1. A particle moves in a two-dimensional orbit defined by

$$x(t) = C(\omega t - \sin \omega t)$$
$$y(t) = C(1 - \cos \omega t)$$

   (a) Find the tangential acceleration a_t and normal acceleration a_n as a function of time where the tangential and normal components are taken with respect to the velocity.(12%)

   (b) Determine at what time in the orbit a_n has a maximum.(8%)

2. A simple harmonic oscillator consists of a 1-kg mass attached to a spring whose force constant is 1 nt/cm. The mass is displaced 5 cm and released from rest. Calculate

   (a) the natural frequency ν_0 and the period τ_0,(10%)

   (b) the total energy,(5%) and

   (c) the maximum speed.(5%)

3. A particle of mass m is attracted to a force center with the force of magnitude k/r^2. Find Hamilton's equations of motion in terms of the plane polar coordinates.(20%)

4. Two gravitating masses m_1 and m_2 are separated by a distance r_0 and released from rest. Find their respective speed when the separation is r $(< r_0)$. (16%)

5. A projectile is fired at an angle of 45° to the sky. At the top of its trajectory, the kinetic energy of the projectile is E_0. At this time, it suddenly explodes with additional energy E_0 into two fragments. One fragment of mass m_1 travels straight down. What is the velocity (magnitude and direction) of the second fragment of mass m_2 and the velocity of the first (in terms of m_1, m_2 and E_0)?(18%) What is the maximal possible value of the ratio of m_1/m_2?(6%)