# GRE Phys, Apr. 11th (E & M)

$$\oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0} \qquad \vec{\nabla}\cdot\vec{E} = \frac{\rho}{\varepsilon_0}$$

$$\oint \vec{B}\cdot d\vec{A} = 0 \qquad \vec{\nabla}\cdot\vec{B} = 0$$

$$\oint \vec{E}\cdot d\vec{s} = -\frac{d\Phi_B}{dt} \qquad \vec{\nabla}\cdot\left[\vec{\nabla}\times\vec{E}\right] = -\frac{\partial\vec{B}}{\partial t}$$

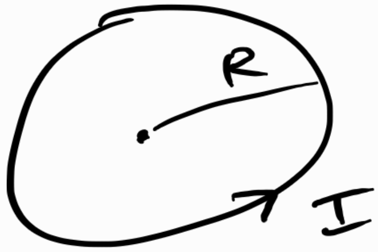
$$\oint \vec{B}\cdot d\vec{s} = \mu_0 I_{enc} + \mu_0\varepsilon_0\frac{d\Phi_E}{dt} \qquad \vec{\nabla}\times\vec{B} = \mu_0\left[\vec{J} + \varepsilon_0\frac{\partial\vec{E}}{\partial t}\right]$$

$k = 9E9$ $\qquad$ $c = 3\times10^{8}\,\frac{m}{s}$

$\varepsilon_0 = 8.85\times10^{-12}$

$\mu_0 = 4\pi\times10^{-7}$

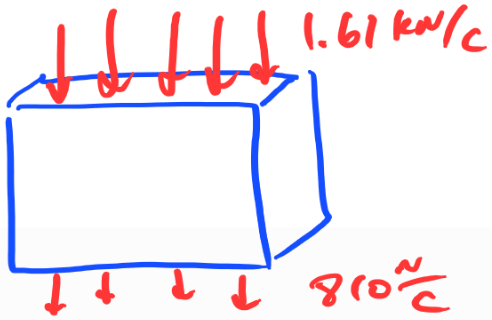

$$d\vec{B} = \frac{\mu_0}{\cancel{2\pi}\,4\pi}\,\frac{I\,d\vec{l}\times\hat{r}}{r^2}$$




$$\vec{B}_{@\,\text{center}} = \frac{\mu_0 I}{2R}$$

**3.** The electric field in a certain region of Earth's atmosphere is directed vertically down (towards the center of the Earth). At an altitude of 50. m, the field has magnitude 1.61 kN/C; at an altitude of 25 m, the magnitude is 810 N/C. Find the net amount of charge contained in a cube 25 m on edge, with horizontal faces at altitudes of 25. m and 50. m.

A) $4.4\,\mu$C
B) $-4.4\,\mu$C
C) $13\,\mu$C
D) $-13\,\mu$C
E) None of the above.




EARF

$$\Phi_e = \frac{q_{enc}}{\varepsilon_0} = -\left(800\,\frac{N}{C}\right)(25\,m)^2 = -5\times10^5\ \frac{N}{C}\cdot m^2$$

$$\underline{q_{enc}} = \varepsilon_0\left(-5\times10^5\ \frac{N}{C}\cdot m^2\right)$$

$$= \left(9\times10^{-12}\right)\left(-5\times10^5\right)$$

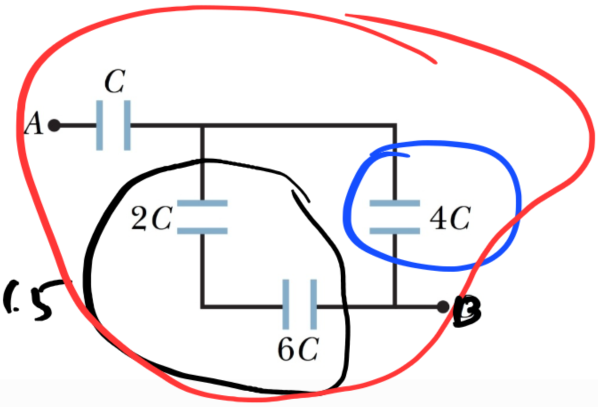
$$= -45\times10^{-7} = \underline{-4.5\times10^{-6}}$$

**5.** In the following figure, a constant potential difference is maintained between points A and B, and the capacitors are in equilibrium. If the charge on the capacitor with capacitance $C$ is $Q$, what is the charge on the capacitor with capacitance $4C$?

A) $(8/11)Q$
B) $Q$
C) $(13/22)Q$
D) $(11/13)Q$
E) $(1/3)Q$

$$\frac{1}{C'_{eq}} = \frac{1}{2C} + \frac{1}{6C} = \frac{4}{6C}$$

$$C'_{eq} = 1.5C$$




$$C''_{eq} = (4 + 1.5)C = 5.5C$$

$$C'''_{final} = \frac{C'C''}{C' + C''} = \frac{(5.5)(1)}{5.5+1} C = \frac{11}{13} C$$

NOT THE QUESTION

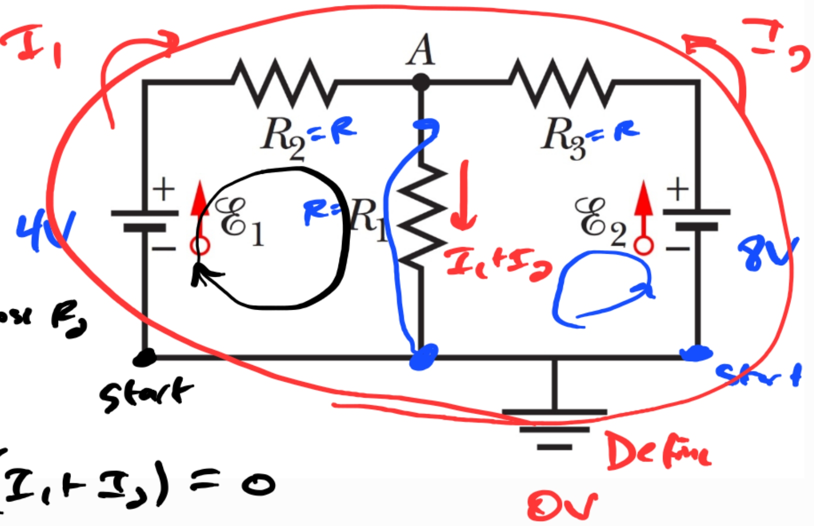
If $C$ has charge $Q$, then $C''_{eq}$ has charge $Q$.

This charge $Q$ is split

$\left(\frac{4}{5.5}\right)Q$ on $4C$

and $\left(\frac{1.5}{5.5}\right)Q$ on $1.5C = C'_{eq}$

**9.** For the circuit shown, $R_1 = R_2 = R_3 = 4\Omega$. Battery 1 (on the left side of the circuit) has EMF $\mathcal{E}_1 = 4$ Volts, and battery 2 (on the right side of the circuit) has EMF $\mathcal{E}_2 = 8$ Volts. In addition, the circuit is grounded as shown, where the ground has potential 0 Volts. What is the electric potential at point $A$?




A) 2 Volts.
B) 4 Volts.
C) 6 Volts.
D) 8 Volts.
E) 12 Volts.

$$4 - \underbrace{4(I_1)}_{\text{Voltage drop across } R_2} - 4(I_1 + I_2) = 0$$

$$8 - 4I_2 - 4(I_1 + I_2) = 0$$

$$(8-4) - 4I_2 + 4I_1 = 0$$

$$4 = 4(I_2 - I_1)$$

$$I_2 - I_1 = 1$$

$$I_2 = I_1 + 1$$

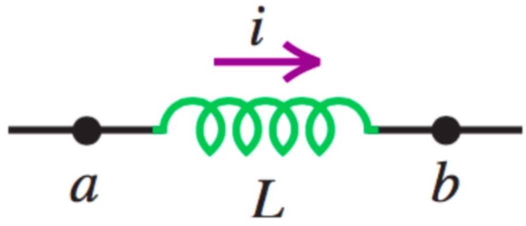
$$4 - 4I_1 - 4(2I_1 + 1) = 0$$

$$4 - 12I_1 - 4 = 0$$

$$\boxed{I_1 = 0}$$

$$\boxed{I_2 = 1}$$

**12.** Current $i = 0.50\,\text{Amps}$ is decreasing at a rate $|di/dt| = 1.0\,\text{Amps/sec}$. It passes from point $a$ to point $b$ through an inductor of inductance $L = 2.0\,\text{H}$. Which point has higher electric "potential" ($a$ or $b$), and by how many volts relative to the other side?



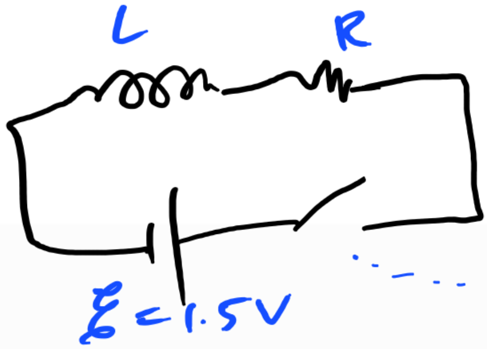

A) Point $a$, 1.0 Volt.
B) Point $a$, 2.0 Volts.
C) Point $a$, 0.5 Volts.
D) Point $b$, 1.0 Volt.
E) Point $b$, 2.0 Volts.

$$V_b - V_a = \mathcal{E}_{back} = -L\frac{di}{dt}$$

$$= -(2)(-1) = +2$$

**14.** You have a spool of copper wire that has resistance per unit length $5.5 \times 10^{-3}$ Ohms per meter and inductance per unit length of $0.30\,\mu$H per meter. Suppose you take 20.0 cm of this wire and connect the ends to the terminals of a 1.5 Volt battery. How long does it take for the current in the wire to reach 80.% of its maximum value?

A) $123\,\mu$s
B) $88\,\mu$s
C) $69\,\mu$s
D) $55\,\mu$s
E) $32\,\mu$s




close S @ $t = 0$.

$$i(t) = i_{max}\left[1 - e^{-t/\tau_L}\right], \quad \text{where } \tau_L = \frac{L}{R}$$

is the inductive time constant for RL circuits.

$$\tau_L = \frac{L}{R} = \frac{L/\ell}{R/\ell} = \frac{0.30 \times 10^{-6}}{5.5 \times 10^{-3}} \text{ sec}$$

$$= \frac{300}{5.5}\,\mu s \simeq 55\,\mu s$$

$\frac{300}{5} = 60$ and $\frac{300}{6} = 50$ ... I interpolated

$$0.80 = 1 - e^{-t/\tau}$$

$$e^{-t/\tau} = 0.20$$

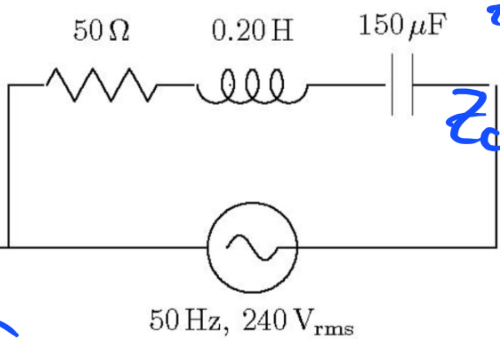
$$t \approx \tau \ln 5 \simeq 1.5\,\tau \simeq (80-90)\,\mu s$$

[if an actual GRE question the ans. choices would be ~ factors of 2 diff from one another (if not orders of magnitude different)]

**18.** For the series RLC-series circuit shown, what is the rms-current? By the way, the numbers shown for the AC source are (close to) what they use in most European countries.

$f = 50\,\text{Hz} \rightarrow \omega = 314\ \text{rad/sec}$

$V = I|Z|$




$Z_L = i\omega L$

$Z_C = \frac{-i}{\omega C}$

A) 8 Amps
B) 2 Amps
C) 4 Amps
D) 1 Amp
E) 0.5 Amps

$240\,V = I_{rms}|Z|$

$$|Z| = \sqrt{R^2 + (X_L - X_C)^2}$$

$$= \sqrt{(50\Omega)^2 + (43\Omega)^2}$$

$$\approx 70\Omega$$

$X_L = \omega L \approx 63\Omega$

$$X_C = \frac{10^6}{(314)(150)}\Omega$$

$$= \frac{10^6}{5\times10^4}\Omega$$

$$= 20\Omega$$