PHY 2060 Spring 2006 — Exam 1

Instructions: Attempt all ten questions, each of which carries a maximum of 10 points. You will receive credit only for knowledge and understanding that you demonstrate in your written solutions. 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 and/or g, the acceleration due to gravity near the Earth's surface. For numerical problems, take $g = 10\,\mathrm{m/s^2}$. Please try to write neatly!

During this exam, you may use one formula sheet 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.*

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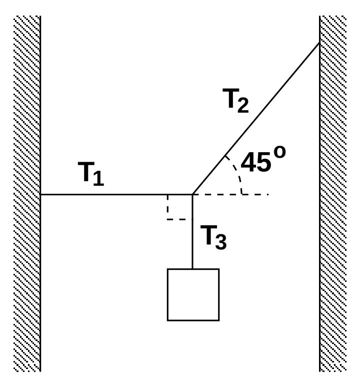
1. The position of a water boatman (an aquatic insect) on the surface of a pond at time t is described by the coordinates $x = 4 - 6t + 3t^2$, $y = -2 - t^3$.
   (a) Find the water boatman's velocity and acceleration at time t.
   (b) Find the insect's average velocity over the interval between $t = 0$ and $t = 3$.
   (c) At what time $0 < t < 3$ is the insect's instantaneous velocity parallel to the average velocity defined in (b)?

2. A boy stands on a balcony and throws a ball horizontally from a height of 20 m above the flat ground. The pebble hits the ground a horizontal distance 30 m from the point where the pebble was released. Air resistance is negligible.
   (a) What is the pebble's initial speed?
   (b) With what velocity (magnitude and direction) does the pebble strike the ground?

3. A 20-kg mass is suspended at rest using three ideal strings attached to two rigid walls, as shown in the diagram. Find the string tensions T_1, T_2, and T_3.

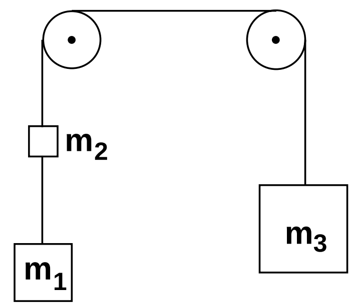


4. A pendulum consists of a bob of mass m swinging the end of an ideal string of length L. Let θ denote the angle of the string measured from the vertical. The bob's speed varies between $v = 0$ at the ends of the swing ($\theta = \pm\theta_{\text{max}}$) and $v = v_{\text{max}}$ at the bottom of the swing ($\theta = 0$).

   (a) Find the bob's acceleration (magnitude and direction) at the bottom of the swing ($\theta = 0$).

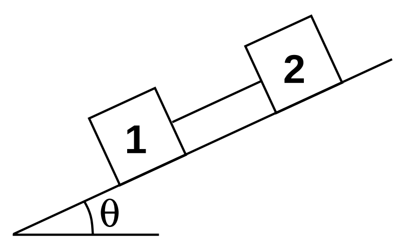
   (b) Find the bob's acceleration (magnitude and direction) at one end of the swing ($\theta = +\theta_0$).

5. Three blocks, with masses $m_1 = 15\,\text{kg}$, $m_2 = 5\,\text{kg}$, and $m_3 = 30\,\text{kg}$, are connected by two ideal strings as shown in the diagram. The pulleys are massless and frictionless. Find the net force on the mass m_1.



6. Two PHY 2060 students want to swim across a straight, 50-m-wide river to a diving platform directly opposite them on the other side. Ina Rush impetuously sets out swimming at right angles to the riverbanks, but is swept downstream by the 0.3-m/s current. When she reaches the far side, Ina finds the riverbank is too steep to climb, so she has to swim upstream parallel to the bank until she reaches the platform. Patience Personified gets out her calculator and protractor, figures out the correct direction to swim to ensure she travels straight across the river, and enters the water 45 seconds after Ina. Assuming that both students swim at $0.5\,\text{m/s}$ through the water, determine which one reaches the platform first, and how much later the other student arrives.

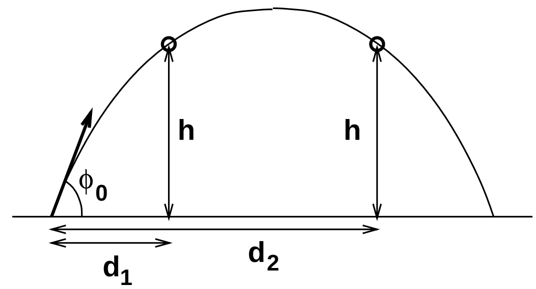
7. Two blocks 1 and 2, of mass m_1 and m_2, respectively, slide down a long ramp making an angle θ with the horizontal. The blocks are connected by an ideal string that runs parallel to the slope. The coefficient of kinetic friction between the slope and block 1 is μ_1. The coefficient of kinetic friction between the slope and block 2 is μ_2. Assume that $\mu_2 > \mu_1$. Find the magnitude of the blocks' acceleration.



8. A passenger train is traveling at $50\,\text{m/s}$ when the engineer sees that a freight train is only $1.6\,\text{km}$ ahead on the same track. The freight train is moving at a constant speed of $10\,\text{m/s}$ in the same direction as the passenger train. The engineer immediately applies the passenger train's brakes. What is the minimum magnitude of the resulting acceleration (in m/s^2) if a collision is just to be avoided?

   Hint: Consider the freight train's position relative to the passenger train.

9. A big-money archery challenge requires the contestants to fire a single arrow through two small rings located at the same height h above the firing point. The horizontal distance from the firing point to the first ring is d_1, while that to the second ring is d_2 (see diagram). At what angle ϕ_0 to the horizontal must an arrow be fired to win the prize? Assume that air resistance is negligible.



Hint: It may be useful to recall that $a^2 - b^2 = (a + b)(a - b)$.

10. A highway curve of radius R is banked to allow a vehicle moving at speed v_0 to traverse the curve without any sideways frictional force between the tires and the road. Suppose that a car instead traverses the curve at a constant speed v (which may be greater or less than v_0). Find an expression for the minimum coefficient of static friction between the tires and the road necessary to prevent slippage.

Hint: Apply Newton's second law in the radial and vertical directions.