(20%) 1. Briefly describe the following terminologies:

(1) Kepler's Laws

(2) Precession and Nutation

(3) Coulomb friction

(4) Resonance

(20%) 2. The two uniform links, each of mass m, are in the vertical plane and are connected and constrained as shown in the following figure. As the angle θ between the links increases with the application of the horizontal force P, the light rod, which is connected at A and passes through a pivoted collar at B, compresses the spring of stiffness k. If the spring is uncompressed in the position equivalent to that for wich $\theta = 0$, determine the force P which will produce equilibrium at the angle θ.

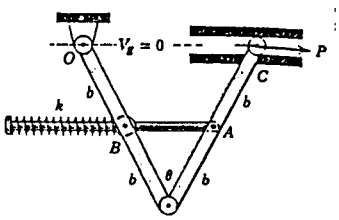

Figure 1

(20%) 3. Consider a wheel of radius "a" rolling on the inside of a fixed circular track of a radius r_0. An arm connecting the fixed point o and the wheel hub o' moves at a constant angular velocity ω. Assuming that there is no slipping between wheel and track, find the acceleration of a point P on the circumference of the wheel. The position of P relative to the arm is given by the angle ϕ.

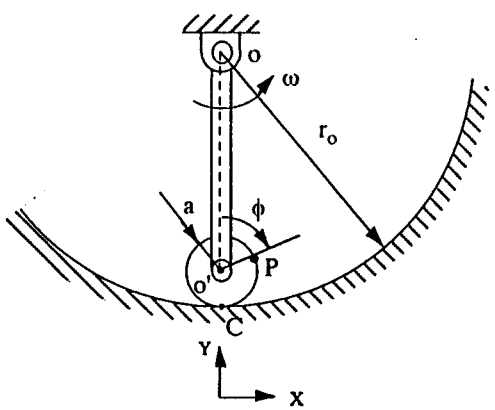

Figure 2

(20%) 4. A rocket is fired vertically from rest at ground. The initial combined mass of a rocket and propellant is $m_0 = 2.5 \times 10^6$ kg. If the propellant mass is $m_f = 20 \times 10^6$ kg, the burning rate is $\dot{m}_f = 8.0 \times 10^3$ kg/s, and the propellant relative speed at the exit nozzle is 3×10^3 m/s, determine

(1) the rocket speed V_b at the instant of propellant burn out,

(2) the altitude h_b of (1), hint $\int \ell n|x|dx = x\ell n|x| - x$.
Assume constant gravitational field at (1) and (2).

(3) For altitude dependent gravitational field, do you get a smaller, equal, or large V_b and h_b?

(20%) 5. A motor weighing 350 ℔ is supported by four springs, each having a constant of 750 ℔/in. The unbalance of the rotor is equivalent to a weight of 1 oz located 6 in. from the axis of rotation. Knowing that the motor is constrained to move vertically,

(a) determine the speed in rpm at which resonance occur,

(b) calculate the amplitude of the vibration of the motor at a speed of 1200 rpm.

(c) briefly discuss the dynamic characteristic of the system.

Hint: 1 ℔ = 16 oz