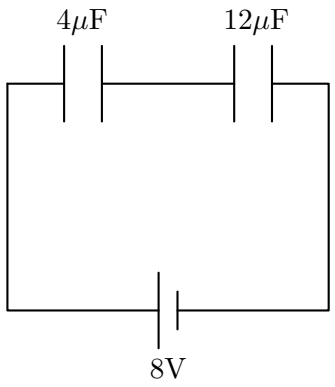
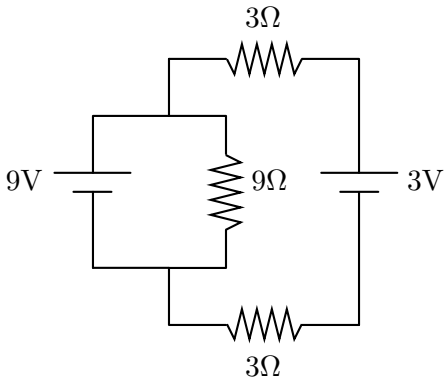
SOLVE ALL OF THE FOLLOWING PROBLEMS.

1. (3 POINTS) When it hits the negative plate, what is the speed of a proton accelerated from rest at the positive plate of the 12 μF capacitor in the circuit below?



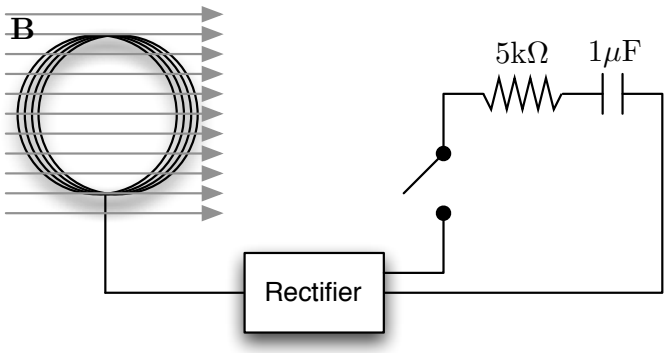
2. (2 POINTS) For an electric field given by $\mathbf{E} = (2x^2 + 4x^3)\,\mathbf{i}$ N/m, what is the potential difference between a point at the origin and a point located at $x = 5.0$ m?

3. (3 Points) In the circuit below, what is the power delivered to the 9 Ω resistor?



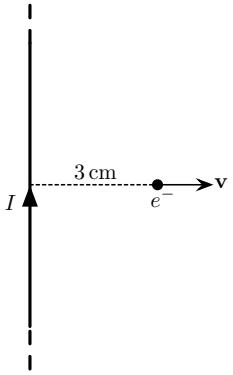
4. (2 Points) What is the magnitude of the magnetic field at the center of a 15 cm long solenoid of 300 turns carrying a current of 60 mA?

5. (3 Points) A coil of wire of cross-sectional area $A = 0.1$ m^2 is rotated at frequency $f = 60$ Hz in a magnetic field of strength $B = 0.5$ T, generating an alternating current that is converted to DC by a rectifier circuit as shown below. The rectifier circuit produces a steady emf $\mathcal{E}$ at 70% of the peak emf $\mathcal{E}_{\text{max}}$ generated by the rotating coil. The steady emf is used to power an RC-circuit when the switch is thrown. If 3 ms after the switch is thrown, the current in the resistor is 14.5 mA, how many turns are in the coil?



6. (2 Points) Two protons in a molecule are 4.10×10^{-10} m apart. What is the magnitude of the electrostatic force exerted on one proton by the other?

7. (3 Points) At some instant, an electron is traveling at speed $v = 2 \times 10^6$ m/s perpendicularly away from a wire carrying a current $I = 3$ A, as shown below. What is the direction and magnitude of the magnetic force on the electron?



8. (2 Points) A current of 3.0 A is maintained in a circular loop having a circumference of 12 cm. An external magnetic field of 8.1 T is directed so that the angle between the field and the normal to the loop is 15°. How much torque does the loop experience?

9. (3 Points) A long solenoid of radius R has n turns of wire per unit length and carries a time varying current given by

$$I(t) = I_{\text{max}} \cos \omega t,$$

where I_{max} is the maximum current and ω is the angular frequency of the alternating current source. What is the magnitude of the induced electric field outside the solenoid at a distance $r > R$ from its long central axis?

10. (2 Points) What is magnetism?

Bonus (2 points)

The speed of the proton in Problem 1 of this exam can be expressed as

$$v = \sqrt{\frac{2e\mathcal{E}C_1}{m_{\text{p}}(C_1 + C_2)}}.$$

Use dimensional analysis to show that the units agree on both sides of the equation.