Ph.D. Candidacy Exam – Classical Mechanics – Spring 2012
Physics Department – Kent State University

1. (25 points) A rocket of initial mass m_o is travelling upwards with the gravitational field being constant with height. It expels downwards a gaseous mass per unit time, $a=\Delta m/\Delta t$, with constant speed v_o relative to the rocket. Find the speed v and the height h of the rocket as a function of time.

2. (25 points) In a relativistic elastic collision a particle of light mass m_1 and momentum of magnitude p_1, collides with a stationary particle of light mass m_2. The target particle is observed to recoil with a momentum of magnitude $p_{2'}$. Find the angle φ between the direction of the incident (projectile) and the recoil particle. Simplify your answer in the case where the collision is ultra-relativistic.

3. a. (5 points) A monkey rests on a horizontal table. If the table is accelerated in a horizontal direction, under what conditions will the monkey start slipping?
   b. (15 points) Another monkey crawls outward with constant speed v along a radius of a horizontal, disk-shaped platform. The platform rotates with a constant angular speed ω about its vertical axis. How far can this monkey move before it starts to slip?

4. A frictionless straight wire of length L is attached at a fixed point A with a fixed angle ϑ as shown in the figure. The wire is threaded through a bead of mass m, so that the bead is constrained to move along the wire. The wire rotates with constant angular speed ω about the vertical axis.
   a. (25 points) Determine, using Lagrangian dynamics, the position r of the bead as a function of time.
   b. (5 points) Assuming that the bead starts from rest at A, how long will it take to reach the end B of the wire?