PHYSICS 241 FINAL EXAM April 30, 2002

Name_____

SID# _____

WARNING: Some questions require angles in radians. You may even need to work in degrees and radians in the same problem!

The total possible points is 150. You should have 10 pages containing 21 different questions. In some sense this is only 15 problems as several logical problems are broken into two or three questions to allow partial credit.
The op-scan answer sheet should be green, that is, more or less match the test color.

You may use your three two-sided crib sheets and your calculator.
You may take this test booklet with you. If you also record the answers in the test booklet, you may be able to check your grade against a posted key before the official test scores are posted.

Print and encode your name and student ID number and course number on the answer sheet and sign it.

Mark the single best answer for each question on the answer sheet. Double marking a problem or entering your answers under the wrong problem number can be costly.

CONSTANTS

k or $k_E = \frac{1}{4\pi\epsilon_0} = 8.99\text{E}9\ (\text{N}\cdot m^2/C^2)$

$\epsilon_0 = 8.85\text{E-}12\ C^2/(N \cdot m^2)$ or F/m

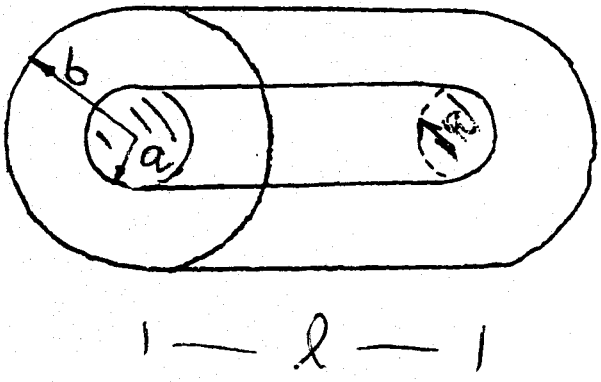
$\mu_0 = 4\pi\ \text{E-}7\frac{T\cdot m}{A} = 1.257\text{E-}6\frac{T\cdot m}{A}$

e = 1.60E-19 C = $-q_{electron} = q_{proton}$

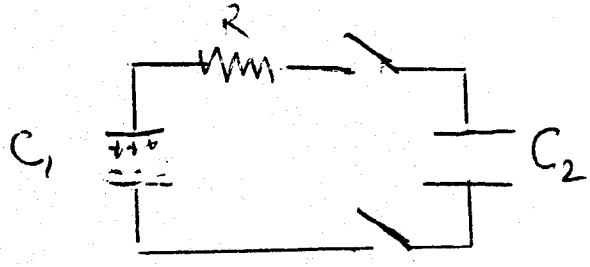
g = 9.81 m/s^2

c = 2.98E8 m/s

1. (9 points) A solid conducting cylinder of radius a = 0.100 m and length ℓ is concentrically surrounded by a thin conducting shell of radius b = 0.400 m and length ℓ as indicated in the Fig. Where there is no conductor, only vacuum is present. ℓ is sufficiently long that the conductors may be treated as infinitely long. If there is uniform linear charge density λ = +6.00E-9 C/m on the inner cylinder and uniform linear charge λ' = -5.00E-9 C/m on the thin shell, what is the magnitude of the electric field at r = 0.300 m in V/m? (Gauss' Law for electrostatics problem).
   A. 35000
   B. 360
   C. 120
   D. 110
   E. 60

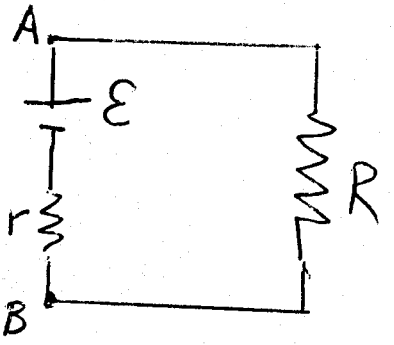


2. (9 points) A capacitor C_1 has a capacitance of 1.00 μF and has a charge of 0.00240 C on one plate and negative charge of the same magnitude on the other. A second capacitor C_2 has a capacitance of 2.00 μF and is initially uncharged. The two capacitors and a large resistor and two switches are connected as shown. At t = 0 the switches are closed and a measurable current flows for a few time constants of the circuit. When static equilibrium is again established, what magnitude of charge in coulombs is on the plates of C_1?
   A. 8.00E-4
   B. 2.4E-3
   C. 0
   D. 1.6E-3
   E. 1.2E-3



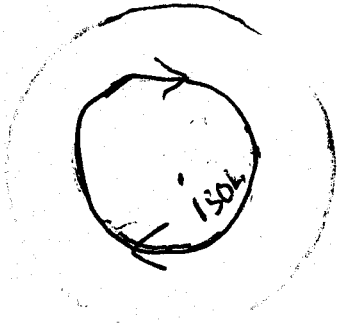
3. (9 points) A real battery of emf $\mathcal{E} = 25.00$ V and internal resistance r = 10.00 Ω is connected to a load resistor R = 3.08 Ω to make the D.C. circuit shown. What is the voltage V_A - V_B?, the so called terminal voltage of the battery in this circuit measured in volts?

A. 19.1
B. 2.50
C. 8.12
D. 5.89
E. 25.0



4. (4 points) A long solenoid with a radius of 40.0 mm has 1000 turns/m. A single circular loop of radius 70.0 mm is placed around the solenoid, the central axis of the loop and the solenoid coinciding. The magnetic field in the solenoid decreases uniformly from 0.200 T to 0.0500 T in 0.0200 s. Seen from an end, the solenoid current i_{sol} flows clockwise. Seen from this same end, the induced current in the loop flows

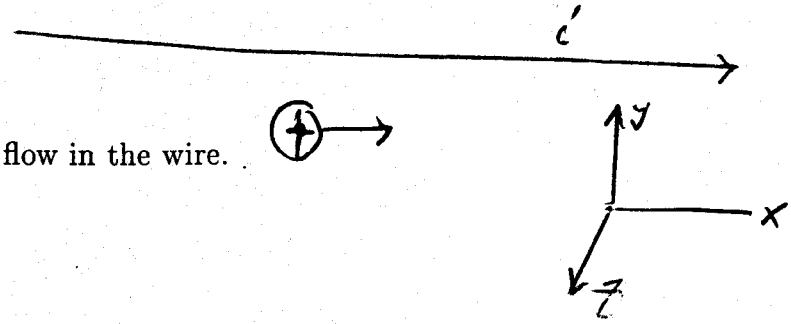
A. Counter-clockwise
B. Clockwise
C. Zero



5. (8 points) In the previous problem, what is the magnitude of the magnetic flux in weber thru the single turn loop at the instant that B = 0.150 T?

A. 6.47E-3
B. 1.89E-2
C. 7.54E-4
D. 2.31E-3
E. 0

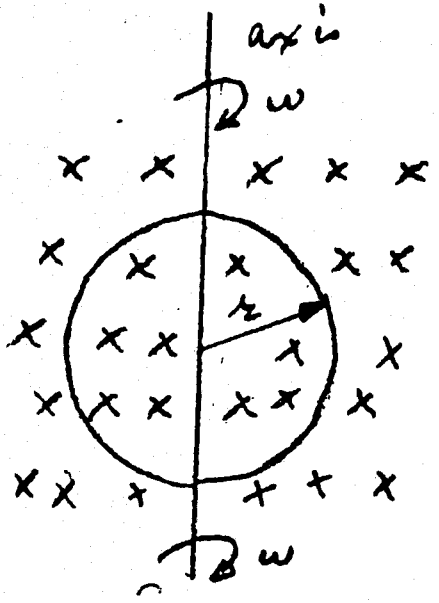
6. (4 points) In the plane of the paper, a long straight wire carries a current i = 3.00 A in the +x direction. In the plane of the paper a proton of charge +e moves with speed v = 200.0 m/s in the +x direction at a distance of 0.250 m below the nearest point of the wire as shown. The wire exerts a magnetic force on the proton that is
   A. toward the wire.
   B. away from the wire.
   C. into the paper.
   D. out of the paper.
   E. in the direction of the current flow in the wire.



7. (6 points) In the above problem, at the location of the proton, the magnitude of the magnetic field due to the long wire in teslas is (Ampere's Law Problem)
   A. 5.02E-6
   B. 1.51E-5
   C. 3.14E-5
   D. 2.40E-6
   E. 4.85E-6

8. (8 points) A uniform $\vec{B}$ field = 0.400 T is directed directly into the paper as shown. A single turn circular loop with radius r = 0.200 m rotates about its diameter. This diameter lies in the plane of the paper and the angular frequency of rotation ω = 10.0 rad/s is in the direction indicated in the Fig. What is the maximum value of the induced emf in Volts?

A. 0.159
B. 7.31
C. 0.502
D. 0.320
E. 0.707



9. (4 points) In the previous problem what is the orientation of the plane of the loop with respect to the plane of the paper when the induced emf is a maximum?

A. the two planes parallel
B. the two planes perpendicular
C. the angle between the two planes ±45°

10. (5 points) An LC circuit (negligible resistance) oscillates with a frequency f = 150 Hz. If L = 0.00250 H, what is the value of the capacitance C in microfarads?
    A. 56.2
    B. 0.00222
    C. 21.2
    D. 0.0228
    E. 450

11. (6 points) In the above problem, if the total energy stored in the capacitor and inductor is 0.00100 J, what is the maximum current i_{max} in amperes that flows in the circuit?
    A. 5.800
    B. 1.60
    C. 0.400
    D. 0.894
    E. 1.26

12. (4 points) In the LC circuit of problem 10, the time average of the current $i(t) = i_{max} \sin(\omega t)$ over many periods equals
    A. $\sqrt{2}\, i_{max}$
    B. $i_{max}/\sqrt{2}$
    C. i_{max}
    D. $i_{max}/2$
    E. 0

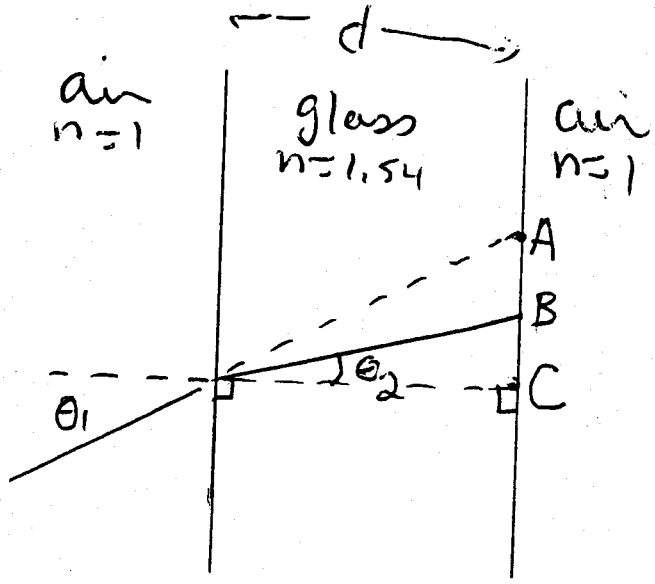
13. (6 points) An object of Height h = 2.00 mm is placed 0.15 m in front of a concave mirror ($|r| = 0.25$ m). What is the magnitude of the height of the image in mm?
A. 5.00
B. 10.0
C. 2.27
D. 20.0
E. 0.455

14. (5 points) In the previous problem the image is
A. virtual, erect
B. virtual, inverted
C. real, inverted, and enlarged
D. real, erect, and reduced in size
E. real, inverted and life-size

15. (9 points) Just above the atmosphere of Venus the intensity I of sunlight is 2560 W/m^2. Assuming the monochromatic plane wave approximation, what is the maximum value E_m (max not rms) of the electric field due to solar electromagnetic radiation near Venus in V/m? Hint: The intensity I is the time average of the magnitude of the Poynting vector $\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$
Thus the instantaneous value of $|S| = EB/\mu_0$ where $E = E_m \sin(kx - \omega t)$
and B = E/c. Remember that the time average of $\sin^2(kx - \omega t)$ is 1/2.
A. 1.91E6
B. 2060
C. 1700
D. 1545
E. 1380

16. (9 points) A light ray strikes a vertical planar plate glass window at an angle of incidence $\theta = 30°$. The index of refraction of the glass is 1.54 and its thickness is d. If there were no refraction, this ray could continue in a straight line and would exit the glass at point A. The ray exits at B such that the distance AB = 1.00 mm. What is the thickness of the glass, d, in mm?

A. 4.27
B. 8.54
C. 6.00
D. 12.2
E. 2.13



17. (9 points) A real object is placed a distance p from a converging lens used as a magnifying glass. The lens has a focal length of magnitude 1.00 cm. It is used to form a virtual image which has a (linear) magnification of magnitude 10. What should the object distance be measured in cm?

A. 1.11
B. 11.1
C. 0.900
D. 0.800
E. 2.00

18. (9 points) A parallel line diffraction grating consists of 14,000 slits per meter. If the wavelength of the light is $\lambda = 500$ nm, at what angle in degrees does the m = 2 line occur?
    A. 0.802
    B. 4.09E-9
    C. 1.00
    D. 3.14
    E. 0.014

19. (9 points) We define visible light as electromagnetic radiation having a wavelength in vacuum in the range from 400 to 700 nm inclusive. Monochromatic light of wavelength λ (measured in vacuum) is normally incident on a thin film glass of thickness L = 3.00E-7 m. The film has an index of refraction = 1.50. Assume vacuum on either side of the film. It is desired that the reflected light be maximal. What wavelength of visible light λ in nanometers (as measured in vacuum) should be used?
    A. 600
    B. 450
    C. 400
    D. 700
    E. 650

20. (9 points) A plane wave of monochromatic light of wavelength 538 nm is incident on a long slit of width 0.025 mm. Fringes are observed on a distance screen. Light traveling at an angle $\theta = 0.180°$ with respect to the light traveling to the central peak at 0.0° is observed on the screen. The intensity observed relative to the central intensity is
Note: At the distant screen, the phase difference α between light from the top and from the middle of the slit is half the phase difference ϕ from the top to the bottom of the slit. The phase difference ϕ is to 2π as the path difference a $\sin\theta$ between light traveling from the top of the slit to the screen and light traveling from the bottom of the slit to the screen is to the wavelength of the light.
Also note: That θ is given in degrees, but α must be in radians in the intensity formula.
A. 0.0175
B. 0.00102
C. 0.000305
D. 0.932
E. 0.965

21. (9 points) A camera lens is made of thick piece of glass of index $n_3 = 1.50$. The front surface of this lens is coated with a thin film of MgF_2 which has an index of refraction $n_2 = 1.38$. Light is normally incident from air ($n_1 = 1.00$) on the film. To minimize loss of light in the film, its thickness L should be as small as possible. It is desired to minimize the reflection of light from the coated lens for light with a vacuum wavelength of 550 nm. What thickness of MgF_2 in nm is needed?
A. 275
B. 138
C. 199
D. 100
E. 92

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241 spring 2002 Keys for Final
prob number, points, salmon key, green key
,.....salm..green

01.	9	D	B
02.	9	D	A
03.	9	A	D
04.	4	A	B
05.	8	C	C
06.	4	A	A
07.	6	C	D
08.	8	E	C
09.	4	B	B
10.	5	B	E
11.	6	D	D
12.	4	E	E
13.	6	A	B
14.	5	C	C
15.	9	D	E
16.	9	E	A
17.	9	C	C
18.	9	C	A
19.	9	D	A
20.	9	A	D
21.	9	B	D

Total = 150