PY111 Midterm 2 and Solutions

NAME: LAST FOUR DIGITS OF SSN:

Answer in the space provided. You may use the backs of sheets if required. Box your answers on questions 2 and 3. There are 30 possible points in this midterm.

written response

[5] 1. Describe as completely as possible what happens from the time you flip a switch connecting AC power to an incandescent light bulb to the time the light gets to you.

The most important point was that electrons in the wire are accelerated by an electric field which is created when the switch is closed. Other points are that the actual speed of the electrons is very low (.01 cm/s), they oscillate back and forth due to the AC current a small distance (roughly 0.01/120 cm), and that light is created in the bulb because the motion of the electrons excites the molecules in the filament, causing it to glow.

partial credit questions

[5] 2. An electron is held 1 m above ground level and released. It moves against gravity towards a charged sphere with $Q = 1.4 \cdot 10^{-19} C$ which is held 8 m directly above the electron's starting point. Determine the speed of the electron when it is 2 m from the sphere.

Conserve energy to answer this question; don't forget gravity!

$$KE_i + EPE_i + mgh_i = KE_f + EPE_f + mgh_f$$

Plug in $h_i = 1$, $h_f = 7$, $EPE_i = kqQ/8$ *and* $EPE_f = kqQ/2$, *and* $KE_i = 0$ *to get* $v_f = 6.9$ *m/s.*

[5] 3. Equipotential surfaces A and B have potentials of 5500V and 7500 V respectively. A positron (a positive electron) is pushed by an external force from surface A to surface B. If the particle's speed on A was 10^7 m/s and on B was $3 \cdot 10^7$ m/s how much work was done by the external force?

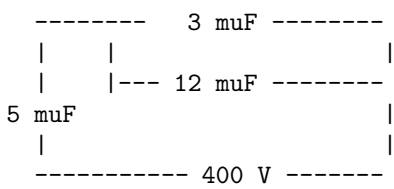
The work done by the external force opposes that done by the electric field and so is given by $W_{ex} = E_B - E_A$ *(note the opposite sign from the usual). Use* $E = KE + EPE$ *to get* $W_{ex} = 68.4 \cdot 10^{-17}$ *J. NOTE: this is problem 20-35 from the text.*

multiple choice questions

[3] 4. An electrical engineer doubles the height, width, and length of a copper wire with a square cross section. What happens to the wire's resistance?

(a) quarters
(b) halves. L doubles, A goes up by 4, so R goes down by 2.
(c) nothing
(d) doubles
(e) quadruples

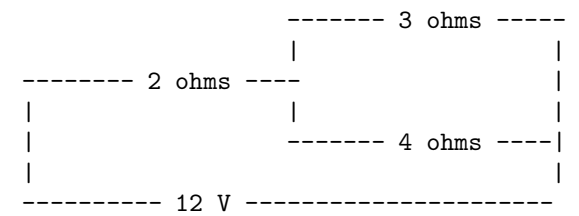
[3] 5. Determine the total charge stored in the following circuit.



(a) 1.0 mF
(b) 1.5 mF. Reduce the capacitors: $1/C_{eq} = 1/5 + 1/(3 + 12)$ *and use* $q = C_{eq}V$.
(c) 2.9 mF
(d) 3.2 mF

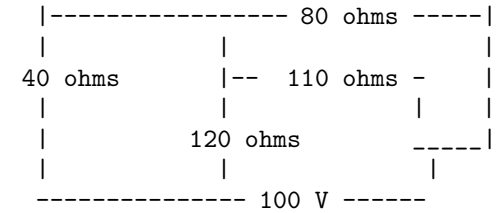
[3] 6. A doctor wishes to cauterize a wound with a wire of resistance R. If the cauterization process requires 1200 J of energy in 3 seconds, and the wire is attached to a 120 V battery, what should R equal?
(a) 0.03 ohms
(b) 0.3 ohms
(c) 3.3 ohms
(d) 36 ohms. The power usage is 1200 J/3 s = 400 W, and $P = V^2/R$.

[3] 7. At what rate is energy dissipated by the 3 ohm resistor?



(a) 4.0 W
(b) 9.7 W
(c) 10.2 W. Reduce the circuit to get $R_{eq} = 2+12/(3+4)$*, hence* $I = V/R_{eq} = 3.24\ A$*,* $V_2 = 6.48\ V$*, thus* $V_{34} = 5.51$ *V, and* $P_3 = V_{34}^2/R_3 = 10.1\ W$.
(d) 13.9 W

[3] 8. What is the voltage drop across the 110 ohm resistor?



(a) 40 V
(b) 60 V. The 40 and 120 are parallel as are the 80 and 110. Reduce them and add to get R_{eq}*. This gives* $I = 1.3A$ *and finally* $V_{34} = 60\ V$*. Note that 100 and 143 are impossible.*
(c) 100 V
(d) 143 V

equations

$W_{AB} = EPE_A - EPE_B \qquad qV = EPE \qquad V = kq/r$
$E = -\frac{\Delta V}{\Delta s} \qquad q = CV \qquad \kappa = E_0/E \qquad C = \kappa\epsilon_0 A/d$
$E = \frac{1}{2}CV^2 \qquad E = \frac{1}{2}\kappa\epsilon_0 E^2 \qquad I = \frac{\Delta q}{\Delta t} \qquad V = IR \qquad R = \rho L/A \qquad P = IV$
$\bar{P} = I_{rms}V_{rms} \qquad V = V_0 \sin 2\pi f t \qquad R_{eq} = R_1 + R_2 + \ldots \qquad 1/R_{eq} = 1/R_1 + 1/R_2 + \ldots$
$C_{eq} = C_1 + C_2 + \ldots \qquad 1/C_{eq} = 1/C_1 + 1/C_2 + \ldots \qquad q = q_0(1 - \mathrm{e}^{-t/RC}) \qquad q = q_0\mathrm{e}^{-t/RC}$
$\epsilon_0 = 8.85 \cdot 10^{-12} C^2/N \cdot m^2 \qquad q_e = -1.6 \cdot 10^{-19} C \qquad m_e = 9.1 \cdot 10^{-31} kg \qquad k = 8.99 \cdot 10^9 N \cdot m^2/C^2$