

PHY 2060 Spring 2007 — Final Exam

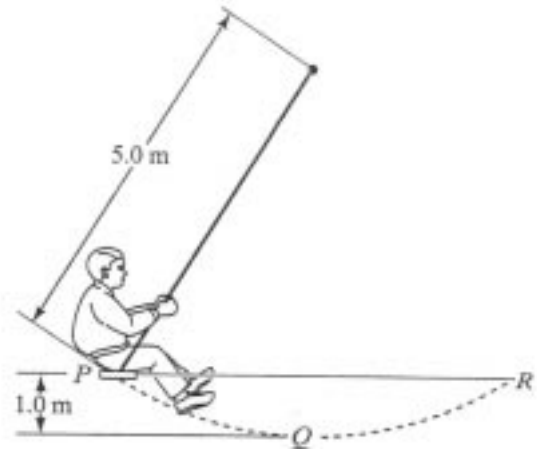
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Instructions: Attempt all ten questions, each of which carries a maximum of 10 points. Write your solution below each question, continuing on additional paper if necessary. Please try to write neatly!

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. (This may benefit you even in the case of the multiple-choice Question 1.) 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 $g = 10 \text{ m/s}^2$ and $c = 3.0 \times 10^8 \text{ m/s}$.

1. (a) P and R mark the highest and Q the lowest positions of a 50.0-kg boy swinging as illustrated in the figure. What is the tension in the rope at point Q ?

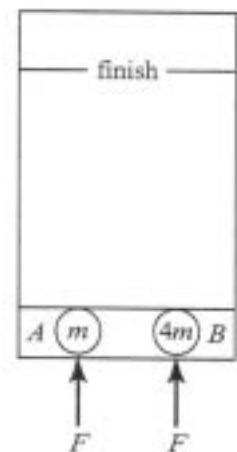
- 1. 250 N
- 2. 525 N
- 3. $7 \times 10^2 \text{ N}$
- 4. $1.1 \times 10^3 \text{ N}$
- 5. None of the above.



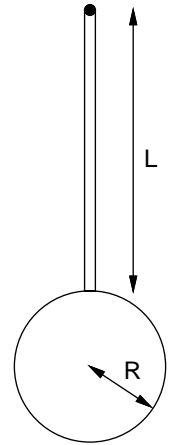
- (b) The diagram depicts two pucks on a frictionless table. Puck B is four times as massive as puck A . Starting from rest, the pucks are pushed across the table by two *equal* forces.

Which puck has the greater kinetic energy upon reaching the finish line?

- 1. Puck A
- 2. Puck B
- 3. They both have the same kinetic energy.
- 4. Too little information to answer



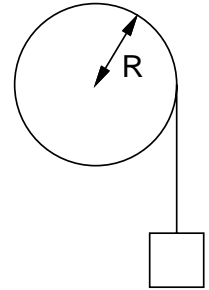
2. A pendulum consists of a solid, uniform sphere of mass M and radius R attached to one end of a thin, uniform rod of mass m and length L . The pendulum swings freely about the other end of the rod. Find the period of small oscillations of this pendulum.



3. Three dense spheres, each of mass M , are located at the corners of an equilateral triangle of sides L . All other bodies in the universe are far enough away that their gravitational influence can be neglected.
- Find the magnitude of the gravitational force exerted on one of the spheres.
 - What minimum amount of work must be done by external forces to move the masses off to infinite separation from one another?
4. (a) Amy throws a ball vertically downward with an initial speed of 10 m/s from the top of the Century Tower. How long does the ball take to reach the ground, 48 m below?
- (b) Bob throws a ball vertically upward from ground level so that it just reaches Amy on top of the Century Tower. How fast does Bob throw the ball?
- (c) Now Amy and Bob repeat their throws simultaneously, and the balls collide in the air. How long after they throw does this collision occur?
5. You apply a horizontal force of 40 N to a box of mass 2.5 kg, initially at rest on a horizontal surface. Applying this force, you slide the box through a distance of 7.0 m. The coefficient of kinetic friction between the box and the table is 0.30.
- How much work do you perform on the box?
 - How fast is the box traveling at the end of the 7.0 m?

6. Greg and Jane, of mass m_G and m_J , respectively, stand at opposite ends of a cart of mass m_c and length L . The cart is free to roll without friction on a horizontal track. Initially the cart is at rest, and Greg holds a pumpkin of mass m_p .
- On a whim, Greg throws the pumpkin towards Jane in such a manner that the horizontal component of the pumpkin's initial velocity relative to the ground is \mathbf{v}_p . Find the velocity of the cart relative to the ground immediately after the pumpkin is thrown.
 - How long does it take the pumpkin to reach Jane?
 - Find the velocity of the cart relative to the ground immediately after Jane catches the pumpkin.

7. A solid, uniform cylinder of mass M and radius R pivots on a fixed, massless, frictionless axle that lies along the cylinder's axis of rotational symmetry. An ideal string is partially wrapped around the cylinder so that the cylinder rotates when a mass $2M$ is hung from the other end of the string.



- What is the angular acceleration of this system just after it is released from rest?
 - What is the angular momentum of the system about the axle at time t after the system was released from rest? (Assume that at time t , the string has not yet fully unwound from the cylinder.)
8. Two spaceships, each 80 m long when measured at rest, travel towards one other at equal speeds of $0.9c$ as measured on Earth.
- How long is each spaceship, as measured on Earth?
 - How long does an observer on spaceship 1 measure spaceship 2 to be?
9. You want to pull a box of mass M over a horizontal floor by using a massless rope tied to the box. The coefficients of static and kinetic friction between the box and the floor are μ_s and μ_k , respectively. Having taken PHY 2060, you realize that it may be to your advantage to pull on the rope (and hence on the box) not horizontally, but rather at an angle θ above the horizontal.
- The box is initially at rest. What angle θ will minimize the force that you must apply to start the box moving?
 - What angle θ will minimize the work that you do in moving the box a horizontal distance s ?

10. A uniform, spherical ball of mass m and radius r is released from rest on a track at a point at height h above the ground. The ball rolls without slipping down to ground level, where it buries itself in a padded box of mass M that has been set up at the end of the track. The coefficient of kinetic friction between the box and the ground is μ_k . The box is attached (as shown in the diagram) to a horizontal, ideal spring of spring constant k . The box with the ball inside compresses the spring a maximum distance d from its initial, unstretched length. Find an expression for d in terms of g and other variables defined in the problem.

