University of Louisville
College of Arts and Sciences

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

Spring 2016

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 2 kg mass hanging from a spring extends the spring 20 cm from its unstretched length.
[**Do not substitute a value for π if it appears in your answers**]

(a) Determine the spring constant, k. [$g = 10\ m/s^2$] (4)

(b) This mass is removed and a 1 kg mass takes its place. The spring is stretched 10 cm from the new equilibrium position and released. Calculate the period of the resultant oscillations. (4)

(c) Evaluate the angular frequency of these oscillations. (4)

(d) Write down the general expression for position (relative to equilibrium position) as a function of time. (4)

(e) Use the initial conditions described in (b) to determine the amplitude and phase constant of the oscillations. (6)

(f) How long does it take the mass to travel 5 cm from its equilibrium position ? (6)

(g) Calculate the kinetic energy of the block when it is 5 cm from its equilibrium position. (7)

Mechanics Intermediate

As shown in the figure below, two masses m_1 and m_2 are connected by a rigid rod of length d and of negligible mass. An extensionless string of length l_1 is attached to m_1 and connected to a fixed point of support P. Similarly, a string of length l_2 connects m_2 and P. Consider only the motion of the system in the plane of m_1, m_2 and P.

(a) Using the angle ϕ as the generalized coordinate, find the Lagrangian of the system. (20)

(b) Find the Lagrange equation of motion. (20)

(c) Calculate the frequency of small oscillations around the equilibrium position. (25)