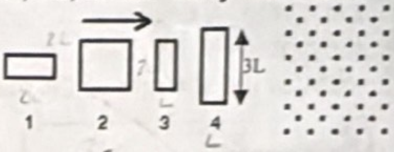
14/09/2023

10/10

Name: [redacted] **Quiz# 1** **Your ID #:** [redacted]

Please answer the below questions:

Q1 (*1pts*): The four wire loops shown have edge lengths of either L, $2L$, or $3L$. They will move with the same speed into a region of uniform magnetic field $\vec{B}$ directed out of the page. Rank them according to the maximum magnitude of the induced emf, least to greatest.



$|\mathcal{E}| = BLv = \left|\frac{d\Phi}{dt}\right|$

$\mathcal{E}_1 = BLv$
$\mathcal{E}_2 = 2BLv$
$\mathcal{E}_3 = 2BLv$
$\mathcal{E}_4 = 3BLv$

A) 1 and 2 tie, then 3 and 4 tie
B) 3 and 4 tie, then 1 and 2 tie
C) 4, then 2 and 3 tie, then 1
D) 1, then 2 and 3 tie, then 4
E) 1, 2, 3, 4

Q1): Answer: D

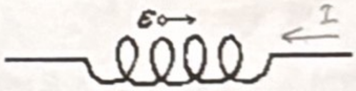
Q2 (*1pts*): In an oscillating LC circuit, the total stored energy is U. The maximum energy stored in the capacitor during one cycle is:

A) $U/2$
B) $U/\sqrt{2}$
C) U
D) $U/(2\pi)$
E) U/π

$U = U_E + U_B$ → at one instance, max U in cap $= U$
oscillates
(all energy stored in cap)

Q2): Answer: C

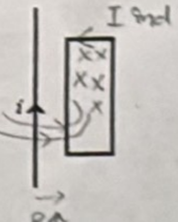
Q3 (*1pts*): The diagram shows an inductor that is part of a circuit. The direction of the emf induced in the inductor is indicated. Which of the following is possible?



A) ~~The current is constant and rightward~~
B) ~~The current is constant and leftward~~
C) The current is increasing and rightward
D) The current is increasing and leftward
E) None of the above

Q4): Answer: D

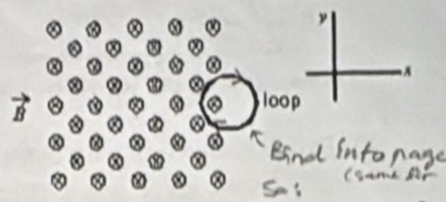
Q4 (*1pts*): A long straight wire is in the plane of a rectangular conducting loop. The straight wire carries a constant current *i*, as shown. While the wire is being moved toward the loop, the current in the loop is:



A) zero
B) clockwise
C) counterclockwise
D) clockwise in the left side and counterclockwise in the right side
E) counterclockwise in the left side and clockwise in the right side

Q4): Answer: C

Q5 (*1pts*): A circular loop of wire is positioned half in and half out of a square region of constant uniform magnetic field directed into the page, as shown. To induce a clockwise current in this loop:



A) move it in $+x$ direction
B) move it in $+y$ direction
C) move it in $-x$ direction
D) move it in $-y$ direction
E) increase the strength of the magnetic field

need into page

cw I

Bind into page (same dir

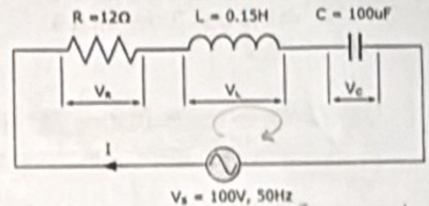
So: B_0 "decreasing" $\Rightarrow \Phi_B$

A

Q4): Answer: A

Q6 (*5pts*): A series RLC circuit containing a resistance of 12Ω, an inductance of 0.15H and a capacitor of 100uF are connected in series across a 100V, 50 Hz supply.

A) Calculate the circuits current,
B) Calculate V_R, V_L and V_C.



$R = 12\,\Omega$

$L = 0.15H$

$C = 100 \times 10^{-6} F$

$V_s = 100V$

$f = 50\,Hz \rightarrow 314.2\,rad/s = \omega$

$I = I_0 \sin(\omega t - \phi) \longleftarrow L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = \varepsilon$

$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$

$I_0 = \frac{\varepsilon_0}{Z},\ Z = \sqrt{R^2 + (X_L - X_C)^2} = 19.4\,\Omega$

By KVL: $V_s - V_R - V_L - V_C = 0$

(A) $I = I_0 \sin(\omega t - \phi) \rightarrow$ max $I = \frac{\varepsilon}{Z} = \frac{100V}{19.4\Omega} = 5.15A$

(B) $V_R = IR$, $V_L = I\omega L$, $V_C = I\frac{1}{\omega C}$

$= 61.8V$ | $= 242.7V$ | $= 163.9V$

[redacted] ε

$\frac{10}{10}$

Name: [redacted] **Quiz# 2**[redacted] **Your ID #:** [redacted]

Please answer the below questions:

Q1 (*1pts*): Of the three chief kinds of magnetic materials (diamagnetic, paramagnetic, and ferromagnetic) which are used to make permanent magnets?

A) only diamagnetic
B) only ferromagnetic
C) only paramagnetic
D) only paramagnetic and ferromagnetic
E) all three

Q1): Answer: B

Q2 (*1pts*): Which of the following types of electromagnetic radiation travels at the greatest speed in vacuum?

A) Radio waves
B) Visible light
C) X rays
D) Gamma rays
E) All of these travel at the same speed

Q2): Answer: E

Q3 (*1pts*): An electromagnetic wave is transporting energy in the negative *y* direction. At one point and one instant the magnetic field is in the positive *x* direction. The electric field at that point and instant is:

A) positive *y* direction
B) negative *y* direction
C) positive *z* direction
D) negative *z* direction
E) negative *x* direction

$\vec{S} \to -\hat{j} = \vec{E} \times \vec{B}$

$(-\hat{k}) \times \hat{i}$

Q3): Answer: D

Q4 (*1pts*): If the amplitude of the electric field in a plane electromagnetic wave is 100 V/m then the amplitude of the magnetic field is:

A) 3.3×10^{-7} T
B) 6.7×10^{-7} T
C) 0.27 T
D) 8.0×10^{7} T
E) 3.0×10^{10} T

$E_m = 100$ V/m

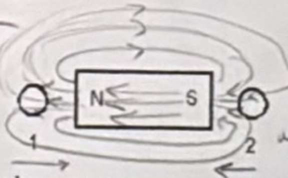
$B_m = ?$

$c = \frac{E_m}{B_m} \to B_m = \frac{E_m}{c} = 3\times10^{-7}$

Q4): Answer: A

same dir

Q5 (*1pts*): The diagram shows two small paramagnetic spheres, one near each end of a bar magnet. Which of the following statements is true?



paramagnetic = weakly attracted

A) The force on 1 is toward the magnet and the force on 2 is away from the magnet
B) The force on 1 is away from the magnet and the force on 2 is away from the magnet
C) The forces on 1 and 2 are both toward the magnet
D) The forces on 1 and 2 are both away from the magnet
E) The magnet does not exert a force on either sphere

Q5): Answer: C

Q6 (*2pts*): If the electric field in a plane electromagnetic wave is given by $E_m \sin[(3 \times 10^6\ \mathrm{m}^{-1}\, x) - \omega t]$, the value of ω is:

A) 0.01 rad/s
B) 10 rad/s
C) 100 rad/s
D) 9×10^{14} rad/s
E) 9×10^{16} rad/s

Show your answer:

$E(t) = E_m \sin(kx - \omega t)$; $k = 3\times10^6\ \mathrm{m}^{-1}$

$k = \frac{2\pi}{\lambda}$, $\omega = 2\pi f$

$c = \lambda f = \frac{2\pi}{k}\cdot\frac{\omega}{2\pi} = \frac{\omega}{k} \Longrightarrow \omega = kc = (3\times10^6)(3\times10^8)$

$= 9.0\times10^{14}$ rad/s

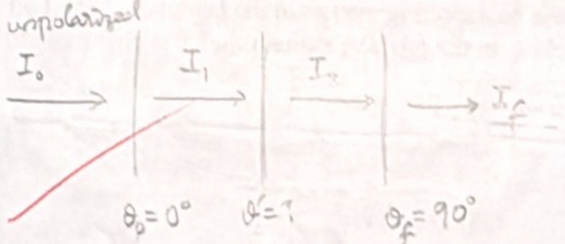
Q6): Answer: $\boxed{D}$

2

Q7 (*3pts*): Three polarizing sheets are placed in a stack with the polarizing directions of the first and third perpendicular to each other. What angle should the polarizing direction of the middle sheet make with the polarizing direction of the first sheet to obtain maximum transmitted intensity when unpolarized light is incident on the stack?

A) 0°
B) 30°
C) 45°
D) 60°
E) 90°

Show your answer:



$0 \le \cos^2\theta \le 1$

$0 \le \sin^2\theta \le 1$

$\theta = \frac{\pi}{4}$ ↗ $\frac{1}{2}$ ↘ $\frac{1}{2}$ $\Rightarrow \frac{1}{4}$

$\theta = \frac{\pi}{3}$ ↗ $\frac{1}{4}$ ↘ $\frac{3}{4}$ $\Rightarrow \frac{3}{16}$

$\theta = \frac{\pi}{6}$ ↗ $\frac{3}{4}$ ↘ $\frac{1}{4}$ $\Rightarrow \frac{3}{16}$

$I_1 = \frac{1}{2} I_0$ (I_0 is unpolarized)

$I_2 = I_1 \cos^2\theta'$

what we want to make I_f max

$I_f = I_2 \cos^2(90 - \theta') = I_2 \sin^2\theta'$

$= I_1 \cos^2\theta' \sin^2\theta' = I_1 (\cos\theta' \sin\theta')^2$

will be max for $2\sin\theta\cos\theta$ also $= \sin 2\theta \Longrightarrow \sin(2\frac{\pi}{4}) = 1$

cos, sin alternate between increasing and decreasing, so maximum value will be at the only point at which they are equal: $\theta' = \frac{\pi}{4} = 45°$

Q7): Answer: $\boxed{C}$

9/10

Name: [redacted] **Quiz# 3** [redacted] **Your ID #:** [redacted]

Please answer the below questions:

Q1 (*1pts*): The term "virtual" as applied to an image made by a mirror means that the image:
A) is on the mirror surface
B) cannot be photographed by a camera
C) is in front of the mirror
D) is the same size as the object
E) cannot be shown directly on a screen

Q1): Answer: E

Q2 (*1pts*): Two plane mirrors make an angle of 120□with each other. The maximum number of images of an object placed between them is:
A) one
B) two
C) three
D) four
E) more than four

Q2): Answer: B

Q3 (*1pts*): An object is in front of a converging lens, at a distance less than the focal length from the lens. Its image is:
A) virtual and larger than the object
B) real and smaller than the object
C) virtual and smaller than the object
D) real and larger than the object
E) virtual and the same size as the object

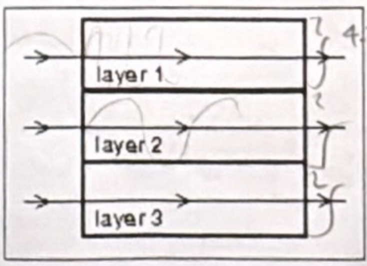
$\frac{1}{f} = \frac{1}{p} + \frac{1}{i}$

10 4 -6.6

Q3): Answer: A

Q4 (*1pts*): The light waves represented by the three rays shown in the diagram all have the same frequency. 4.7 wavelengths fit into layer 1, 3.2 wavelengths fit into layer 2, and 5.3 wavelengths fit into layer 3. Rank the layers according to the speeds of the waves, least to greatest.

A) 1, 2, 3
B) 2, 1, 3
C) 3, 1, 2
D) 3, 2, 1
E) 1, 3, 2



4.7λ
3.2λ
5.3λ

$\downarrow\lambda_n = \frac{\lambda}{n\uparrow}$ $\uparrow n = \frac{c}{\downarrow v}$ $f = \frac{\downarrow v}{\downarrow\lambda}$

Q4): Answer: C

Q5 (*1pts*): When light travels from one medium into a different medium with a different index of refraction,
A) the frequency, wavelength, and speed all change.
B) the frequency and wavelength change but the speed stays the same.
C) the speed and wavelength change but the frequency stays the same.
D) the speed and frequency change but the wavelength stays the same.
E) only the speed changes; the frequency and the wavelength stay the same.

Q5): Answer: C

Q6 (*2.5pts*): In a compound microscope, the objective has a focal length of 1.0 cm, the eyepiece has a focal length of 2.0 cm, and the tube length is 25 cm. What is the magnitude of the overall magnification of the microscope?

A) 25
B) 50
C) 100.
D) 250
E) 310

Q6): Answer: E

Show your answer:

$f_{ob} = 1.0cm$ $\quad |M| = \left| -\frac{25}{1} \cdot \frac{25}{2} \right| = 312.5$

$f_{ey} = 2.0cm$

$s = 25cm$

$M = m m_\theta = ? = -\frac{L}{f} \cdot -\frac{d_{ob}}{f_{ey}}$

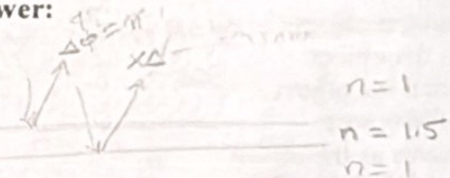
$M = -\frac{s}{f_{ob}} \cdot \frac{25cm}{f_{ey}}$

Q7 (*2.5pts*): A soap film is illuminated by white light normal to its surface. The index of refraction of the film is 1.50. Wavelengths of 480 nm and 800 nm and no wavelengths between are intensified in the reflected beam. The thickness of the film is:

A) 1.5×10^{-5} cm
B) 2.4×10^{-5} cm
C) 3.6×10^{-5} cm
D) 4.0×10^{-5} cm
E) 6.0×10^{-5} cm

Q7): Answer: B

Show your answer:



$\lambda_1 = 480nm \leftarrow$ maximum

$\lambda_2 = 800nm$

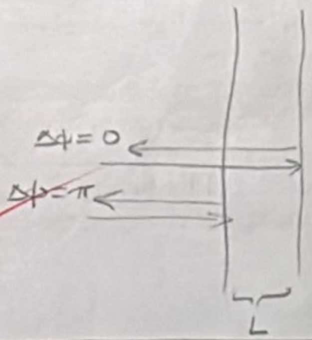
Maxima in thin films for single phase shift:

$2n_2 L = (m + \frac{1}{2})\lambda$

$L = \frac{m + \frac{1}{2}}{2n_2} \lambda = \frac{(1) + \frac{1}{2}}{2(1.5)} \cdot (480) = 240$

1.5

$m = 1$



10/10 well done

[redacted]

Name: [redacted] **Quiz# 4** [redacted] **Your ID #:** [redacted]

Please answer the below questions:

Q1(*3pts*): Bragg's law for x-ray diffraction is $2d\sin\theta = m\lambda$, where θ is the angle between the incident beam and:

A) a reflecting plane of atoms
B) the normal to a reflecting plane of atoms
C) the scattered beam
D) the normal to the scattered beam
E) the refracted beam

plane θ θ

Q1): Answer: A

Q2(*1pts*): In the equation $d\sin\theta = m\lambda$ for the lines of a diffraction grating, $d\sin\theta$ is:

A) the number of slits
B) the slit width
C) the slit separation
D) the order of the line
E) the path length difference

Q2): Answer: E

$\sin\theta = \frac{\Delta}{d}$

Q3(*1pts*): A diffraction grating just resolves the wavelengths 400.0 nm and 400.1 nm in first order. The number of slits in the grating is:

A) 400
B) 1000
C) 2500
D) 4000
E) not enough information is given

$\lambda_1 = 400\,nm$
$\lambda_2 = 400.1\,nm$
$m = 1$

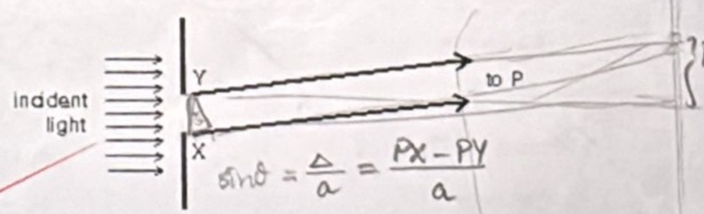
$R = \frac{\lambda_{avg}}{\Delta\lambda} = Nm$

$N = \frac{400.05}{0.1} \approx 4000$

Q3): Answer: D

Q4 (*2pts*): The diagram shows a single slit with the direction to a point P on a distant screen (not shown). At P, the pattern has its second minimum (from its central maximum). If X and Y are the edges of the slit, what is the path length difference (PX) – (PY)?

A) $\lambda/2$
B) λ
C) $3\lambda/2$
D) 2λ
E) $5\lambda/2$



$\sin\theta = \frac{\Delta}{a} = \frac{PX - PY}{a}$

Q4): Answer: D

Show your answer:

m = 2

single slit

$a\sin\theta = m\lambda$

min

$\Delta = PX - PY = P(X - Y) = a\sin\theta = m\lambda$

(path diff.)

$2\lambda = \Delta = PX - PY$

Q5(*2.5pts*): The intensity of the single-slit diffraction pattern at any angle θ is given by $I(\theta) = I_m\left(\frac{\sin\alpha}{\alpha}\right)^2$. For light of wavelength 480 nm falling on a slit of width 3.5 μm, what is the value of α when θ = 18°?

A) 0.31 rad
B) 2.3 rad
C) 7.1 rad
D) 7.3 rad
E) 9.8 rad

Q5): Answer: C

Show your answer:

$\lambda = 480\,nm$

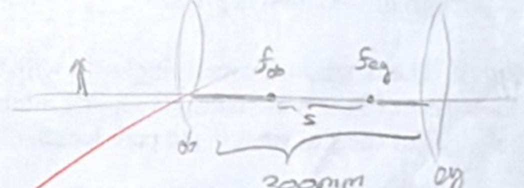
$a = 3.5\,\mu m$

$\alpha = ?$

$\theta = 18^\circ$

$\alpha = \frac{\pi a}{\lambda}\sin\theta = 7.08\,rad \approx 7.1\,rad$

Q6) (*2.5pts*): An object is 10.0 mm from the objective of a certain compound microscope. The lenses are 300 mm apart, and the intermediate image is 50.0 mm from the eyepiece. What overall magnification is produced by the instrument?



$P_o = 10\,mm$

$d = f_{ob} + s + f_{ey} = 300\,mm$

$P_e = 50.0\,mm \approx f_{ey}$

$L_o = \overset{d - P_e}{300 - 50} = 250\,mm$

$f_{ob} = \frac{1}{\frac{1}{L_o} + \frac{1}{P_o}} = 9.62\,mm$

$s = d - f_{ob} - f_{ey} = 300 - 9.62 - 50 \approx 240\,mm$

$M = -\frac{s}{f_{ob}} \cdot \frac{250\,mm}{f_{ey}}$

$= -\frac{240 \cdot 250}{9.62 \cdot 50}$

$\boxed{M \approx -125}$

V. good

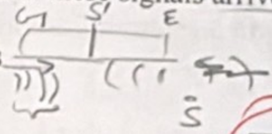
8
10

Name: [redacted] Quiz# 5 [redacted] Your ID #: [redacted]

Please answer the below questions:

Q1(*1pts*): A train traveling very fast ($v = 0.6c$) has an engineer (E) at the front, a guard (G) at the rear and an observer (S') exactly half way between them. Both E and G are equipped with yellow signaling lamps. The train passes a station, closely observed by the station master (S). Both E and G use their lamps to send signals. According to both S and S' these signals arrive simultaneously at the instant S' is passing S. According to S':

A) E and G sent their signals simultaneously from different distances
B) G sent his signal before E and from further away
C) G sent his signal before E but was the same distance away
D) E sent his signal before G and from further away
E) none of the above



Q1): Answer: A

Q2(*1pts*): The mass of a particle is m. In order for its total energy to be twice its rest energy, its momentum must be:

A) $mc/2$
B) $mc/\sqrt{2}$
C) mc
D) $\sqrt{3}mc$
E) $2mc$

$E = \sqrt{(pc)^2 + E_0^2} = 2E_0$

$(pc)^2 + E_0^2 = 4E_0^2$

$(pc)^2 = 3E_0^2 = 3m_0^2c^4 = p^2c^2$

$p = \sqrt{3}mc$

Q2): Answer: D

Q3(*1pts*): The probability that a particle is in a given small region of space is proportional to:

A) its energy
B) its momentum
C) the magnitude of its wave function
D) the wavelength of its wave function
E) the square of the magnitude of its wave function

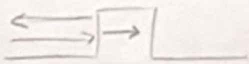
$|\psi|^2 =$ prob.

Q3): Answer: E

Q4(*1pts*): The reflection coefficient R for a certain barrier tunneling problem is 0.80. The corresponding transmission coefficient T is:

A) 0.80
B) 0.60
C) 0.50
D) 0.20
E) 0

$R = 0.80$



$T = 1 - R = 0.20$

Q4): Answer: D

Q5(*1pts*): The length of a meter stick moving at $0.95c$ in the direction of its length with respect to the laboratory is measured by simultaneously marking its ends on an axis which is stationary in the laboratory. As measured by clocks moving with the stick, the time interval between the making of the back mark and the making of the front mark is:

A) 0 s
B) 1.1×10^{-9} s
C) 3.2×10^{-9} s
D) 3.5×10^{-9} s
E) 1.1×10^{-8} s

$\beta = 0.95$, $L_0 = 1m \rightarrow \gamma = 3.20 \rightarrow L = \frac{L_0}{\gamma} = 0.313m$

$\Delta t_0 = ? = \frac{\Delta t}{\gamma}$

Q5): Answer: C

Q6(*2.5pts*): Identical particles, each with energy E, are incident on the following four potential energy barriers:

1. barrier height = $5E$, barrier width = $2L$
2. barrier height = $10E$, barrier width = L
3. barrier height = $17E$, barrier width = $L/2$
4. barrier height = $26E$, barrier width = $L/3$

Rank the barriers in terms of the probability that the particles tunnel through them, from least probability to greatest probability.

A) 1, 2, 3, 4
B) 4, 3, 2, 1
C) 1 and 2 tied, then 3, then4
D) 1, then 2 and 3 tied, then 4
E) 3, 2, 1, 4

Show your answer:

$T \approx e^{-2bL}$, $b = \sqrt{\frac{8\pi^2 m(U_b - E)}{h^2}} \rightarrow b \propto \sqrt{E}$

$\equiv \alpha$

① $b = 2\sqrt{\alpha E}$, $T = \frac{1}{e^{4\sqrt{\alpha E}L}}$ $\xrightarrow{2L}$ $= \frac{1}{(e^{20L})^4} \rightarrow \frac{1}{\phi^4}$

② $b = \sqrt{9\alpha E} = 3\sqrt{\alpha E}$, $T = \frac{1}{e^{9\sqrt{\alpha E}L}} = \frac{1}{\phi^3}$ ϕ

③ $b = 4\sqrt{\alpha E}$, $T = \frac{1}{\phi^2}$

④ $b = 5\sqrt{\alpha E}$, $T = \frac{1}{\phi^{1.667}}$

T↑ when denom↓ $\Longrightarrow$ 4, 3, 2, 1

??

α

Q6): Answer: $\boxed{B}$

2

Q7(*2.5pts*): An electron in an atom initially has an energy 5.5 eV above the ground state energy. It drops to a state with energy 3.2 eV above the ground state energy and emits a photon in the process. The wave associated with the photon has a wavelength of:

A) 5.4×10^{-7} m
B) 3.0×10^{-7} m
C) 1.7×10^{-7} m
D) 1.2×10^{-7} m
E) 1.0×10^{-7} m

Show your answer:

e^-

$E_i = 5.5eV + E_1$

$E_f = 3.2eV + E_1$

$-\Delta E = -2.3eV \longrightarrow E = \frac{h\lambda}{c} \Rightarrow \lambda = \frac{Ec}{h} =$

emitted

$= 3.69\times10^{-19}$ J

h = 1240 eV nm

Q7): Answer: $\boxed{A}$

2