

## PHY 2060 Spring 2006 — Final Exam

### DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO

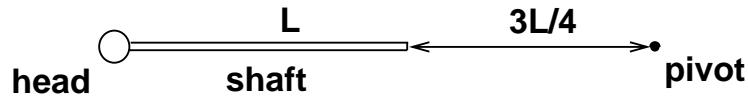
**Instructions:** Attempt all ten questions, each of which carries a maximum of 10 points. You will receive credit only for knowledge and understanding that you demonstrate in your written solutions. To maximize your score, you should briefly explain your reasoning and show all working. Give all final answers in terms of variables defined in the problem, and/or any of the following quantities:  $G$  (the gravitational constant),  $g$  (the acceleration due to gravity near the Earth's surface), and  $c$  (the speed of light in a vacuum). For numerical problems, take  $G = 7 \times 10^{-11} \text{ N}\cdot\text{m}^2/\text{kg}^2$ ,  $g = 10 \text{ m/s}^2$ , and  $c = 3 \times 10^8 \text{ m/s}$ . Please try to write neatly!

During this exam, you may use up to four 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.*

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1. A passenger boards a Ferris wheel of radius  $R$  and sits on a scale that allows her to read her apparent weight. Once the wheel begins moving, it eventually reaches a constant angular speed  $\omega$ .
  - (a) What is the smallest value of  $\omega$  for which the passenger feels “weightless” at some point in each rotation?
  - (b) When the Ferris wheel is rotating at the angular speed defined in (a), what is the ratio of the passenger's maximum apparent weight to her true weight?
2. An unstable high-energy particle is created in a particle collider-detector experiment and is observed in the laboratory to travel a distance 1.53 m at a speed of  $0.99c$  before it decays.
  - (a) What is the particle's proper lifetime?
  - (b) How far would the particle have traveled in the laboratory had its speed instead been  $0.999c$ ?
3. A simple pendulum of length 0.5 m undergoes small-amplitude oscillations. The pendulum's bob has a maximum speed of 0.1 m/s. Find the maximum angular displacement of the pendulum from its equilibrium position.

4. A golf club consists of a shaft of mass  $m$  and length  $L$  attached to a head of mass  $M$  and linear dimensions much smaller than  $L$ . Treating the shaft as a thin, uniform rod, find an approximate expression for the rotational inertia of the club when it is rotating about a point a distance  $3L/4$  beyond the end of the handle (representing a pivot point between a player's shoulders).

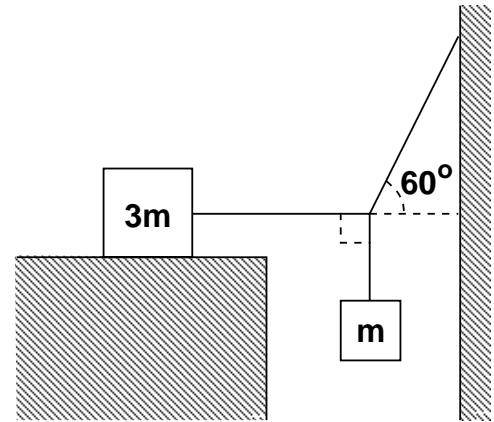


5. A ladder of length  $L$  and negligible mass leans against a frictionless wall. The angle between the ladder and the ground is  $\theta$ . The coefficient of static friction between the ladder and the ground is  $\mu_s$ . A person of mass  $m$  starts slowly up the ladder. What fraction of the way up the ladder can the person reach before the ladder becomes unstable?
6. A thin uniform rod of mass  $M$  and length  $L$  is pivoted at one end about a fixed point ( $P$ ). The opposite end of the rod ( $Q$ ) is attached to an ideal spring of constant  $k$ . The other end of the spring is secured to a fixed support in such a way that the rod hangs in equilibrium in a horizontal position as shown in the figure. The end  $Q$  is now pulled down a small distance below its equilibrium position. Find the angular frequency of the simple harmonic motion that follows the release of the rod.



7. A small sphere is suspended on the end of a string in a swimming pool full of water (density  $1000 \text{ kg/m}^3$ ). At time  $t = 0$ , the string is cut, and the sphere begins to fall. The sphere hits the bottom of the pool,  $5 \text{ cm}$  below its initial position, at time  $t = 0.15 \text{ s}$ .
- Find  $\bar{\rho}$ , the average density of the sphere, making the approximation that drag forces are negligible.
  - Is the true average density of the sphere greater or less than the approximate value obtained in (a)? **Do not** attempt to calculate an explicit value for  $\bar{\rho}$  in the presence of drag. Instead, provide an argument as to whether taking drag into account will increase or reduce the value of  $\bar{\rho}$  deduced from the data given.
8. A simple U-tube, open at each end, initially contains mercury (density  $13.6 \text{ g/cm}^3$ ) to a depth of roughly  $8 \text{ cm}$  in each arm. Then  $3.8 \text{ cm}$ -depth of water (density  $1.0 \text{ g/cm}^3$ ) is poured into the left arm of the tube. After the two immiscible liquids have reached equilibrium, what is the height (magnitude and sign) of the upper surface of the water in the left arm relative to the upper surface of the mercury in the right arm?

9. A mass  $m$  is supported as shown in the figure by ideal strings connected to a rigid wall and to a mass  $3m$  sitting on a horizontal surface. What is the minimum coefficient of static friction between the larger mass and the surface that permits the system to remain in equilibrium in the situation shown?



10. A small, frictionless rod is fixed in a horizontal position, a distance  $2L$  above the ground. A uniform rope of length  $L$  and mass  $M$  is hung, initially at rest, over the rod, such that  $2/3$  of the rope hangs on one side of the rod and  $1/3$  lies on the other side.
- (a) How fast will the lower end of the rope be traveling when it hits the ground?
- (b) How fast will the upper end of the rope be traveling when it hits the ground?