F232 -(11)

Indian Institute of Technology Kharagpur

Date: (FN/AN) Time: 2 Hrs., Full Marks: 60, Department: Aerospace Engineering
No. of Students: 48, Mid Autumn Semester Examination (2012-13)
Sub. No. AE21003, Sub. Name Dynamics for Aerospace Engineers
2nd yr. B. Tech.(H)/M. Tech (Dual)

Note: Attempt all seven questions. Assume any missing data suitably.

Q 1 Two space stations S_1 and S_2 are describing coplanar circular counterclockwise orbits of radius r_0 and $8r_0$, respectively, around the earth. It is desired to send a vehicle from S_1 to S_2. The vehicle is to be launched in a direction tangent to the orbit of S_1 and is to reach S_2 with a velocity tangent to the orbit of S_2. After a short powered phase, the vehicle will travel in free flight from S_1 to S_2. (a) Determine the launching velocity (velocity of the vehicle relative to S_1), in terms of the velocity v_0 of S_1, (b) Determine the angle θ defining the required position of S_2 relative to S_1 at the time of launching **(Fig.Q.1).** **(7)**

Q 2 A small package of weight W is projected into a vertical return loop at A with a velocity v_0. The package travels without friction along a circle of radius r and is deposited on a horizontal surface at C. For each of the two loops shown in **Fig. Q.2**, determine (a) the smallest velocity v_0 for which the package will reach the horizontal surface at C, (b) the corresponding force exerted by the loop on the package as it passes point B. Now, suppose that it is required to have the package deposited on the horizontal surface at C with a speed of 1.5 m/s. Knowing that r = 0.3 m, (c) show that this requirement cannot be fulfilled by the first loop, (b) determine the required initial velocity v_0 when the second loop is used. **(7)**

Q 3 After completing their moon-exploration mission, the two astronauts forming the crew of an apollo lunar excursion module (LEM) would prepare to rejoin the command module which was orbiting the moon at an altitude of 140 km. They would fire the LEM's engine, bring it along a curved path to a point A, 8 km above the moon's surface, and shut off the engine. Knowing that the LEM was moving at that time in a direction parallel to the moon's surface and that it then coasted along an elliptic path to a rendezvous at B with command module, determine (a) the speed of the LEM at engine shutoff, (b) the relative velocity with which the command module approached the LEM at B **(Fig. Q.3)**. The radius of the moon is 1740 km and its mass is 0.01230 times the mass of the earth. **(8)**

Q4.(A) The depth of water flowing in a rectangular channel of width b at a speed v_1 and depth d_1 increases to a depth d_2 at a hydraulic jump. (a) Express the rate of flow Q in terms of b, d_1, and d_2. (b) what will be the rate of flow in the channel if d_1 = 1.2m, d_2 = 1.5 m, and the channel is 4m wide **(Fig. Q.4a)**. **(5)**

Q4.(B) A chain of length l and total mass m lies in a pile on the floor. If its end A is raised vertically at a constant speed v, determine (a) the force P applied to A at the time when half the chain is off the floor, (b) the reaction exerted by the floor at that time, and (c) again solve (a) and (b) assuming that the end A of the chain is being lowered to the floor at a constant speed v **(Fig. Q4b)**. **(5)**

Q5.A1 A jet airline is cruising at a speed of 900 km/h with each of its three engine discharging air with a velocity of 800 m/s relative to the plane. Determine the speed of the airline after it has lost the use of (a) one of its engines, (b) two of its engines. Assume that the drag due to air friction is proportional to the square of the speed and that the remaining engines keep operating at the same rate. **(4)**

Q5.A2 The helicopter shown in **Fig. Q5A2** has a mass of 12 Mg when empty and can produce a maximum downward air speed of 30 m/s in its 16m diameter slipstream. Assuming ρ =1.21 kg/m^3 for air, determine the maximum combined payload and fuel load the helicopter can carry while hovering in midair. (4)

Q 5.B A possible method for reducing the speed of a training plane as it lands on an aircraft carrier consists in having the tail of the plane hook into the end of a heavy chain of length l which lies in a pile below deck. Denoting by m the mass of the plane and by v_0 its speed at a touch down, and assuming no other retarding force, determine (a) the required mass of the chain if the speed of the plane is to be reduced to βv_0, where β <1, (b) the maximum value of the force exerted by the chain on the plane **(Fig. Q5B).** (4)

Q 6 The small cone shown rolls without slipping on the inside surface of the large fixed cone. Denoting by ω_1 the constant angular velocity of the axis OB about the y axis, determine in terms of ω_1, β, and γ , (a) the rate of spinning of the cone about the axis OB, (b) the total angular velocity of the cone, (c) the angular acceleration of the cone **(Fig. Q6).** (8)

Q 7 Manufactured items are sprayed as they pass through the automated work station shown. Knowing that the bent pipe ACE rotates at the constant rate ω_1 =0.4 rad/s and that at point D the paint moves through the pipe at a constant relative speed u = 150 mm/s, determine, for the position shown in Fig. Q7, (a) the velocity of the paint at D, (b) the acceleration of the paint at D. (8)