Quiz 4 solutions

May 28, 2012

1. The current in a 20 ohm resistor increases linearly from 3.0 A to 5.0 A in 3.0 s. How much charge flows through the resistor in that time, in C?
12
First we can get the expression of current I as a function of time t:

$$I(t) = \frac{2}{3}t + 3,$$

where t is in s and I is in A. Then we can get the total charge:

$$Q = \int_0^3 I(t)dt = \int_0^3 (\frac{2}{3}t + 3)dt = 3 + 9 = 12(C).$$

2. A battery has an emf of 1.6 V. When delivering 1.0 A, the load receives 1.5 W of power. What is the battery's internal resistance, in ohms?
0.10
We set internal resistance as r, load resistance as R. Then we have:

$$R + r = \frac{emf}{I} = \frac{1.6V}{1A} = 1.6\Omega.$$

From $P = I^2R$, we have:

$$R = \frac{P}{I^2} = \frac{1.5W}{(1A)^2} = 1.5\Omega.$$

Thus we get the internal resistance:

$$r = 1.6\Omega - 1.5\Omega = 0.1\Omega.$$

3.A wire lies on the ground, and carries a current from south to north. Consider a point on the ground to the east of the wire: which way does the B-field from the wire point?
into the earth

Using the right hand rule, we can determine the direction of the magnetic field. Please see Figure 22.23 on page 744 for right hand rule.

4. A capacitor is charged, and disconnected from the circuit. It stores energy. I insert a dielectric between the plates. What happens to the stored energy?
it decreases
Because $C = \kappa C_0$ and $\kappa > 1$. This dielectric increases the capacitance of the capacitor. According to electric potential energy $U = \frac{Q^2}{2C}$, C increases while Q is the same(because the capacitor is disconnected from the current), so U drops.

5.A hollow steel tube carries 5.0 A. The resistance of the tube is 0.10 ohm per meter. What is the B-field in the center of the tube, in T? (The current is along the length of the tube.)
0.0
(See answer to Question 22.11 on page 139.)Let's apply Ampere's law to a closed concentric circle within the wire. Since there is no current through this path, and because of the symmetry of the configuration, the magnetic field inside the tube must be zero.

6. A platinum wire is 0.50 mm in diameter. What fraction of the B-field at its surface exists at a radius of 0.25 mm from the center of the wire?
all of it
$0.50mm/2 = 0.25mm$, so "at a radius of 0.25 mm from the center of the wire" equals "at its surface".
For a general radius, using the Ampere's law, we can get the magnitude of the magnetic field as a distance r from a long, straight wire carrying current I:

$$B = \frac{\mu_0 I}{2\pi r}.$$

For this problem, we know that $I = I_{total}\frac{\pi r^2}{\pi R^2}$, where I_{total} is the total current carried by the wire, and $R = 0.5mm/2$ is the radius of the wire. So we get:

$$B(r) = \frac{\mu_0 I_{total} r}{2\pi R^2} \propto r.$$

7.A horizontal B-field is 2.0 T. A 10 g hummingbird sits on a 10 cm horizontal wire, which is perpendicular to the B-field. How much current must the wire carry to lift the bird, in A?
0.49
To lift the bird, we need that the magnetic force equals the gravity, i.e. $BIL = mg$. Thus we have

$$I = \frac{mg}{BL} = \frac{10^{-2}kg \times 9.8m/s^2}{2T \times 0.1m} = 0.49A$$

8. A platinum wire is 0.50 mm in diameter. It carries a current of 4.0 A. What fraction of the current is carried within a radius of 0.25 mm of the center of the wire?
all of it
$0.50mm/2 = 0.25mm$, so the result is the total current.
For a general radius, we know that the current carried within a radius of r of the center of the wire is $I(r) = I_{total}\frac{\pi r^2}{\pi R^2}$, where I_{total} is the total current carried by the wire, and $R = 0.5mm/2$ is the radius of the wire.

9.(This question will not count.) An electric motor has a rotor coil with 50 turns of 22 gauge wire, which carries 2.0 A. The coil is immersed in a magnetic field of 1.0e-4 T. What is the maximum torque (= force x distance) of the motor, in N-m?
not enough information
We have known N, I and B, but we still need the size of the coil to calculate the magnetic force and distance.

10. A rectangular loop carries 5.0 A. It is 0.20 m wide by 0.30 m tall. A 0.040 T magnetic field passes through the loop, perpendicular to the plane of the loop. What is the net effect on the loop?
nothing
From $\vec{F} = I\vec{l} \times \vec{B}$, we know that the magnetic force on each pair of opposite sides cancels(because $\vec{B}$ and I are the same but $\vec{l}$ are opposite). Thus the net force is zero.