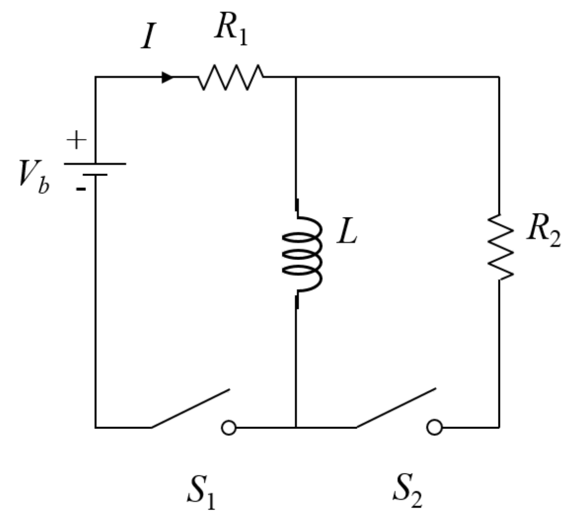
The next three questions pertain to the situation described below.

The circuit below consists of a battery with voltage, V_b = 24 V, two resistors, R_1 = 20 Ω and R_2 = 30 Ω, an inductor, L = 22 mH and two switches, S_1 and S_2. S_1 and S_2 have been open for a long time. At t = 0, S_1 is closed.



1) What is the rate of change of current through the inductor immediately after switch S_1 is closed (e.g. t = 0)?

a. dI/dt = 1090 A/s
b. dI/dt = 1.2 A/s
c. dI/dt = 0.48 A/s
d. dI/dt = 0.8 A/s
e. dI/dt = 0 A/s

2) What is the magnitude of the current through resistor R_1 at time t = 1.4 ms after switch S_1 is closed?

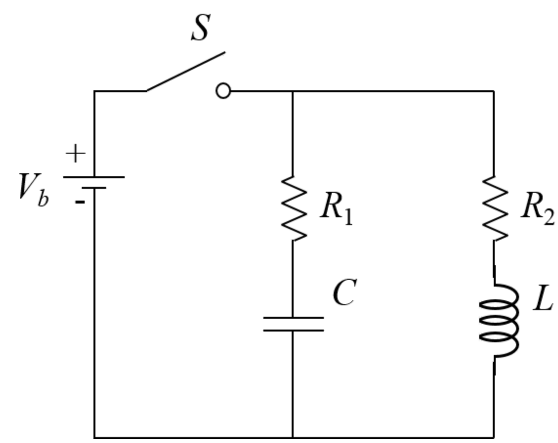
a. $|I_{R1}|$ = 0.864 A
b. $|I_{R1}|$ = 0.336 A
c. $|I_{R1}|$ = 1.02 A

3) After S_1 has been closed for a long time, S_2 is closed, and then S_1 is opened. What is the magnitude of the voltage across resistor R_2, immediately after switch S_1 is opened?

a. $|V_{R2}|$ = 24 V
b. $|V_{R2}|$ = 36 V
c. $|V_{R2}|$ = 16 V

The next three questions pertain to the situation described below.

A circuit is composed of a battery with voltage $V_b = 6$ V, two resistors $R_1 = 40\ \Omega$ and $R_2 = 24\ \Omega$, a capacitor $C = 17$ nF, an inductor $L = 28$ mH and a switch S. The switch has been open for a long time; at $t = 0$, it is closed.



4) What is the current through the battery at $t = 0$, just after the switch is closed?

a. $I_b = 0.0938$ A
b. $I_b = 0.15$ A
c. $I_b = 0.4$ A
d. $I_b = 0$ A
e. $I_b = 0.25$ A

5) What is V_C, the voltage across the capacitor, after the switch has been closed for a long time?

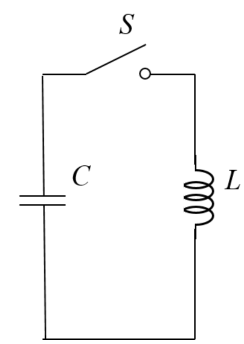
a. $V_C = 3.75$ V
b. $V_C = 0$ V
c. $V_C = 6$ V

6) How much energy is stored in the inductor after the switch has been closed for a long time?

a. $U_L = 0.315$ mJ
b. $U_L = 51$ mJ
c. $U_L = 0.875$ mJ
d. $U_L = 0$ mJ
e. $U_L = 1.5$ mJ

The next three questions pertain to the situation described below.

The circuit shown consists of a capacitor, $C = 4$ μF that has an initial charge $Q_i = 24$ μC, an unknown inductor, L, and an open switch, S. At time $t = 0$ the switch is closed.



7) At $t = 0$, the total energy, E_{tot}, stored in the circuit is

a. $E_{tot} = 0.072$ mJ
b. $E_{tot} = 0.144$ mJ
c. $E_{tot} = 0$ mJ

8) At the instants in time when the current through the inductor is not changing ($dI/dt = 0$), what is V_C, the voltage across the capacitor?

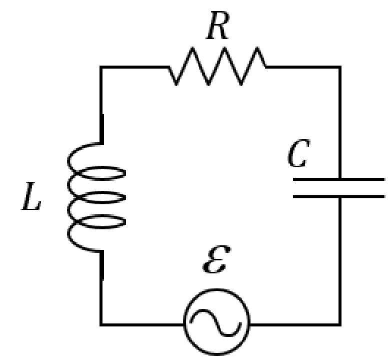
a. $V_C = 12$ V
b. $V_C = 0$ V
c. $V_C = 6$ V

9) After the switch is closed, the frequency of the oscillations in the circuit is measured to be $f = 40$ kHz. At $t = 107$ μs, what is the magnitude of the voltage across the inductor?

a. $V_L = 1.12$ V
b. $V_L = 6$ V
c. $V_L = 0$ V
d. $V_L = 3$ V
e. $V_L = 5.89$ V

The next four 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) = 28 sin(ωt) Volts, a 10 Ω resistor, a 1.5 μF capacitor, and a 2.4 mH inductor.



10) At resonance, which of the following components has the largest peak voltage across it?

a. Generator
b. Capacitor
c. Resistor

11) What is the peak current through the circuit when the generator is running at $\omega = 2 \times 10^4$ rad/s?

a. $I_{max} = 0.583$ A
b. $I_{max} = 1.58$ A
c. $I_{max} = 2.8$ A

12) What is the magnitude of the phase angle between the voltage across generator, and the current through the generator when the generator is running at $\omega = 2 \times 10^4$ rad/s?

a. $|\varphi| = 16.7^o$
b. $|\varphi| = 0^o$
c. $|\varphi| = 55.7^o$

13) With the generator frequency still set to 2×10^4 rad/s, what is the first time after t=0, that the magnitude of the voltage across the resistor is a maximum?

a. $t = 7.85 \times 10^{-5}$ s
b. $t = 1.27 \times 10^{-4}$ s
c. $t = 4.86 \times 10^{-5}$ s

The next four questions pertain to the situation described below.

The electric field in an electromagnetic wave traveling through the vacuum is given by

$\vec{E} = \frac{E_0}{\sqrt{2}}[\hat{x}\cos(kz+\omega t) + \hat{y}\sin(kz+\omega t)]$, where $\omega > 0$ and $k > 0$. The wavelength is $\lambda = 0.5$ cm.

14) What is the angular frequency ω of this wave?

a. $\omega = 1.88 \times 10^{11}$ rad/s
b. $\omega = 3.77 \times 10^{11}$ rad/s
c. $\omega = 1.33 \times 10^{11}$ rad/s

15) The electromagnetic wave is

a. unpolarized.
b. linearly polarized.
c. circularly polarized.

16) Which equation describes the magnetic field of this wave?

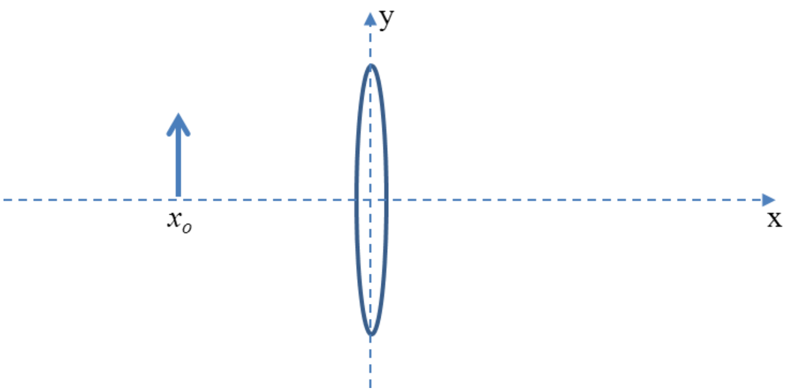
a. $\vec{B} = \frac{E_0}{\sqrt{2}c}[\hat{x}\sin(kz+\omega t) - \hat{y}\sin(kz+\omega t)]$
b. $\vec{B} = \frac{E_0}{\sqrt{2}c}[\hat{x}\sin(kz+\omega t) + \hat{y}\cos(kz+\omega t)]$
c. $\vec{B} = \frac{E_0}{\sqrt{2}c}[\hat{x}\sin(kz+\omega t) - \hat{y}\cos(kz+\omega t)]$
d. $\vec{B} = \frac{E_0}{\sqrt{2}c}[\hat{x}\cos(kz+\omega t) - \hat{y}\sin(kz+\omega t)]$
e. $\vec{B} = \frac{E_0}{\sqrt{2}c}[\hat{x}\cos(kz+\omega t) + \hat{y}\sin(kz+\omega t)]$

17) Which of the following statements about the magnitude of the Poynting vector $|\vec{S}|$ for this wave is correct?

a. $|\vec{S}|$ varies as a function of t but is independent of z.
b. $|\vec{S}|$ varies as a function of both z and t.
c. $|\vec{S}|$ is independent of both z and t.

The next four questions pertain to the situation described below.

A converging lens, made of glass with index of refraction n = 1.5, has a focal length f = 0.25 m. The lens is positioned at x = 0, as shown below.



18) At what position, x_0, to the left of the lens should an object be placed so that the resulting image has a magnification M = -2.5 ?

a. x_0 = -0.35 m
b. x_0 = -0.25 m
c. x_0 = -0.15 m
d. x_0 = -0.1 m
e. x_0 = -0.625 m

19) The resulting image is

a. real
b. virtual

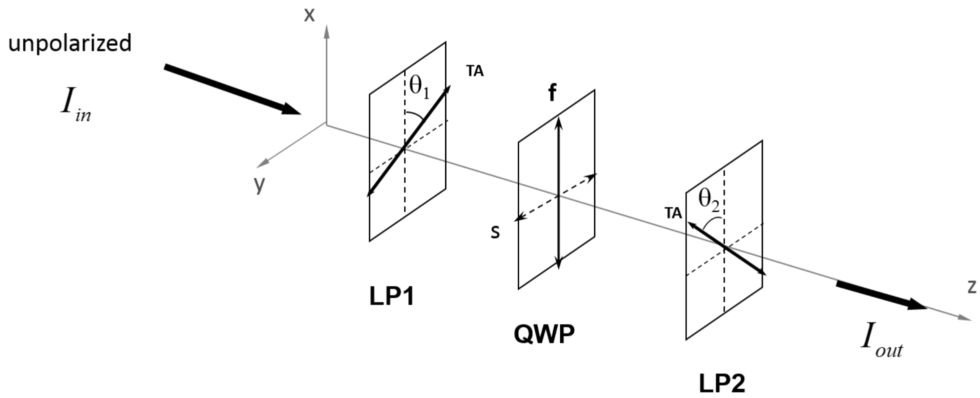
20) The resulting image is

a. upright
b. inverted

21) If the entire apparatus was placed inside an aquarium filled with water (n=1.3), in order to produce an image with the same magnification M = -2.5, the object should be moved

a. closer to the lens.
b. at the same location as when the system was in air.
c. further from the lens.

The next three questions pertain to the situation described below.



Consider a beam of unpolarized light with initial intensity I_{in} traveling in the $+z$ direction that goes through an arrangement of two linear polarizers (LP1 and LP2) and a quarter wave plate (QWP) as shown in the figure. The surfaces of the polarizers and QWP are parallel to the *xy* plane. The transmission axes of the polarizers are at $\theta_1 = 45^{\circ}$ one way and $\theta_2 = 60^{\circ}$ the opposite way with respect to the x-axis, as shown in the diagram. The fast axis of the QWP is parallel to the x axis.

22) What is the polarization of the light immediately after it passes through the quarter wave plate (QWP)?

a. linearly polarized at 60° relative to the *x* axis.
b. left circularly polarized
c. right circularly polarized
d. linearly polarized at 45° relative to the *x* axis.
e. unpolarized

23) What is the intensity of the transmitted light?

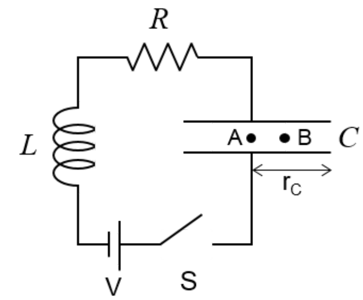
a. $I_{\text{out}} = 0.5 * I_{\text{in}}$
b. $I_{\text{out}} = 0.25 * I_{\text{in}}$
c. $I_{\text{out}} = I_{\text{in}}$
d. $I_{\text{out}} = 0.066 * I_{\text{in}}$
e. $I_{\text{out}} = 0.033 * I_{\text{in}}$

24) If the first polarizer is rotated such that $\theta_1 = 0^{\circ}$, what would happen to the intensity of the transmitted light I_{out}?

a. I_{out} would decrease
b. I_{out} would not change
c. I_{out} would increase

The next two questions pertain to the situation described below.

A series RLC circuit is connected to a battery. The capacitor consists of two parallel, circular plates of radius $r_C = 0.045$ m. At time $t = 0$, the switch is closed.



25) **Immediately** after the switch is closed (e.g. t=0), which of the following correctly describes the magnitude of the magnetic field at points **A** and **B**

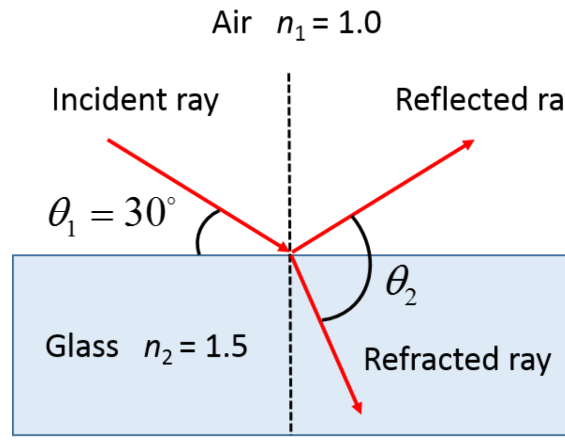
a. $|B_A| < |B_B|$
b. $|B_A| > |B_B|$
c. $|B_A| = |B_B|$

26) At the instant in time when the current through the resistor is 0.4 A, what is the magnitude of the magnetic field at point **B**, a distance $r = 0.015$ m from the center of the capacitor?

a. $|B| = 0$ T
b. $|B| = 5.34 \times 10^{-6}$ T
c. $|B| = 1.98 \times 10^{-7}$ T
d. $|B| = 5.93 \times 10^{-7}$ T
e. $|B| = 1.78 \times 10^{-6}$ T

The next two questions pertain to the situation described below.

A light ray is incident from the air into a glass of index of refraction $n_2 = 1.5$ at an angle $\theta_1 = 30^o$. The angle between the reflected ray and the refracted ray is θ_2 as shown in the figure.



27) What is the value of θ_2?

a. $\theta_2 = 90.0^o$
b. $\theta_2 = 19.5^o$
c. $\theta_2 = 84.7^o$

28) if θ_1 decreases to 25^o, how would θ_2 change?

a. θ_2 would not change
b. θ_2 would increase
c. θ_2 would decrease