5. A plate cam with a reciprocating flat-face follower is to be designed such that the lift of the follower will be - $y = 62.5\theta^2 - 25\theta^3$ mm; where, the cam rotation angle θ is in radians. The prime-circle radius R_o = 38 mm and the cam is to rotate counterclockwise. For the cam rotation angle θ = 60^o = $\pi/3$ rad, determine: the coordinates of the trace point in the moving coordinate system and the radius of curvature of the cam profile. **[12]**

6. A pinion having 20 involute teeth of module pitch 6 mm rotates at 200 rpm and transmits 1.5 kW to a gear wheel having 50 teeth. The addendum on both the wheel is ¼ of the circular pitch. The angle of obliquity is 20^o. Find (a) the length of the path of approach; (b) the length of the arc of approach; (c) the normal force between the teeth at an instant where there is only pair of teeth in contact. **[12]**

7. The rotor of a turbine installed in a boat with its axis along the longitudinal axis of the boat makes 1500 rpm clockwise when viewed from the stern. The rotor has a mass of 750 kg and a radius of gyration of 300 mm. If at an instant, the boat pitches in the longitudinal vertical plane so that the bow rises from the horizontal plane with an angular velocity of 1 rad/s, determine the torque acting on the boat and the direction in which it tends to turn the boat at the instant.

MTME(MDA) - 2
ATMM

Full Marks : 70
Time : 3 hours

Answer **Q. No. 1** and any **four** from the rest

The figures in the right-hand margin indicate marks

1. Answer all questions in brief and to the point: **[2×11]**

   (i) What is D'Alembert's principle? Why is it necessary in dynamic analysis of mechanisms?
   (ii) Explain why flywheels are used in punching machines.
   (iii) Why is balancing of rotating parts necessary for high speed engines?
   (iv) Explain why only a part of the unbalanced force due to reciprocating masses is balanced by revolving mass.
   (v) Show that the critical speed for a rotating shaft is the same as the frequency of natural transverse vibration.
   (vi) Define the terms 'pressure angle and stroke of the follower' as applied to cam.
   (vii) What are the different types of motion with which a follower can move?

(viii) What do you mean by interference and undercutting of involute teeth?

(ix) What is 'Geneva mechanism'?

(x) Explain the application of gyroscopic principles to aircrafts.

(xi) A disc is spinning with an angular velocity of 31.42 rad/s about the axis of spin. The mass moment of inertia of the disc is 0.056 kg-m2 and its angular velocity of precession is 16.7 rad/s. Find the gyroscopic couple applied to the disc causing precession.

2. A shaft 12.5 mm diameter rotates in long bearings and a disc of mass 16 kg is secured to a shaft at the middle of its length. The span of the shaft between the bearings is 0.5 m. The mass centre of the disc is 0.5 mm from the axis of the shaft. Neglecting the mass of the shaft and taking E = 200 GN/m^2, find the critical speed of rotation in rpm and the range of speed over which the stress in the shaft due to bending will not exceed 120 MN/m^2. Take the static deflection of the shaft for a beam fixed at both ends, i.e. $\delta = Wl^3/192EI$. **[12]**

3. The reciprocating masses of the first three cylinders of -

a four cylinder engine are 4.1, 6.2 and 7.4 tonnes respectively. The centre lines of the three cylinders are 5.2 m, 3.2 m and 1.2 m from the fourth cylinder. If the cranks for all the cylinders are equal, determine the reciprocating mass of the fourth cylinder and the angular position of the cranks such that the system is completely balanced for the primary force and couple. If the cranks are 0.8 m long, the connecting rods 3.8 m, and the speed of the engine 75 rpm; find the maximum unbalanced secondary force and the crank angle at which it occurs. **[12]**

4. A The turning moment diagram of an engine consists of a curve represented by the equation-

$T = (19614 + 9316.7\sin 2\theta - 5590\cos 2\theta)$ N.m; where θ is the angle moved by the crank from inner dead centre. If the resisting torque is constant, determine –

(a) Power developed by the engine

(b) Moment of inertia of the flywheel in kg-m^2, if the total fluctuation of speed is not to exceed 1 % of mean speed which is 180 rpm and

(c) Angular acceleration of the flywheel when the crank has turned through 45^o from the i.d.c. **[12]**