PHYS 212 Exam 2 - Practice Test - Solutions

1E
In order to use the equation for discharging, we should consider the amount of charge *remaining* after three time constants, which would have to be $q(t)/q_0$. Also we can substitute time, t, with 3τ, which is three time constants. We can also substitute RC, which is also equal to τ, and we get:

$$\frac{q(t)}{q_0} = e^{\frac{-t}{RC}} = e^{\frac{-3\tau}{\tau}} = e^{-3} = 0.0498 = 4.98\%$$

This means that after three time constants, we have 4.98% left, which means that charge has been reduced by 95.02%.
Note that the fact that charge had been reduced by 63% after one time constant was useless information if you solve it this way.

2D
Looking at the currents entering and leaving any of the junctions where the wires meet gives the following equation: $I_2 + I_3 = -I_1$.
This can be rewritten to get answer D.

3A
Remember that going across a battery from + to – makes the potential drop negative, and going against the direction of current when crossing a resistor makes the drop positive. Only answer A obeys these rules.

4D
Initially, the capacitor will not affect the resistance of the circuit, and you can pretend that it is not even there. Thus the current in the circuit will be I = V/R, regardless of the capacitance, and is thus 18/2 = 9 Amps.

5D
For any RC circuit, you can use the loop law to include the capacitor (assuming it has charge) so that it looks as follows:

$$\varepsilon - Ri - \frac{q}{C} = 0$$

This can be rewritten to solve for current:

$$i = \frac{\varepsilon - \frac{q}{C}}{R} = 4$$

6D
The Biot-Savart Law for magnetic fields from a current is used to determine the direction of the field. By pointing your thumb in the direction of the current, your fingers curl in the direction of the magnetic field. From this we determine that the two wires on the right going into the page will cancel each other out at point P (the top right wire produces a field to the left, and the bottom right wire produces an equal field to the right). The other wires both produce magnetic fields pointing right at point P.

7B
The equation for any circular loop is given by:

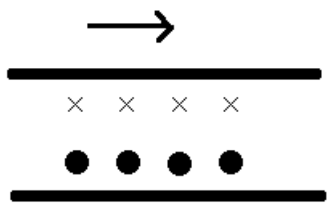
$$\vec{B} = -\frac{\mu_0 i}{2R} = 2.0 \times 10^{-5} T$$

However, since we are only dealing with half a loop, we will get half the amount of magnetic field, B/2, which equals 1.0×10^{-5} T.

8E
For a charge/current moving in a circular path, the Biot-Savart Law says to point your thumb in the direction of motion and your fingers will curl in the direction of the magnetic field. Doing this with the particles causes your fingers to curl into the page at the center of the circle. However, all rules are reversed when the charge is negative, and so the field will point out of the page instead.

9C

For each wire the direction of the magnetic field can be determined by pointing your thumb along the wire and curling your fingers in the direction of the field. Since both currents are parallel (and assuming the current moves to the right), the top wire produces a field going into the page, while the bottom wire makes a field going out of the page, as shown below:



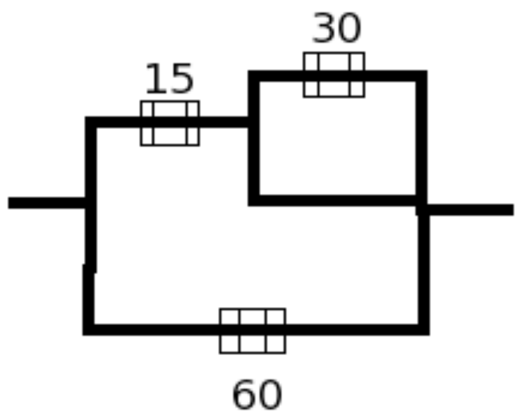
This means that at the midway point, which is 0.2 m from each wire, the fields will oppose each other, and the net magnetic field will be the difference between the two. For a straight wire carrying current, the magnetic field at a distance, R, from the wire is:

$$\vec{B} = -\frac{\mu_0 i}{2\pi R}$$

Thus the net field will be $B_1 - B_2$:

$$\vec{B}_1 - \vec{B}_2 = \left(-\frac{\mu_0(4)}{2\pi(0.1)}\right) - \left(-\frac{\mu_0(5)}{2\pi(0.1)}\right) = 2 \times 10^{-6} T$$

10D
Using the appropriate equations for resistors in parallel, the two resistors at the top left of the circuit can be combined into equivalent resistance of 15 ohms. Also, the two resistors in series at the bottom are the equivalent of 60 ohms. Thus the circuit can be redrawn as shown below:



At this stage the current can get from "a" to "b" by travelling through either the 15 ohm resistor or the 60 ohm resistor. It does not need to go via the 30 ohm resistor at the top right. Which means that for all intents and purposes we can ignore it. So now we really have a simple parallel circuit with resistors of 15 and 60 ohms, and an equivalent resistance of 12 ohms.

11D
The voltage drops from 9 V to 8.5 V due to the internal resistance. This 0.5 V lost within the battery can be set equal to V = IR, allowing us to solve for the current, I, to get:

$I = V/R = 0.5/0.1 = 5$ A

12D
Firstly, the correct answer is not listed among the answer choices, so my apologies if you wasted a lot of time on this problem before realizing there was an error with the answer choices.

This problem is similar to one we did during the exam review, where at time t = 0 the capacitor already has its maximum voltage, V_0 = 80 V, and is ready to discharge across the resistor once the switch is flipped. Thus we'll need the equation for discharging a capacitor, written in terms of voltage, not charge:

$$V(t) = V_0(e^{-\frac{t}{\tau}})$$

We can replace the time constant, τ, with its equivalent value RC, and the value for V(t) is equal to IR = 19.6 V, using the 7.0 μA current given in the problem.

So when we solve for time we should get:

$$t = -RC\ln\left(\frac{V(t)}{V_0}\right) = 86.6\ \text{s}$$

13A
The most basic definition of current is: I (Amperes) = Coulombs / second
Thus, the time in seconds is given by s = C/A = (5)/(10) = 0.5 s

14C
Starting at point h and moving counter-clockwise we create the loop law going via points f and then c, before returning to point h.

The resulting loop law becomes:

$$-(0.5)(23)+17-(0.3)(30)+I_2(25)+11=0$$

$$7.5=-25I_2$$
$$I_2=-0.3A$$

15D
Energy dissipation is the same thing as power. So let's see the equations for power:

$$P = V_0 I = I^2 R = \frac{V^2}{R}$$

We can analyze each answer choice as follows:

(a) False – if you half V (with R constant) the power decreases by a factor of one fourth.
(b) False – if you half I (with R constant) the power decreases by a factor of one fourth.
(c) False – if you half R (with V constant) the power will double.
(d) True – according to $P = I^2R$, if you half R (with I constant) the power will half.
(e) False – if you half both V and I the power decreases by a factor of one fourth..

16C
Remember that resistivity is a property of a material, and so both wires have the same resistivity (this rules out A).

The graph shows that at any given voltage the current in wire A is greater than that of wire B. This can only happen if wire A has a smaller resistance, since current and resistance are inversely proportional. That means that statement ii is correct. We should also remember that if everything else is held constant, the shorter the conductor is, the smaller the resistance will be. So since wire A has the smaller resistance, we can assume it has a shorter length, and thus statement v is also correct.