sketch.	16	4	Analyze
5.	Explain the inversion of Double Slider crank chain with neat sketch.	16	5	Evaluate
6.	Describe the working of Oldham's coupling with a neat sketch and state its application.	16	5	Evaluate
7.	Explain the working of Whitworth quick return mechanism with a neat sketch.	16	4	Analyze
8.	Explain the working of crank and slotted lever quick return motion mechanism with a neat sketch.	16	4	Analyze
9.	What are the types of joints in a chain?	16	5	Evaluate
10.	A crank and slotted lever mechanism used in a shaper has a centre distance of 300 mm between the centre of oscillation of the slotted lever and the centre of rotation of the crank. The radius of the crank is 120 mm. Find the ratio of the time of cutting to the time of return stroke.	16	4	Analyze
11.	In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres is 240 mm and the length of the driving crank is 120 mm. Find the inclination of the slotted bar with the vertical in the extreme position and the time ratio of cutting stroke to the return stroke. If the length of the slotted bar is 450 mm, find the length of the stroke if the line of stroke passes through the extreme positions of the free end of the lever.	16	4	Analyze
12.	Fig. 1 shows the lay out of a quick return mechanism of the oscillating link type, for a special purpose machine. The driving crank BC is 30 mm long and time ratio of the working stroke to the return stroke is to be 1.7. If the length of the working stroke of R is 120 mm, determine the dimensions of AC and AP. 	16	4	Analyze

13.	In a Whitworth quick return motion mechanism, as shown in Fig. 2, the distance between the fixed centers is 50 mm and the length of the driving crank is 75 mm. The length of the slotted lever is 150 mm and the length of the connecting rod is 135 mm. Find the ratio of the time of cutting stroke to the time of return stroke and also the effective stroke. 	16	4	Analyze
14.	In a crank and slotted lever quick return mechanism, the distance between the fixed centres is 150 mm and the driving crank is 75 mm long. Determine the ratio of the time taken on the cutting and return strokes.	16	4	Analyze
15.	In a crank and slotted lever quick return motion mechanism, the distance between the fixed centres O and C is 200 mm. The driving crank CP is 75 mm long. The pin Q on the slotted lever, 360 mm from the fulcrum O, is connected by a link QR 100 mm long, to a pin R on the ram. The line of stroke of R is perpendicular to OC and intersects OC produced at a point 150 mm from C. Determine the ratio of times taken on the cutting and return strokes.	16	4	Analyze
16.	In a crank and slotted lever quick return mechanism, as shown in Fig. 3, the driving crank length is 75 mm. The distance between the fixed centres is 200 mm and the length of the slotted lever is 500 mm. Find the ratio of the times taken on the cutting and idle strokes. Determine the effective stroke also. 	16	4	Analyze
17.	The Whitworth quick return motion mechanism has the driving crank 150 mm long. The distance between fixed centres is 100 mm. The line of stroke of the ram passes through the centre of rotation of the slotted lever whose free end is connected to the ram by a connecting link. Find the ratio of time of cutting to time of return.	16	4	Analyze
18.	A Whitworth quick return motion mechanism, as shown in Fig. 4, has the following particulars : Length of stroke = 150 mm ; Driving crank length = 40 mm;	16	4	Analyze

	[Time of cutting stroke / Time of return stroke] = 2. Find the lengths of CD and PD. Also determine the angles α and β. 			

UNIT II KINEMATICS OF CAM MECHANISMS			
Classification of cams and followers – Terminology and definitions – Displacement diagrams – Uniform velocity, parabolic, simple harmonic and cycloidal motions – 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 cam?	2	Understand
2.	Define tangent cam.	1	Remember
3.	Distinguish radial and cylindrical cams.	2	Understand
4.	What are the different motions of the follower?	1	Remember
5.	Compare Roller and mushroom follower of a cam.	2	Understand
6.	Explain offset follower.	1	Remember
7.	Define trace point in the study of cams.	1	Remember
8.	Define pressure angle with respect to cams.	1	Remember
9.	Define Lift (or) Stroke in cam.	1	Remember
10.	Define undercutting in cam. How it occurs?	2	Understand
11.	What do you know about Nomogram?	1	Remember
12.	What are the classifications of cam based on the follower movement?	1	Remember
13.	What are the different types of cams?	1	Remember
14.	What do you know about gravity cam?	2	Understand
15.	Define Trace point	1	Remember
16.	Define pressure angle.	1	Remember
17.	Define Prime circle.	1	Remember
18.	Define Angle of Ascent.	1	Remember
19.	What is meant by Simple Harmonic Motion?	2	Understand
20.	What are the different shapes of high speed cams?	1	Remember
21.	Define cam angle.	1	Remember
22.	What are the classifications of follower based on the follower movement?	1	Remember
23.	Define Pitch curve.	1	Remember
24.	What are the classifications of the follower based on the path of motion of the follower?	1	Remember
25.	What are the classifications of cam base on the constraint of the follower?	1	Remember
Part – B (16 Marks)			
S. No.	**Questions**	**Marks**	**Level**	**Competence**
1.	Describe the different types of motions made by the follower.	16	4	Analyze
2.	Explain in detail about the types of followers.	16	5	Evaluate
3.	Draw the displacement, velocity and acceleration curves, when the follower moves with simple	16	6	Create

	harmonic motion and derive the expression for maximum velocity and maximum acceleration.			
4.	A cam is to give the following motion to a knife-edged follower : 1. Outstroke during 60° of cam rotation ; 2. Dwell for the next 30° of cam rotation ; 3. Return stroke during next 60° of cam rotation, and 4. Dwell for the remaining 210° 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	4	Analyze
5.	A cam, with a minimum radius of 25 mm, rotating clockwise at a uniform speed is to be designed to give a roller follower, at the end of a valve rod, motion described below : 1. To raise the valve through 50 mm during 120° rotation of the cam ; 2. To keep the valve fully raised through next 30°; 3. To lower the valve during next 60°; and 4. To keep the valve closed during rest of the revolution i.e. 150° ; The diameter of the roller is 20 mm and the diameter of the cam shaft is 25 mm. Draw the profile of the cam when (a) the line of stroke of the valve rod passes through the axis of the cam shaft, and (b) the line of the stroke is offset 15 mm from the axis of the cam shaft. The displacement of the valve, while being raised and lowered, is to take place with simple harmonic motion. Determine the maximum acceleration of the valve rod when the cam shaft rotates at 100 r.p.m. Draw the displacement, the velocity and the acceleration diagrams for one complete revolution of the cam.	16	4	Analyze
6.	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 the line of stroke of the follower passes through 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	4	Analyze

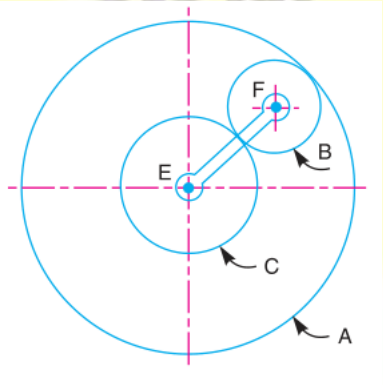
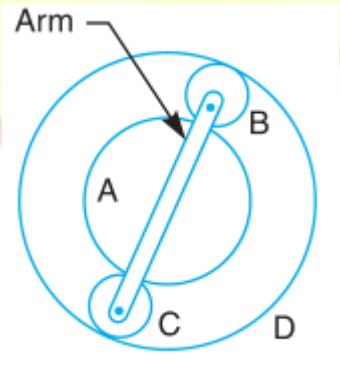
7.	A cam is to give the following motion to a knife-edged follower : 1. Outstroke during 60° of cam rotation ; 2. Dwell for the next 30° of cam rotation ; 3. Return stroke during next 60° of cam rotation, and 4. Dwell for the remaining 210° of cam rotation. The stroke of the follower is 40 mm and the 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 is offset by 20 mm from the axis of the cam shaft.	16	4	Analyze
8.	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 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	4	Analyze
9.	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 profile of the cam.	16	4	Analyze
10.	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	6	Create
11.	Draw a cam profile to drive an oscillating roller follower to the specifications given below : (a) Follower to move outwards through an angular displacement of 20° during the first 120° rotation of the cam ; (b) Follower to return to its initial position during next 120° rotation of the cam ; (c) Follower to dwell during the next 120° of cam rotation.	16	4	Analyze

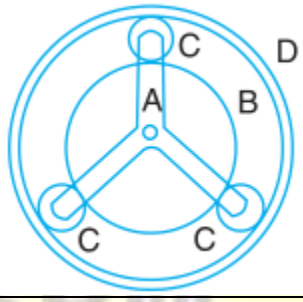
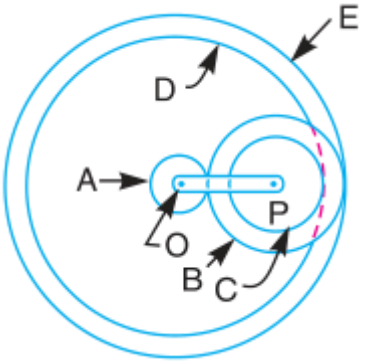
	The distance between pivot centre and roller centre = 120 mm ; distance between pivot centre and cam axis = 130 mm ; minimum radius of cam = 40 mm ; radius of roller = 10 mm ; inward and outward strokes take place with simple harmonic motion.			
12.	A cam, with a minimum radius of 50 mm, rotating clockwise at a uniform speed, is required to give a knife edge follower the motion as described below : 1. To move outwards through 40 mm during 100° rotation of the cam ; 2. To dwell for next 80° ; 3. To return to its starting position during next 90°, and 4. To dwell for the rest period of a revolution i.e. 90°. Draw the profile of the cam when the line of stroke of the follower passes through the centre of the cam shaft. The displacement of the follower is to take place with uniform acceleration and uniform retardation. Determine the maximum velocity and acceleration of the follower when the cam shaft rotates at 900 r.p.m. Draw the displacement, velocity and acceleration diagrams for one complete revolution of the cam.	16	4	Analyze
13.	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	4	Analyze
14.	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	4	Analyze
15.	A cam has straight working faces which are tangential to a base circle of diameter 90 mm. The follower is a roller of diameter 40 mm and the centre of roller moves along a straight line passing through the centre line of the cam shaft. The angle between the tangential faces of the cam is 90° and	16	4	Analyze

	the faces are joined by a nose circle of 10 mm radius. The speed of rotation of the cam is 120 revolutions per min. Find the acceleration of the roller centre 1. when during the lift, the roller is just about to leave the straight flank ; and 2. when the roller is at the outer end of its lift.			
16.	A cam consists of a circular disc of diameter 75 mm with its centre displaced 25 mm from the camshaft axis. The follower has a flat surface (horizontal) in contact with the cam and the line of action of the follower is vertical and passes through the shaft axis as shown in Fig. 20.50. The mass of the follower is 2.3 kg and is pressed downwards by a spring which has a stiffness of 3.5 N/mm. In the lowest position the spring force is 45 N. 1. Derive an expression for the acceleration of the follower in terms of the angle of rotation from the beginning of the lift. 2. As the cam shaft speed is gradually increased, a value is reached at which the follower begins to lift from the cam surface. Determine the camshaft speed for this condition.	16	4	Analyze
17.	A flat ended valve tappet is operated by a symmetrical cam with circular arc for flank and nose. The straight line path of the tappet passes through the cam axis. Total angle of action = 150°. Lift = 6 mm. Base circle diameter = 30 mm. Period of acceleration is half the period of retardation during the lift. The cam rotates at 1250 r.p.m. Find : 1. flank and nose radii ; 2. maximum acceleration and retardation during the lift.	16	4	Analyze
18.	Describe the terminologies of circular arc cam with flat face follower and derive expressions related to it.	16	6	Create

UNIT III GEARS AND GEAR TRAINS			
Law of toothed gearing – Involutes and cycloidal tooth profiles – definitions–Gear tooth action–contact ratio–Interference and under cutting. 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)			
S. No.	**Questions**	**Level**	**Competence**
1.	State law of Gearing.	1	Remember
2.	Define normal and axial pitch in helical gears.	2	Understand
3.	What is the maximum efficiency in worm and worm gear?	2	Understand
4.	What are the advantages and limitations of gear drive? Write any two.	1	Remember
5.	Define interference.	1	Remember
6.	Define cycloidal tooth profile and involute tooth profile.	1	Remember
7.	Define circular pitch and diametral pitch in spur gears.	1	Remember
8.	Define Backslash.	1	Remember
9.	What is gear train of train of wheels?	2	Understand
10.	Write velocity ratio in compound train of wheels?	2	Understand
11.	Define simple gear train.	1	Remember
12.	What is reverted gear train?	2	Understand
13.	Where the epicyclic gear trains are used?	2	Understand
14.	Write down the difference between involute and cycloidal tooth profile.	2	Understand
15.	Define Contact Ratio.	1	Remember
16.	What is an angle of obliquity in gears?	2	Understand
17.	What is bevel gearing? Mention its types.	1	Remember
18.	What are the methods to avoid interference?	1	Remember
19.	What is the advantage when arc of recess is equal to arc of approach in meshing gears?	2	Understand
20.	What do you know about tumbler gear?	2	Understand
21.	What you meant by non-standard gear teeth?	2	Understand
22.	What is meant by compound gear train?	2	Understand
23.	What is the advantage of a compound gear train over a simple gear train?	2	Understand
24.	State the methods to find the velocity ratio of epicyclic gear train.	1	Remember
25.	What is the externally applied torques used to keep the gear train in equilibrium?	1	Remember
Part – B (16 Marks)			
S. No.	**Questions**	**Marks**	**Level**	**Competence**
1.	With a neat sketch, describe the terminologies used in gears.	16	5	Evaluate
2.	The number of teeth on each of the two equal spur gears in mesh are 40. The teeth have 20° involute profile and the	16	4	Analyze

	module is 6 mm. If the arc of contact is 1.75 times the circular pitch, find the addendum.			
3.	A pinion having 30 teeth drives a gear having 80 teeth. The profile of the gears is involute with 20° pressure angle, 12 mm module and 10 mm addendum. Find the length of path of contact, arc of contact and the contact ratio.	16	4	Analyze
4.	Two involute gears of 20° 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 : 1. The angle turned through by pinion when one pair of teeth is in mesh ; and 2. The maximum velocity of sliding.	16	4	Analyze
5.	A pair of gears, having 40 and 20 teeth respectively, are rotating in mesh, the speed of the smaller being 2000 r.p.m. 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° 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	5	Evaluate
6.	The following data relate to a pair of 20° involute gears in mesh : Module = 6 mm, Number of teeth on pinion = 17, Number of teeth on gear = 49 ; Addenda on pinion and gear wheel = 1 module. Find : 1. The number of pairs of teeth in contact ; 2. 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 (iii) is at the pitch point.	16	4	Analyze
7.	A pair of spur gears with involute teeth is to give a gear ratio of 4 : 1. The arc of approach is not to be less than the circular pitch and smaller wheel is the driver. The angle of pressure is 14.5°. Find : 1. the least number of teeth that can be used on each wheel, and 2. the addendum of the wheel in terms of the circular pitch ?	16	4	Analyze
8.	Determine the minimum number of teeth required on a pinion, in order to avoid interference which is to gear with, 1. a wheel to give a gear ratio of 3 to 1 ; and 2. an equal wheel. The pressure angle is 20° and a standard addendum of 1 module for the wheel may be assumed.	16	4	Analyze

9.	A pinion of 20 involute teeth and 125 mm pitch circle diameter drives a rack. 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 contact and the minimum number of teeth in contact at a time.	16	5	Evaluate
10.	In an epicyclic gear train, an arm carries two gears A and B having 36 and 45 teeth respectively. If the arm rotates at 150 r.p.m. in the anticlockwise direction about the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed, makes 300 r.p.m. in the clockwise direction, what will be the speed of gear B ?	16	4	Analyze
11.	In a reverted epicyclic gear train, the arm A carries two gears B and C and a compound gear D - E. The gear B meshes with gear E and the gear C meshes with gear D. The number of teeth on gears B, C and D are 75, 30 and 90 respectively. Find the speed and direction of gear C when gear B is fixed and the arm A makes 100 r.p.m. clockwise.	16	4	Analyze
12.	An epicyclic gear consists of three gears A, B and C as shown in Fig. 5. The gear A has 72 internal teeth and gear C has 32 external teeth. The gear B meshes with both A and C and is carried on an arm EF which rotates about the centre of A at 18 r.p.m.. If the gear A is fixed, determine the speed of gears B and C. 	16	5	Evaluate
13.	An epicyclic train of gears is arranged as shown in Fig. 6. How many revolutions does the arm, to which the pinions B and C are attached, make : 1. when A makes one revolution clockwise and D makes half a revolution anticlockwise, and 2. when A makes one revolution clockwise and D is stationary ? The number of teeth on the gears A and D are 40 and 90 respectively. 	16	4	Analyze
14.	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	16	4	Analyze

	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 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.			
15.	In an epicyclic gear of the 'sun and planet' type shown in Fig. 7, the pitch circle diameter of the internally toothed ring is to be 224 mm and the module 4 mm. When the ring D is stationary, the spider A, which carries three planet wheels C of equal size, is to make one revolution in the same sense as the sunwheel B for every five revolutions of the driving spindle carrying the sunwheel B. Determine suitable numbers of teeth for all the wheels. 	16	4	Analyze
16.	Two shafts A and B are co-axial. A gear C (50 teeth) is rigidly mounted on shaft A. A compound gear D-E gears with C and an internal gear G. D has 20 teeth and gears with C and E has 35 teeth and gears with an internal gear G. The gear G is fixed and is concentric with the shaft axis. The compound gear D-E is mounted on a pin which projects from an arm keyed to the shaft B. Sketch the arrangement and find the number of teeth on internal gear G assuming that all gears have the same module. If the shaft A rotates at 110 r.p.m., find the speed of shaft B.	16	4	Analyze
17.	Fig. 8 shows diagrammatically a compound epicyclic gear train. Wheels A , D and E are free to rotate independently on spindle O, while B and C are compound and rotate together on spindle P, on the end of arm OP. All the teeth on different wheels have the same module. A has 12 teeth, B has 30 teeth and C has 14 teeth cut externally. Find the number of teeth on wheels D and E which are cut internally. If the wheel A is driven clockwise at 1 r.p.s. while D is driven counter clockwise at 5 r.p.s., determine the magnitude and direction of the angular velocities of arm OP and wheel E. 	16	4	Analyze

18.	An internal wheel B with 80 teeth is keyed to a shaft F. A fixed internal wheel C with 82 teeth is concentric with B. A compound wheel D-E gears with the two internal wheels; D has 28 teeth and gears with C while E gears with B. The compound wheels revolve freely on a pin which projects from a disc keyed to a shaft A co-axial with F. If the wheels have the same pitch and the shaft A makes 800 r.p.m., what is the speed of the shaft F ? Sketch the arrangement.	16	4	Analyze

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)			
S. No.	**Questions**	**Level**	**Competence**
1.	Define inertia and inertia force.	1	Remember
2.	Define dynamic force analysis.	1	Remember
3.	List the sufficient conditions of static equilibrium of a body.	2	Understand
4.	Mention some examples of applied forces.	1	Remember
5.	Differentiate between active force and reactive force.	2	Understand
6.	Define constraint forces.	1	Remember
7.	Point out the methods used for static force analysis of mechanisms.	2	Understand
8.	State the principle of superposition.	1	Remember
9.	What are the conditions for dynamic equilibrium?	2	Understand
10.	State D'Alembert's principle.	1	Remember
11.	Write the expression for acceleration of the piston at the inner dead centre position.	1	Remember
12.	Write the expression for piston effort for a vertical engine by considering the weight of the engine and frictional resistance.	1	Remember
13.	List the uses of turning moment diagram.	2	Understand
14.	Define crank pin effort.	1	Remember
15.	Define coefficient of fluctuation of speed.	1	Remember
16.	Define obliquity ratio.	1	Remember
17.	Sketch the turning moment diagram for a single cylinder double acting steam engine.	1	Remember
18.	Sketch the turning moment diagram for a single cylinder four stroke IC engine.	1	Remember
19.	List the significance of turning moment diagram.	2	Understand
20.	Multi cylinder engines have less fluctuation in turning moment diagram. Justify	2	Understand
21.	Mention the significance of flywheels used in engines.	2	Understand
22.	Write the expression for maximum fluctuation of energy stored in a flywheel.	1	Remember
23.	Define coefficient of steadiness.	1	Remember
24.	Differentiate the functions of flywheel and governor.	2	Understand
25.	What is the purpose of flywheel used in an engine?	2	Understand
Part – B (16 Marks)			
S. 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	6	Create

2.	Derive the expression for the forces acting in the reciprocating parts of an engine neglecting the weight of the connecting rod.	16	6	Create
3.	The crank and connecting rod of a steam engine are 0.3 m and 1.5 m in length. The crank rotates at 180 r.p.m. clockwise. Determine the velocity and acceleration of the piston when the crank is at 40 degrees from the inner dead centre position. Also determine the position of the crank for zero acceleration of the piston.	16	4	Analyze
4.	In a slider crank mechanism, the length of the crank and connecting rod are 150 mm and 600 mm respectively. The crank position is 60° from inner dead centre. The crank shaft speed is 450 r.p.m. (clockwise). Using analytical method, determine: 1. Velocity and acceleration of the slider, and 2. Angular velocity and angular acceleration of the connecting rod.	16	4	Analyze
5.	The crank-pin circle radius of a horizontal engine is 300 mm. The mass of the reciprocating parts is 250 kg. When the crank has travelled 60° from I.D.C., the difference between the driving and the back pressures is 0.35 N/mm^2. The connecting rod length between centres is 1.2 m and the cylinder bore is 0.5 m. If the engine runs at 250 r.p.m. and if the effect of piston rod diameter is neglected, calculate : 1. pressure on slide bars, 2. thrust in the connecting rod, 3. tangential force on the crank-pin, and 4. turning moment on the crank shaft.	16	4	Analyze
6.	A vertical double acting steam engine has a cylinder 300 mm diameter and 450 mm stroke and runs at 200 r.p.m. The reciprocating parts has a mass of 225 kg and the piston rod is 50 mm diameter. The connecting rod is 1.2 m long. When the crank has turned through 125° from the top dead centre, the steam pressure above the piston is 30 kN/m^2 and below the piston is 1.5 kN/m^2. Calculate the effective turning moment on the crank shaft.	16	4	Analyze
7.	The crank and connecting rod of a petrol engine, running at 1800 r.p.m.are 50 mm and 200 mm respectively. The diameter of the piston is 80 mm and the mass of the reciprocating parts is 1 kg. At a point during the power stroke, the pressure on the piston is 0.7 N/mm^2, when it has moved 10 mm from the inner dead centre. Determine : 1. Net load on the gudgeon pin, 2. Thrust in the connecting rod, 3. Reaction between the piston and cylinder, and 4. The engine speed at which the above values become zero.	16	4	Analyze
8.	A vertical petrol engine 100 mm diameter and 120 mm stroke has a connecting rod 250 mm long. The mass of the piston is	16	4	Analyze

	1.1 kg. The speed is 2000 r.p.m. On the expansion stroke with a crank 20° from top dead centre, the gas pressure is 700 kN/m^2. Determine: 1. Net force on the piston, 2. Resultant load on the gudgeon pin, 3. Thrust on the cylinder walls, and 4. Speed above which, other things remaining same, the gudgeon pin load would be reversed in direction.			
9.	A horizontal steam engine running at 120 r.p.m. 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/m^2 and that on the crank end side is 70 kN/m^2. Considering the diameter of the piston rod equal to 50 mm, determine: 1. turning moment on the crank shaft, 2. thrust on the bearings, and 3. acceleration of the flywheel, if the power of the engine is 20 kW, mass of the flywheel 60 kg and radius of gyration 0.6 m.	16	4	Analyze
10.	Derive the expression for the energy stored in a flywheel.	16	6	Create
11.	A horizontal cross compound steam engine develops 300 k W at 90 r.p.m. The coefficient of fluctuation of energy as found from the turning moment diagram is to be 0.1 and the fluctuation of speed is to be kept within ± 0.5% of the mean speed. Find the weight of the flywheel required, if the radius of gyration is 2 metres.	16	5	Evaluate
12.	The turning moment diagram for a petrol engine is drawn to the following scales : Turning moment, 1 mm = 5 N-m ; crank angle, 1 mm = 1°. The turning moment diagram repeats itself at every half revolution of the engine and the areas above and below the mean turning moment line taken in order are 295, 685, 40, 340, 960, 270 mm2. The rotating parts are equivalent to a mass of 36 kg at a radius of gyration of 150 mm. Determine the coefficient of fluctuation of speed when the engine runs at 1800 r.p.m.	16	4	Analyze
13.	The turning moment diagram for a multicylinder engine has been drawn to a scale 1 mm = 600 N-m vertically and 1 mm = 3° horizontally. The intercepted areas between the output torque curve and the mean resistance line, taken in order from one end, are as follows : + 52, – 124, + 92, – 140, + 85, – 72 and + 107 mm2, when the engine is running at a speed of 600 r.p.m. If the total fluctuation of speed is not to exceed ± 1.5% of the mean, find the necessary mass of the flywheel of radius 0.5 m.	16	4	Analyze
14.	The flywheel of a steam engine has a radius of gyration of 1 m and mass 2500 kg. The starting torque of the steam engine is 1500 N-m and may be assumed constant.	16	4	Analyze

	Determine: 1. the angular acceleration of the flywheel, and 2. the kinetic energy of the flywheel after 10 seconds from the start.			
15.	The turning moment diagram for a four stroke gas engine may be 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 m2; Compression stroke = 1.7 × 10–3 m2; Expansion stroke = 6.8 × 10–3 m2; Exhaust stroke = 0.65 × 10–3 m2. Each m2 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	4	Analyze
16.	The turning moment diagram for a multi-cylinder engine has been drawn to a scale of 1 mm to 500 N-m torque and 1 mm to 6° of crank displacement. The intercepted areas between output torque curve and mean resistance line taken in order from one end, in sq. mm are – 30, + 410, – 280, + 320, – 330, + 250, – 360, + 280, – 260 sq. mm, when the engine is running at 800 r.p.m. The engine has a stroke of 300 mm and the fluctuation of speed is not to exceed ± 2% of the mean speed. Determine a suitable diameter and cross-section of the flywheel rim for a limiting value of the safe centrifugal stress of 7 MPa. The material density may be assumed as 7200 kg/m^3. The width of the rim is to be 5 times the thickness	16	5	Evaluate
17.	A multi-cylinder engine is to run at a speed of 600 r.p.m. On drawing the turning moment diagram to a scale of 1 mm = 250 N-m and 1 mm = 3°, the areas above and below the mean torque line in mm2 are : + 160, – 172, + 168, – 191, + 197, – 162. The speed is to be kept within ± 1% of the mean speed of the engine. Calculate the necessary moment of inertia of the flywheel. Determine the suitable dimensions of a rectangular flywheel rim if the breadth is twice its thickness. The density of the cast iron is 7250 kg/m^3 and its hoop stress is 6 MPa. Assume that the rim contributes 92% of the flywheel effect.	16	4	Analyze
18.	A punching press is driven by a constant torque electric motor. The press is provided with a flywheel that rotates at maximum speed of 225 r.p.m. The radius of gyration of the flywheel is 0.5 m. The press punches 720 holes per hour; each punching operation takes 2 second and requires 15 kN-m of energy. Find the power of the motor and the minimum mass of the flywheel if speed of the same is not to fall below 200 r. p. m	16	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)			
S. No.	**Questions**	**Level**	**Competence**
1.	Why balancing is necessary?	2	Understand
2.	Define static balancing of shaft.	1	Remember
3.	State the reason for choosing multi cylinder engine in comparison with that of the single cylinderengine	2	Understand
4.	What do you mean by partial balancing of single cylinder engine?	2	Understand
5.	In case of balancing of rotary masses in different planes, in how many number of planes the balancing masses will be kept?	2	Understand
6.	Differentiate between the unbalanced force due to a reciprocating mass and that due to revolving masses.	1	Remember
7.	Why complete balancing is not possible in reciprocating engine?	2	Understand
8.	Differentiate static and dynamic balancing.	1	Remember
9.	Why single cylinder engines are not fully balanced ?	2	Understand
10.	Why are the cranks of a locomotive, with two cylinders, placed at 90 degrees to each other?	2	Understand
11.	List down the planes of considering for uncoupled and coupled locomotives?	1	Remember
12.	What are primary and secondary unbalanced forces?	1	Remember
13.	What is meant by primary balancing?	2	Understand
14.	Define tractive force.	1	Remember
15.	What is Hammer Blow?	2	Understand
16.	What is swaying couple?	2	Understand
17.	Why rotating masses are to be dynamically balanced?	2	Understand
18.	State the condition for static balancing.	1	Remember
19.	State the condition for dynamic balancing.	1	Remember
20.	Why is only a part of the unbalanced force due to reciprocating masses balanced by revolving mass ?	2	Understand
21.	What are the different types of balancing machines?	1	Remember
22.	State the condition for complete balance of several masses revolving in different planes of a shaft.	1	Remember
23.	List the effects of partial balancing of locomotives.	1	Remember
24.	What is meant by secondary balancing?	2	Understand
25.	What is the effect of hammer blow?	2	Understand
Part – B (16 Marks)			
S. No.	**Questions**	**Marks**	**Level**	**Competence**

1.	Explain about balancing of a single rotating mass by a single mass rotating in the same plane.	16	5	Evaluate
2.	Write about balancing of a single rotating mass by two masses rotating in different planes.	16	4	Analyze
3.	Four masses m1, m2, m3 and m4 are 200 kg, 300 kg, 240 kg and 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 angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m.	16	4	Analyze
4.	A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100 mm, between X and Y is 400 mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions.	16	4	Analyze
5.	Four masses A, B, C and D as shown below are to be completely balanced. Their corresponding masses are x kg, 30 kg, 50 kg, 40 kg respectively. The corresponding radius (mm) values are 180, 240, 120, 150 respectively. The planes containing masses B and C are 300 mm apart. The angle between planes containing B and C is 90°. B and C make angles of 210° and 120° respectively with D in the same sense. Find : 1. The magnitude and the angular position of mass A ; and 2. The position of planes A and D.	16	4	Analyze
6.	A, B, C and D are four masses carried by a rotating shaft at radii 100, 125, 200 and 150 mm respectively. The planes in which 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	4	Analyze
7.	A shaft carries four masses in parallel planes A, B, C and D in this order along its length. The masses at B and C are 18 kg and 12.5 kg respectively, and each has an eccentricity of 60 mm. The masses at A and D have an eccentricity of 80 mm. The angle between the masses at B and C is 100° and that between the masses at B and A is 190°, both being measured in the same direction. The axial distance between the planes A and B is 100 mm and that between B and C is	16	4	Analyze

	200 mm. If the shaft is in complete dynamic balance, determine : 1. The magnitude of the masses at A and D ; 2. the distance between planes A and D ; and 3. the angular position of the mass at D.			
8.	A shaft has three eccentrics, each 75 mm diameter and 25 mm thick, 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 adding two masses at a radius 75 mm and at distances of 100 mm from the central plane of the middle eccentric, find the amount of the masses and their angular positions.	16	4	Analyze
9.	A shaft is supported in bearings 1.8 m apart and projects 0.45 m beyond bearings at each end. The shaft carries three pulleys one at each end and one at the middle of its length. The mass of end pulleys is 48 kg and 20 kg and their centre of gravity are 15 mm and 12.5 mm respectively from the shaft axis. The centre pulley has a mass of 56 kg and its centre of gravity is 15 mm from the shaft axis. If the pulleys are arranged so as to give static balance, determine : 1. relative angular positions of the pulleys, and 2. dynamic forces produced on the bearings when the shaft rotates at 300 r.p.m.	16	4	Analyze
10.	A single cylinder reciprocating engine has speed 240 r.p.m., stroke 300 mm, mass of reciprocating parts 50 kg, mass of revolving parts at 150 mm radius 37 kg. If two third of the reciprocating parts and all the revolving parts are to be balanced, find : 1. The balance mass required at a radius of 400 mm, and 2. The residual unbalanced force when the crank has rotated 60° from top dead centre.	16	4	Analyze
11.	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 centre lines 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	4	Analyze

12.	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 : 1. the magnitude and the position of the balancing masses required at a radius of 0.6 m ; and 2. the hammer blow per wheel when the axle makes 6 r.p.s.	16	4	Analyze
13.	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	4	Analyze
14.	The following data apply to an outside cylinder uncoupled locomotive : 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.	16	4	Analyze
15.	A four cylinder vertical engine has cranks 150 mm long. The planes of rotation of the first, second and fourth cranks are 400 mm, 200 mm and 200 mm respectively from the third crank and their reciprocating masses are 50 kg, 60 kg and 50 kg respectively. Find the mass of the reciprocating parts for the third cylinder and the relative angular positions of the cranks in order that the engine may be in complete primary balance.	16	4	Analyze
16.	Derive the expression for primary and secondary unbalanced forces of reciprocating masses.	16	6	Create
17.	Write short notes on partial balancing of unbalanced primary forces in a reciprocating engine.	16	5	Evaluate

18.	Enumerate on the effect of partial balancing of reciprocating parts of two cylinder locomotives.	16	5	Evaluate