SP212 Exam #5

Name and Alpha: Version A

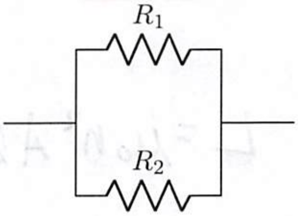
1. Two resistors (with different resistances) are wired in parallel. Which of the following is true?

   A. Neither the current flowing through them nor the voltage across them will be the same for the two resistors.

   B. Both the current flowing through them and the voltage across them will be the same for the two resistors.

   [✓ C.] The two resistors will have the same voltage across them, but different currents flowing through them.

   D. The two resistors will have the same current flowing through them, but different voltages across them



Parallel circuit elements will always have the same voltage.

V=IR so different R's (& same V) implies different I's.

2. A 0.85 m long wire carries a 4.7 A current in the $+x$ direction through a region with a uniform magnetic field in the $+z$ direction given by $(1.3\text{ T})\hat{k}$. What is the size of the magnetic force acting on this wire?

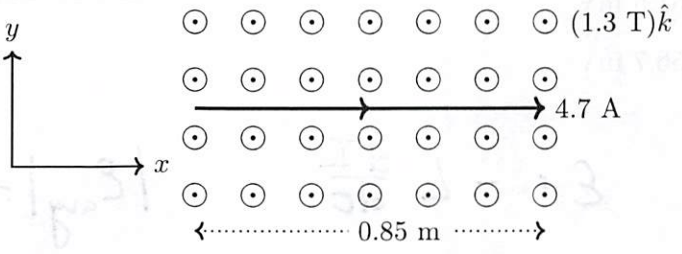
   A. 5.66 N

   [✓ B.] 5.19 N

   C. 7.19 N

   D. 6.37 N

   E. 4.09 N



$\vec{F}=I\vec{\ell}\times\vec{B}$ $F=I\ell B\sin\theta$

$(4.7A)(.85m)(1.3T)\sin 90° = 5.19\ N$

3. A solenoid has a length of 0.060 m and a cross sectional area of 7.5×10^{-5} m^2. It is wound with 425 turns. What is the inductance of this solenoid?

A. 0.253 mH

B. 0.318 mH

C. 0.356 mH

D. 0.226 mH

[✓ E. 0.284 mH]

$$L = \mu_0 n^2 A l = \mu_0 \left(\frac{425}{.06m}\right)^2 (7.5\times10^{-5} m^2)(.06m) = 2.84\times10^{-4} H$$

4. The current passing through a 24.0 mH inductor increases from 8.0 A to 19.0 A over a period of 3.5 s. What was the magnitude of the average voltage across the inductor during this time?

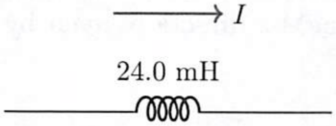
A. 68.6 mV

B. 62.3 mV

[✓ C. 75.4 mV]

D. 51.5 mV

E. 56.7 mV



$$\mathcal{E} = -L\frac{dI}{dt} \qquad |\mathcal{E}_{avg}| = L\left|\frac{\Delta I}{\Delta t}\right|$$

$$(24\times10^{-3} H)\left(\frac{11.0 A}{3.5 s}\right) = 7.54\times10^{-2} V$$

5. What strength magnetic field will have the same energy density as an electric field of strength 1200 N/C?

[✓ A. 4.00 µT]

B. 6.00 µT

C. 5.50 µT

D. 4.50 µT

E. 5.00 µT

$u_e = \frac{1}{2}\varepsilon_0 E^2$ $\quad u_B = \frac{B^2}{2\mu_0}$

$$\frac{B^2}{2\mu_0} = \frac{1}{2}\varepsilon_0 (1200\,N/C)^2$$

$$B = \sqrt{\varepsilon_0 \mu_0}\,(1200\,N/C) = 4.00\times10^{-6}\,T$$

6. An RL circuit is built with a 16 V battery, a 2.0 Ω resistor, and an unknown inductor. The switch is closed at $t = 0$. The current in the circuit is shown in the graph below. What is the value of the inductor?

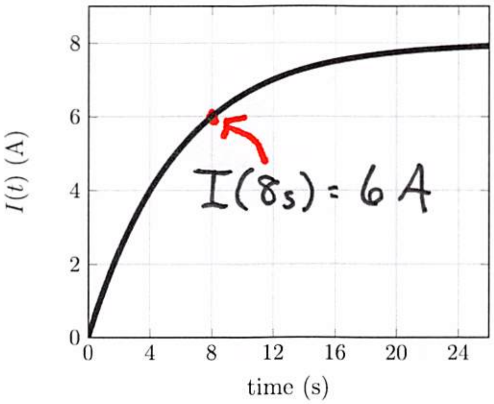
[✓ A. 11.5 H]

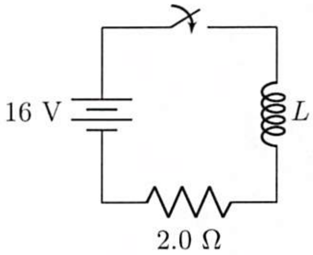
B. 8.59 H

C. 5.69 H

D. 17.3 H

E. 14.4 H





$$I(t) = \frac{\varepsilon}{R}\left(1 - e^{-t/\tau}\right)$$

$$(6.0\,A) = \left(\frac{16V}{2\Omega}\right)\left(1 - e^{-(8s)/\tau}\right)$$

$0.75 = 1 - e^{-(8s)/\tau}$ $\quad 0.25 = e^{-(8s)/\tau}$

$\tau = \frac{-8s}{\ln 0.25} = 5.77s$ $\quad \tau = \frac{L}{R}$ $\quad$ so $L = (2\Omega)(5.77s)$

$= 11.5\,H$

7. As shown in the circuit below, a 9.0 V battery is initially used to charge a 12 mF capacitor to a charge of $Q_{\text{peak}} = 108$ mC. Then, at time $t = 0$, the switch is flipped to position B so that the capacitor is now connected only to a 15 mH inductor. How much potential energy is stored by the inductor at time $t = 0.063$ s?

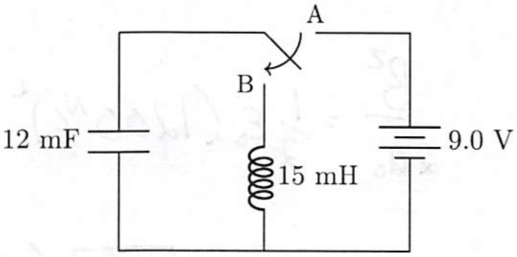
[✓ A. 0.486 J]

B. 0.162 J

C. 0.270 J

D. 0.378 J

E. 0.0546 J



$$I = -\omega Q_{peak} \sin(\omega t) \qquad \omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(15\times10^{-3}H)(12\times10^{-3}F)}} = 74.5 \tfrac{rad}{s}$$

$$I(t=.063s) = -(74.5\tfrac{rad}{s})(.108C)\sin((74.5\tfrac{rad}{s})(.063s)) = 8.048A$$

$$U_m = \tfrac{1}{2}LI^2 \qquad \tfrac{1}{2}(15\times10^{-3}H)(8.048A)^2 = 0.486 J$$

8. An air-filled capacitor has plates with an area of 8.2×10^{-5} m^2. The electric field strength inside this capacitor is given by $E(t) = [3.5 \times 10^5 \text{ N}/(\text{C} \cdot \text{s}^3)]t^3$. What is the instantaneous value of the displacement current at time $t = 1.2$ s?

A. 0.963 nA

B. 1.25 nA

[✓ C. 1.10 nA]

D. 1.43 nA

E. 1.63 nA

$$I_d = \varepsilon_0 \frac{d\Phi_e}{dt} = \varepsilon_0 A \frac{dE}{dt}$$

$$\frac{dE}{dt} = 3 \cdot \left(3.5 \times 10^5 \frac{N}{C \cdot s^3}\right)(1.2 s)^2 = 1.512 \times 10^6 \frac{N}{C \cdot s}$$

$$I_d = \varepsilon_0 \left(8.2 \times 10^{-5} m^2\right)\left(1.512 \times 10^6 \frac{N}{C \cdot s}\right) = 1.10 \times 10^{-9} A$$

9. The graph below shows a snapshot of the electric field component as a function of position for an electromagnetic wave traveling through vacuum. What is the frequency of this wave?

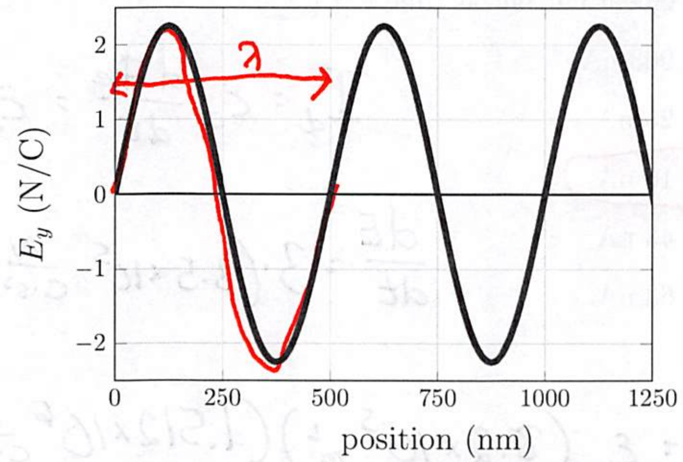
A. 240 THz

B. 750 THz

C. 480 THz

D. 400 THz

[✓ E. 600 THz]



$\lambda = 500$ nm $\qquad c = \lambda F \qquad f = \frac{c}{\lambda}$

$$f = \frac{3.00\times10^{8}\ \text{m/s}}{500\times10^{-9}\ \text{m}} = 6.00\times10^{14}\ \text{Hz}$$

10. The average intensity of sunlight reaching the top of the earth's atmosphere is 1360 W/m^2. What is the amplitude of the oscillating electric field of this sunlight?

A. 0.0676 N/C

B. 5.54×10^{-4} N/C

[✓ C. 1010 N/C]

D. 4.54×10^{-6} N/C

E. 8.24 N/C

$$I = \frac{E_0 B_0}{2\mu_0} \qquad B_0 = \frac{E_0}{c}$$

so $$I = \frac{E_0^2}{2\mu_0 c} \qquad E_0 = \sqrt{2\mu_0 c I}$$

$$\sqrt{2\mu_0 c\,(1360\ \text{W/m}^2)} = 1012\ \text{N/C}$$

SP212 Exam #5

Name and Alpha: Version B

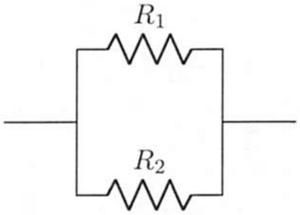
1. Two resistors (with different resistances) are wired in parallel. Which of the following is true?

A. Both the current flowing through them and the voltage across them will be the same for the two resistors.

B. The two resistors will have the same current flowing through them, but different voltages across them

[✓ C.] The two resistors will have the same voltage across them, but different currents flowing through them.

D. Neither the current flowing through them nor the voltage across them will be the same for the two resistors.



Same as version A

2. A 0.85 m long wire carries a 3.7 A current in the $+x$ direction through a region with a uniform magnetic field in the $+z$ direction given by $(1.3\text{ T})\hat{k}$. What is the size of the magnetic force acting on this wire?

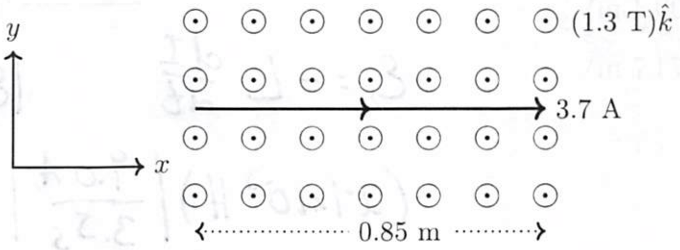
A. 5.66 N

B. 6.37 N

C. 7.19 N

[✓ D. 4.09 N]

E. 5.19 N



$\vec{F} = I\vec{\ell}\times\vec{B}$ $\quad$ $F = I\ell B\sin\theta$

$F = (3.7\,A)(.85\,m)(1.3\,T)\sin 90° = 4.09\,N$

3. A solenoid has a length of 0.060 m and a cross sectional area of 8.5×10^{-5} m^2. It is wound with 425 turns. What is the inductance of this solenoid?

[✓ A. 0.322 mH]

B. 0.403 mH

C. 0.360 mH

D. 0.287 mH

E. 0.452 mH

$$L = \mu_0 n^2 A l = \mu_0 \left(\frac{425}{.06\text{m}}\right)^2 (8.5\times10^{-5}\,\text{m}^2)(.06\text{m})$$

$$= 3.22 \times 10^{-4}\ H$$

4. The current passing through a 24.0 mH inductor increases from 8.0 A to 17.0 A over a period of 3.5 s. What was the magnitude of the average voltage across the inductor during this time?

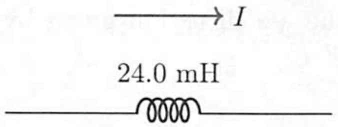
A. 82.1 mV

B. 67.9 mV

[✓ C. 61.7 mV]

D. 90.4 mV

E. 74.7 mV



$$\mathcal{E}_L = -L\frac{dI}{dt} \qquad |\mathcal{E}|_{avg} = L\left|\frac{\Delta I}{\Delta t}\right|$$

$$(24\times10^{-3}\,H)\left|\frac{9.0\,A}{3.5\,s}\right| = 6.17\times10^{-2}\ V$$

5. What strength magnetic field will have the same energy density as an electric field of strength 1500 N/C?

A. 4.50 µT

B. 4.00 µT

C. 6.00 µT

D. 5.50 µT

[✓ E. 5.00 µT]

$u_e = \frac{1}{2}\varepsilon_0 E^2$ $\quad u_B = \frac{B^2}{2\mu_0}$

$$\frac{B^2}{2\mu_0} = \frac{1}{2}\varepsilon_0 (1500\ N/C)^2$$

$$B = \sqrt{\mu_0\varepsilon_0}\,(1500\ N/C) = 5.00\times10^{-6}\ T$$

6. An RL circuit is built with a 24 V battery, a 3.0 Ω resistor, and an unknown inductor. The switch is closed at $t = 0$. The current in the circuit is shown in the graph below. What is the value of the inductor?

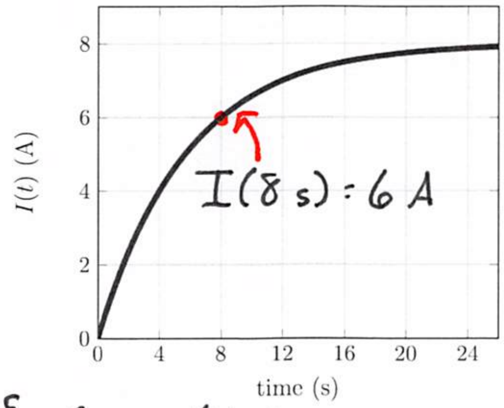
A. 14.4 H

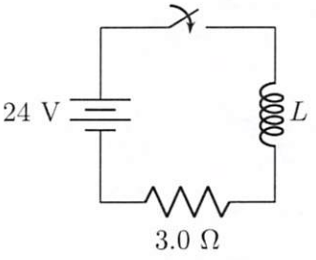
[✓ B. 17.3 H]

C. 11.5 H

D. 8.59 H

E. 5.69 H





$$I(t) = \frac{\mathcal{E}}{R}\left(1-e^{-t/\tau}\right)$$

$6\ A = \frac{24\ V}{3\ \Omega}\left(1-e^{-(8s)/\tau}\right)$ $\quad 0.75 = 1-e^{-(8s)/\tau}$

$0.25 = e^{-(8s)/\tau}$ so $\tau = \frac{-8s}{\ln(0.25)} = 5.77s$

$\tau = \frac{L}{R}$ so $L = (3\ \Omega)(5.77s) = 17.3\ H$

7. As shown in the circuit below, a 9.0 V battery is initially used to charge a 12 mF capacitor to a charge of $Q_{\text{peak}} = 108$ mC. Then, at time $t = 0$, the switch is flipped to position B so that the capacitor is now connected only to a 15 mH inductor. How much potential energy is stored by the inductor at time $t = 0.073$ s?

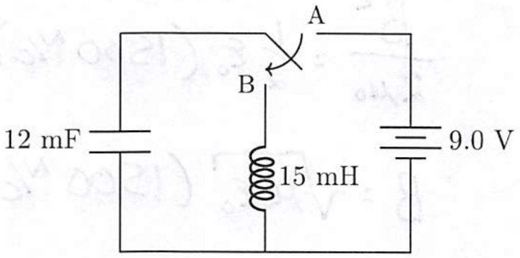
A. 0.486 J

B. 0.0546 J

[✓ C. 0.270 J]

D. 0.378 J

E. 0.162 J



$$\omega = \frac{1}{\sqrt{(LC)}} = \frac{1}{\sqrt{(15\times10^{-3}\,H)(12\times10^{-3}F)}} = 74.5\ \frac{rad}{s}$$

$$I = -\omega\, Q_{peak}\ \sin(\omega t)$$

$$= -(74.5\ \tfrac{rad}{s})(.108\,C)\ \sin((74.5\ \tfrac{rad}{s})(.073s)) = 6.005\,A$$

$$U = \frac{1}{2}LI^2 = \frac{1}{2}(15\times10^{-3}\,H)(6.005\,A)^2 = 0.270\,J$$

8. An air-filled capacitor has plates with an area of 8.2×10^{-5} m^2. The electric field strength inside this capacitor is given by $E(t) = [4.5 \times 10^5 \text{ N}/(\text{C} \cdot \text{s}^3)]t^3$. What is the instantaneous value of the displacement current at time $t = 1.2$ s?

[✓ A. 1.41 nA]

B. 1.83 nA

C. 1.61 nA

D. 1.09 nA

E. 1.24 nA

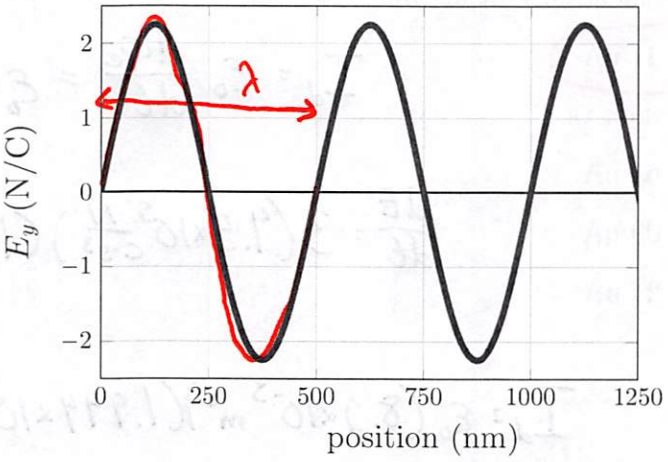
$$I_d = \varepsilon_0 \frac{d\Phi_e}{dt} = \varepsilon_0 A \frac{dE}{dt}$$

$$\frac{dE}{dt} = 3\left(4.5\times10^5 \frac{N}{C\cdot s^3}\right)(1.2\,s)^2 = 1.944\times10^6 \frac{N}{C\cdot s}$$

$$I_d = \varepsilon_0 (8.2\times10^{-5}\,m^2)\left(1.944\times10^6 \frac{N}{C\cdot s}\right) = 1.41\times10^{-9}\ A$$

9. The graph below shows a snapshot of the electric field component as a function of position for an electromagnetic wave traveling through vacuum. What is the frequency of this wave?

- A. 750 THz
- [✓ B. 600 THz]
- C. 400 THz
- D. 480 THz
- E. 240 THz



Same as version A

10. The average intensity of sunlight reaching the top of the earth's atmosphere is 1360 W/m^2. What is the amplitude of the oscillating electric field of this sunlight?

- [✓ A. 1010 N/C]
- B. 0.0676 N/C
- C. 8.24 N/C
- D. 5.54×10^{-4} N/C
- E. 4.54×10^{-6} N/C

Same as Version B