Student ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part D, January, 2016, 14:00–17:00

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

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part D, January, 2016, 14:00–17:00

D1. **(Mitselmakher)** A particle of mass M is at rest, and decays into three particles A, B, C of different masses m_A, m_B, m_C. Note that the energies of these three particles in general case will not be fixed, *i.e.*, they will vary from decay to decay.

Consider only the case when the particle C has its *minimum* allowed energy.

(a) [**points**] What is this minimum energy E_C for the particle C?

(b) [**points**] What would the energies E_A and E_B of the other two particles A and B be in this case (as functions of masses M, m_A, m_B, m_C)?

(c) [**points**] Draw the momentum vectors of all three particles for this case.

PRELIMINARY EXAMINATION
Department of Physics
University of Florida
Part D, January, 2016, 14:00–17:00

D2. **(Furic)** There are two common models for air resistance. Laminar flow is modeled with a resistive force proportional to the velocity of the object: $F_L = -\alpha\, v$. Turbulent flow is more accurately modeled with a resistive force proportional to the square of the velocity of the object: $F_T = -\beta v^2$.

(a) [**2 points**] Calculate the terminal velocity of free fall in a gravitational field of strength g for each of the two models.

For the remaining calculation, assume the object is a bullet launched horizontally through the air with an initial velocity of v_0. The launch speed is large enough that gravitational contributions to the speed can be ignored.

(b) [**2 points**] Calculate the velocity of the bullet as a function of time, for laminar flow.

(c) [**2 points**] Calculate the position of the bullet as a function of time for laminar flow.

(d) [**2 points**] Calculate the velocity as a function of position for turbulent flow. (Hint: *consider the energy loss of the bullet.*)

(e) [**2 points**] Calculate the position of the bullet as a function of time for turbulent flow.

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part D, January, 2016, 14:00–17:00

D3. **(Avery)** A planet of mass M and radius R has a moon of mass m and radius r in a circular orbit with a distance d between the centers of the two bodies.

(a) [**5 points**] If the moon's mass is neglected, its orbital period is calculated to be 5 days. Observations show that the true orbital period is 4 days. What is m/M?

(b) [**3 points**] Ignore the answer to (a) and now assume a different moon with $m \ll M$. If the moon is held together only by gravitational forces, show that if it is not to be torn apart by tidal forces (*i.e.*, an object on the moon's surface will not float away) then $d > R(2\rho_M/\rho_m)^{1/3} \simeq 1.26R(\rho_M/\rho_m)^{1/3}$, where ρ_M and ρ_m are the densities of the planet and moon, respectively. Assume the moon is not rotating.

(c) [**2 points**] If the moon's rotation is synchronously locked to its orbital period, show that $d > R(3\rho_M/\rho_m)^{1/3} \simeq 1.44R(\rho_M/\rho_m)^{1/3}$, for the moon not to be torn apart by tidal forces.