SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur– 603 203

DEPARTMENT OF MECHANICAL ENGINEERING

QUESTIONBANK

III Semester

1909308 - Theory of Machines

Regulation–2019

Academic Year 2021– 2022

Prepared by

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DEPARTMENT OF MECHANICAL ENGINEERING

Subject Code & Name : **1909309 - Theory of Machines**

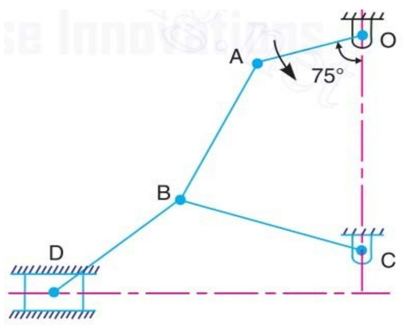
Semester & Year : **III / II year**

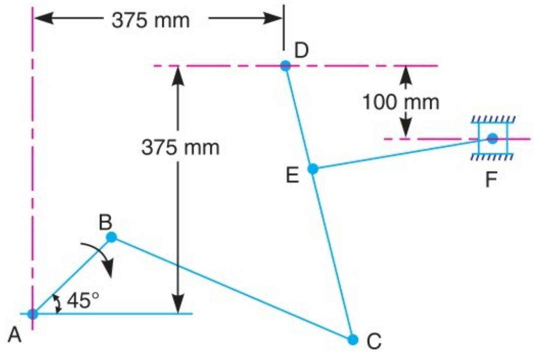
UNIT- I:TERMINOLOGY

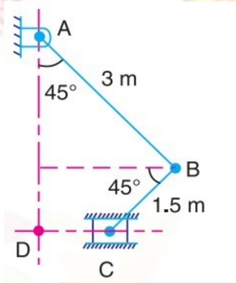
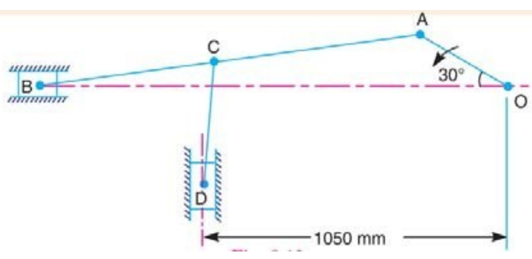
Definitions - Kinematic links - Pairs - Chain - Machines and mechanism - Types and uses- Kinematic inversion of four bar chain and slider crank mechanism. Velocity and acceleration in simple mechanisms - Vector polygon and instantaneous centre methods- Coriolis component of acceleration.

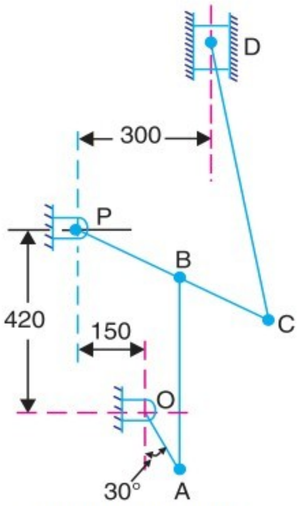
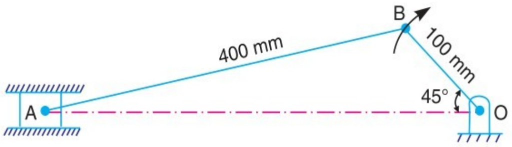
PART-A (2 Marks)

Q.No	Questions	BT Level	Competence
1.	Define Machine.	BT-1	Remembering
2.	Describe Kinematic link or Element.	BT-1	Remembering
3.	Examine the resistant body.	BT-1	Remembering
4.	Summarize the characteristics of link.	BT-2	Understanding
5.	List the types of links.	BT-1	Remembering
6.	Compare a Machine and a Structure.	BT-2	Understanding
7.	Define kinematic pair.	BT-1	Remembering
8.	Interpret the types of Constrained Motions.	BT-2	Understanding
9.	Classify kinematic pairs according to the type of relative motion between the elements.	BT-4	Analyzing
10.	Extend kinematic pairs according to the type of contact between the elements.	BT-2	Understanding
11.	Describe Kinematic chain.	BT-1	Remembering
12.	Label the types of joints in a chain.	BT-1	Remembering
13.	Identify the Mechanism.	BT-1	Remembering
14.	Interpret the Simple and Compound mechanism.	BT-2	Understanding
15.	Discuss driver and follower in mechanism.	BT-2	Understanding
16.	Contrast the types of Kinematic chains.	BT-2	Understanding
17.	Collect the methods for determining the Velocity of a Point on a Link	BT-1	Remembering

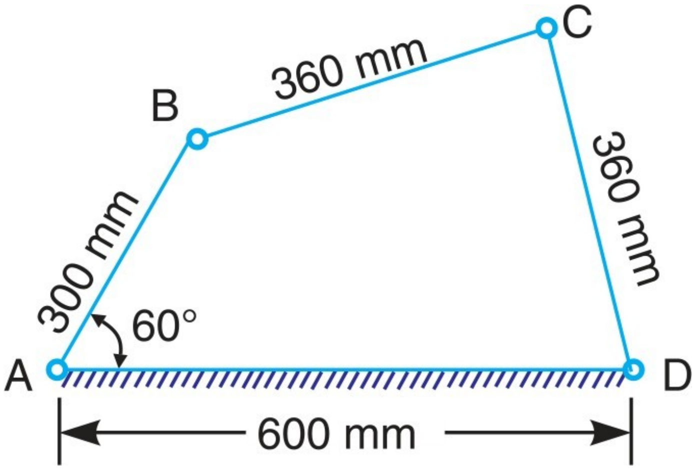
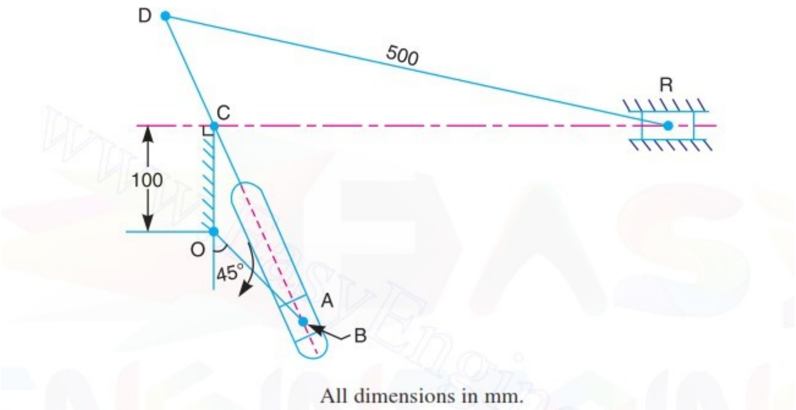
18.	Discuss in brief the Instantaneous centre of rotation.	BT-1	Remembering
19.	Label the types of Instantaneous centres.	BT-1	Remembering
20.	Define rubbing velocity at a pin joint.	BT-1	Remembering
	PART-B (13 Marks)		
1.	(a) Classify the kinematic pairs and define each pair. (7)	BT-3	Applying
	(b) Explain the types of constrained motions with neat sketch (6)	BT-3	Applying
2.	Discuss the types of Kinematic chain with neat sketch.	BT-2	Understanding
3.	In a four bar chain ABCD, AD is fixed and is 150 mm long. The crank AB is 40 mm long and rotates at 120 r.p.m. clockwise, while the link CD = 80 mm oscillates about D. BC and AD are of equal length. Evaluate the angular velocity of link CD when angle BAD = 60°.	BT-5	Evaluating
4.	The crank and connecting rod of a theoretical steam engine are 0.6 m and 2.5 m long respectively. The crank makes 200 r.p.m. in the clockwise direction. When it has turned 45° from the inner dead centre position, Evaluate: 1. velocity of piston, 2. angular velocity of connecting rod, 3. velocity of point E on the connecting rod 1.5 m from the gudgeon pin.	BT-5	Evaluating
5.	In Fig 1.1, the angular velocity of the crank OA is 600 r.p.m. Evaluate the linear velocity of the slider D and the angular velocity of the link BD, when the crank is inclined at an angle of 75° to the vertical. The dimensions of various links are: OA = 28 mm; AB = 44 mm; BC = 49 mm; and BD = 46 mm. The centre distance between the centres of rotation O and C is 65 mm. The path of travel of the slider is 11 mm below the fixed point C. The slider moves along a horizontal path and OC is vertical.  Fig 1.1	BT-4	Analyzing

6.	The mechanism, as shown in Fig. 1.2, has the dimensions of various links as follows: AB = DE = 150 mm; BC = CD = 450 mm; EF = 375 mm. The crank AB makes an angle of 45° with the horizontal and rotates about A in the clockwise direction at a uniform speed of 120 r.p.m. The lever DC oscillates about the fixed point D, which is connected to AB by the coupler BC. The block F moves in the horizontal guides, being driven by the link EF. Determine: 1. velocity of the block F, 2. angular velocity of DC, and 3. rubbing speed at the pin C which is 50 mm in diameter.  Fig 1.2	BT-4	Analyzing
7.	A four bar mechanism has the following dimensions: DA = 300 mm; CB = AB = 360 mm; DC = 600 mm. The link DC is fixed and the angle ADC is 60°. The driving link DA rotates uniformly at a speed of 100 r.p.m. clockwise and the constant driving torque has the magnitude of 50 N-m. Evaluate the velocity of the point B and angular velocity of the driven link CB. Also find the actual mechanical advantage and the resisting torque if the efficiency of the mechanism is 70 per cent.	BT-3	Applying
8.	The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 r.p.m. The crank is 150 mm and the connecting rod is 600 mm long. Evaluate: 1. linear velocity and acceleration of the midpoint of the connecting rod, and 2. angular velocity and angular acceleration of the connecting rod, at a crank angle of 45° from inner dead centre position.	BT-3	Applying
9.	An engine mechanism is shown in Fig. 8.5. The crank CB = 100 mm and the connecting rod BA = 300 mm with centre of gravity G, 100 mm from B. In the position shown, the crankshaft has a speed of 75 rad/s and an angular acceleration of 1200 rad/s^2. Find: 1. velocity of G and	BT-5	Evaluating

	angular velocity of AB, and 2. acceleration of G and angular acceleration of AB.		
10.	PQRS is a four bar chain with link PS fixed. The lengths of the links are PQ = 62.5 mm; QR = 175 mm; RS = 112.5 mm; and PS = 200 mm. The crank PQ rotates at 10 rad/s clockwise. Draw the velocity and acceleration diagram when angle QPS = 60° and Q and R lie on the same side of PS. Find the angular velocity and angular acceleration of links QR and RS.	BT-3	Applying
11.	In the mechanism shown in Fig. 1.3, the slider C is moving to the right with a velocity of 1 m/s and an acceleration of 2.5 m/s^2. The dimensions of various links are AB = 3 m inclined at 45° with the vertical and BC = 1.5 m inclined at 45° with the horizontal. Determine: 1.the magnitude of vertical and horizontal component of the acceleration of the point B, and 2. the angular acceleration of the links AB and BC  Fig 1.3	BT-5	Evaluating
12.	In the mechanism, as shown in Fig. 1.4, the crank OA rotates at 20 r.p.m. anticlockwise and gives motion to the sliding blocks B and D. The dimensions of the various links are OA = 300 mm; AB = 1200 mm; BC = 450 mm and CD = 450 mm. For the given configuration, determine: 1. velocities of sliding at B and D, 2. angular velocity of CD, 3. linear acceleration of D, and 4. angular acceleration of CD.  *Fig 1.4*	BT-4	Analyzing

13.	Find out the acceleration of the slider D and the angular acceleration of link CD for the engine mechanism shown in Fig. 1.5. The crank OA rotates uniformly at 180 r.p.m. in clockwise direction. The various lengths are: OA = 150 mm; AB = 450 mm; PB = 240 mm; BC = 210 mm; CD = 660 mm.  All dimensions in mm. Fig 1.5	BT-3	Applying
14	Locate all the instantaneous centres of the slider crank mechanism as shown in Fig.1.6. The lengths of crank OB and connecting rod AB are 100 mm and 400 mm respectively. If the crank rotates clockwise with an angular velocity of 10 rad/s, find: 1. Velocity of the slider A, and 2. Angular velocity of the connecting rod AB.  Fig 1.6	BT-5	Evaluating

PART-C (15 Marks)			
1.	In a pin jointed four bar mechanism, as shown in Fig. 1.7, AB = 300 mm, BC =CD=360 mm, and AD = 600 mm. The angle BAD = 60°. The crank AB rotates uniformly at 100 r.p.m. Develop all the instantaneous centres and find the angular velocity of the link BC.	BT-6	Creating

	 Fig 1.7		
2.	Formulate the types of lower pair with neat sketch, and tabulate the pair variable, symbol and degree of freedom for each pair	BT-6	Create
3.	The crank and connecting rod of a theoretical steam engine are 0.5 m and 2 m long respectively. The crank makes 180 r.p.m. in the clockwise direction. When it has turned 45° from the inner dead centre position, determine : 1. velocity of piston, 2. angular velocity of connecting rod, 3. velocity of point E on the connecting rod 1.5 m from the gudgeon pin, 4. velocities of rubbing at the pins of the cdrank shaft, crank and crosshead when the diameters of their pins are 50 mm, 60 mm and 30 mm respectively, 5. Position and linear velocity of any point G on the connecting rod which has the least velocity relative to crank shaft.	BT-3	Applying
4.	In a Whitworth quick return motion, as shown in Fig. 1.8, OA is a crank rotating at 30 r.p.m. in a clockwise direction. The dimensions of various links are: OA = 150 mm; OC = 100 mm; CD = 125 mm; and DR = 500 mm. Develop the acceleration of the sliding block R and the angular acceleration of the slotted lever CA.  Fig.1.8	BT-6	Create

UNIT-II: FRICTION AND APPLICATION			
Sliding and rolling friction –friction in screw threads-Bearing and lubrication- Friction clutches- Belt drives- Friction aspects in brakes.			
PART-A (2 Marks)			
1.	Define Friction.	BT-1	Remembering
2.	List the types of friction.	BT-1	Remembering
3.	Describe Static friction.	BT-1	Remembering
4.	Label Dynamic friction	BT-1	Remembering
5.	Interpret the Sliding friction.	BT-1	Remembering
6.	Discuss Rolling friction.	BT-2	Understanding
7.	Summarize Laws of Static Friction.	BT-2	Understanding
8.	Describe Laws of Kinetic or Dynamic Friction.	BT-2	Understanding
9.	Examine Coefficient of Friction.	BT-1	Remembering
10.	Identify the Limiting Angle of Friction.	BT-1	Remembering
11.	Define Angle of Repose.	BT-1	Remembering
12.	Interpret bearing and Journal.	BT-2	Understanding
13.	List the types of friction clutches.	BT-1	Remembering
14.	Summarize the factors affecting power transmission in belt drive.	BT-2	Understanding
15.	Describe the factors consider in selection of belt drive.	BT-2	Understanding
16.	Express the types of belt drive.	BT-2	Understanding
17.	Tabulate the types of belt.	BT-1	Remembering
18.	Give the materials used for belt drive.	BT-2	Understanding
19.	Express the types of flat belt drive.	BT-2	Understanding
20.	Interpret slip of belt.	BT-1	Remembering

PART-B (13 Marks)			
1.	A body, resting on a rough horizontal plane required a pull of 180 N inclined at 30º to the plane just to move it. It was found that a push of 220 N inclined at 30º to the plane just moved the body. Determine the weight of the body and the coefficient of friction.	BT-5	Evaluating
2.	An effort of 1500 N is required to just move a certain body up an inclined plane of angle 12º, force acting parallel to the plane. If the angle of inclination is increased to 15º, then the effort required is 1720 N. Find the weight of the body and the coefficient of friction.	BT-4	Analyzing
3.	An electric motor driven power screw moves a nut in a horizontal plane against a force of 75 kN at a speed of 300 mm/min. The screw has a single square thread of 6 mm pitch on a major diameter of 40 mm. The coefficient of friction at the screw threads is 0.1. Estimate power of the motor.	BT-5	Evaluating
4.	A vertical screw with single start square threads 50 mm mean diameter and 12.5 mm pitch is raised against a load of 10 kN by means of a hand wheel, the boss of which is threaded to act as a nut. The axial load is taken up by a thrust collar which supports the wheel boss and has a mean diameter of 60 mm. If the coefficient of friction is 0.15 for the screw and 0.18 for the collar and the tangential force applied by each hand to the wheel is 100 N; find suitable diameter of the hand wheel.	BT-4	Analyzing
5.	(a) A 150 mm diameter valve, against which a steam pressure of 2 MN/m^2 is acting, is closed by means of a square threaded screw 50 mm in external diameter with 6 mm pitch. If the coefficient of friction is 0.12; find the torque required to turn the handle.	BT-5	Evaluating
	(b) A square threaded bolt of root diameter 22.5 mm and pitch 5 mm is tightened by screwing a nut whose mean diameter of bearing surface is 50 mm. If coefficient of friction for nut and bolt is 0.1 and for nut and bearing surface 0.16, find the force required at the end of a spanner 500 mm long when the load on the bolt is 10 kN.	BT-5	Evaluating
6.	The cutter of a broaching machine is pulled by square threaded screw of 55 mm external diameter and 10 mm pitch. The operating nut takes the axial load of 400 N on a flat surface of 60 mm internal diameter and 90 mm external diameter. If the coefficient of friction is 0.15 for all	BT-5	Evaluating

	contact surfaces on the nut, determine the power required to rotate the operating nut, when the cutting speed is 6 m/min.		
7.	The mean diameter of a square threaded screw jack is 50 mm. The pitch of the thread is 10 mm. The coefficient of friction is 0.15. What force must be applied at the end of a 0.7 m long lever, which is perpendicular to the longitudinal axis of the screw to raise a load of 20 kN	BT-5	Evaluating
8.	A load of 10 kN is raised by means of a screw jack, having a square threaded screw of 12 mm pitch and of mean diameter 50 mm. If a force of 100 N is applied at the end of a lever to raise the load, what should be the length of the lever used? Take coefficient of friction = 0.15. What is the mechanical advantage obtained? State whether the screw is self-locking.	BT-5	Evaluating
9.	A conical pivot supports a load of 20 kN, the cone angle is 120º and the intensity of normal pressure is not to exceed 0.3 N/mm2. The external diameter is twice the internal diameter. Find the outer and inner radii of the bearing surface. If the shaft rotates at 200 r.p.m. and the coefficient of friction is 0.1, find the power absorbed in friction. Assume uniform pressure.	BT-5	Evaluating
10.	A thrust shaft of a ship has 6 collars of 600 mm external diameter and 300 mm internal diameter. The total thrust from the propeller is 100 kN. If the coefficient of friction is 0.12 and speed of the engine 90 r.p.m., find the power absorbed in friction at the thrust block, assuming l. uniform pressure; and 2. Uniform wear.	BT-4	Analyzing
11.	Determine the maximum, minimum and average pressure in plate clutch when the axial force is 4 kN. The inside radius of the contact surface is 50 mm and the outside radius is 100 mm. Assume uniform wear.	BT-5	Evaluating
12.	a. A single plate clutch, with both sides effective, has outer and inner diameters 300 mm and 200 mm respectively. The maximum intensity of pressure at any point in the contact surface is not to exceed 0.1 N/mm^2. If the coefficient of friction is 0.3, determine the power transmitted by a clutch at a speed 2500 r.p.m. (7)	BT-4	Analyzing
	b. A single plate clutch, effective on both sides, is required to transmit 25 kW at 3000 r.p.m. Determine the outer and inner radii of frictional surface if the coefficient of friction is 0.255, the ratio of radii is 1.25	BT-4	Analyzing

	and the maximum pressure is not to exceed 0.1 N/mm^2. Also determine the axial thrust to be provided by springs. Assume the theory of uniform wear. (6)		
13.	A casting weighing 9 kN hangs freely from a rope which makes 2.5 turns round a drum of 300 mm diameter revolving at 20 r.p.m. The other end of the rope is pulled by a man. The coefficient of friction is 0.25. Determine 1. The force required by the man, and 2. The power to raise the casting.	BT-4	Analyzing
14.	(a). An engine, running at 150 r.p.m., drives a line shaft by means of a belt. The engine pulley is 750 mm diameter and the pulley on the line shaft being 450 mm. A 900 mm diameter pulley on the line shaft drives a 150 mm diameter pulley keyed to a dynamo shaft. Find the speed of the dynamo shaft, when 1. There is no slip, and 2. There is a slip of 2% at each drive. (7)	BT-6	Creating
	(b). The power is transmitted from a pulley 1 m diameter running at 200 r.p.m. to a pulley 2.25 m diameter by means of a belt. Find the speed lost by the driven pulley as a result of creep, if the stress on the tight and slack side of the belt is 1.4 MPa and 0.5 MPa respectively. The Young’s modulus for the material of the belt is 100 MPa. (6)	BT-6	Creating

PART-C (15 Marks)			
1.	A shaft which rotates at a constant speed of 160 r.p.m. is connected by belting to a parallel shaft 720 mm apart, which has to run at 60, 80 and 100 r.p.m. The smallest pulley on the driving shaft is 40 mm in radius. Investigate the remaining radii of the two stepped pulleys for 1. A crossed belt, and 2. An open belt. Neglect belt thickness and slip.	BT-6	Create
2.	A shaft rotating at 200 r.p.m. drives another shaft at 300 r.p.m. and transmits 6 kW through a belt. The belt is 100 mm wide and 10 mm thick. The distance between the shafts is 4m. The smaller pulley is 0.5 m in diameter. Formulate the stress in the belt, if it is 1. An open belt drive, and 2. A cross belt drive. Take $\mu = 0.3$.	BT-6	Create
3.	Two pulleys, one 450 mm diameter and the other 200 mm diameter are on parallel shafts 1.95 m apart and are connected by a crossed belt. Find the length of the belt required and the angle of contact between the belt and each pulley. What power can be transmitted by the belt when the larger pulley rotates at 200 rev/min, if the maximum permissible tension in the belt is 1 kN, and the coefficient of friction between the belt and pulley is 0.25?	BT-6	Create
4.	A single dry plate clutch transmits 7.5 kW at 900 r.p.m. The axial pressure is limited to 0.07 N/mm2. If the coefficient of friction is 0.25, find 1. Mean radius and face width of the friction lining assuming the ratio of the mean radius to the face width as 4, and 2. Outer and inner radii of the clutch plate.	BT-4	Analyzing

UNIT III- MOTION OF CAM AND FOLLOWER

Cam and follower - types - application – displacement diagrams - profile layout for uniform velocity Uniform acceleration and retardation - simple harmonic and cycloidal motion.

PART-A (2 Marks)			
1.	Define Cam.	BT - 1	Remembering
2.	Describe follower.	BT - 2	Understanding
3.	List the types of follower according to the surface in contact.	BT - 2	Understanding
4.	Tabulate the types of follower according to the motion of the follower.	BT - 2	Understanding
5.	Label the types of follower according to the path of motion of the follower.	BT - 2	Understanding
6.	Classify the types of Cam.	BT - 3	Applying
7.	Summarize the terms Used in Radial Cams.	BT - 2	Understanding
8.	Describe the different types of motions with which a follower can move.	BT - 2	Understanding
9.	Discuss the dwell time.	BT - 2	Understanding
10.	Identify the tangent Cam.	BT - 1	Remembering
11.	Define Circular Arc Cam.	BT - 1	Remembering
12.	Collect the pitch circle as applied to cam with a neat sketch	BT - 1	Remembering
13.	Quote the base circle as applied to cam with a neat sketch.	BT - 2	Understanding
14.	Describe the pressure angle as applied to cam with a neat sketch.	BT - 1	Remembering
15.	Interpret the pitch point as applied to cam with a neat sketch.	BT - 2	Understanding
16.	Contrast plane motion.	BT - 1	Remembering
17.	Define translatory motion.	BT - 2	Understanding
18.	Examine plane curvilinear motion.	BT - 1	Remembering
19.	Describe trace point.	BT - 1	Remembering
20.	Identify Linear Displacement.	BT - 1	Remembering

PART-B (13 Marks)			
1.	Infer the terms used in Radial Cams with neat sketch.	BT - 4	Analyzing
2.	Explain and classification of followers.	BT - 4	Analyzing
3.	Assess the Displacement, velocity and acceleration diagrams, when the follower moves with uniform velocity?	BT - 5	Evaluating
4.	Summarize the displacement, velocity and acceleration diagrams. When the follower moves with simple harmonic motion?	BT - 5	Evaluating
5.	Deduce the Displacement, Velocity and Acceleration Diagrams when the follower moves with Uniform Acceleration and Retardation.	BT - 5	Evaluating
6.	Discriminate the displacement, velocity and acceleration diagrams. when the follower moves with cycloidal motion?	BT - 5	Evaluating
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. Construct the profile of the cam when (a) the axis of the follower passes through the axis of the cam shaft, and (b) the axis of the follower is offset by 20 mm from the axis of the cam shaft.	BT – 6	Create
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°. Construct 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	BT – 6	Create

	during its ascent and descent, if the cam rotates at 240 r.p.m.		
9.	Construct a cam for operating the exhaust valve of an oil engine. It is required to give equal uniform acceleration and retardation during opening and closing of the valve each of which corresponds to 60° of cam rotation. The valve must remain in the fully open position for 20° of cam rotation. The lift of the valve is 37.5 mm and the least radius of the cam is 40 mm. The follower is provided with a roller of radius 20 mm and its line of stroke passes through the axis of the cam	BT – 6	Create
10.	A cam rotating clockwise at a uniform speed of 1000 r.p.m. is required to give a roller follower the motion defined below : 1. Follower to move outwards through 50 mm during 120° of cam rotation, 2. Follower to dwell for next 60° of cam rotation, 3. Follower to return to its starting position during next 90° of cam rotation, 4. Follower to dwell for the rest of the cam rotation. The minimum radius of the cam is 50 mm and the diameter of roller is 10 mm. The line of stroke of the follower is off-set by 20 mm from the axis of the cam shaft. If the displacement of the follower takes place with uniform and equal acceleration and retardation on both the outward and return strokes, Construct profile of the cam and find the maximum velocity and acceleration during out stroke and return stroke	BT – 6	Create
11.	Construct the profile of a cam to suit the following specifications : Cam shaft diameter = 40 mm; Least radius of cam = 25 mm; Diameter of roller = 25 mm; Angle of lift = 120°; Angle of fall = 150°; Lift of the follower = 40 mm; Number of pauses are two of equal interval between motions. During the lift, the motion is S.H.M. During the fall the motion is uniform acceleration and deceleration. The speed of the cam shaft is uniform. The line of stroke of the follower is off-set 12.5 mm from the centre of the cam	BT – 6	Create
12.	It is required to construct the profile of a cam to give the following motion to the reciprocating follower with a flat mushroom contact face : (i) Follower to have a stroke of 20 mm during 120° of cam rotation ;	BT – 6	Create

	(ii) Follower to dwell for 30° of cam rotation ; (iii) Follower to return to its initial position during 120° of cam rotation ; and (iv) Follower to dwell for remaining 90° of cam rotation. The minimum radius of the cam is 25 mm. The out stroke of the follower is performed with simple harmonic motion and the return stroke with equal uniform acceleration and retardation.		
13.	It is required to construct the profile of a cam with oscillating follower for the following motion : (a) Follower to move outward through an angular displacement of 20° during 90° of cam rotation ; (b) Follower to dwell for 45° of cam rotation ; (c) Follower to return to its original position of zero displacement in 75° of cam rotation ; and (d) Follower to dwell for the remaining period of the revolution of the cam. The distance between the pivot centre and the follower roller centre is 70 mm and the roller diameter is 20 mm. The minimum radius of the cam corresponds to the starting position of the follower as given in (a). The location of the pivot point is 70 mm to the left and 60 mm above the axis of rotation of the cam. The motion of the follower is to take place with S.H.M. during out stroke and with uniform acceleration and retardation during return stroke.	BT – 6	Create
14.	Construct 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.	BT – 6	Create

PART-C (15 Marks)

1.	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. Formulate the maximum acceleration of the valve rod when the cam shaft rotates at 100 r.p.m. Construct the displacement, the velocity and the acceleration diagrams for one complete revolution of the cam.	BT – 6	Create
2.	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. Construct the profile of the cam.	BT – 6	Create
3.	Construct 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. The distance between pivot centre and roller centre = 120 mm;	BT – 6	Create

	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.		
4.	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 (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 off-set by 15 mm. 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. Construct the displacement, velocity and acceleration diagrams for one complete revolution of the cam.	BT – 6	Create

UNIT-IV: GEARS AND GEAR TRAINS

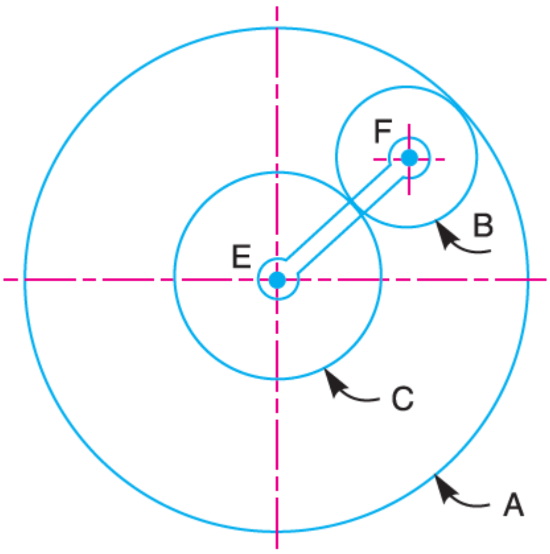
Gears - classification - terminology -law of gearing - tooth profile - interference between rack and pinion. Gear trains - simple - compound reverted. Simple epicyclic geartrains.

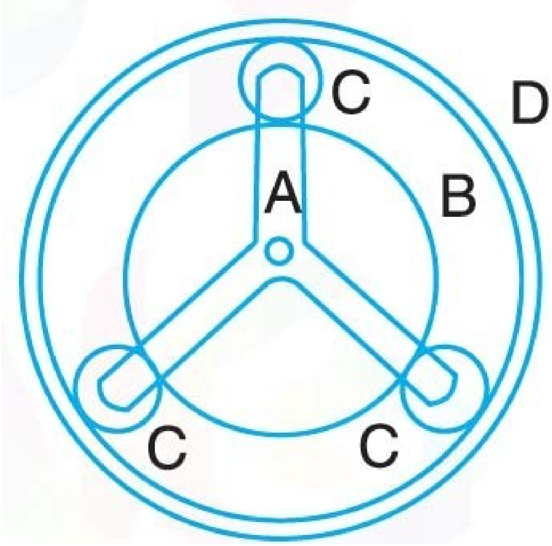
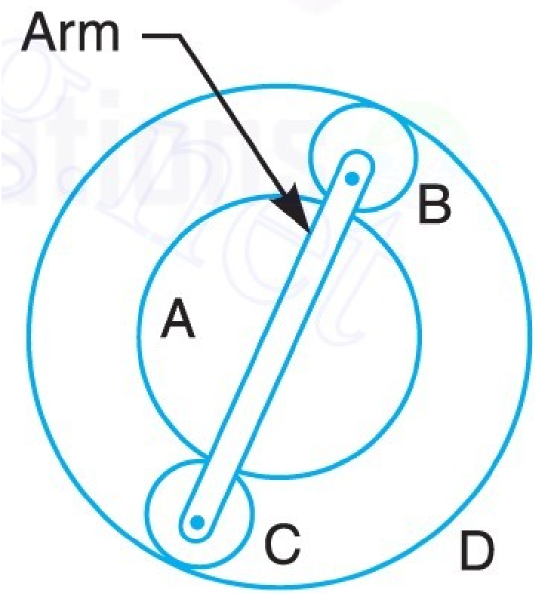
PART-A (2 Marks)

1.	Summarize the advantages of gear drive.	BT – 2	Understanding
2.	Describe the disadvantages of gear drive.	BT – 2	Understanding
3.	Classify the toothed wheels according to the position of axes of the Shafts.	BT – 3	Applying
4.	Relate the toothed wheels according to the peripheral velocity of the gears.	BT – 3	Applying
5.	Interpret the toothed wheels according to the type of gearing.	BT – 2	Understanding
6.	Contrast the toothed wheels according to position of teeth on the gear surface.	BT – 2	Understanding
7.	Define pitch circle.	BT – 1	Remembering
8.	Label pitch circle diameter.	BT – 1	Remembering
9.	Define addendum.	BT – 1	Remembering
10.	Describe dedendum.	BT – 1	Remembering
11.	Examine the module.	BT – 1	Remembering
12.	Quote the path of contact.	BT – 1	Remembering
13.	Contrast the arc of contact.	BT – 2	Understanding
14.	Define gear train.	BT – 1	Remembering
15.	Collect types of gear trains.	BT – 2	Understanding
16.	Define speed ratio.	BT – 1	Remembering
17.	Express train value.	BT – 2	Understanding
18.	Examine simple gear train.	BT – 1	Remembering
19.	Describe compound gear train.	BT – 1	Remembering
20.	Identify the reverted gear train.	BT - 1	Remembering

PART-B (13 Marks)			
1.	(a). 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°. (8)	BT – 3	Applying
	(b). Differentiate Between Involute and Cycloidal Gears. (5)	BT – 4	Analyzing
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 module is 6 mm. If the arc of contact is 1.75 times the circular pitch, Evaluate the addendum.	BT – 5	Evaluating
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. Evaluate the length of path of contact, arc of contact and the contact ratio.	BT – 5	Evaluating
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, Evaluate : 1. The angle turned through by pinion when one pair of teeth is in mesh ; and 2. The maximum velocity of sliding.	BT – 5	Evaluating
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. Evaluate the velocity of sliding between the gear teeth aces 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.	BT – 5	Evaluating
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. Evaluate: 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.	BT – 5	Evaluating

7.	Summarize the Classification of Toothed Wheels.	BT – 5	Evaluating
8.	Criticize the Terms used in Gears with neat sketch.	BT – 5	Evaluating
9.	Describe Simple Gear Train with neat sketch and interpret speed ratio and train value.	BT – 2	Understanding
10.	Explain Compound Gear Train with neat sketch and interpret speed ratio and train value.	BT – 4	Analyzing
11.	The gearing of a machine tool is shown in Fig. 13.3. The motor shaft is connected to gear and rotates at 975 r.p.m. The gear wheels B, C, D and E are fixed to parallel shafts rotating together. The final gear F is fixed on the output shaft. What is the speed of gear F? The number of teeth on each gear are as given below : Gear : A B C D E F No. of teeth : 20 50 25 75 26 65	BT - 5	Evaluating
12.	Two parallel shafts, about 600 mm apart are to be connected by spur gears. One shaft is to run at 360 r.p.m. and the other at 120 r.p.m. Design the gears, if the circular pitch is to be 25 mm.	BT - 5	Evaluating
13.	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?	BT - 5	Evaluating
14.	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.	BT - 5	Evaluating

PART-C (15 Marks)			
1.	A pair of gears, having 50 and 25 teeth respectively, are rotating in mesh, the speed of the smaller being 1800 r.p.m. Formulate 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.	BT – 6	Create
2.	An epicyclic gear consists of three gears A, B and C as shown in Fig.4.1 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, develop the speed of gears B and C.  Fig 4.1	BT - 6	Create
3.	In an epicyclic gear of the 'sun and planet' type shown in Fig.4.2 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 sun wheel B for every five revolutions of the driving spindle carrying the sun wheel B. Determine suitable numbers of teeth for all the wheels.	BT - 5	Evaluating

	 Fig 4.2		
4.	An epicyclic train of gears is arranged as shown in Fig.4.1. 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.  Fig 4.3	BT - 5	Evaluating

UNIT-V FLYWHEEL AND BALANCING

Inertia - turning moment - flywheel - fluctuation of speed and energy. Balancing of rotating masses and reciprocating masses.

PART-A (2 Marks)

1.	Define fluctuations of energy.	BT - 1	Remembering
2.	Label the maximum fluctuation of energy.	BT - 1	Remembering
3.	Describe coefficient of fluctuation of energy.	BT - 1	Remembering
4.	Where flywheel is used in machines?	BT - 1	Remembering
5.	Identify the function of flywheel in engine.	BT - 1	Remembering
6.	Describe coefficient of fluctuation of speed.	BT - 1	Remembering
7.	Examine coefficient of steadiness.	BT - 1	Remembering
8.	Quote balancing of rotating masses.	BT - 1	Remembering
9.	Describe static balancing.	BT - 1	Remembering
10.	Examine dynamic balancing.	BT - 1	Remembering
11.	Identify reference plane.	BT - 1	Remembering
12.	Collect the function of governor.	BT - 1	Remembering
13.	Predict the turning moment diagram for a four stroke cycle internal combustion engine.	BT-2	Understanding
14.	Associate the turning moment diagram for a single cylinder, double acting steam engine.	BT-2	Understanding
15.	Discuss the turning moment diagram for a multi-cylinder engine.	BT-2	Understanding

16.	Examine turning moment diagram.	BT - 1	Remembering
17.	When the turning moment is positive?	BT - 1	Remembering
18.	Define negative turning moment.	BT - 1	Remembering
19.	Discuss negative loop occur in the turning moment diagram.	BT-2	Understanding
20.	Predict positive loop occur in the turning moment diagram.	BT-2	Understanding

PART-B (13 Marks)			
1.	(a). The mass of flywheel of an engine is 6.5 tonnes and the radius of gyration is 1.8 metres. It is found from the turning moment diagram that the fluctuation of energy is 56 kN-m. If the mean speed of the engine is 120 r.p.m., find the maximum and minimum speeds. (7)	BT - 5	Evaluating
	(b). 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. Determine: 1. the angular acceleration of the flywheel, and 2. the kinetic energy of the flywheel after 10 seconds from the start. (6)	BT - 5	Evaluating
2.	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.	BT - 5	Evaluating
3.	The turning moment diagram for a multi-cylinder 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 mm^2, when the engine is running at a speed of 600 r.p.m. If the total fluctuation of speed is not to	BT - 5	Evaluating

	exceed ± 1.5% of the mean, find the necessary mass of the flywheel of radius 0.5 m.		
4.	A shaft fitted with a flywheel rotates at 250 r.p.m. and drives a machine. The torque of machine varies in a cyclic manner over a period of 3 revolutions. The torque rises from 750 N-m to 3000 N-m 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 600 mm.	BT - 5	Evaluating
5.	During forward stroke of the piston of the double acting steam engine, the turning moment has the maximum value of 2000 N-m when the crank makes an angle of 80° with the inner dead centre. During the backward stroke, the maximum turning moment is 1500 N-m when the crank makes an angle of 80° with the outer dead centre. The turning moment diagram for the engine may be assumed for simplicity to be represented by two triangles. If the crank makes 100 r.p.m. and the radius of gyration of the flywheel is 1.75 m, find the coefficient of fluctuation of energy and the mass of the flywheel to keep the speed within ± 0.75% of the mean speed. Also determine the crank angle at which the speed has its minimum and maximum values.	BT - 5	Evaluating
6.	A three cylinder single acting engine has its cranks set equally at 120° and it runs at 600 r.p.m. The torque-crank angle diagram for each cycle is a triangle for the power stroke with a maximum torque of 90 N-m at 60° from dead centre of corresponding crank. The torque on the return stroke is sensibly zero. Evauate: 1. power developed. 2. Coefficient of fluctuation of speed, if the mass of the flywheel is 12 kg and has a radius of gyration of 80 mm, 3. Coefficient of fluctuation of energy, and 4. Maximum angular acceleration of the flywheel.	BT - 5	Evaluating
7.	A single cylinder, single acting, four stroke gas engine develops 20 kW at 300 r.p.m. The work done by the gases during the expansion stroke is three times the work done on the gases during the compression stroke, the work done during the suction and exhaust strokes being negligible. If the	BT - 5	Evaluating

	total fluctuation of speed is not to exceed ± 2 per cent of the mean speed and the turning moment diagram during compression and expansion is assumed to be triangular in shape, find the moment of inertia of the flywheel.		
8.	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} 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.	BT - 5	Evaluating
9.	A certain machine requires a torque of (5000 + 500 sin θ) N-m to drive it, where θ is the angle of rotation of shaft measured from certain datum. The machine is directly coupled to an engine which produces a torque of (5000 + 600 sin 2θ) N-m. The flywheel and the other rotating parts attached to the engine has a mass of 500 kg at a radius of gyration of 0.4 m. If the mean speed is 150 r.p.m., find: 1. the fluctuation of energy, 2. the total percentage fluctuation of speed, and 3. the maximum and minimum angular acceleration of the flywheel and the corresponding shaft position.	BT - 5	Evaluating
10.	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 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.	BT - 5	Evaluating
11.	A shaft has three eccentrics, each 75 mm diameter and 25 mm thick, machined in one piece with the shaft. The central plane 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.	BT - 5	Evaluating

	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.		
12.	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, Evaluate : 1. relative angular positions of the pulleys, and 2. dynamic forces produced on the bearings when the shaft rotates at 300 r.p.m.	BT - 5	Evaluating
13.	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. Summarize 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.	BT - 5	Evaluating
14.	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, Summarize : 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.	BT - 5	Evaluating

PART-C (15 Marks)			
1.	Four masses m_1, m_2, m_3 and m_4 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.	BT - 6	Create
2.	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.	BT - 6	Create
3.	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, formulate their magnitudes and angular positions.	BT - 6	Create
4.	A single cylinder double acting steam engine develops 150 kW at a mean speed of 80 r.p.m. The coefficient of fluctuation of energy is 0.1 and the fluctuation of speed is ± 2% of mean speed. If the mean diameter of the flywheel rim is 2 metre and the hub and spokes provide 5% of the rotational inertia of the flywheel, find the mass and cross-sectional area of the flywheel rim. Assume the density of the flywheel material (which is cast iron) as 7200 kg/m^3.	BT - 6	Create