Student ID Number: _____

PRELIMINARY EXAMINATION

Department of Physics

University of Florida

Part B, January, 2014, 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

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B1. An electron is in the spin state $\chi = A \begin{pmatrix} 3i \\ 4 \end{pmatrix}$.

(a) **[2.5 points]** Find the normalization constant "A".

(b) **[2.5 points]** Calculate the expectation values of S_x, S_y and S_z.

(c) **[2.5 points]** Find the "uncertainties" $\delta(S_x), \delta(S_y), \delta(S_z)$

(d) **[2.5 points]** Check if the uncertainty principle is satisfied for all permutations of x, y, z: $\delta(S_x)\delta(S_y) \geq \frac{\hbar}{2}|\langle S_z \rangle|$ for the value of the results obtained in (b) and (c).

Hint: you may find the Pauli spin matrices useful.

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \ \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \ \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

and remember that $\boldsymbol{S} = \left(\frac{\hbar}{2}\right)\boldsymbol{\sigma}$.

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B2. A non-conducting sphere of radius R carries a charge density

$$\rho = \frac{k}{r}$$

in the region $r \leq R$, where k is a positive constant and r is the distance from the center of the sphere (see the enclosed figure). The sphere is surrounded by a thick, concentric metal shell with an inner radius a and an outer radius b. The shell carries no net charge.

(a) **[2 points]** Find the surface charge density at the inner and the outer surface of the conductor.

(b) **[4 points]** Find the electric field $\vec{E}$ in all four regions (i) $r < R$; (ii) $R < r < a$, (iii) $a < r < b$, and (iv) $r > b$

(c) **[3 points]** Find the potential V at the center of the sphere using infinity ($r = \infty$) as a reference point.

(d) **[1 points]** If the outer shell is grounded, what would be the potential at the center of the sphere using the same reference point as in (c)?

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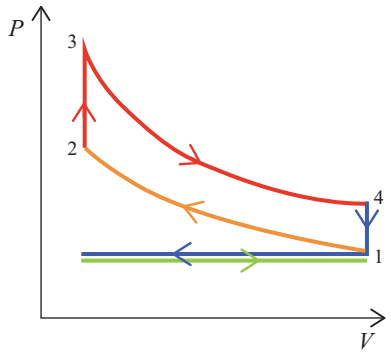
B3. The Otto cycle is as shown in the figure. With an ideal gas as a working substance, it consists of two isobaric steps (in blue and green), two adiabatic steps (1-2) and (3-4) and two isochoric steps (2-3) at volume V_- and (4-1) at volume V_f. The adiabatic index $\lambda = \frac{C_P}{C_V} = 1.4$ and the compression ratio $r = \frac{V_f}{V_i} = 10$.



(a) **[5 points]** Calculate the efficiency of the cycle.

(b) **[5 points]** Calculate the work done on the gas in the compression process (1-2) assuming $V_i = 2$ liters and $P = 1$ bar.