

University of Louisville  
College of Arts and Sciences

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

**Fall 2009**

*Paper A – Mechanics*

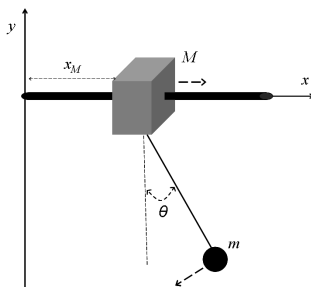
Time allowed – 90 minutes

**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 are clearly indicated

- 1) Two blocks A and B, of mass 2 kg each, are released from rest on a  $30^\circ$  incline when they are 3 meters apart. The coefficients of kinetic friction between the incline and the upper block (A) and the incline and the lower block (B) are 0.2 and 0.4, respectively.
- (a) Calculate the time required for the two blocks to collide. (15)
- (b) Treating the collision between the blocks as completely inelastic, find the speed of the blocks immediately after the collision. (10)
- (c) As the two blocks move down the ramp together after their collision, calculate the contact force between them. (10)

- 2) A plane pendulum of length  $\ell$  and mass  $m$  is suspended from a block of mass  $M$ . The block moves without friction and is constrained to move horizontally only (i.e. along the  $x$  axis). You may assume all motion is confined to the  $xy$  plane. At  $t = 0$ , both masses are at rest, the block is at  $x_M = x_0$ , and the pendulum has angular deflection  $\theta = \theta_0$  with respect to the  $y$  axis.



- (a) Using  $x_M$  and  $\theta$  as generalized coordinates, find the Lagrangian of the system. (20)
- (b) Obtain the Lagrange equations of motion of the system. (20)
- (c) Assuming  $\theta_0 \ll 1$ , find  $x_M$  and  $\theta$  as functions of time. (25)