PHYS 101 MIDTERM October 21st, 2013

The exam comprises two parts on a total of four pages: 6 short-answer questions, and 5 problems. 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!

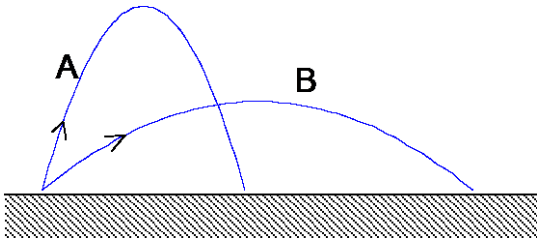
The short answer problems are worth four points each, and the problems are worth 10 points each. Put all answers in the **answer booklets** provided, and **return this exam** with your exam booklet.

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.**

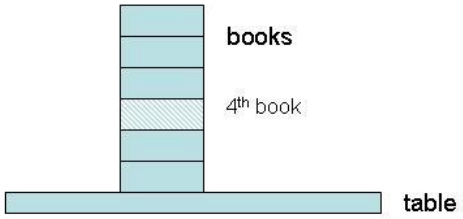
1) [4 pts] A hot-air balloon is rising vertically upwards. At some point during its ascent, a stone is dropped from the basket of the balloon. At the same moment, an airplane flying horizontally at the same altitude as the balloon also drops a stone. Which stone will hit the ground first, or will they hit at the same? Explain your reasoning.

2) [4 pts] Two projectiles are fired from a cannon, as shown in the drawing below. For projectile A, the cannon is tilted upwards from the horizontal at an angle that is twice that of projectile B (of course, both angles are less than 90°). As usual, we neglect air resistance. Which projectile, A or B, spends more time in the air? Explain your reasoning.



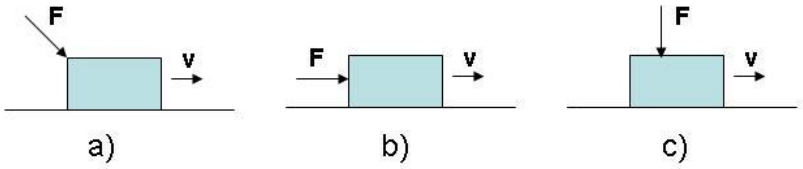
3) [4 pts] An elevator suspended by a cable is moving upwards towards the 5th floor of a building and slowing to a stop. Draw the free-body diagram of the elevator, and state the direction of the net force if it is non-zero.

4) [4 pts] Imagine a vertical stack of books – all identical – lying on a table, as shown in the diagram below. You want to pull a book out from the stack by applying a horizontal force **F**, and you choose the 4th book down from the top. There **is** friction between the books. Draw a free-body diagram of the forces on the 4th book, with all the forces clearly labeled. Remember that the book is in contact with the books both below and above it!



5) [4 pts] You've seen your instructor in class whirl a ball around in a vertical circle on the end of a rope. Assume that the speed of the ball in the circle is constant. At what position in the circle is the tension in the rope the greatest, and why?

6) [4 pts] In the drawing below, the same force **F** pushes in different ways on the block. In each case, the block is moving at constant velocity **v** to the right (the force **F** is not the only force on the block). Rank the three situations in order of ascending work (ie, smallest to largest) done by the force **F**. Explain your reasoning.



Problems (attempt them all):

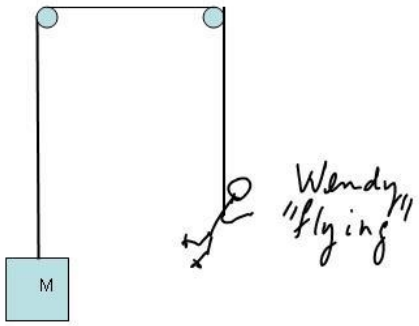
1) [10 pts] The Montreal green-line metro, travelling between the McGill and Peel stops, has motion that can be divided up into three periods: an initial period of (constant) acceleration, a period of constant velocity, and a period of (constant) negative acceleration. The three periods are of equal length, 15 seconds. The distance between the stations is 482 m.

   a. Draw a position-vs-time graph of the motion, clearly indicating each stage.

b. What is the acceleration in the first 15 second stage?
c. What is the speed during the second 15 second stage?

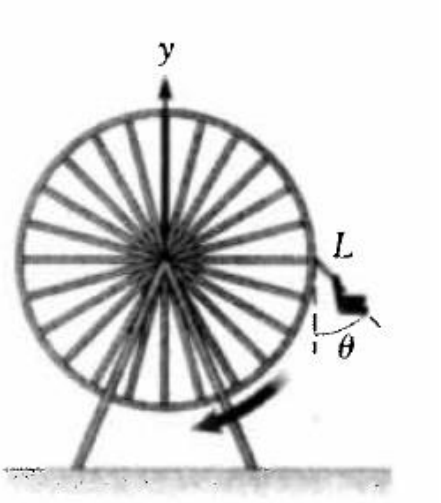
2) [10 pts] In a stage production of Peter Pan, the actress playing Wendy has to 'fly in'. The setup shown in the figure below is used, consisting of a counterweight M attached to Wendy by a massless wire running over massless, frictionless pulleys. At the right moment, Wendy steps off her raised platform, the counterweight is allowed to move and Wendy gracefully 'flys in'. Wendy has a mass of 55 kg and starts from rest from a height of 4.5 m above the stage. She must arrive on stage in 2.2 seconds (at constant acceleration) to be in time with the music.

a. Calculate the acceleration she has during her 'fly-in', and her vertical speed when she lands;
b. Find the mass of the counterweight;
c. Find the tension in the wire during the stunt.



3) [10 pts] Consider a Ferris wheel where the chairs hang down from the main wheel by a cable. The cable's length L is 2.0 m, and the radius of the wheel is 12 m. When the chair is at the half-way position (at the same height as the axle of the wheel), the cable makes a 20^{o} angle with the vertical (as shown in the drawing below).

a. Find the speed of the chair
b. Find the tension in the cable if the chair's mass is 20. kg.



4) [10 pts] On a trip to New York City you visit the observation deck (which is 373 m above the sidewalk below) of the Empire State Building, and bring a watermelon along for a picnic. Suddenly, Superman appears, flying straight downwards at a constant speed of 35 m/s. You are so surprised by his sudden appearance that you drop the watermelon off the side of the observation deck, exactly at the moment that Superman is at your height. Ignore air resistance in this question.

   a. Calculate the speed of the watermelon when it passes Superman on the way down.
   b. At what vertical distance below the observation deck does this occur?

5) [10 pts] Consider the skier shown in the figure below. After a cold night the snow is hard and we can consider it frictionless. The skier skies down the slope, a circular arc carries her through a 90° turn, and then she launches off of a ramp that is 3.0 m high.

   a. How fast is she moving as she leaves the ramp?
   b. How far is she from the ramp when she lands?
   c. How much time does she have in the air (that is, from the time she leaves the ramp to when she lands)?