Exam 3, Physics 3
11:30-1:00 Tuesday May 8 2018

You may use a 3" x 5" card of notes, both sides. You may use your calculator.

NO PHONES. **There is no acceptable reason for your work to look exactly like someone else's work.** "Someone else" includes other people, the textbook, anything on the web, and handed out solutions.

Leave some values and integrals uncalculated.

Do all derivatives.

Do simple integrals: $\int \mathrm{a}z^n dz$, $\int \mathrm{a}e^x dx$, $\int \mathrm{a}(\cos\theta)d\theta$, $\int \mathrm{a}(\sin\phi)d\phi$, and $\int \mathrm{a}\ln(g)dg$.

Leave other integrals unintegrated. Include the limits of integration, move constants out of the integral, and simplify.

$$E_z = \frac{\mathrm{kq}}{2\ell}\int_a^{2b} \frac{z}{(z^2-\mathrm{b}^2)^{3/2}}dz \qquad \text{is perfect}$$

$$E_z = \int \frac{\mathrm{kq}}{2\ell(z^2-\mathrm{b}^2)}\frac{z}{\sqrt{(z^2-\mathrm{b}^2)}}dz \qquad \text{is not}$$

Do simple calculations: (1) multiply, divide, subtract and add integers and (2) sine and cosine of 0, integer multiples of $\frac{\pi}{6}$ (that is $\frac{\pi}{6}, \frac{\pi}{3}, \frac{\pi}{2}, \frac{2\pi}{3}, \ldots$), and integer multiples of $\frac{\pi}{4}$ (that is $\frac{\pi}{4}, \frac{\pi}{2}, \frac{3\pi}{4}, \ldots$)

Leave other calculations uncalculated. Provide an expression that requires a single calculation from your calculator. This means using the correct units.

$$v_f = \left[(10\mathrm{m/s})^2 + (\frac{300\mathrm{N/m}}{0.3\mathrm{kg}})(12\times10^{-2}\mathrm{m})^2\right]^{1/2} \qquad \text{is perfect}$$

$$\frac{1}{2}(0.3)v_f^2 = \frac{1}{2}(0.3)(10)^2 + \frac{1}{2}(300)(12\mathrm{cm})^2 \qquad \text{is not}$$

CONSTANTS AND EQUATIONS

$$k = 1/4\pi\epsilon_0 = 9\times10^9\ \mathrm{N\cdot m^2/C^2} \qquad e = 1.6\times10^{-19}\ \mathrm{C}$$
$$\epsilon_0 = 9\times10^{-12}\ \mathrm{C^2/N\cdot m^2} \qquad m_{\mathrm{proton}} = 1.7\times10^{-27}\mathrm{kg}$$
$$\mu_0 = 4\pi\times10^{-7}\mathrm{T\cdot m/A} \qquad m_{\mathrm{electron}} = 9.1\times10^{-31}\mathrm{kg}$$
$$g = 9.8\ \mathrm{m/s^2} \qquad N_A = 6\times10^{23}\ \mathrm{atoms/mol}$$

Present clear and complete solutions. Start solutions with definitions (e.g. $\vec{v} \equiv \frac{d\vec{r}}{dt}$), theorems (e.g. Newton's laws), and commonly used equations (e.g. constant acceleration equations). Any physics/engineering/math/chem major should be able to understand your solution.

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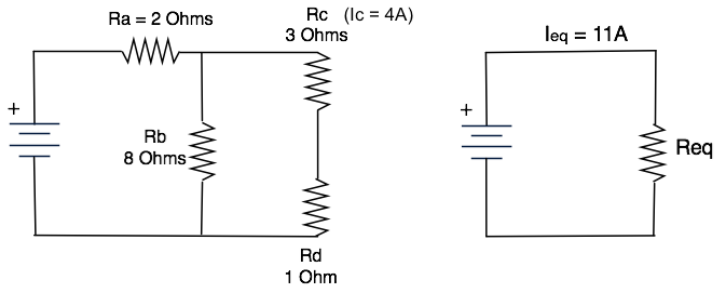
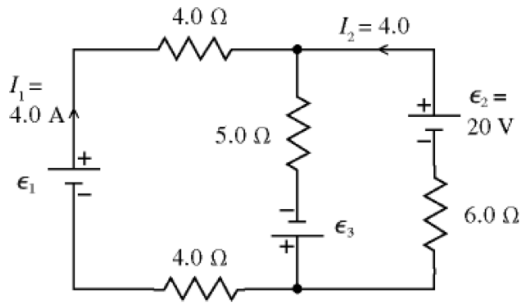
1. Circuit Y and its equivalent circuit is shown below. A current of 4A goes through R_c.

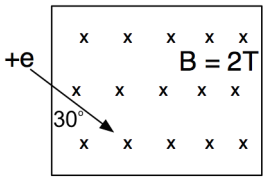


Determine
(a) R_{eq}
(b) the power dissipated by R_{a}
(c) the voltage across R_{d}
(d) current through R_b

2. Calculate ε_1 in the following circuit.

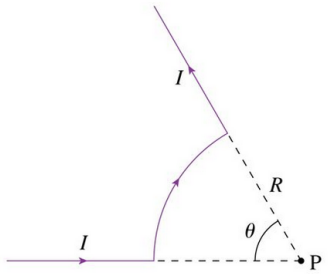


3. A charged particle of mass 5g and charge $+e$ enters a region with a uniform and constant magnetic field. It has an initial speed of 100m/s, with a direction shown below.



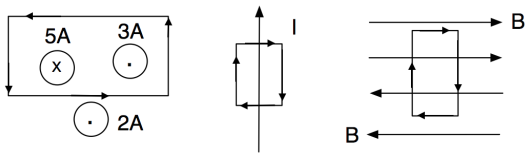
(a) Sketch the direction of the magnetic force.
(b) Calculate the magnitude of the force.

4. *Derive* the expression for the magnitude of $\vec{B}$ at P. Determine the direction of $\vec{B}$.

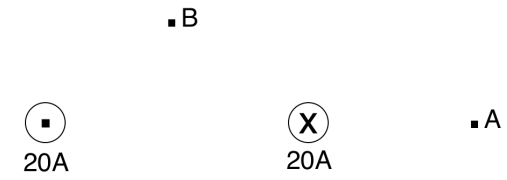


5. A 150μF defibrillator capacitor is charged to 1500V. When it discharges through a patient's chest, it loses 95% of its voltage in 40ms. Calculate the effective resistance of the patient's chest.

6. For each loop, identify whether $\oint \vec{B} \cdot d\vec{\ell}$ is positive, negative, or zero. (No calc or justification req'd.)



7. Two infinitely long, straight current carrying wires are shown below.

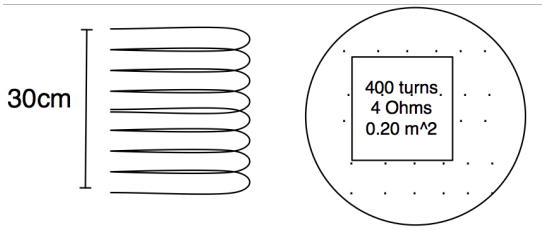


(a) Sketch the magnetic field at A and B. Make these to scale and take care with the direction.

(b) A third current is placed at A. This current points out of the page. Sketch the direction of the force on the third current.

8. A superconducting electromagnet (a solenoid) is designed to generate 2.4T with a current of 12A.

(a) Calculate the number of coils in the magnet.



A conducting loop is in the electromagnet. The solenoid current falls to zero in 30s. Determine the

(b) average current induced in the coil.
(c) direction of the induced current.

Answer one of the following

9. How does an electric motor work? Include a diagram, 1 or 2 equations, and 2-4 sentences of text.

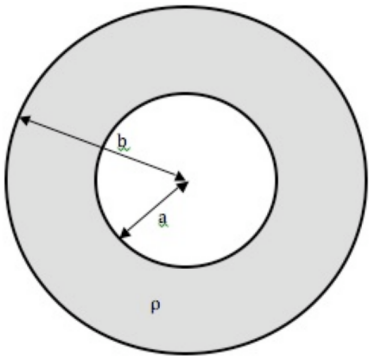
10. Rank the following B's, from smallest to greatest.

(A) 50cm away from an infinitely long straight wire carrying 10A
(B) At the center point of a current loop with a radius of 50cm. The loop carries 10A.
(C) 50cm along the axis of a permanent magnet with a dipole moment of $0.1\pi\text{A}\cdot\text{m}^2$

Justify your answer with relevant calculations.

From Exam 2

7. A sphere has an inner radius a and outer radius b. It's uniformly charged with a charge density of ρ.



Use Gauss's law to determine the electric field at a point in the shell, $a < r < b$. Include a well-labelled sketch that shows the surface you're integrating over and the electric field.
