Student ID Number: __________

PRELIMINARY EXAMINATION

Department of Physics
University of Florida

Part D, 4 January 2008, 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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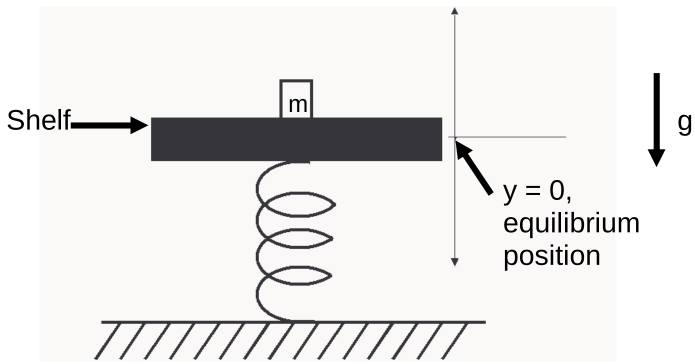
D1. A horizontal shelf moves vertically with simple harmonic motion, the time period of which is 1 second and the amplitude of which is 30 cm (see figure). A very light particle of mass m



(negligible mass compared to the shelf) is laid on the shelf at time $t = 0$ when the shelf is at its lowest position i.e. $y = -30$ cm (the particle is light enough such that it does not affect the simple harmonic motion of the shelf).

(a) (*2 points*) Write down the expression for the displacement y of the shelf as a function of time using the conditions given above ($y = 0$ is the equilibrium position).

(b) (*5 points*) After the mass m is placed on the shelf, at what value of y does this mass leave the shelf?

(c) (*3 points*) How much higher does the mass m travel after leaving the shelf?

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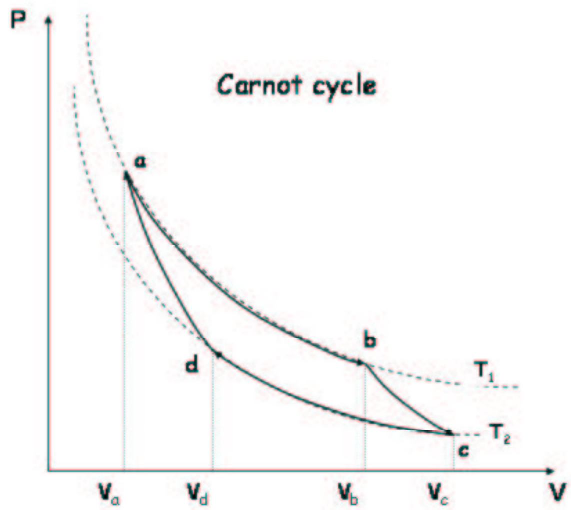
D2. In 1824 French engineer Sadi Carnot developed a hypothetical idealized heat engine operating between two thermal reservoirs (at T_1 and T_2 as shown in the figure). The Carnot engine runs



through a cycle composed of two reversible isothermal (a→b and c→d) and two reversible adiabatic (b→c and d→a) processes. Consider a Carnot engine using an ideal gas as the working substance. Hint: The internal energy of an ideal gas is only a function of temperature and $PV^\gamma =$ const. for a reversible adiabatic process in an ideal gas where $\gamma = 1 + R/c_V$ (c_V: constant volume molar specific heat) is considered as a constant. The gas constant $R = 8.31$ J/mol·K.

(a) (*2 points*) Specify the segment of the cycle in which heat is rejected by the engine and calculate the amount of heat rejected Q_r. Repeat for the segment in which heat (Q_a) is absorbed by the engine.

(b) (*2 points*) Show that

$$\frac{V_b}{V_a} = \frac{V_c}{V_d}.$$

(c) (*3 points*) Suppose 0.2 mole of a monatomic ideal gas ($\gamma = 5/3$) undergoes a Carnot cycle between 600 K and 300 K. Starting from the state a in the figure at the pressure $P_a = 20 \times 10^5$ Pa, the volume doubles in the first isothermal process a→b. Find V_c and V_d in m^3.

(d) (*3 points*) How much work is produced in one cycle of the Carnot engine described in (c)?

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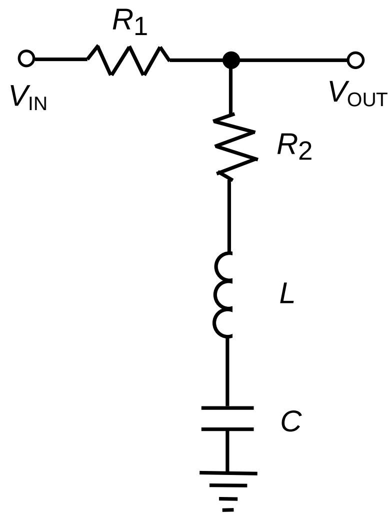
D3. Consider the circuit given in the figure. The input voltage, V_{IN}, has an arbitrary angular frequency, ω.



(a) (*4 points*) What is the ratio of the output voltage, V_{OUT}, to the input voltage, V_{IN}? In other words, what is $\frac{V_{\mathrm{OUT}}}{V_{\mathrm{IN}}}$ in terms of the two resistors, R_1 and R_2, the inductor, L, the capacitor, C, and the angular frequency, ω?

(b) (*2 points*) If $R_2 = 0$, what is the *magnitude* of the ratio of the output voltage, V_{OUT}, to the input voltage, V_{IN}? In other words, what is $|\frac{V_{\mathrm{OUT}}}{V_{\mathrm{IN}}}|$ in terms of the resistor, R_1, the inductor, L, the capacitor, C, and the angular frequency, ω?

(c) (*4 points*) For $R_2 = 0$, sketch $|\frac{V_{\mathrm{OUT}}}{V_{\mathrm{IN}}}|$ versus ω. Justify the features of the sketch.