Student ID Number: __________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part C, January 5, 2019, 09:00–12:00

Instructions

1. You may use a calculator and CRC Math tables or equivalent. No other tables or aids are allowed or required. You may **NOT** use programmable calculators to store formulae.

   (a) All of the problems will be graded and will be tabulated to generate a final score. Therefore, you should submit work for all of the problems.

   (b) For convenience in grading please write legibly, use only one side of each sheet of paper, and work different problems on separate sheets of paper. The sheets for each problem will be stapled together but separately from the other two problems.

   (c) Your assigned student **ID Number**, the **Problem Number**, and the **Page Number** should appear in the upper right hand corner of each sheet. Do **NOT** use your name anywhere on the Exam.

   (d) All work must be shown to receive full credit. Work must be clear and unambiguous. Be sure that you hand your completed work to the Proctor.

   (e) Each problem is worth 10 points.

   (f) Following the UF Honor Code, your work on this examination must reflect your own independent effort, and you must not have given, nor received, any unauthorized help or assistance. If you have any questions, ask the Proctor.

University of Florida Honor Code: We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

DO NOT OPEN EXAM UNTIL INSTRUCTED

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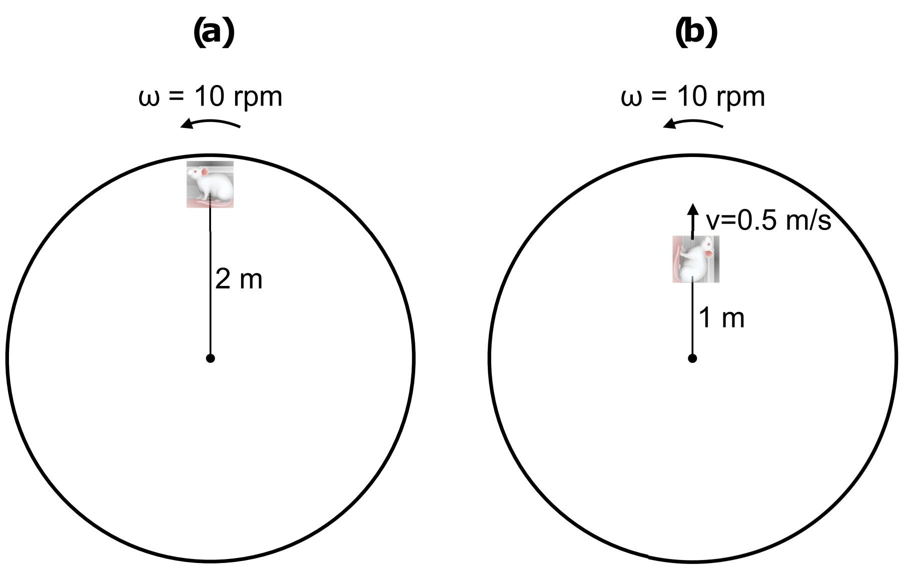
C1. A mouse of mass $m = 200$ g runs radially outward on a merry-go-round, which is turning at a constant angular speed of 10 rpm (i.e., revolutions per minute). The mouse then stops when it is 2 m away from the merry-go-round's axis of rotation, and remains stationary in the rotating frame of the merry-go-round.

(a) [**4 points**] What is the magnitude (in Newtons) and the direction of the force of friction on the mouse after it has stopped?

(b) [**6 points**] Assume that as the mouse was running outward (before it stopped), it had a constant speed of 0.5 m/s relative to the merry-go-round. In other words, in the rotating frame of the merry-go-round, the mouse moved at a constant speed in a straight line (i.e. unaccelerated motion). What additional acceleration did the mouse feel while it was running outward, compared to when it was stopped? Find the magnitude (in Newtons) and direction of the total force of friction that the merry-go-round exerted on the running mouse when it was 1 m from the axis of rotation.



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C2. Four point objects of mass m are located at the corners of a square of side d. The square rotates about its center at an angular velocity ω which is just enough to compensate the gravitational forces between the objects and thus maintain the shape of the square as it rotates.

(a) [**3 points**] Show that $\omega^2 = \frac{Gm}{d^3}(2 + \frac{1}{\sqrt{2}})$, where G is the gravitational constant.

(b) [**3 points**] What is the total energy of the system in terms of G, d and m?

(c) [**4 points**] Two masses at opposite corners are suddenly removed from the system without affecting the other two masses. The motion of the remaining masses is determined by their initial velocity (before the removal of the other two masses) and their mutual gravitational attraction. What will be the minimum and maximum velocities of the objects as the system evolves? Express your answer in terms of G, d and m.

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C3. A particle has three energy levels, $\epsilon = 0$, Δ, and 4Δ, where Δ is a positive constant. The lowest energy level is nondegenerate, whereas the other two are both doubly degenerate.

(a) [**2 points**] Write the partition function for this particle.

(b) [**2 points**] Write the internal energy U of a system consisting of one mole of such particles, as a function of temperature T.

(c) [**2 points**] Approximate the U for high temperatures, $T >> \Delta/k_B$, and calculate the heat capacity. Here k_B is Boltzmann's constant.

(d) [**2 points**] Now approximate the U for low temperatures, $T << \Delta/k_B$, and calculate the heat capacity.

(e) [**2 points**] What is the entropy of the system in the limit of $T \to \infty$?