PHYS 101 MIDTERM October 16th, 2014

The exam comprises two parts on a total of four pages: 5 short-answer questions (4 or 6 points each), and 4 problems (8 points each). Calculators are allowed. There is a formula sheet at the back of this exam.

Attempt all the questions and problems. Explain your reasoning and show all your work!

Put all answers in the **answer booklets** provided, and **return this exam** with your exam booklet.

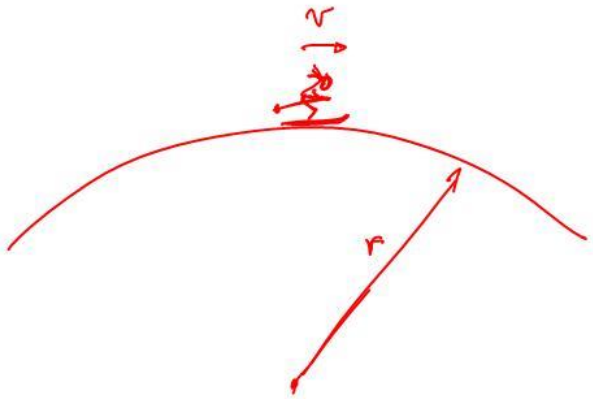
Good luck !

Short answer questions (answer all): you should not need to do any calculations for these questions. Answer in **a few words, a short phrase, or a simple sketch.**

1) [4 pts] A skier is skiing as shown in the figure. At the instant she is on top of the bump, her speed is v, and she remains in contact with the ground.

    a) Draw a free-body diagram indicating the forces on her at that moment. Label all forces in the FBD.
    b) Write down the correct equation (including signs) describing her situation which combines the terms mg, mv^2/r, and F_N.

    Explain your reasoning.



2) [4 pts] A Physics 101 student is in an elevator with a bathroom scale. Normally (ie, outside the elevator, on firm and level ground), the scale reads mg where m is her mass. What can you say about the reading of the scale if:

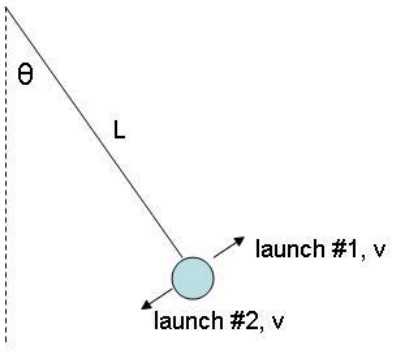
    a) The elevator is moving upwards?
    b) The elevator is accelerating upwards?

Fully explain your reasoning.

3) [6 pts] You attach a mass to a string and whirl it in a **vertical** circle. For each of the 'forces' below determine whether the force does work on the mass during any part of the path. Explain your reasoning!
    a) The force of gravity
    b) The tension in the string
    c) The centrifugal force

4) [4 pts] Draw a) a position-vs-time graph and b) a velocity-vs-time graph for a ball that you throw vertically upwards and then catch some time later. You catch the ball at the same height that you released it from. On each graph, take t=0 to be the moment the ball is thrown, and clearly indicate the time T when the ball returns to your hand, and the moment when the ball is at the highest point of its trajectory.

5) [4 pts] A pendulum is launched with a speed v from a point that is above its lowest point, as shown in the figure. Which launch – launch 1, upwards, or launch 2, downwards – will result in the largest speed of the pendulum at the bottom of its swing? Explain.



Problems (attempt them all):

1) [8 pts] Your cousin has built a model rocket that she wishes to launch in your back yard. You're a little worried by this (you live near an airport) and ask her for some details. She says to you: "When I launch the rocket straight upwards (vertically), it will accelerate at 3.5*g* (*g* = the acceleration due to gravity) for 4.3 seconds. Then the rocket will burn out (stop firing)." Ignore air friction in your calculations.

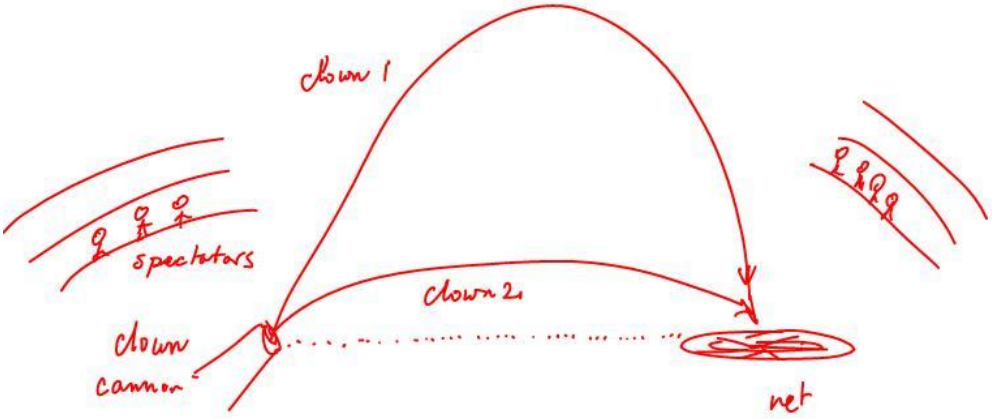
    a. What is the maximum height the rocket will reach?
    b. What will be the time from launch until the rocket returns to the ground?

c. What will be the impact speed of the rocket at the ground?

2) [8 pts] In your new job as a circus director, you are perfecting a new act. You will use a "clown cannon" to project a clown towards a net. Of course, many circuses in the past have done this – so you're going to improve upon them by launching *two* different clowns, as shown in the drawing – and they're going to land together (ie, at the same time and place)!

You launch the clown on the upper trajectory first. The launch speed of the cannon is 28.5 m/s and the net where the clowns land (at the same height as they are launched from) is 39.4 m from the launch point.

a. What is the launch angle of the upper clown?
b. What is the launch angle of the lower clown?
c. How much time in the air does the upper clown have?
d. How much time must there be between the launches of the two clowns so that they land together?



3) [8 pts] A helicopter works by having the blades exert a downwards force on the air (and by Newton's third law, the air exerts an upwards force on the helicopter). Consider a helicopter rising vertically with a heavy load underneath it, attached by a cable. The helicopter has a mass of 3850 kg, and the load underneath it has a mass of 739 kg (the cable is massless). The helicopter accelerates (uniformly) upwards from rest to 7.3 m/s in a time of 3.7 seconds.

a. What is the average power generated by the lifting force during the 3.7 second period?
b. What is the tension in the cable during the lift?

4) [8 pts] An amusement park ride has a rotating cylinder platform 8.0 m in diameter, with 12.5 kg seats suspended by massless chains of length 2.5 m (as shown in the figure below). When the platform is rotating, the chains make an angle of 28^{o} from the vertical. Assume a child's mass is 45.0 kg for your calculations.

a. Draw a free-body diagram of the "child+seat" when the system is rotating.
b. What is the speed of the seat and the child when the system is rotating?
c. What is the tension in the chain with the child in the seat?