PHY 2060 Fall 2006 — Exam 2

DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO

Instructions: Attempt all ten questions, each of which carries a maximum of 10 points. Write your solution below each question, continuing on additional paper if necessary. Please try to write neatly!

You will receive credit only for knowledge and understanding that you demonstrate in your written solutions. It is in your best interest to write down something relevant for every question, even if you can't provide a complete answer. To maximize your score, you should briefly explain your reasoning and show all working. Give all final algebraic answers in terms of variables defined in the problem, g (the acceleration due to gravity near the Earth's surface), and/or c (the speed of light). For numerical problems, take $g = 10\,\mathrm{m/s^2}$ and $c = 3.0 \times 10^8\,\mathrm{m/s}$.

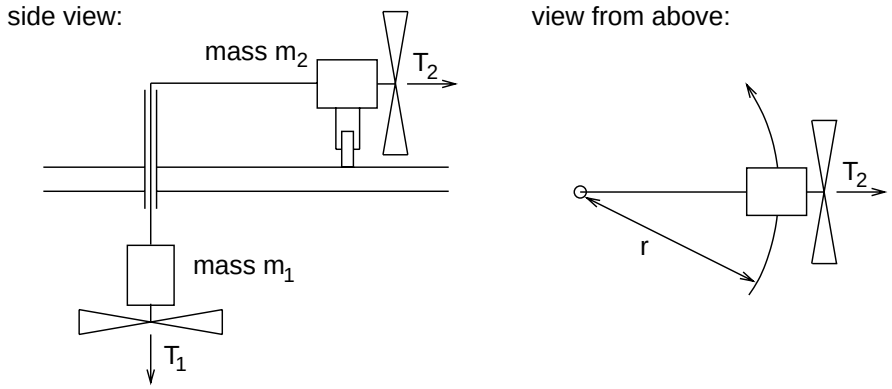
During this exam, you may use two formula sheets and an electronic calculator. You are not permitted (a) to consult any other books, notes, or papers, (b) to use any other electronic device, or (c) to communicate with anyone other than the proctor. In accordance with the UF Honor Code, by turning in this exam to be graded, you affirm the following pledge: *On my honor, I have neither given nor received unauthorized aid in doing this assignment.*

1. A muon of mass $1.88 \times 10^{-28}\,\mathrm{kg}$ enters the Earth's atmosphere from outer space with a momentum $1.39 \times 10^{-19}\ \mathrm{kg{\cdot}m/s}$. What is the muon's speed in m/s?

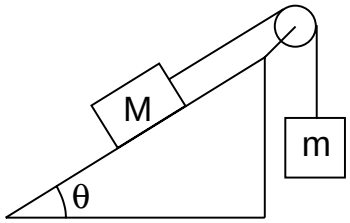
2. A soccer ball has a circumference of 69 cm and a mass of 430 g. As a prank, it has been doctored by having a 100-gram point mass glued to one location on the interior surface. How far from the ball's center is the center of mass of the combined object? Treat the undoctored ball as a perfect sphere.

3. At an archery exhibition, an archer fires a 25-gram arrow that buries itself in a 100-gram apple resting on a horizontal, frictionless platform situated 1.25 m above the (level) ground. At the moment of impact, the arrow is traveling at 75 m/s in a direction parallel to the ground. How far horizontally from the apple's initial position do the apple and the arrow hit the ground?

4. Two model-aircraft engines are connected by an ideal string that runs through a hole in a horizontal, frictionless tabletop. Engine 1 (of mass m_1) hangs from one end of the string while its propeller exerts a downwards thrust T_1. Engine 2 (of mass m_2) rotates on the tabletop at a constant speed v around the circumference of a circle of radius r while its propeller exerts a thrust T_2 radially outward from the center of motion. Find r in terms of the other quantities specified.

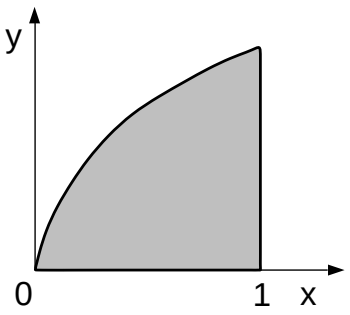


5. Two blocks, connected by an ideal string running over a massless, frictionless pulley, are released from rest in the initial positions shown in the figure. What is the subsequent acceleration of the mass M for the case where $\theta = 30°$, $M = 2.0\,\text{kg}$, $m = 0.4\,\text{kg}$, the coefficient of static friction between mass M and the slope is 0.3, and the corresponding coefficient of kinetic friction is 0.2?

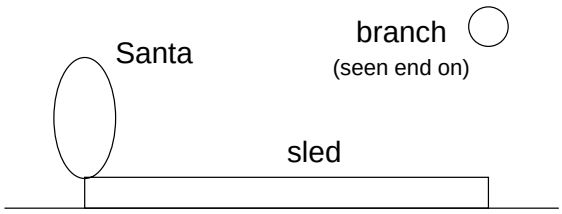


6. At a candy factory, chocolate-covered nuts, each of mass 10 g, are dropped at a rate of 30 nuts/second into a cardboard box resting on a scale, which has been adjusted to read zero when the box is empty. The nuts are dropped from rest out of the chocolate-coating machine at a height of 50 cm above the box, and land on the bottom of the box without rebounding. What will be the reading on the scale (in newtons) right after the fiftieth nut has landed? The scale's response is sufficiently slow that you can treat the flow of matter as continuous rather than being made up of discrete nuts.

7. A plate of uniform thickness is bounded by the lines $y = 0$, $y = \sqrt{x}$, and $x = 1$, as shown in the figure. Find the x and y coordinates of the plate's center of mass.

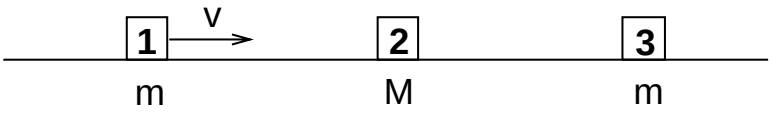


8. Santa and his sled are stranded on the surface of a frozen pond. (Santa's reindeer are nowhere in sight.) The sled is 4 m long, and (fully loaded with toys) has a mass of 1000 kg. Santa (whose mass is 100 kg) is standing at the rear of the sled.



A tree branch hangs right over the front end of the sled. Afraid that the ice will crack, Santa scrambles forward to try to grab onto the branch. Assuming that there is negligible friction between the ice and the sled, how far horizontally from the tree branch will Santa find himself by the time he reaches the front end of the sled?

9. Three carts are spaced out as shown in the figure along a straight track that permits the carts to move (without friction) in only one dimension. Carts 1 and 3 have mass m, and cart 2 has mass $M > m$. Carts 2 and 3 are initially stationary, while cart 1 is initially moving towards cart 2 at speed v. Assume that all subsequent collisions are elastic. What value of M/m ensures that carts 1 and 3 have the same final speed?



10. A block of mass m lies on a block of mass M, which in turn sits on a horizontal table, as shown in the figure. The coefficients of static and kinetic friction between the two blocks are μ_s and μ_k, respectively, with $\mu_s > \mu_k$. The coefficients of static and kinetic friction between the lower block and the table are ν_s and ν_k, respectively, with $\nu_s > \nu_k$. A string attached to the upper block exerts a horizontal force on the block. The magnitude F of this force is chosen so as to give the lower block its maximum possible acceleration.

(a) What is the magnitude of the maximum possible acceleration that the lower block can experience?

(b) What value of F is required to give the lower block its maximum acceleration?