Indian Institute of Engineering Science and Technology, shibpur
B. E. (Aero.) Part-II 4th Semester Final Examination, 2014

Dynamics for Aerospace Engineers (AE 404)

Time: 3 Hrs. Full Marks: 70

All questions are of equal value

Separate Answer scripts are not required

Group A

Answer any FOUR of the following:

1. The circular disk B of radius r rolls without slipping in a circle of radius b on the disk C that rotates with a constant angular velocity Ω about the z-axis when viewed from above. The arm OA rotates as shown in the figure Q. 1. Determine the expression for angular velocity ω and angular acceleration α of the disk B. 14

2. For the instant represented collar B is moving along the fixed shaft in the X-direction with a constant velocity v_B = 4 m/s. Also at this instant X = 0.3 m and Y = 0.2 m. Calculate the velocity of collar A, which moves along the fixed shaft parallel to the Y-axis. Each clevis is free to rotate about the axis of the rod. (Fig. Q.2) 14

3. a) Derive the expression for kinetic energy for a rigid body moving with mass centre velocity v and angular velocity ω. 5

   b) The aircraft landing gear viewed from the front is being retracted immediately after takeoff, and the wheel is spinning at the rate corresponding to the takeoff speed of 200 km/h. The 45-kg wheel has a radius of gyration about its z-axis of 370 mm. Neglect the thickness of the wheel and calculate the angular momentum of the wheel about G and about A for the position where θ is increasing at the rate of 30^0 per second. (Fig. Q. 3 (b)) 9

4. a) Derive the expression for the moment of inertia about any axis (OM) in terms of the direction cosines of the axis and the moments and products of inertia about the x-y-z coordinate axis. 7

   b) The large satellite-tracking antenna has a moment of inertia I about its z-axis of symmetry and a moment of inertia I_0 about each of the x- and y- axes. Determine the angular acceleration α of the antenna about the vertical Z-axis caused by a torque M applied about Z by the drive mechanism for a given orientation θ. (Fig. Q. 4 (b)) 7

5. a) The irregular rod has a mass ρ per unit length and rotates about the shaft z-zxis at the constant angular velocity ω. Determine the bending moment in the rod at A Neglect the small moment due to the weight of the rod. (Fig. Q.5). 6

b) If the rod of previous problem (question 5 (a)) starts from rest under the action of a torque M_0 applied to it by the collar at A about the z-axis, determine the initial bending moment M in the rod at A. Neglect the small moment due to the weight of the rod. (Fig. Q.5). 8

6. a) Derive the expressions for the general equations of rotation of a symmetrical body about either the mass centre or about a fixed point. 7

   b) Derive the approximate expression for precession of steady-state gyroscopic motion when spin motion is much larger compared to the precession motion. 7

Group B

Answer any one of the following:

7. a) Prove that $\sum\lambda_i a_{ij}$ is nothing but the generalized constraint force corresponding to the generalized coordinate q_j where λ_i s are the Lagrange multipliers and $\sum a_{ij}\delta q_j = 0$; i = 1, 2, ...(m-n) represent the constraint equations. (You need not start from the very beginning and can refer to the relevant mathematical parts only.) m and n are the number of generalized coordinates and the degrees of freedom, respectively.

   5

   b) The fig. Q. 7 (b) shows a spring mass system that can freely move along the horizontal direction. x_1, x_2 and x_3 represent displacements of m_1, m_2 and m_3 from their respective equilibrium positions. Derive (i) the expression for the Lagrangian and (ii) the Lagrange's equation of motion.

   9

8. a) Mathematically show that workless constraints imply zero generalized constraint forces.

   5

   b) Find out the friction force acting on the uniform circular cylinder, of mass m and radius r, that is rolling (without slipping) down the inclined surface of the wedge of mass M that can itself move freely in the horizontal direction on a smooth floor. The inclination of the wedge surface is β and its mass is M. Use Lagrange multiplier technique. fig. Q. 8 (b)

   9

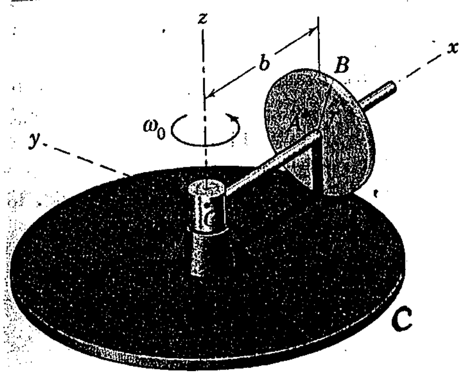

Fig Q.1

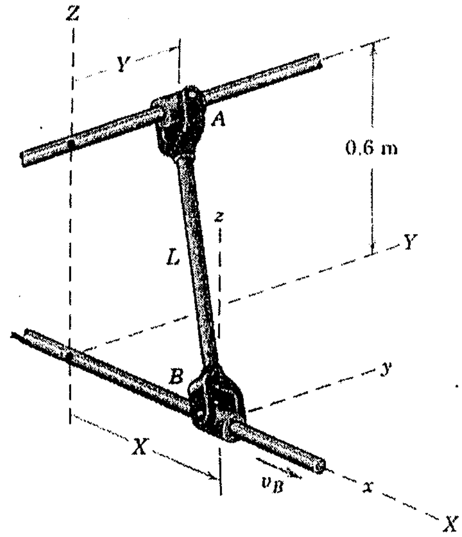

Fig Q.2

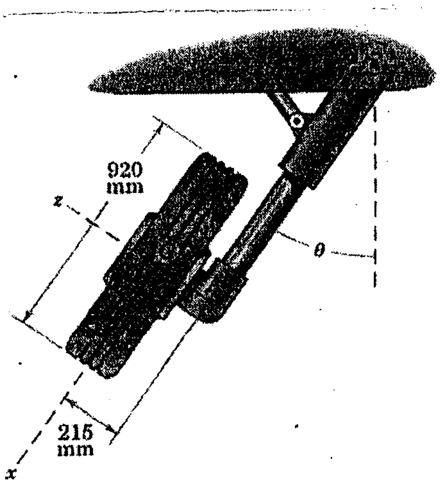

Fig Q.3 (b)

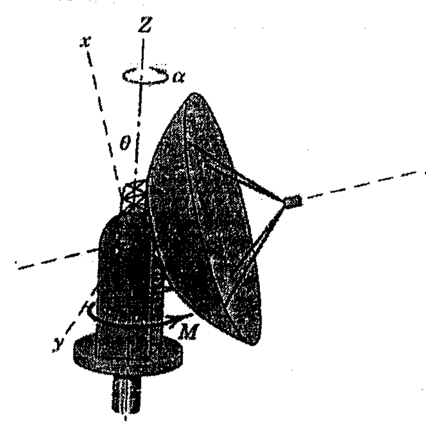

Fig Q.4 (b)

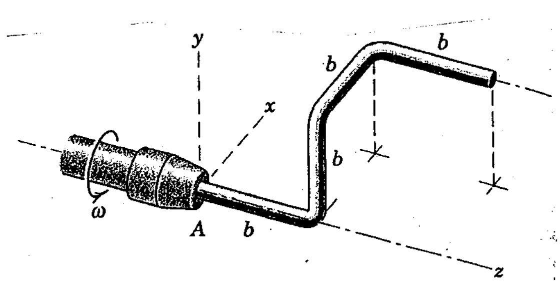

Fig Q.5

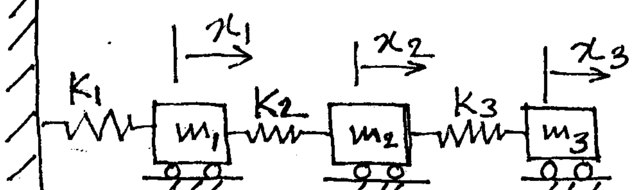

Fig Q.7 (b)

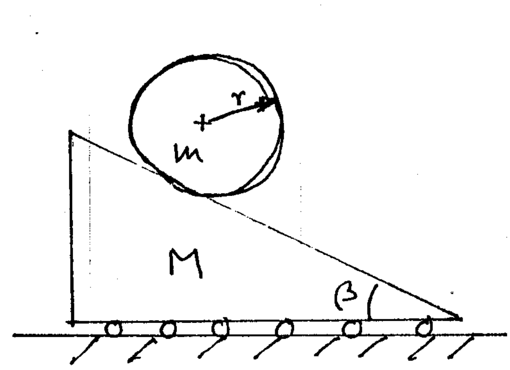

Fig. Q.8 (b)