Midterm 1

September 25^{th}, 2012
120minutes ⋄ 100points

Physics 7A
University of California at Berkeley

This midterm is closed book and closed notes. You are allowed a single side of a sheet of paper on which you may write whatever you wish. You are not allowed to use calculators. Anyone who does use a wireless capable device will automatically receive a zero for this midterm. Cell phones must be turned off.

Please make sure that you do the following during the midterm:

- ⋄ Write your name, discussion number, ID number on all documents you hand in.
- ⋄ Make sure that the grader knows what s/he should grade by circling your final answer.
- ⋄ Cross out any parts of your solutions that you do not want the grader to grade.
- ⋄ Answer all questions that require a numerical answer to one significant figure.
- ⋄ For questions without numerical values give all your answers in terms of variable names specified in the text of the question and well known physical constants.
- ⋄ Your answers might not depend on all given values/variables.

We will give partial credit on this midterm, so if you are not altogether sure how to do a problem, or if you do not have time to complete a problem, be sure to write down as much information as you can on the problem. This includes any or all of the following: drawing a clear diagram of the problem, telling us how you would do the problem if you had the time, telling us why you believe (in terms of physics) the answer you got to a problem is incorrect, and telling us how you would mathematically solve an equation or set of equations once the physics is given and the equations have been derived. Don't get too bogged down in the mathematics; we are looking to see how much physics you know, not how well you can solve math problems. If at any point in the exam you have any questions, just raise your hand, and we will see if we are able to answer them.

Problem 1 ⋄ *30points* ⋄ Monkey crosses River

A monkey of mass m can swim at constant speed v_m in still water. She goes for a swim in a river whose width is W and the river current has speed v_c which is smaller than the speed of the swimmer.

- ⋄ **A** ⋄ *10points* ⋄ If the monkey aims her swim directly across the river how far downstream (from the point opposite her starting point) will she reach the other shore?
- ⋄ **B** ⋄ *5points* ⋄ How long will it take her to cross the river if she aims directly across?
- ⋄ **C** ⋄ *10points* ⋄ At what angle β (measure from the direction of river flow) must the monkey aim upstream in order to arrive directly across the stream?
- ⋄ **D** ⋄ *5points* ⋄ How long will it take her to cross the river if she aims at this angle?

Problem 2 ⋄ *15points* ⋄ Monkey Satellite

Monkeys have a satellite that orbits the Earth in a circular trajectory very close to the surface of the planet. What is the period of monkey satellite's orbit?
You can think of the Earth as a uniform sphere of radius r_E and neglect satellite's altitude in comparison with r_E. Express your answer in terms of gravitational acceleration on the surface of the Earth g and r_E.

Problem 3 ⋄ *35points* ⋄ Falling off a Ball

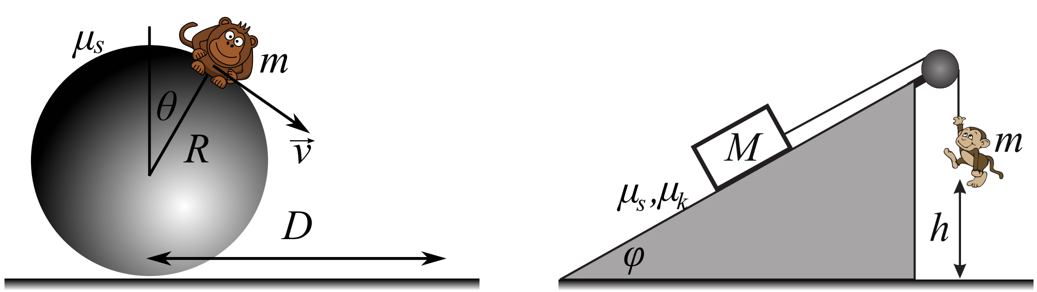
A charming circus monkey of mass m climbs on a large ball of radius R that is fixed to the floor so it cannot roll as in Figure 1a. The coefficient of static friction between the monkey and the ball is μ_s.

- ⋄ **A** ⋄ *10points* ⋄ At what smallest angle θ would the monkey start sliding down the ball?
- ⋄ **B** ⋄ *10points* ⋄ The monkey tries to stand on the ball at this θ but slips on a banana peel and immediately looses contact with the ball, starting to fall down with initial speed ν tangential to the ball. At what distance D measured from the bottom of the ball does the monkey hit the ground?
- ⋄ **C** ⋄ *10points* ⋄ If the the ball were on an elevator that accelerates upward with acceleration a, at what angle θ_a would the monkey start sliding down the ball?
- ⋄ **D** ⋄ *5points* At what distance D_a would monkey hit the elevator floor slipping on banana as before?

Problem 4 ⋄ *20points* ⋄ Monkey Hang — Monkey Fall

A box of mass M rests on a fixed surface inclined at angle φ to the horizontal. The coefficients of static and kinetic friction between the box and the inclined plane are μ_s and μ_k, where $\mu_k < \mu_s$. This box is connected to a monkey of mass m that is hanging on a string going over a pulley as in Figure 1b. Assume that the string has no mass and that the pulley is massless and frictionless.

- ⋄ **A** ⋄ *10points* ⋄ What relations between M, m, φ, and μ_s have to be satisfied so that box starts accelerating up?
- ⋄ **B** ⋄ *10points* ⋄ Suppose these conditions are satisfied and the box slides up. What is the speed v of the monkey just before he hits the ground if he is at height h above the the floor when the system is released from rest?



(a) Problem 3 (b) Problem 4

Figure 1