Prelim ID Number: ______

PRELIMINARY EXAMINATION

Department of Physics
University of Florida
Part D, 14:00–17:00, Aug 20, 2010

Instructions

(a) 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.

(b) 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.

(c) 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.

(d) You will be assigned a **Prelim ID Number**, *different from your UF ID Number*. The **Prelim 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 or UF ID Number anywhere on the Exam.

(e) 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.

(f) Each problem is worth 10 points.

(g) 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. Thevenin's theorem for linear electrical networks states that any combination of voltage sources and resistors with two terminals is electrically equivalent to a single voltage source V_{th} and a single series resistor R_{th}. For AC systems operating at a single frequency ω, the theorem can also be applied to general impedances, $Z(\omega)$, not just resistors.

As a straightforward example consider the circuit comprising two resistors and a voltage source in Fig. (a). To determine the Thevenin voltage, V_{th}, and the Thevenin resistance, R_{th}, of the equivalent circuit shown in Fig. (b), two calculations are needed:

First, calculate the output voltage, V_{out}, when in open circuit condition (no load resistor, i.e., $R_L = \infty$). Under these conditions, $V_{th} = V_{out}$.

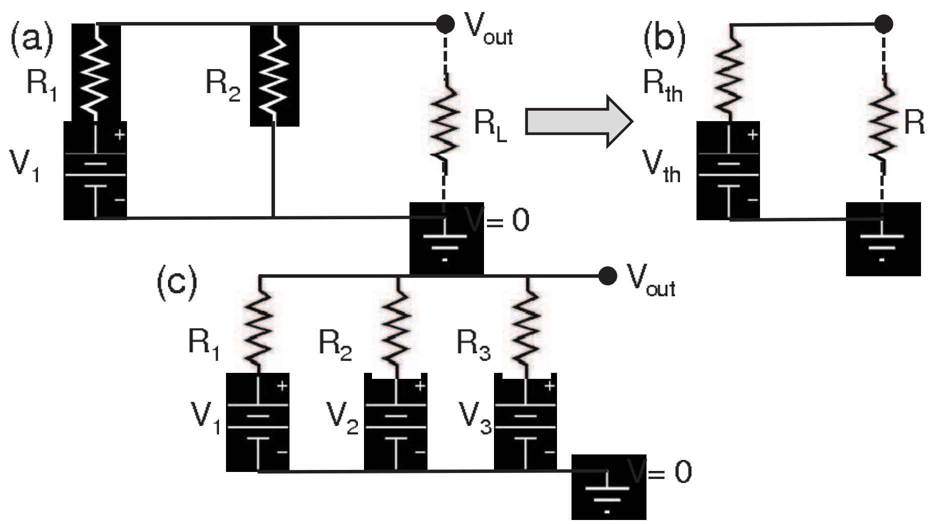
Second, calculate the output current, I_{short}, when the output terminals are short circuited (load resistance $R_L = 0$) and then use the expression $R_{th} = V_{th}/I_{short}$.

(a) (2 points) Calculate V_{th} and R_{th} for the above circuit.

(b) (3 points) Find the current drawn by an arbitrary load resistance, R_L, for the circuit in Fig. (a) and in Fig. (b). These currents should be the same if you have done the problem correctly. The Thevenin equivalent of any circuit thus shows in a very transparent way the internal voltage drop $I_L R_{th}$ associated with the current I_L drawn by a load.

(c) (4 points) For the circuit with three different voltage sources and three different resistors shown in Fig. (c), find V_{th} (2 points) and R_{th} (2 points).

(d) (1 point) Replace the resistors R_1, R_2 and R_3 with capacitors C_1, C_2, and C_3, and find an expression for V_{out} assuming that all the voltage sources are operating at the same frequency ω.



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D2. A spin 1/2 electron with magnetic moment μ is placed in a uniform magnetic field $\vec{B} = B\hat{k}$ in the positive z-direction. The intrinsic spin of the electron is pointed along the positive x-direction at t=0.

(a) (*2 points*) Write down the Schrodinger equation for the two component wave function for the electron at rest

(b) (*3 points*) Find the corresponding time-dependent wave function

(c) (*3 points*) Calculate the expectation values $\langle S_x(t)\rangle, \langle S_y(t)\rangle, \langle S_z(t)\rangle$

(d) Find the probability as a function of time that the intrinsic spin will be pointed along:

- (*1 point*) the positive z-direction
- (*1 point*) the positive x-direction

These may be useful:

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

$$\mid S_z^+\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix} \mid S_x^+\rangle = \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ 1 \end{pmatrix} \tag{2}$$

D3.

A pointlike particle is moving in a two-dimensional plane. The distance $r(t)$ from the particle to the origin O, described by polar coordinates in that plane, is given by

$$r(t) = R[1 + \sin \omega t],$$

for constants R and ω, and the polar angle $\phi(t)$ with respect to the fixed x-axis is given by

$$\phi(t) = \omega t\ .$$

(a) (*2 points*) Compute the velocity vector of the object as a function of time.

(b) (*1 point*) For which time t is the velocity completely radial, and for which is it completely tangential?

(c) (*2 points*) Compute the acceleration vector of the object as a function of time.

(d) (*1 point*) When is the acceleration of the object perpendicular to its velocity?

(e) (*2 points*) What is the work done by the force $\vec{F}$ from $t = 0$ to t'?

(f) (*1 point*) What is the power exerted by the force at any given time t?

(g) (*1 point*) Sketch the trajectory of the object.