Student First Name: Student Last Name:
Student Rocket ID:

You may use the backside of all pages. No calculators are allowed. Express all answers only in terms of given quantities.

Questions 1: Figure 1 shows an overhead view of a ring that can rotate about its center like a merry-go-round. Its outer radius is R_2, its inner radius is R_1, and its moment of inertia is I. It initially rotates at an angular speed of ω with a cat of mass m resting on its outer edge, at radius R_2. The cat then walks in a radial direction and stops at the inner edge at radius R_1. (a) What is the new angular speed ω_f of the cat-ring system? What is the new kinetic energy K? (**2 points**)
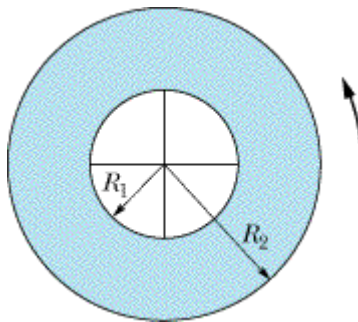

Fig. 1

Question 2: A satellite of mass m_s is in a circular Earth orbit. The area of the circular orbit is A. The mass of the earth is M, the universal constant of gravitation is G. Find (a) the speed of the satellite and (b) the angular momentum of the satellite, both with respect to the center of the earth. (**2 points**)

Question 3: The system in Figure 2 is in equilibrium. The angles θ_1 and θ_2 are as defined in the figure, and the ball has mass M. The magnitude of the acceleration due to gravity is g. Assume for simplicity that $\theta_2 = 0$. What is the tension in (a) string ab and (b) string bc? (**2 points**)
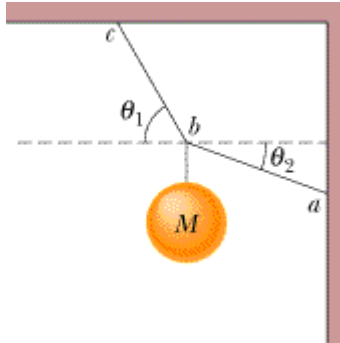

Fig. 2

Question 4: In Figure 3, water flows through a horizontal pipe and then out into the atmosphere at a speed v_1. The diameters of the left and right sections of the pipe are known to be d_2 and d_1 as shown. The density of water is ρ. Assume that as the water comes out of the right section it is at atmospheric pressure p_0. Note that the speed v_2 is not given. (a) What volume of water flows into the atmosphere during a period T? In the left section of the pipe, what is the pressure p_2? (**2 points**)
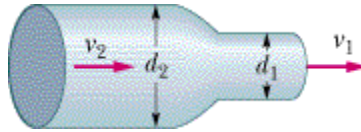

Fig. 3

Question 5: The acceleration $a(t)$ of a particle undergoing simple harmonic motion is graphed in Figure 4. (a) Which of the labeled points corresponds to the particle at its maximum positive displacement? (b) At point 8, is the velocity of the particle positive, negative, or zero? Give brief explanation of your answers. (**2 points**)
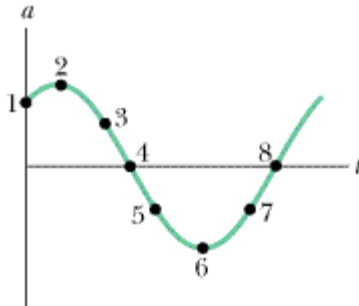
Fig. 4