MULTIPLE CHOICE: CHOOSE BEST ANSWER (EACH OF 15 QUESTIONS IS WORTH THE SAME AMOUNT)

1. An LR series circuit with a switch and battery has an ammeter to measure the current in the circuit. At what time in s (of the choices given below) is the current greatest after the switch is closed?

a. 0 
b. After one time constant. 
c. 1 
**d. Ten time constants.** 
e. When \( t = \frac{L}{R} \).

\[ i(t) = \frac{\varepsilon}{R} (1 - e^{-\frac{t}{\tau}}) \]

term decreases as \( t \) increases!

\( \therefore i \) largest when \( t \) largest

\( \text{m.e. } \tau = \frac{L}{R} \)

2. A coil of 1.5 mH self inductance induces an emf of 0.30 V. What is the time rate of current change in A/s?

\[ |\varepsilon| = L \frac{di}{dt} \]

\[ 0.3 = 1.5 \times 10^{-3} \frac{di}{dt} \]

\[ \frac{di}{dt} = 2 \times 10^{-2} \text{ A/s} \]

3. Lenz's law says that the direction of an induced current will

a. tend to increase the effect that produced it. 
b. be counterclockwise. 
c. produce an increased heating effect. 
d. produce a greater voltage. 
**e. oppose the effect that produced it.**
4. The coil shown in the figure has 2 turns, a cross-sectional area of 0.20 m², and a field (parallel to the axis of the coil) with a magnitude give by \( B = (4 + 3t) \) T, where \( t \) is in s. What is the potential difference, \( V_A - V_C \), at \( t = 3.0 \) s in \( V\)?

\[ E = -N \frac{d\phi}{dt} \]
\[ = -2 \cdot \frac{d}{dt}(0.4(6t)) \]
\[ = -0.4(18) = -7.2 \]

5. If a conducting bar of length \( l \) moves perpendicularly through a field with a speed \( v \), what is the magnitude of the motivational emf produced?

\[ a. \quad \frac{a + B}{\ell} \]
\[ b. \quad B \ell v \]
\[ c. \quad \frac{B \ell}{v} \]
\[ d. \quad \frac{Bv}{\ell} \]
\[ e. \quad \frac{v \ell}{B} \]

**NEED DRAWING**

6. A solenoid carries a constant current. How does the magnetic field inside the coil change if the length of the coil remains the same and the number of turns is doubled?

\( B_0 = \mu_0 n I \), \( n = \frac{N}{\ell} \)

\( N \rightarrow 2N \) then \( n \rightarrow 2n \) and \( B \rightarrow 2B \)
7. A long straight wire that has a diameter of 2.0 mm carries a current of 40 A. What is the magnitude in mT of the magnetic field 1.5 mm from the axis of the wire?

a. 4.6
b. 13
c. 5.3
d. 8.4
e. 7.0

\[ \oint B \cdot dl = \mu_0 I \]
\[ B(2\pi r) = \mu_0 I \]
\[ B = \frac{2\mu_0 I}{2\pi r} = \frac{2 \times 10^{-7}}{1.5 \times 10^{-3}} \]
\[ = 5.3 \times 10^{-3} \text{ T} \]

8. A wire 2.0 m long is suspended parallel to a uniform magnetic field of 0.50 T. If the current in the wire is 0.60 A, what is the force in N on the wire?

a. 6.7
b. 3.3
c. 0.30
d. 0.15

\[ F = I \vec{L} \times \vec{B} = I (0) = 0 \]

Since \( \vec{L} \parallel \vec{B} \)

9. A charged particle moves perpendicular to a magnetic field in a circular path. Which statement best describes the work the field does on the particle?

a. Work is done at a constant rate.
b. Work is done at a decreasing rate.
c. Work is done at an increasing rate.
d. The field does no work on the particle.
e. Work done on the particle is negative.

\[ \vec{F} = q \vec{v} \times \vec{B} \text{ is } \perp \text{ to displacement} \]

\[ dW = \vec{F} \cdot d\vec{r} = 0 \]
10. Three long wires parallel to the x axis carry currents as shown. If $I = 20 \, \text{A}$, what is the magnitude of the magnetic field at the origin in $\mu\text{T}$?

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

\begin{itemize}
  
  a. 37
  b. 28
  c. 8
  d. 47
  e. 12
\end{itemize}

![Diagram showing magnetic field at a point](image)

$$4I : \text{Field into Page (+)}$$

$$\frac{\mu_0 4I}{2\pi (2)}$$

$$3I : \text{Field into Page (+)}$$

$$\frac{\mu_0 3I}{2\pi (1)}$$

$$I : \text{Field out of Page (-)}$$

$$\frac{\mu_0 I}{2\pi (3)}$$

11. What is the current in A in the 15 $\Omega$ resistor?

\begin{itemize}
  
  a. 0.20
  b. 0.30
  c. 0.10
  d. 0.26
  e. 0.60
\end{itemize}

![Diagram of a circuit](image)

$$R_{eq} = \frac{15 \times 30}{15 + 30} = 10 \, \Omega$$

$$I_1 = \frac{9}{30} = 0.3 \, \text{A}$$

$$V = I_1 (10) = 0.3 \times 10 = 3 \, \text{V}$$

$$I_2 = \frac{3 \, \text{V}}{15 \, \Omega} = \frac{1}{5} = 0.2 \, \text{A}$$
14. A light bulb is rated at 30 W when operated at 120 V. How much charge in C passes through this bulb in 1.0 min?

\[ P = V \cdot I \]
\[ 30 = 120 \cdot I \]
\[ I = \frac{30}{120} = 0.25 \text{ A} = 0.25 \frac{C}{A} \]
\[ Q = I \times \text{time} = (0.25)(60) = 15 \text{ C} \]

15. What maximum power in W can be generated from an 18 V emf using any combination of a 6.0 \( \Omega \) resistor and a 9.0 \( \Omega \) resistor?

\[ P = I^2 R = \left(\frac{V}{R}\right)^2 R = \frac{V^2}{R} \]
\[ P_{\text{max}} \text{ when } R_{\text{min}} \]
\[ R_S = 6 + 9 = 15 \Omega \]
\[ R_{\text{ult}} = \frac{(6)(9)}{6 + 9} = 3.6 \Omega \]
\[ P_{\text{max}} = \frac{18^2}{3.6} = 90 \text{ W} \]

16. SEE PAGE 7 FOR EXTRA CREDIT
EXTRA CREDIT (SIX POINTS TOTAL):

16. (a) What is the charge on the capacitor (in C) 0.011s after the circuit is closed in an RC circuit if \( R = 220 \Omega \), \( C = 5 \times 10^{-6} \) F, and \( E = 300 \) V? (Assume that before the circuit is closed, the charge on the capacitor is zero and the current in the circuit is zero.)

\[
\varphi(t) = \varphi_0 \left( 1 - e^{-t/RC} \right)
\]

\[
\varphi_0 = CV = (5 \times 10^{-6}) (300) = 0.0015
\]

\[
RC = (220 \Omega)(5 \times 10^{-6}) = 0.011
\]

\[
\frac{t}{RC} = \frac{0.011}{0.011} = 1
\]

\[
\varphi = 0.0015 \left( 1 - e^{-1} \right) = 0.95 \times 10^{-3} \text{ C}
\]

(b) At the same time as above (0.011s after the circuit is closed), what is the current (in A) in the circuit?

\[
I = \frac{d\varphi}{dt} = \varphi_0 \left( \frac{1}{RC} \right) e^{-t/RC} = \frac{0.0015}{0.011} (0.37)
\]

\[
= 0.05 \text{ A}
\]

(c) At the same time as above (0.011s after circuit is closed), what is the voltage (in V) on the capacitor?

\[
V_c = \frac{\varphi}{C} = \frac{0.95 \times 10^{-3}}{5 \times 10^{-6}} = 190 \text{ V}
\]