Final Exam PHYS-241
December 16, 2004

1.- Three 8 1/2" x 11" crib sheets are allowed. They must be of your own creation.

2.- Please print your name on the top edge of the op-scan sheet and sign it.

3.- Use a #2 pencil to fill in your full name, your student identification number,your recitation division number, and finally the answers for problems 1–20.

$$k = \frac{1}{4\pi\varepsilon_0} = 9\times10^{9}\ \frac{\mathrm{N\cdot m^2}}{\mathrm{C^2}}$$

$$\varepsilon_0 = 8.85\times10^{-12}\ \frac{\mathrm{C^2}}{\mathrm{N\cdot m^2}}$$

$$\mu_0 = 4\pi\times10^{-7}\ \frac{\mathrm{N}}{\mathrm{A^2}}$$

$$e = 1.602\times10^{-19}\ \mathrm{C}$$

$c = 2.99792458\times10^{8}$ m/s (speed of light)

$N_{Avogadro} = 6.022\times10^{23}$ (number of atoms in 12 g of ^{12}C)

$\mathrm{m} \Rightarrow 10^{-3}$ $\mu \Rightarrow 10^{-6}$ $\mathrm{n} \Rightarrow 10^{-9}$ $\mathrm{p} \Rightarrow 10^{-12}$ $\mathrm{f} \Rightarrow 10^{-15}$

$\mathrm{k} \Rightarrow 10^{3}$ $\mathrm{M} \Rightarrow 10^{6}$ $\mathrm{G} \Rightarrow 10^{9}$ $\mathrm{T} \Rightarrow 10^{12}$ $\mathrm{P} \Rightarrow 10^{15}$

For $ax^2+bx+c=0$

$$x = \frac{-b\pm\sqrt{b^2-4ac}}{2a}$$

1. You apply a material with $n = 1.25$ to a lens ($n_g = 1.5$) to make a nonreflective coating due to destructive interference at a wavelength (in a vacuum) of 555 nm. What is the minimum thickness of the coating that you need?

A) 56 nm
B) 111 nm
C) 222 nm
D) 280 nm
E) 140 nm

2. A hollow, charged spherical conducting thin shell has a radius b and a charge q. Find the potential $V(r)$ everywhere, assuming that $V=0$ at $r = \infty$

A) $V = 0,\ r > 0$

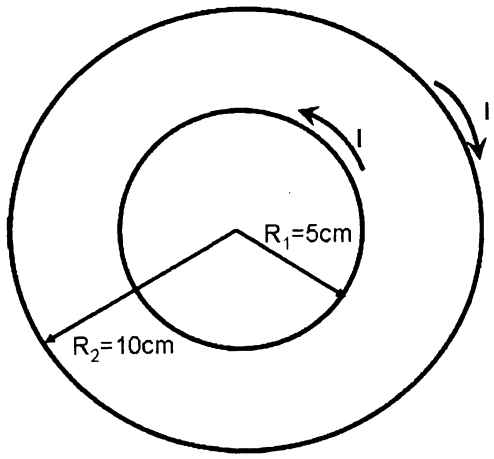
B) $V = \frac{kq}{r},\ r \geq b; \quad V = 0,\ 0 < r \leq b$

C) $V = 0,\ r \geq b; \quad V = \frac{kq}{r},\ 0 < r \leq b$

D) $V = \frac{kq}{b},\ r > 0$

E) $V = \frac{kq}{r},\ r \geq b; \quad V = \frac{kq}{b},\ 0 < r \leq b$

3. Two concentric loops of radii R_1=5cm and R_2=10cm carry equal anti-parallel currents I=5A as in the figure below. Calculate the magnitude and the direction of the total magnetic field in the center:



A) 3.14×10^{-5} T out of the page
B) 3.14×10^{-5} T into the page
C) 1.17×10^{-4} T out of the page
D) 1.17×10^{-6} T into the page
E) 6.42×10^{-6} T into the page

4. Two ideal polarizing sheets with their planes of polarization parallel to each other pass light of intensity I. If the planes are rotated in such a way that their planes of polarization make an angle of 40.0°, the intensity is approximately

A) $0.293I$
B) $0.383I$
C) $0.502I$
D) $0.585I$
E) $0.770I$

5. Two slits separated by 1.0 mm are illuminated with light of a single unknown wavelength. The **tenth bright** line from the central point of the interference pattern is observed to be at an angle of 0.34°. What is the wavelength of the light?

A) 620 nm
B) 590 nm
C) 560 nm
D) 450 nm
E) 600 nm

6. An erect object is $2f$ in front of a converging lens of focal length f. The image is:

A) real, inverted, magnified
B) real, erect, same size
C) real, inverted, same size
D) virtual, inverted, reduced
E) real, inverted, reduced

7. An *LR* circuit has a resistance $R = 25\ \Omega$, an inductance $L = 5.4$ mH, and a battery of emf = 9.0 V. How much energy is stored in the inductance of this circuit when a steady current is achieved?

A) zero
B) 0.35 J
C) 0.35 mJ
D) 0.70 mJ
E) 0.97 mJ

8. You connect a 100-Ω resistor, a 800-mH inductor, and a 10.0-μF capacitor in series across a 60.0-Hz, 120-V (peak) source. Determine the impedance and the approximate resonant frequency of your circuit:

A) 100 Ω and 354 Hz
B) 106 Ω and 60Hz
C) 106 Ω and 56 Hz
D) 100 Ω and 60 Hz
E) None of these is correct.

9. An objet 2 cm high is 10 cm from a convex mirror with a radius of curvature of 10 cm. Locate the position of the image (s') and the height of the image (h')

A) s'= -3.33 cm , h' = 2 cm
B) s'= -3.33 cm , h' = 0.667 cm
C) s'= 3.33 cm , h' = -0.667 cm
D) s'= 3.33 cm , h' = -2 cm
E) s'= -10 cm , h' = 2 cm

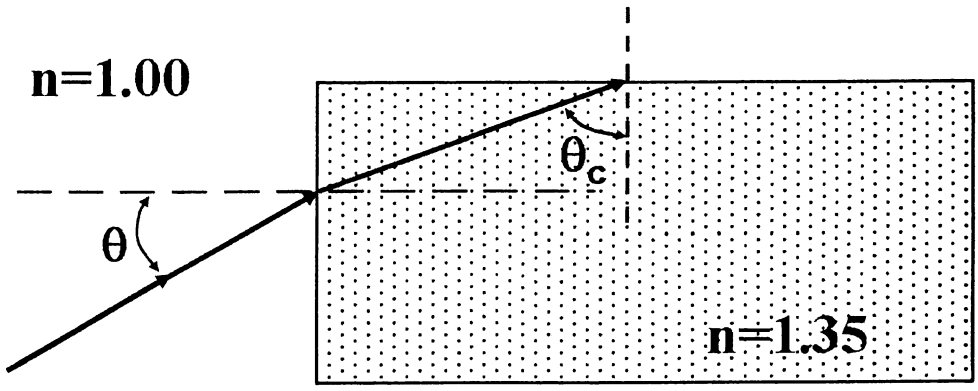
10. Light of wavelength 450 nm is incident on a narrow slit. The diffraction pattern is observed on a screen 5.0 m from the slit, and the central maximum is observed to have a width of 22 cm. What is the width of the slit?

A) 4.5 μm
B) 5.0 μm
C) 10 μm
D) 20 μm
E) 0.20 μm

11. A single loop of wire with a radius of 7.5 cm rotates about a diameter perpendicular to a uniform magnetic field of 1.6 T. To produce a maximum emf of 1.0 V, it should rotate at:

A) 0.0 rad/s
B) 2.7 rad/s
C) 5.6 rad/s
D) 35 rad/s
E) 71 rad/s

12. A ray of light traveling in air enters the end of a rectangular block of a material that has an index of refraction $n = 1.35$. The largest value of the angle θ for which total internal reflection occurs at the **upper surface** of the material is approximately

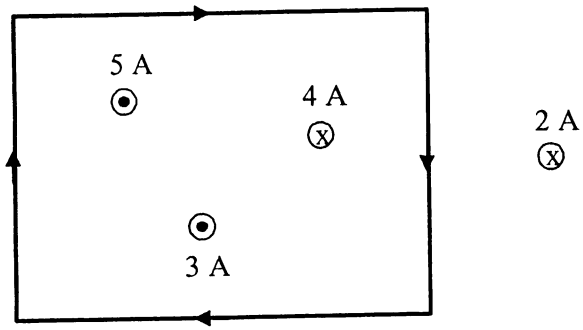


A) 75°
B) 65°
C) 56°
D) 78°
E) None of these is correct.

13. A characteristic number for the rate per unit area at which solar energy is delivered to a spot on the Earth is 1000 W/m^2. Use this number to estimate the amplitude of the electric and magnetic fields in the waves that deliver this energy

A) $E_0=0.6 \times 10^3$ V/m $\quad B_0=0.2\times 10^{-5}$ T
B) $E_0=0.9 \times 10^3$ V/m $\quad B_0=0.3\times 10^{-5}$ T
C) $E_0=0.2 \times 10^3$ V/m $\quad B_0=0.9\times 10^{-5}$ T
D) $E_0=0.3 \times 10^3$ V/m $\quad B_0=0.6\times 10^{-5}$ T
E) $E_0=0.6 \times 10^3$ V/m $\quad B_0=0.9\times 10^{-5}$ T

14. What is the value of $\oint_C \vec{B} \bullet d\vec{\ell}$ for the closed curve shown below? (Note that ⊙ represents a current coming out of the page, and ⊗ represents a current going into the page; the arrows indicate the direction of integration).



A) -5.03×10^{-6} T·m
B) 5.03×10^{-6} T·m
C) -1.51×10^{-6} T·m
D) 1.51 T·m
E) 0 T·m

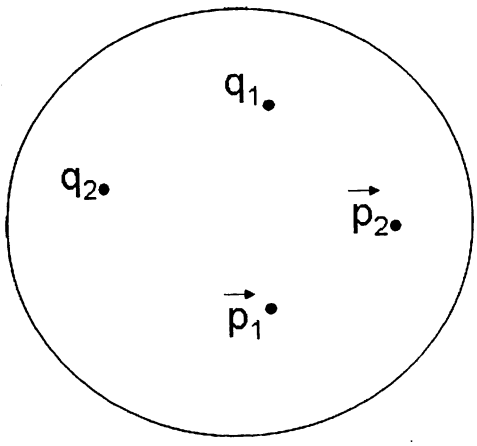
15. A 0.120-μF capacitor, initially uncharged, is connected in series with a 10.0-kΩ resistor and a 12.0-V battery of negligible internal resistance. The charge on the capacitor after a very long time is approximately

A) 28.8 μC
B) 14.4 μC
C) 144 μC
D) 2.88 μC
E) 1.44 μC

16. Two small charged objects repel each other with a force F when separated by a distance d. If the charge on each object is reduced to one-fourth of its original value and the distance between them is reduced to $d/2$ the force becomes:

A) $F/16$
B) $F/8$
C) $F/4$
D) $F/2$
E) F

17. Consider a spherical Gaussian surface of radius 1 m which surrounds two electric dipoles and two charges (one positive and one negative) as shown below. Here $q_1=7$ nC, $q_2=-4$ nC and $p_1=p_2=10^{-10}\ \mathrm{C}\cdot\mathrm{m}$. What is the net flux through the Gaussian surface?



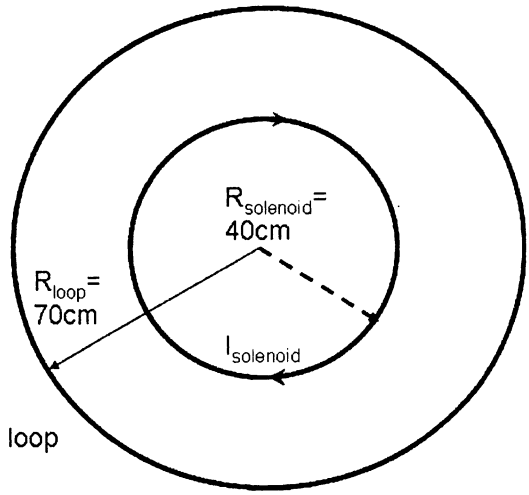
A) 561 $\mathrm{Nm^2/C}$
B) 7959 $\mathrm{Nm^2/C}$
C) 4649 $\mathrm{Nm^2/C}$
D) 339 $\mathrm{Nm^2/C}$
E) 2325 $\mathrm{Nm^2/C}$

18. A proton of mass $m=1.67\times10^{-27}$ kg and charge $q=e=+1.6\times10^{-19}$ C moves in a circle of radius r =21cm perpendicular to a magnetic field $B=$ *0.*4 T. Find the speed of the proton.

A) 3.0×10^{8} m/s
B) 8.76×10^{-6} m/s
C) 2.19×10^{-6} m/s
D) 2.01×10^{6} m/s
E) 8.05×10^{6} m/s

19. A long solenoid with a radius of 40 cm has 10000 turn/m.
a) Find the value of the B field generated inside the solenoid (on the solenoid's axis) when a current of I=10 A flows clockwise (seen from the end of the solenoid).

b) A single circular loop of radius 70 cm is placed around the solenoid, the central axis of the loop and the solenoid coinciding. If the magnetic field in the solenoid decreases uniformely from the value found in part a) to 0.025 T in 0.02 s. Determine the direction of the induced current in the loop.



A)	a) B= 0.13 T	b) counter-clockwise
B)	a) B= 0.13 T	b) clockwise
C)	a) B= 0.048 T	b) counter-clockwise
D)	a) B= 0.048 T	b) clockwise
E)	a) B= 0.084 T	b) counter-clockwise

20. A uniform electric field of 300 N/C makes an angle of 25° with the dipole moment of an electric dipole. If the moment has a magnitude of $2\times10^{-9}\,\mathrm{C\cdot m}$, the torque exerted by the field has a magnitude of:

A) $6.7\times10^{-12}\,\mathrm{N\cdot m}$
B) $2.5\times10^{-7}\,\mathrm{N\cdot m}$
C) $5.4\times10^{-7}\,\mathrm{N\cdot m}$
D) $6.0\times10^{-7}\,\mathrm{N\cdot m}$
E) $2.8\times10^{-12}\,\mathrm{N\cdot m}$

Answer Key

1. B
2. E
3. A
4. D
5. B
6. C
7. C
8. C
9. B
10. D
11. D
12. B
13. B
14. A
15. E
16. C
17. D
18. E
19. B
20. B