University of Louisville
College of Arts and Sciences

Department of Physics and Astronomy PhD Qualifying Examination (Part I)

Spring 2013

Paper A – Mechanics

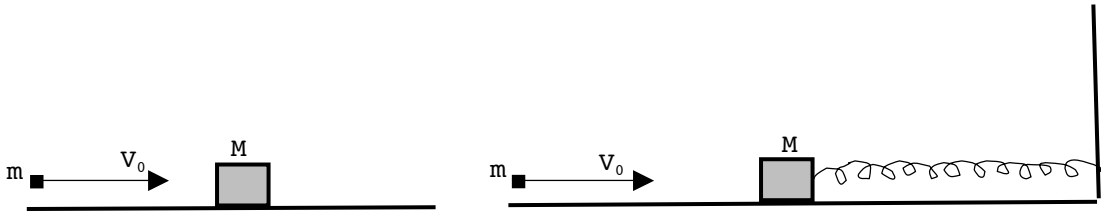
Time allowed – 90 minutes

Instructions and Information:

- Answer both questions
- This is a closed book examination
- Start each question on a new sheet of paper – use only one side of each sheet
- Write your identification number on the upper right hand corner of each answer sheet
- You may use a non programmable calculator
- Partial credit will be awarded.
- Correct answers without adequate explanations will not receive full credit.
- Make sure your work is legible and clear
- The points assigned to each part of each question is clearly indicated

Mechanics Basic

A 20 g bullet (m) is fired into a 1 kg block of wood resting on a frictionless surface as in (i) below. In all cases you should ignore the mass of the bullet with respect to the mass of the block.



(i) (ii)

(a) If v_0 , the initial velocity of the bullet, is 300 m/s, what is the velocity of the block and bullet immediately after the collision ? (7)

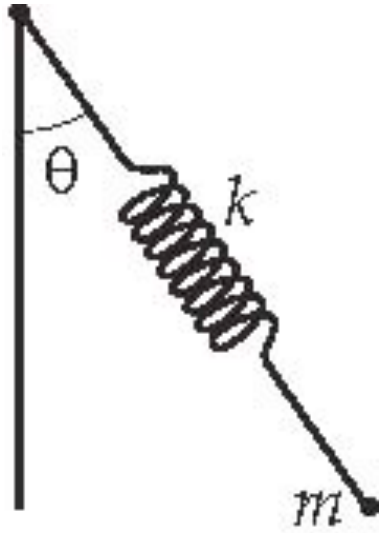
(b) How much kinetic energy is gained or lost in the collision ? Is the collision elastic or inelastic ? (8)

(c) If instead (as in (ii) above), the block is attached to a wall by a spring with a spring constant of 200 N/m, how far is the spring compressed ? Assume the spring is initially neither extended nor compressed. (10)

(d) Suppose now that the surface is not frictionless, having $\mu_k = 0.5$. By applying conservation of energy with non-conservative forces obtain a quadratic equation and solve for x, the amount by which the spring is compressed. [$g = 10 m/s^2$] (10)

Mechanics Intermediate

A pendulum consists of a point mass m suspended by a massless spring with unextended length l_0 and spring constant k, as shown in the figure below. The motion is confined to a vertical plane and the spring stays straight.



(a) Find the Lagrangian of the system using the angle θ and the length of the spring l as generalized co-ordinates. (20)

(b) Find Lagrange's equations of motion. (20)

(c) Find the values of θ and l at the equilibrium point. (10)

(d) Find the frequencies of small oscillations near the equilibrium point. (15)