Student ID Number: ________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part C,January 7, 2015, 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. **- Ramond**

A particle of mass m oscillates happily and frictionlessly along some direction with period T.

(a) [**points**] Write its Lagrangian, and derive the equation of motion.

(b) [**points**] By applying a damping force, we find that the particle's period of oscillation doubles. Express the damping force in terms of m and T.

(c) [**points**] $t_{2/3}$ seconds after the damping force has been applied, the amplitude of oscillation is reduced to $2/3$ of its original value. Express $t_{2/3}$ in terms of m and T.

(d) [**points**] Finally, an external force $F(t) = f \cos \omega t$ is applied. After a long time the particle is found to oscillate. What is its new period of oscillation? Find the maximum value of the amplitude of the oscillation.

(e) [**points**] Find the maximum value of the amplitude of the oscillations.

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C2. **- Yelton**

A motor boat is going through the water at a uniform velocity V. If the water resistance is $-bV$, where b is a constant;

(a) [**points**] What is the power of the motor?

(b) [**points**] If the motor it turned off, how far does the boat go before coming to a stop?

Once the boat has stopped, a passenger leans over the side and holds a rock, of mass M and volume, below the water surface. He then lets it go and it falls through the water (density ρ. Assuming this time that the water resistance on the rock is cV, where c is a constant,

(c) [**points**] What is the terminal velocity of the rock?

(d) [**points**] How long will it take to get to 90% of its terminal velocity?

(e) [**points**] If it is going at 90% of its terminal velocity when it hits the bottom, how deep is the lake?

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C3. **- Yoonseok Lee**

Two identical copper blocks with the same heat capacity, C_p, are at temperatures T_1 and T_2 ($T_1 > T_2$), respectively. When the two blocks are put together and allowed to reach thermal equilibrium, they will reach the final temperature of $T_f = (T_1 + T_2)/2$. This process is *irreversible*. Suppose that a Carnot's engine is inserted between the two bodies and put them into thermal equilibrium through a *reversible* process. In this case, the Carnot's engine works between two temperatures initially at T_1 and T_2 but varying in time throughout the process. Assume that the heat capacity of each copper block is independent of temperature.

(a) [**3 points**] How much of the total entropy change has occurred in the *irreversible* process where the two objects reached equilibrium while in direct thermal contact? Did it increase or decrease?

(b) [**3 points**] Show that the final equilibrium temperature reached through the *reversible* process is $T_f^R = \sqrt{T_1 T_2}$. (*Hint: In a reversible process the entropy of an isolated system remains the same.*)

(c) [**2 points**] Calculate the total amount of work (W) produced in the *reversible* process involving a Carnot's engine.

(d) [**2 points**] Show that the average efficiency of the Carnot's engine in the process is given by

$$\langle \eta \rangle = \frac{W}{Q_{ab}} = 1 - \frac{\sqrt{T_2}}{\sqrt{T_1}},$$

where Q_{ab} is the amount of heat absorbed from the block in the process.