Department of Physics

Preliminary Exam: January 6–10, 2014

Day 1: Classical Mechanics

Monday, January 6, 2014

9:00 a.m.–12:00 p.m.

Instructions:

1. Write the answer to each question on a separate sheet of paper. If more than one sheet is required, staple all the pages corresponding to a *single* question together in the correct order. But, do *not* staple all problems together. This exam has *five* questions.

2. Be sure to write your exam identification number (*not* your name or student ID number!) and the problem number on each problem sheet.

3. The time allowed for this exam is three hours. All questions carry the same amount of credit. Manage your time carefully.

4. If a question has more than one part, it may not always be necessary to successfully complete one part in order to do the other parts.

5. The exam will be evaluated, in part, by such things as the clarity and organization of your responses. It is a good idea to use short written explanatory statements between the lines of a derivation, for example. Be sure to substantiate any answer by calculations or arguments as appropriate. Be concise, explicit, and complete.

6. The use of electronic calculators is permissible and may be needed for some problems. No other electronic device is permitted. Obtaining preprogrammed information from programmable calculators or using any other reference material is strictly prohibited. The Oklahoma State University Policies and Procedures on Academic Integrity will be followed.

Attempt **all five** *problems. Each problem is worth 20 points.*

Problem 1

For this two-part question, choose the correct answer from the options given and write that in a separate paper. Also show your reasoning. Partial credits can be earned.

(I) A car pushes on a broken down truck on a straight highway. They move with constant speed. The magnitude of the force that the car exerts on the truck is

a) greater than the magnitude of the truck pushing back on the car.

b) equal to the magnitude of the truck pushing back on the car.

c) less than the magnitude of the truck pushing back on the car.

d) the only force acting because the truck is being pushed.

e) cannot be determined.

(II) A car pushes on a broken down truck on a straight highway. They are accelerating up to speed. The magnitude of the force that the car exerts on the truck is

a) greater than the magnitude of the truck pushing back on the car.

b) equal to the magnitude of the truck pushing back on the car.

c) less than the magnitude of the truck pushing back on the car.

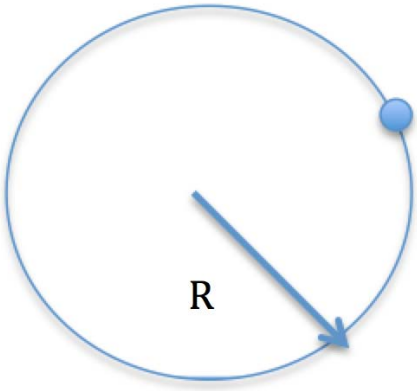
d) the only force acting because the truck is being pushed.

e) cannot be determined.

Problem 2

A ball of mass M is dropped from a fifth floor window in this building. Estimate how far from vertical, and in what direction, that the ball strikes the ground due to the Coriolis force. Give a simple qualitative explanation for this drift.

Problem 3



A bead of mass M slides without friction on a vertical circular hoop of radius R at ground level (see figure above). Find the equation(s) of motion for the bead and interpret the acceleration terms that arise.

Problem 4

A tennis ball of mass m is held on top of a basketball of mass M. The balls are dropped together from a height H such that the large ball bounces from the floor. Calculate how high the small ball goes. State your assumptions. (HINT: Assume there is a tiny gap between the two balls when the basketball strikes the ground.)

Problem 5

A particle moves in a spherically symmetric force field with potential energy given by $U(r) = -k/r$ where k is a positive constant.

(a) Construct the Lagrangian of the system in spherical polar coordinates (r, θ, ϕ).

(b) Calculate the Hamiltonian of the system in spherical polar coordinates.

(c) Obtain the canonical equations of motion.

(d) Explain using the results of part (c) if there are any constants of motion. Also explain whether the Hamiltonian equals the total energy of the system.