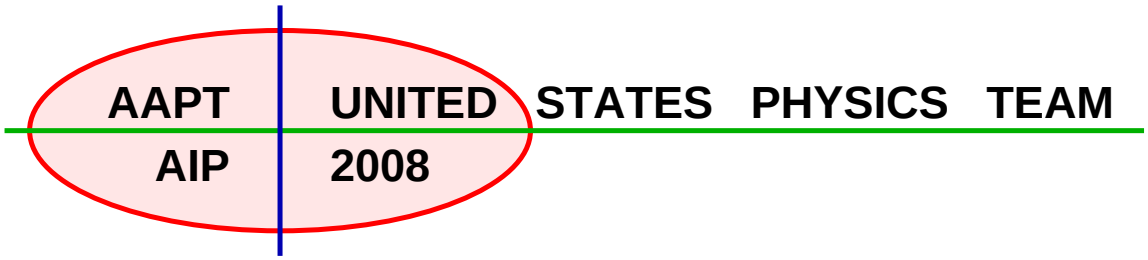



# 2008 Quarter-Final Exam

4 QUESTIONS - 60 MINUTES

## INSTRUCTIONS

### DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO BEGIN

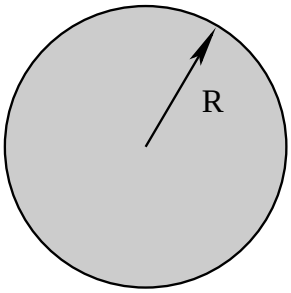
- Show all your work. Partial credit will be given.
- Start each question on a new sheet of paper. Put your name in the upper right-hand corner of each page, along with the question number and the page number/total pages for this problem. For example,

  Doe, Jamie

  Prob. 1 - P. 1/3

- A hand-held calculator may be used. Its memory must be cleared of data and programs. You may use only the basic functions found on a simple scientific calculator. Calculators may not be shared.
- Cell phones may not be used during the exam or while the exam papers are present. You may not use any tables, books, or collections of formulas.
- Each of the four questions is worth 25 points. The questions are not necessarily of the same difficulty. Good luck!
- **In order to maintain exam security, do not communicate any information about the questions (or their answers or solutions) on this contest until after March 10, 2008.**

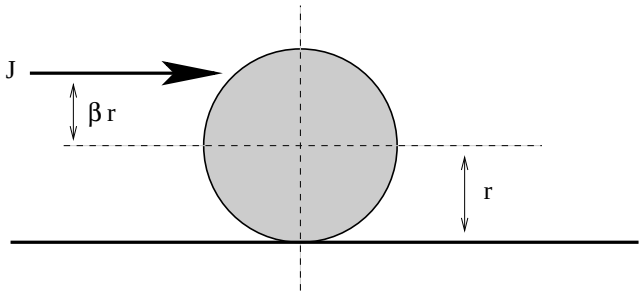
1. A charged particle with charge $q$ and mass $m$ is given an initial kinetic energy $K_0$ at the middle of a uniformly charged spherical region of total charge $Q$ and radius $R$. $q$ and $Q$ have opposite signs. The spherically charged region is not free to move. Throughout this problem consider electrostatic forces only.




   (a) Find the value of $K_0$ such that the particle will just reach the boundary of the spherically charged region.

   (b) How much time does it take for the particle to reach the boundary of the region if it starts with the kinetic energy $K_0$ found in part (a)?

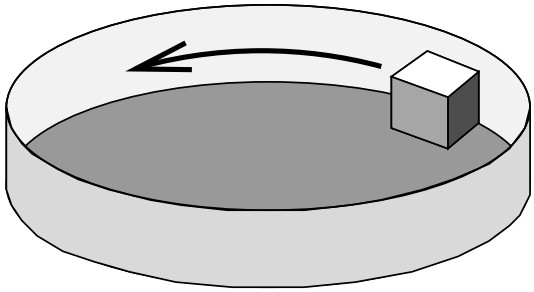
2. A uniform pool ball of radius $r$ and mass $m$ begins at rest on a pool table. The ball is given a horizontal impulse $J$ of fixed magnitude at a distance $\beta r$ above its center, where $-1 \leq \beta \leq 1$. The coefficient of kinetic friction between the ball and the pool table is $\mu$. You may assume the ball and the table are perfectly rigid. Ignore effects due to deformation. (The moment of inertia about the center of mass of a solid sphere of mass $m$ and radius $r$ is $I_{cm} = \frac{2}{5}mr^2$.)




   (a) Find an expression for the final speed of the ball as a function of $J$, $m$, and $\beta$.

   (b) For what value of $\beta$ does the ball immediately begin to roll without slipping, regardless of the value of $\mu$?

3. A block of mass $m$ slides on a circular track of radius $r$ whose wall and floor both have coefficient of kinetic friction $\mu$ with the block. The size of the block is small compared to the radius of the track. The floor lies in a horizontal plane and the wall is vertical. The block is in constant contact with both the wall and the floor. The block has initial speed $v_0$.



   (a) Let the block have kinetic energy $E$ after traveling through an angle $\theta$. Derive an expression for $\frac{dE}{d\theta}$ in terms of $g$, $r$, $\mu$, $m$ and $E$.

   (b) Suppose the block circles the track exactly once before coming to a halt. Determine $v_0$ in terms of $g$, $r$, and $\mu$.

4. Two beads, each of mass $m$, are free to slide on a rigid, vertical hoop of mass $m_h$. The beads are threaded on the hoop so that they cannot fall off of the hoop. They are released with negligible velocity at the top of the hoop and slide down to the bottom in opposite directions. The hoop remains vertical at all times. What is the maximum value of the ratio $m/m_h$ such that the hoop always remains in contact with the ground? Neglect friction.