Physics 24 Practice Final - 3 hours

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Write your answers in a blue book. Calculators and two pages of notes allowed. No textbooks allowed. Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**

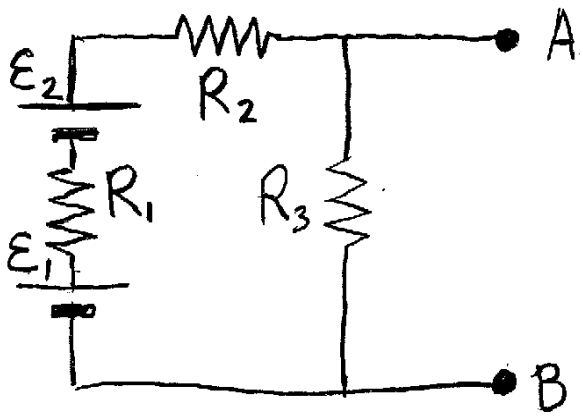

Figure 1: For use in Problem 1.

1. See Fig. 1, and consider connecting something between points A and B. The values of the elements in the figure are: $\varepsilon_1 = 7.5\,\mathrm{V}$, $\varepsilon_2 = 2.5\,\mathrm{V}$, $R_1 = 5\,\Omega$, $R_2 = 5\,\Omega$, and $R_3 = 10\,\Omega$.

   (a) Evaluate the Thévenin equivalent voltage $\mathcal{E}_{\mathrm{th}}$, symbolically and numerically.

   (b) Evaluate the Thévenin equivalent resistance R_{th}, symbolically and numerically.

   (c) A resistor $R_4 = 5\,\Omega$ is connected between points A and B. What current flows in this resistor, numerically?

2. A small conducting sphere of radius $b = 1/4\,\mathrm{cm}$ is surrounded by a spherical region containing material with resistivity $\rho = 12.6\Omega{-}\mathrm{cm}$. This material extends out to a radius $a = 1\,\mathrm{cm}$, where there is another conducting electrode in the shape of a spherical shell. Find, both symbolically and numerically, the resistance between the electrodes.

3. An infinite plane has 6.63×10^8 excess electrons per square centimeter. At a distance of $2\,\mathrm{cm}$ above the plane, evaluate:

   (a) The electric and magnetic fields in the rest frame of the plane.

(b) The electric and magnetic fields in a frame that is moving at a speed $(\sqrt{3}/2)$c in a direction parallel to the plane.

4. Space is filled with the vector potential:

$$\vec{A} = \frac{\hat{z}}{\sqrt{x^2 + y^2}}$$

(a) Find the magnetic field, $\vec{B}$.

(b) Make a sketch in the $x - y$ plane of a magnetic field line at a radius $r = \sqrt{x^2 + y^2}$, and evaluate the magnitude of the magnetic field at r.

(c) Find the current I that flows through a circle of radius $r = \sqrt{x^2 + y^2}$ in the $x - y$ plane.

5. Two circular loops of current each have radius $r = 10\,\text{cm}$ and current $I = 0.282\,\text{Amps}$. They are concentric and parallel to one another, but they are separated by a small distance $d = 0.1\,\text{cm}$ along the axis that goes through their centers, perpendicular to their planes. The currents in the loops are going in the same direction.

(a) Make a diagram of the situation.

(b) Estimate the direction and the magnitude of the net force between the loops, symbolically and numerically.
