The University of Georgia

Department of Physics and Astronomy

Graduate Qualifying Exam ─ Part I

2 January 2018

Instructions:

- Attempt all problems. You *must* show your work and/or clearly explain your answers in order to be able to earn a passing grade for a problem.
- Start each problem on a new sheet of paper. Write the problem number on the top left of each page, and your pre-arranged prelim **ID number** (but *not* your name) on the top right of each page. Leave margins for stapling and photocopying.
- Put your answers only on one-side of the paper. Please **DO NOT** write on the back side.
- This is a closed-book exam. You are permitted to bring one page of notes (equations, definitions, physical constants, etc.) per exam day. You must hand in this page of notes with the exam each day.
- You may use a calculator, but *only* for arithmetic functions (i.e., not for referring to notes stored in memory, doing symbolic algebra, etc.).

Part I has five problems, numbered 1 — 5.

Problem 1: (one part)

Find the magnetic field vector $\boldsymbol{B}$, a distance s from an infinitely long straight wire carrying a steady current I. Calculate the amplitude of the field to show that it decays with $1/s$.

Problem 2: (one part)

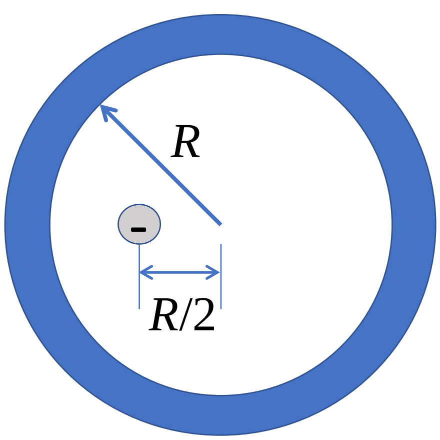
A fashion-show model in an outfit is standing in front of a (plane) mirror for a last minute check before the show. The mirror is of a rectangular shape with the dimensions $a\times b$ with $b > a$ and hanging vertically on the wall of the fitting room, *i.e.*, the longer side of the mirror is in the vertical position. Unfortunately, the mirror is small; so to see herself entirely in the mirror, the model tries to go farther way from the mirror. What is the minimum distance at which the model will see herself entirely in the mirror? Your answer may be surprising. Assume that the model's height and width, with her outfit, are h and w ($h > w$), respectively.

Problem 3: (One part)

A plane inclined at an angle θ (angle between the inclined plane and horizontal) is covered with dust. An essentially massless dustpan on wheels is released from rest and rolls down the plane, gathering up dust. The linear density of dust in the path of the dustpan is constant σ. What is the acceleration of the dustpan?

Problem 4: (three parts)

The figure shows a cross-section of a spherical metal shell of inner radius R. A point charge of -5.0 μC is located at a distance $R/2$ from the center of the shell. If the shell is electrically neutral, what are the (induced) charges on its inner and outer surfaces? Are those charges uniformly distributed? What is the field pattern inside and outside the shell?



Problem 5: (two parts)

Consider a particle with mass m sliding off a frictionless hemisphere of radius R under the influence of gravity (see figure below). The hemisphere is massive and does not move. Initially, the particle is at rest and at an infinitesimally close distance from the top of the hemisphere, i.e., $\theta = 0$. Find the equation of motion of the particle and determine the angle $\theta = \theta_0$ when the particle falls off the hemisphere. Solve the problem using the Newtonian mechanics. Repeat the problem using the Lagrangian mechanics.