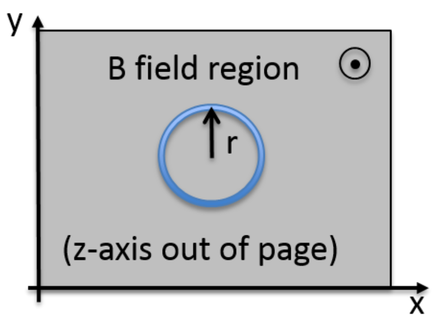
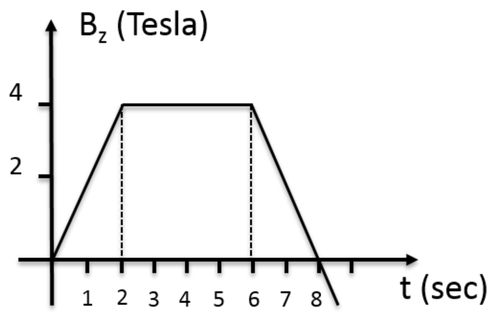
The next three questions pertain to the situation described below.





A loop of wire of radius r = 0.25 m and resistivity 8 Ohms per meter lies in the x-y plane. The loop is fully contained in a spatially constant, but time-varying magnetic field. A graph of the time-dependence of the magnetic field is shown.

1) What is the direction of the induced current in the loop at t = 8 seconds?

a. The induced current is zero at t = 8 seconds
b. Counter-clockwise
c. Clockwise

2) What is the magnitude of the induced current at t = 1.5 seconds?

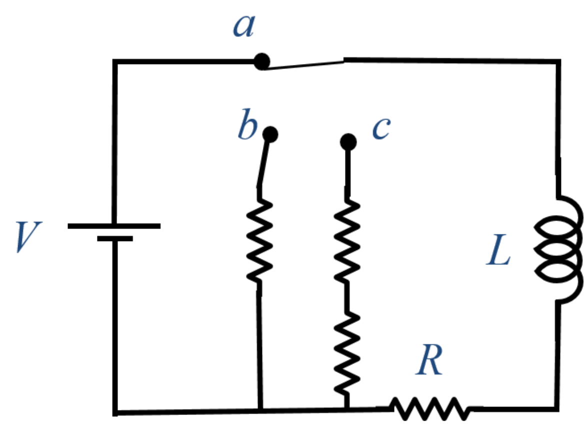
a. $I_{1.5} = 0$ A
b. $I_{1.5} = 0.0468$ A
c. $I_{1.5} = 0.0156$ A
d. $I_{1.5} = 0.0312$ A
e. $I_{1.5} = 0.159$ A

3) Compare the magnitude of the current at t = 4 seconds to the magnitude of the current at t = 7 seconds.

a. $|I_4| = |I_7|$
b. $|I_4| < |I_7|$
c. $|I_4| > |I_7|$

The next four questions pertain to the situation described below.

Consider the electrical circuit shown. It consists of an ideal 18 Volt battery and four 36 Ω resistors and an 24 mH inductor. The switch has been in position **a** as shown for a long time.



4) What is the voltage across the inductor after the switch has been in position **a** for a long time?

a. V_L = 9 Volts
b. V_L = 18 Volts
c. V_L = 0 Volts

5) How much energy is stored in the inductor after the switch has been in position **a** for a long time?

a. U_L = 0.003 Joules
b. U_L = 9 Joules
c. U_L = 0 Joules

6) After being in position **a** for a long time, the switch is instantaneously moved to position **c**. What is the voltage across the inductor immediately after the switch is in position **c**?

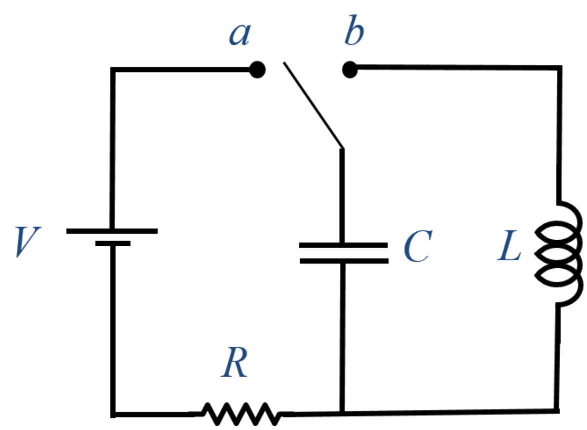
a. V_L = 6 Volts
b. V_L = 54 Volts
c. V_L = 18 Volts

7) After being in position **a** for a long time, you have the option to instantaneously move the switch to either position **b** or position **c**. Which position will result in the energy in the inductor being dissipated the fastest?

a. Position **b**
b. Both positions will dissipate energy at the same rate.
c. Position **c**

The next three questions pertain to the situation described below.

Consider the electrical circuit shown. It consists of an ideal 18 Volt battery a 3.6 Ω resistor a 15 mF capacitor and a 24 mH inductor. The switch has been in position **a** for a long time.



8) After being in position **a** for a long time, the switch is moved to position **b**. What is the rate at which the current through the inductor is changing immediately after the switch is in position **b**?

a. $dI_L/dt = 5$ A/s
b. $dI_L/dt = 750$ A/s
c. $dI_L/dt = 0.675$ A/s

9) Let I_{max} represent the maximum current that flows through the inductor while the switch is in position **b**. After the switch is moved to position b, what is the current through the inductor when the charge on the capacitor is ¼ its maximum value?

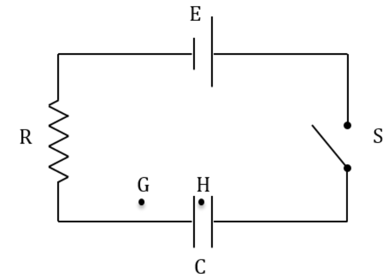
a. $I_{1/4} = 0.97\ I_{max}$
b. $I_{1/4} = 0.5\ I_{max}$
c. $I_{1/4} = 0.063\ I_{max}$
d. $I_{1/4} = 0.75\ I_{max}$
e. $I_{1/4} = 0.25\ I_{max}$

10) Which expression best represents the charge on the top plate of the capacitor if t=0 corresponds to the moment the switch was moved from position **a** to position **b**?

a. $Q(t) = +Q_{max}\sin(\omega t)$
b. $Q(t) = +Q_{max}\cos(\omega t)$
c. $Q(t) = 0$
d. $Q(t) = -Q_{max}\sin(\omega t)$
e. $Q(t) = -Q_{max}\cos(\omega t)$

The next two questions pertain to the situation described below.

Consider the RC circuit shown. It consists of an ideal 18 Volt battery a 30 Ω resistor and a 15 mF capacitor. The capacitor consists of two circular plates separated by a small distance, and is initially uncharged. At time t=0, the switch is closed.



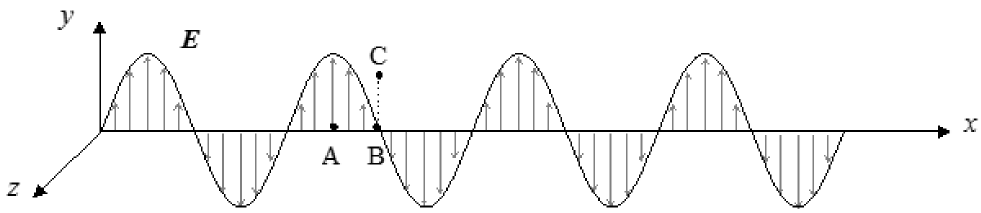
11) Compare the magnitude of the magnetic field at point G, a distance *d* above the wire, and point H, midway between the plates of the capacitor and a distance *d* above its center just after the switch is closed. Note $d<r$ the radius of the capacitor plate.

a. $B_G > B_H$
b. $B_G < B_H$
c. $B_G = B_H$

12) How fast is the electric flux between the capacitor plates changing just after the switch is closed?

a. $d\Phi_E/dt = 3.39 \times 10^{10}\ Nm^2C^{-1}s^{-1}$
b. $d\Phi_E/dt = 6.78 \times 10^{10}\ Nm^2C^{-1}s^{-1}$
c. $d\Phi_E/dt = 4.79 \times 10^{10}\ Nm^2C^{-1}s^{-1}$

The next three questions pertain to the situation described below.



A linearly polarized electromagnetic wave propagates in vacuum. The electric field associated with the wave is:

$\vec{E} = E_0 \sin(kx + \omega t)\hat{y}$

The figure above shows a snapshot of the electric field at t=0.

13) At t = 0, which option best describes the relative magnitudes of the electric field at points A, B and C? Note that A, B and C lie on the x-y plane.

a. $E_C > E_A = E_B = 0$;
b. $E_A > E_C > E_B = 0$;
c. $E_A > E_C = E_B = 0$

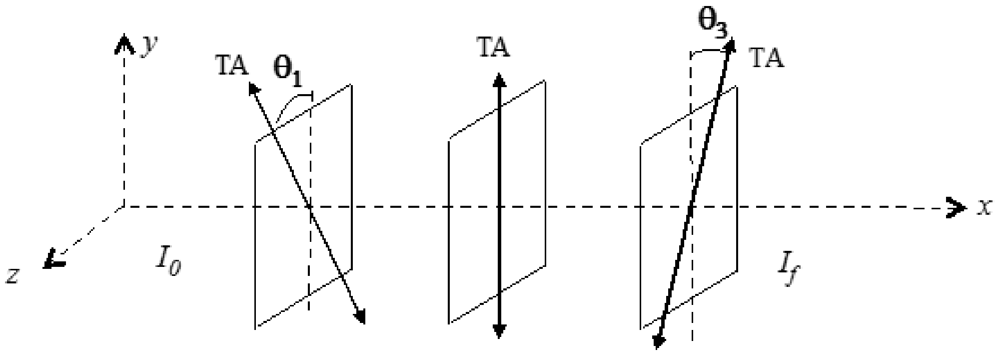
14) Which of the following best describes the magnetic field associated with the electromagnetic wave? Note $E_0 > 0$ and $B_0 > 0$.

a. $\vec{B} = -B_0 \sin(kx - \omega t)\hat{y}$
b. $\vec{B} = -B_0 \sin(kx + \omega t)\hat{z}$
c. $\vec{B} = B_0 \cos(kx + \omega t)\hat{y}$
d. $\vec{B} = B_0 \sin(kx + \omega t)\hat{z}$
e. $\vec{B} = -B_0 \sin(kx + \omega t)\hat{y}$

15) If the amplitude of the magnetic field is $B_0 = 6 \times 10^{-5}$ T, what is the average intensity of the wave?

a. 6.08×10^5 W/m^2
b. 2.05×10^5 W/m^2
c. 3.04×10^5 W/m^2
d. 4.3×10^5 W/m^2
e. 7.74×10^5 W/m^2

The next three questions pertain to the situation described below.



Consider a beam of unpolarized light with initial intensity I_0 traveling in the +x direction. The beam traverses three linear polarizers parallel to the yz plane whose transmission axes (TA) are indicated in the figure above with $\theta_1 = 25°$ and $\theta_3 = 65°$.

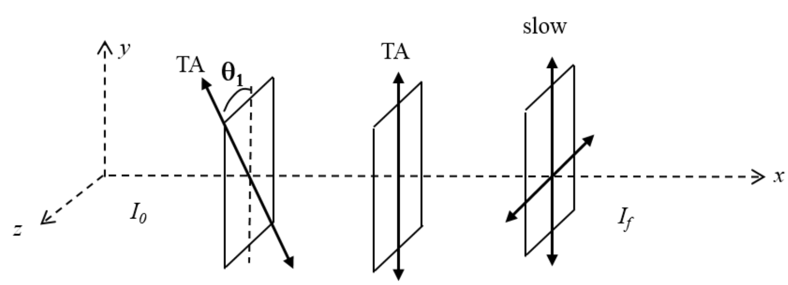
16) Which of the following best describes the relationship between the initial intensity I_f, and the final intensity I_f?

a. $I_f = 0.121\ I_0$
b. $I_f = 0$
c. $I_f = 0.0734\ I_0$

17) Consider the situation where the 2nd and 3rd polarizers are exchanged with each other, how does the final intensity change?

a. I_f will be zero.
b. I_f will not change.
c. I_f will increase.

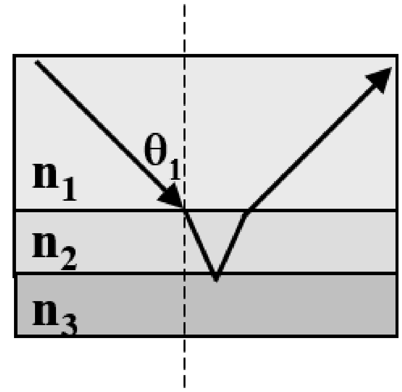
18) Now consider the situation where the third polarizer is replaced with a birefringent material whose slow and fast axes are aligned with the y and z axes respectively as shown in the figure. What is the polarization of the outgoing wave?



a. Right circularly polarized.
b. Left circularly polarized.
c. Linearly polarized.

The next two questions pertain to the situation described below.

Consider the case of light traveling through three different materials in layers with indices of refraction n_1, n_2 and n_3, as shown in the figure.



19) Given the transition between layers 1 and 2 shown in the figure above, what can be concluded about these two materials?

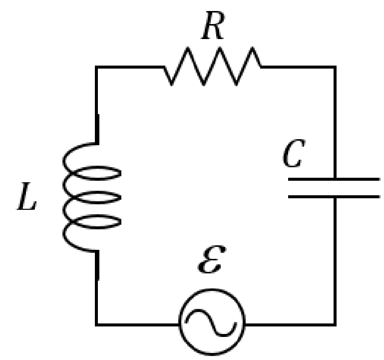
a. $n_1 > n_2$
b. $n_1 = n_2$
c. $n_1 < n_2$

20) If the light is totally reflected between material 2 and 3, which of the following holds?

a. $n_3 \leq n_1 \sin(\theta_1)$
b. $n_3 \geq n_1 \sin(\theta_1)$
c. $n_3 \geq n_1$

The next five questions pertain to the situation described below.

Consider the electrical AC circuit shown. It consists of a variable frequency AC generator providing a voltage V(t) = 18 sin(ωt) Volts, a 10 Ω resistor, a 15 μ F capacitor, and a 24 mH inductor.



21) To what frequency ω should the generator be set in order to maximize the peak voltage across the resistor?

a. ω = 1670 rad/s
b. ω = 0 rad/s
c. The peak voltage across the resistor does not depend on the frequency of the generator.

22) The generator is now set to the resonant frequency for this circuit. What is the maximum energy stored in the inductor at this frequency?

a. U_{max} = 32.4 J
b. U_{max} = 0.0389 J
c. U_{max} = 16.2 J

23) With the generator set to the resonant frequency for this circuit, what is the average power dissipated by the resistor?

a. $\langle P_R \rangle$ = 64.8 W
b. $\langle P_R \rangle$ = 16.2 W
c. $\langle P_R \rangle$ = 32.4 W

24) The generator frequency is now set to 1330 rad/s. Which element has the largest peak voltage?

a. generator
b. capacitor
c. inductor
d. They all have the same peak voltage.
e. resistor

25) With the generator frequency still set to 1330 rad/s, what is the first time after t=0, that the magnitude of the voltage across the resistor is a maximum?

a. $t = 3.78 \times 10^{-4}$ s
b. $t = 8.03 \times 10^{-4}$ s
c. t = 0.00118 s