Physics 241
Fall 2009
Final Exam

December 18, 2009

Giving information to or receiving information from another person while taking this exam is cheating. To intentionally do anything that would cause the level of your knowledge of the material to be misrepresented is cheating. Anyone found to be cheating will receive an F for the course and their names will be forwarded to the Dean of Students.

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Sign Name **Student ID**

If during the exam you feel there is an equation that should be on the equation sheet contact one of the exam proctors. Your request will be considered and placed before all the students, if your request is deemed acceptable.

If you feel any of the questions are ambiguous or unclear, complete the problems according to your interpretation of the problem. Include all your work and calculations clearly. Turn in the paper version of the exam along with your optical scan sheet. This will allow you to argue your case, if your solution does not agree with that given as the answer.

Version 1

Physics 241, Exam
Equation Sheet

$$k = 9\cdot10^{9}\frac{Nm^2}{C^2} \qquad k = \frac{1}{4\pi\varepsilon_o} \qquad \varepsilon_o = 9\cdot10^{-12}\frac{C^2}{Nm^2} \qquad 1eV = 1.6\cdot10^{-19}J \qquad e = 1.6\cdot10^{-19}C$$

$$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r} \qquad \vec{E} = k\frac{q_1}{r^2}\hat{r} \qquad \vec{E}(p) = \sum\vec{E}_{ip} \qquad d\vec{E} = k\frac{dq_1}{r^2}\hat{r} \qquad \vec{E} = \frac{\sigma}{\varepsilon_o} \qquad \Delta\vec{E} = \frac{\sigma}{\varepsilon_o}$$

$$\phi = \int_S \vec{E}\cdot\hat{n}\,dA \qquad \oint_S \vec{E}\cdot\hat{n}\,dA = \frac{Q}{\varepsilon_o} \qquad \Delta V = V_b - V_a = -\int_a^b \vec{E}\cdot d\vec{l} \qquad dU = -\vec{F}\cdot d\vec{l} \qquad \vec{F} = q\vec{E}$$

$$dV = \frac{dU}{q_o} = -\vec{E}\cdot d\vec{l} \qquad V = \frac{kq}{r} \qquad V = \sum\frac{kq_i}{r_i} \qquad E_x = -\frac{dV}{dx} \qquad E_y = -\frac{dV}{dy} \qquad E_z = -\frac{dV}{dz}$$

$$\vec{E} = -\frac{\Delta V}{\Delta\vec{r}} \qquad V = \int\frac{k\,dq}{r} \qquad C = \frac{Q}{V} \qquad C = \frac{\varepsilon_o A}{d} \qquad V = \frac{Qd}{\varepsilon_o A} \qquad U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV = \frac{1}{2}CV^2$$

$$u = \frac{1}{2}\varepsilon_o E^2 \qquad \varepsilon = \kappa\varepsilon_o$$

$$\int\cos(\theta)\,d\theta = sin(\theta) \qquad \int sin(\theta)\,d\theta = -\cos(\theta) \qquad \int\frac{dr}{r^2} = -\frac{1}{r} \qquad \int\frac{dr}{r} = \ln(r) \qquad \int r\,d\theta = r\theta$$

$$\int dr = r \qquad \int r\,dr = \frac{r^2}{2}$$

$$h = 6.63\times10^{-34}\,j\cdot\sec$$

$$c = 3\times10^{8}\,m/\sec$$

$$\tau = RC$$

$$I = \frac{\varepsilon}{R}\exp\left(\frac{-t}{RC}\right)$$

$$Q(t) = Q_0\exp\left(\frac{-t}{RC}\right)$$

$$Q(t) = C\varepsilon\left[1-\exp\left(\frac{-t}{RC}\right)\right]$$

$$\vec{F} = q\,\vec{v}\times\vec{B}$$

$$d\vec{F} = I\,d\vec{l}\times\vec{B}$$

$$v = \frac{E}{B}$$

$$\vec{\mu} = N\,I\,A\,\hat{n}$$

$$\vec{\tau} = \vec{\mu}\times\vec{B}$$

$$U = -\vec{\mu}\cdot\vec{B}$$

$$\vec{B} = \frac{\mu_o}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

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

$$\oint_{Surface}\vec{B}\cdot d\vec{A} = 0$$

$$\oint_{Loop}\vec{B}\cdot d\vec{l} = \mu_o I_{Enclosed}$$

$$\vec{B} = \mu_o\vec{M}$$

$$\vec{B} = \vec{B}_{App} + \mu_o\vec{M}$$

$$\vec{M} = \frac{d\vec{\mu}}{dV}$$

$$\phi_M = \int_S\vec{B}\cdot d\vec{A}$$

$$\phi_M = L\,I$$

$$\phi_{M_1} = L_1 I_1 + M\,I_2$$

$$\phi_{M_2} = L_2 I_2 + M\,I_1$$

$$\varepsilon = -\frac{d\phi_M}{dt}$$

$$\varepsilon = \oint_{Loop}\vec{E}\cdot d\vec{l}$$

$$\varepsilon = -L\frac{dI}{dt}$$

$$L = \frac{\phi_M}{I}$$

$$L = \mu_o n^2 Al$$

$$M = \frac{\phi_{M_{21}}}{I_1} = \frac{\phi_{M_{12}}}{I_2}$$

$$U = \frac{1}{2}LI^2$$

$$u_B = \frac{B^2}{2\mu_o}$$

$$\tau = \frac{L}{R}$$

$$I = \frac{\varepsilon_o}{R}\left[1-\exp\left(\frac{-t}{L/R}\right)\right]$$

$$I = \frac{\varepsilon_o}{R}\exp\left(\frac{-t}{L/R}\right)$$

$$I_{rms} = \sqrt{\langle I^2\rangle_{Avg}}$$

$$I_{rms} = \frac{1}{\sqrt{2}}I_{Max}$$

$$V_{rms} = \frac{1}{\sqrt{2}}V_{Max}$$

$$X_L = \omega L$$

$$X_C = \frac{1}{\omega C}$$

$$N_1 I_1 = N_2 I_2$$

$$V_1 I_1 = V_2 I_2$$

$$V = N\frac{d\phi_{turn}}{dt}$$

$$P = I_{rms}V_{rms}$$

$$P = \frac{1}{2}I_{max}V_{max}$$

$$1G = 10^{-4}T$$

$$\mu_o = 4\pi\times10^{-7}\,Tm/A$$

$$1Wb = 1Tm^2$$

$$I_d = \varepsilon_0 \frac{d\phi_E}{dt} \qquad \int \vec{B}\, d\vec{l} = \mu_0 I + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt} \qquad \int \vec{E}\, d\vec{l} = -\frac{d\phi_B}{dt} \qquad \int \vec{B}\, d\vec{l} = 0$$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = 3x10^8 m/s \qquad \vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_0} \qquad S_{ave} = \frac{1}{2\mu_0} EB \qquad I = u_{ave} c\, S_{ave}$$

$$p = \frac{U}{c} \qquad p = \frac{I}{c} \qquad v = \frac{c}{n} \qquad I = \left(\frac{n_1 - n_2}{n_1 + n_2}\right)^2 I_0 \qquad n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$I = I_0 \cos^2\theta \qquad E = hf = \frac{hc}{\lambda} \qquad hc = 1240\ eV\ nm \qquad \frac{1}{s} + \frac{1}{s'} = \frac{1}{f} \qquad f = \frac{r}{2}$$

$$\frac{n_1}{s} + \frac{n_2}{s'} = \frac{n_1 - n_2}{r} \qquad m = \frac{y'}{y} = -\frac{n_1 s'}{n_2 s} \qquad \frac{1}{f} = \left(\frac{n}{n_{air}} - 1\right)\left(\frac{1}{r_1} + \frac{1}{r_2}\right) \qquad m = -\frac{s'}{s}$$

$$\delta = 2\pi \frac{\Delta r}{\lambda} \qquad d\sin\theta_{max} = m\lambda \qquad d\sin\theta_{min} = \left(m - \frac{1}{2}\right)\lambda \qquad a\sin\theta = \lambda \qquad a\sin\theta_{min} = m\lambda$$

$$a\sin\theta = 1.22\lambda$$

Match the Definition in Questions 1-5 with the words below

[a] Birefringence
[b] Real image
[c] Diffuse
[d] Dispersion
[e] Huygens Principle

Question 1:
Each point on a primary wave front serves as the source of spherical secondary waves.

Question 2:
Reflection from a rough surface.

Question 3:
Light really does emanate from this location.

Question 4:
Dependence of the index of refraction on the wavelength.

Question 5:
The speed of light depends on the polarization and propagation direction.

Match the definition in Questions 6-10 with the works below.

[a] Diffraction
[b] Hysteresis
[c] Spherical Aberration
[d] Displacement Current
[e] Diopters

Question 6:
Reciprocal of the focal length

Question 7:
Rays that strike the lens or mirror far from the optical axis are bent to a different focal point than rays near the optical axis.

Question 8:
Bending of waves around corners or barriers.

Question 9:
Created by a changing electric flux.

Question 10:
Changes in the magnetism of a body lags behind changes in the magnetic field.

Question 11.
A satellite orbits the earth 50km above the surface using a camera sensitive at λ=500-nm. What is the diameter of the lens required to just resolve if a person on earth is smoking a cigar (6cm long) or not using Rayleigh criterion.

[a] 0.5m [b] 12cm [c] 3.4 cm [d] 1.2 cm [e] 0.5cm

Question 12.
A wild daisy is 1.2-cm in diameter and is 90-cm from a camera's zoom lens. The lens focal lens has a magnitude 150-mm. Find the distance between the lens and the film.

[a] 15-cm [b] 1.2-cm [c] 18-cm [d] 12.5-cm [e] 6-cm

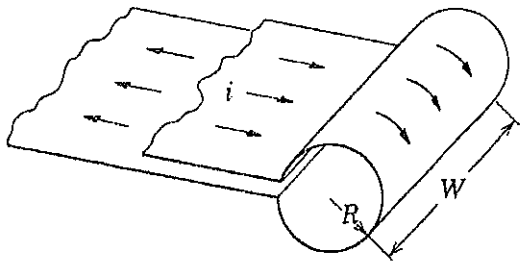
Question 13.
Two coherent radio point sources separated by 2-m are radiating in phase with λ= 50-cm. A detector moved in a circular path around the two sources in a plane containing them will show how many maxima? (Hint: use symmetry)

[a] 12 [b] 16 [c] 21 [d] 8 [e] 36

Question 14.
In a double-slit experiment the intensity of light from one of the slits has an intensity of $4I_o$ and from the other slit the intensity is $9I_o$. When the light from the slits interfere destructively with is the minimum intensity of the light?

[a] I_o [b] $5\ I_o$ [c] $25\ I_o$ [d] 0 [e] $13\ I_o$

Question 15.
A wide copper strip of width **W** is bent into a piece of slender tubing of radius **R** with two plane extensions, as shown in the figure. A current **I** flows through the strip, distributed uniformly over its width.

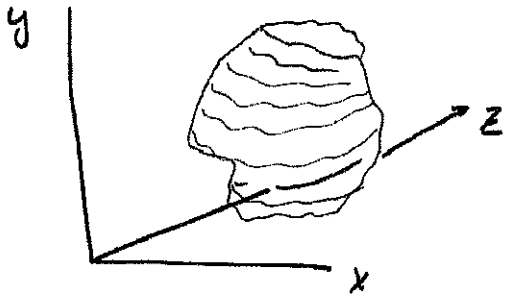


Derive an expression for the magnitude of the magnetic field **B,** well inside the tubular part.

[a] $\frac{\mu_o i W}{R^2}$ [b] $\frac{\mu_o i}{W}$ [c] $\frac{\mu_o i}{R}$ [d] $\frac{\mu_o i R}{W^2}$ [e] $\frac{\mu_o i^2}{W}$

Question 16.

The electric flux, ϕ_E integrated over the closed surface shown in the figure is zero. Which statement is true?



[a] There is no separated charge within the surface.

[b] The charges outside the surface sum to zero.

[c] The charges inside and outside the surface sum to zero.

[d] There is no charge inside or outside the surface.

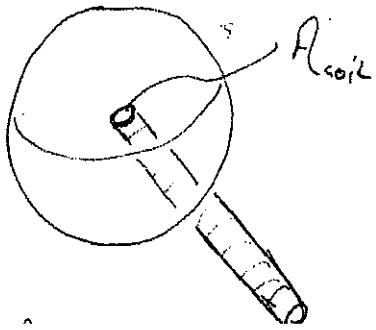
[e] The net charge within the surface is zero.

Question 17.

A generator consists of 10 turns of wire formed into a rectangular loop 50-cm by 30-cm, whose axis of rotation is placed perpendicular to a uniform, B = 3.5-T magnetic field. What is the value of maximum value of the emf produced when the loop is spun at 76 radians per second about an axis perpendicular to **B**?

[a] 12 V [b] 400 V [c] 5200 V [d] 24 V [e] 4×10^6 V

Question 18.
One end of a long thin solenoid with a cross sectional area, A_{coil} of 1-cm^2 or 1x10^{-4}m^2 with a magnetic field strength of 2-tesla is surrounded by a <u>closed</u> Gaussian surface. What is the value of ϕ_B over the Gaussian surface if its radius is 0.3m?



[a] zero

[b] 2x10^{-4} T-m^2

[c] 0.23 T-m^2

[d] 5.2x10^{-3} T-m^2

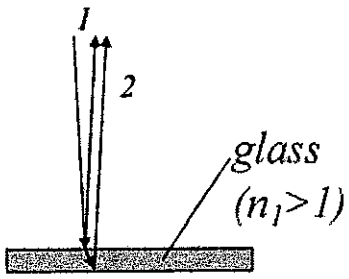
[e] 0.07 T-m^2

Question 19.
A pulse from a ruby laser (λ = 633 nm) has an average power of **2** kW and lasts **2.4** ns. How many photons are emitted in this pulse?

[a] 2.4 x 10^8 [b] 6.3x 10^9 [c] 4.8x 10^{11} [d] 1.5x 10^{13} [e] 7.7x 10^{16}

Question 20.

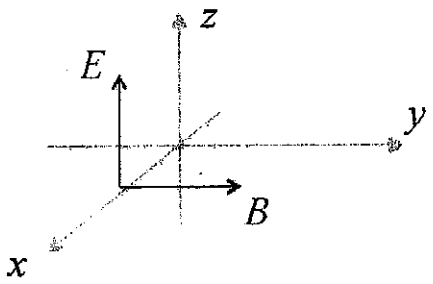
Light of wavelength λ in air is incident normal to a thin layer of glass held in air as shown. If the reflection is suppressed (dark) by interference of rays 1 and 2, what is a possible thickness d of the glass layer?



[a] $\lambda/(4n_1)$ [b] $\lambda/4$ [c] $\lambda/(2n_1)$ [d] $\lambda/2$ [e] $3\lambda/(4n_1)$

Question 21.

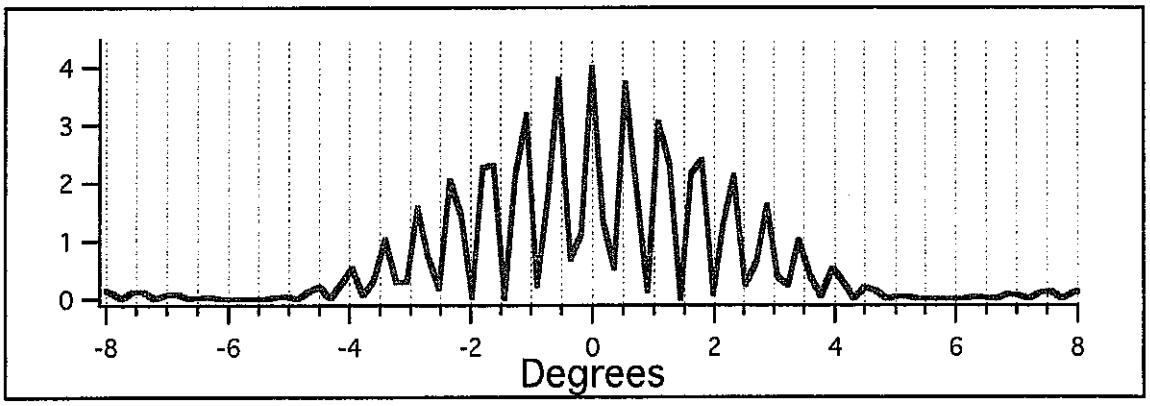
An electromagnetic wave is traveling through a particular point in space where the direction of the electric field is along the +z direction and that of the magnetic field is along the +y direction at a certain instant in time. Which direction is this wave traveling?



[a] +y [b] −y [c] +x [d] −x [e] +z

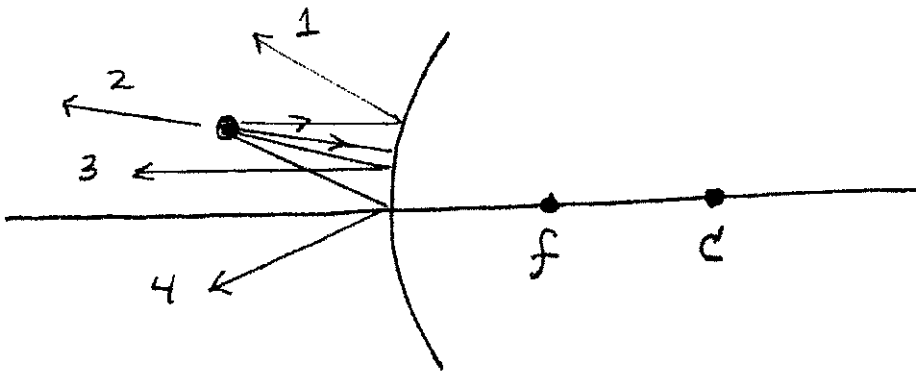
Question 22.
Unpolarized light of intensity I_0 is sent through 3 polarizers, each of the last two rotated 60^0 from the previous polarizer so that the last polarizer is rotated by 120^0 from the first. What is the intensity transmitted by this system?

[a] 0.25 I_0 [b] 0.125 I_0 [c] 0.0625 I_0 [d] 0.03125 I_0 [e] 0



Question 23.
The following intensity pattern is observed on a distant plane from light of $\lambda = 500$-nm falling on a double-slit screen. From the observed pattern **estimate** the size of the slits **a** and the spacing of the slits **d.**

	d	**a**
[a]	500-μm	0.5 μm
[b]	50-μm	5-μm
[c]	5-μm	50-μm
[d]	0.5–μm	5-μm
[e]	50-μm	0.5 μm



Question 24.
A convex mirror, with focal length f and radius of curvature C is shown above. An object is shown as a black ball with a number of rays. Which rays are miss drawn in this ray diagram?

[a] 4 and 2

[b] 1 and 4

[c] 1 only

[d] 3 and 2

[e] all are correct

Question 25.

In the figure a coin is right up against the far edge of the bottom of the mug. When the mug has no water in it the eye can just see the far edge of the coin, ray 1 being a straight line. When the mug is full of water (n=1.33) the eye can just see the entire coin. If the dimensions of the mug are as shown in the figure determine x to find the diameter of the coin?

[a] 1.2-cm

[b] 1.9-cm

[c] 2.1-cm

[d] 2.8-cm

[e] 3.4-cm