Student ID Number: _____

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part D, 18 August 2006, 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.

2. 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.

3. 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.

4. 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.

5. 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.

6. Each problem is worth 10 points.

7. 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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DEPARTMENT OF PHYSICS

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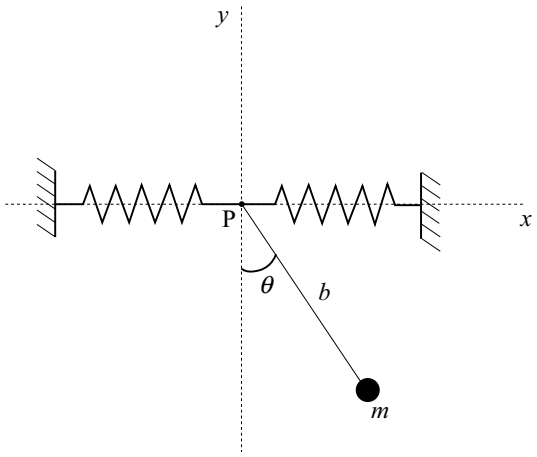
D1. 1. The pendulum bob of mass m, shown in the figure below, is suspended by an inextensible, massless string of length b at point P. However, point P is free to move along the x-axis (marked in the figure) under the action of the two springs each of spring constant k. The springs are massless and are at their equilibrium lengths when point P is at the origin $(x = 0, y = 0)$.



(a) (4 points) Using appropriate generalized coordinates find the kinetic and potential energies of this system and hence form the Lagrangian.

(b) (2 points) Find the equations of motion for the mass m.

(c) (1 point) Use the small angle (θ) approximation to simplify these equations (you should also use the small angular velocity approximation).

(d) (3 points) Find the frequency of small oscillations of the pendulum.

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D2. The entropy of a paramagnetic material in magnetic field H is given by

$$S = a - b\frac{H^2}{T^2},$$

where T is the temperature and a and b are constants.

(a) (5 points) Find the expression for the heat capacity of this material, when the magnetic field is held constant.

(b) (5 points) Give the magnetic moment M of this material as a function of H and T, assuming that M is zero in the limit of $T \to \infty$. You may use Maxwell's relation

$$\left(\frac{\partial M}{\partial T}\right)_H = \left(\frac{\partial S}{\partial H}\right)_T.$$

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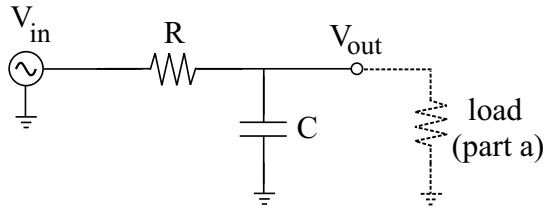
D3. The questions pertain to the circuit below. The generator V_{in} is capable of providing DC, AC and AC-DC combinations.



(a) (2 points) For 10 volts DC at V_{in}, with resistor $R = 1\ M\Omega$, and capacitor $C = 1$ mF, a $1\ M\Omega$ resistive load is attached to V_{out}. What voltage appears across the load?

(b) (1 point) The resistor R is replaced with a $1\ k\Omega$ resistor and the load detached. V_{in} is now a $10\ V$ peak to peak AC signal. As the frequency is increased from low to high frequencies does V_{out} (at the point so labelled) increase or decrease?

(c) (2 points) Explain, qualitatively, how the circuit achieves the result in part (b).

(d) (3 points) For the same circumstance as in part (b), when $V_{out} = 0.707\ V_{in}$ what is the frequency?

(e) (2 points) For components having the same values as in parts (b) and (c) and for the frequency when $V_{out} = 0.707\ V_{in}$, by how much does the frequency shift from that in part (d) if the resistor and capacitor are switched?