APL 100 (Jul.-Dec. 2016)
Minor 2 (Part II)

Answer all questions. Each question carries 10 marks.

1. A rod *DE* of mass *m* and length *L* is mounted on a massless shaft *AB* which rotates about the *x* axis at a constant rate ω (Fig. P1). Calculate the bearing reactions at *A* and *B*. Here *AB*=*L*, and at this instant *DE* is in the *x*-*z* plane. The bearing at *A* does not provide any axial constraint, and the bearings do not provide any rotational constraint.

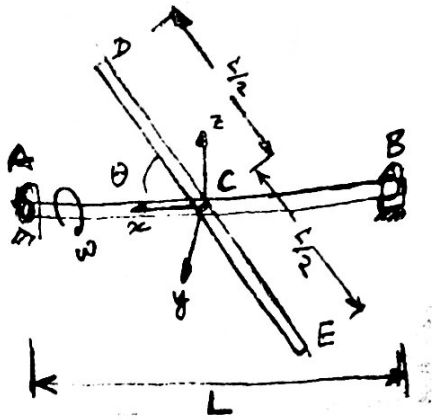

Fig. P1

2. A three bladed rotor rotates at rates $\omega_3, \dot{\omega}_3$ relative to forked arm *2* which rotates at rates $\omega_2, \dot{\omega}_2$ relative to a vertical shaft *1* rotating at rates $\omega_1, \dot{\omega}_1$ about a fixed vertical axis (see Fig. P2). The mass of the rotor is *m*. The axial torque applied by the motor about the *z* axis to the rotor is *T* N-m. The axial and transverse moments of inertia of the rotor including the blade are I_{zz} and $I_{xx}=I_{yy}$. The blades are in the *x*-*y* plane.
   1. Write down the expressions for the angular velocity and angular acceleration of the rotor with respect to the ground, $\omega_{3IG}, \dot{\omega}_{3IG}$.
   2. Is $\dot{H}_B = M_B$ correct? Determine the angular acceleration $\dot{\omega}_3$ of the rotor w.r.t. arm 2 and also the moment reactions M_x and M_y by the frame on the rotor (note that M_z = *T*, the motor torque).
   3. Determine the acceleration a_B of *B* w.r.t. the ground frame *G*. And hence determine the force reaction $\mathbf{F}_R$ by the forked arm on the rotor.

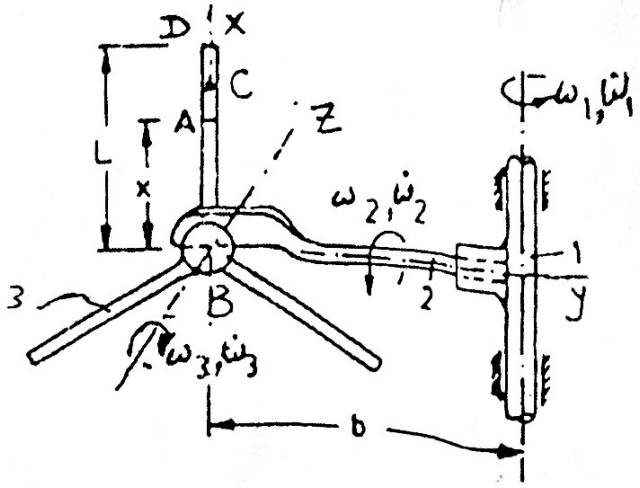

Fig. P2

3. A satellite is in elliptic orbit with eccentricity 0.5 around the earth (G,M) with its maximum distance from the earth's centre being r_o. Find, (i) the speed of the satellite when it is at the maximum distance and (ii) the time period of the satellite.