YOUR NAME _____

Final Examination Physics 2301, Fall 2000

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Closed books, except for the use of unprogrammed simple calculators. Partial credit may be given for some of the problems if you clearly show your work. All 20 problems carry a credit of 10 points. You may use the formula sheet received in class (also attached). To this you were allowed to add twenty (20) additional formulas of your choice and bring that sheet with you to this examination. No other formula sheet is allowed.

Useful constants: $e=1.6x10^{-19} \text{ C}, m_e=9.1x10^{-31} \text{ kg}, m_p=1.67x10^{-27} \text{ kg}, \epsilon_0=8.85x10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2, k_e=8.99x10^9 \text{ N}\cdot\text{m}^2/\text{C}^2, \mu_0=4\pi\times10^{-7} \text{ Wb/A}\cdot\text{m}.$

Problem 1 At a distance r from a positive point charge q, the electric potential is 400V and the magnitude of the electric field is 300 N/C. Determine the value of q.

Answer: *q* = _____

Problem 2 A solid conducting sphere is surrounded by a larger concentric, spherical, conducting shell. The inner sphere has a net charge +Q (Q>0), and the outer shell has a net charge -3Q. The charges are in electrostatic equilibrium.

- (a) On the figure on the right, clearly indicate the amount of charge accumulating on *each of the three surfaces*.
- (b) Draw electric field lines in the space between the solid sphere and the hollow shell.
- (c) Write down the electric potential as a function of radius, V(r), outside the conducting shell.



Problem 3 The electric bill for operating a standard 75 W lightbulb at 120 V in a 30-day month is 25 cents. If one kWh of electricity costs 8.0 cents, how much charge flowed through the light bulb?

Q = _____ **Problem 4** (2 points for each question) a) Two identical point charges of 1.5 µC are separated by a distance of 0.50 m. The magnitude of the electric force acting between them is F = b) The electric field is defined by the equation c) The electric flux from the sphere of a Van de Graaff generator is 400,000 Nm²/C. What is the charge on the sphere? Q =_____ d) A pure inductance L (R = 0) is connected at t = 0 to a Back-emf = battery having an emf ε . What is the back-emf at t > 0? e) The current in an RL circuit raises to 63% of its maximum value in a time 0.17 s. What is the time constant of the circuit? Time constant = **Problem 5** (2 points for each question) a) The source of the **B**-field is b) The defining equation for the **B**-field in **VECTOR FORM** is c) The force on a straight wire carrying a current I in a uniform **B**-field is d) Write down an important property of magnetic field lines: e) The change in the kinetic energy of a charged particle moving in a **B**-field is

<u>Problem 6</u> A proton $(1.67 \times 10^{-27} \text{ kg})$ is being accelerated from rest through a potential difference of 300 V. It then enters a magnetic field of 0.065 T perpendicular to the direction of motion. Calculate the radius of the path of the proton in the magnetic field.

Radius = _____

<u>Problem 7</u> Using only 10 μ F capacitors, design a combination capacitor, which has an equivalent capacitance of 35 μ F. You can use as many 10 μ F capacitors as you need.

Problem 8 A 0.75 μ F is charged by a 40 V power supply. The fully charged capacitor is then discharged through a 9.0 mH inductor. Find the maximum current in the resulting oscillations.

 $I_{max} =$

Problem 9 A circular coil lying in the plane of this paper has an area of 80 cm² and is made of 200 turns of copper, resulting in a resistance of 2.0 Ω . A uniform magnetic field of 0.085 T points perpendicularly outward through the coil towards you and decreases uniformly to zero in 0.45s. a) What is the current in the coil while the field decreases? (5 points)

Current =

b) The direction of the induced current is (5 points)

Up____ down _____ clockwise ______ counter-clockwise _____

<u>**Problem 10**</u> A solenoid inductor is 4.0 cm long and has a cross sectional area of 1.2 cm^2 . When the current through the solenoid decreases at a rate of 12 A/s, the induced emf is 20 mV. Find the number of turn per m of the solenoid.

Number of turns/m = _____

Problem 11 A closed rectangular conducting loop is placed near a long straight wire carrying current *I*. The straight wire is moving away from the loop with velocity $\vec{\mathbf{v}}$, as shown in the figure.

- (1) What is the direction of the induced current in the loop?
 - (a) Clockwise
 - (b) Counterclockwise
 - (c) No current

(2) What is the direction of *net* magnetic force on the loop?

- (a) Left
- (b) Right
- (c) Up
- (d) Down
- (e) Into the paper
- (f) Out of Paper
- (g) None of above



Problem 12 The magnification produced by a converging lens is found to be -4 for an object placed 0.25 m from the lens. What is the focal length of the lens?

Answer: *f* = _____

Problem 13 A certain kind of glass has an index of refraction of 1.66 for blue light (440 nm) and an index of 1.59 for red light (690 nm). Now a beam containing these two colors is incident at an angle of 35° on a piece of this glass. What is the angle between the two beams inside the glass?

<u>Problem 14</u> The light reflected from a soap bubble of refraction index 1.33 appear red ($\lambda = 612$ nm). What is the minimum thickness?

- a) 115 nm
- b) 153 nm
- c) 230 nm
- d) 306 nm
- e) 345 nm
- f) 459 nm
- g) None of above

<u>Problem 15</u> An optical fiber with index of refraction of 1.6 is submerged in water ($n_w = 1.33$). What is the critical angle for total internal reflection to occur under water?

- a) 45°
- b) 65°
- c) 39°
- d) 49°
- e) 33°
- f) 56°
- g) None of above

1. The Kirchhoff's junction rule is based on the conservation of charge. ſ 1 2. The equivalent capacitance of a series combination is always larger than any individual Γ 1 capacitance in the combination. 3. Γ If a moving charge does not experience any magnetic force, the magnetic field must be 1 zero in that region. 4. Γ Due to the oscillations of current and charge in an LC circuit, the total energy of the 1 system also oscillates. 5. Total internal reflection cannot occur when light travels from vacuum to an optical Γ 1 medium with higher index of refraction. **Problem 17** (check all partial questions, 2 points each) Optical dispersion occurs because The frequency of monochromatic light changes The color of light changes in the medium

 The color of light changes in the medium
 T _____ F ____

 The index of refraction depends on wavelength
 T _____ F ____

 Images formed by a curved concave mirror may:
 T _____ F ____

 Invert up and down
 T _____ F ____

 Invert left and right
 T _____ F ____

Problem 16 Fill in a **T/F** answer for each statement below:

Problem 18 Consider a divergent lens with a focal length f. Place an upright object within the interval f and 2f to the left of the lens and construct the image with a straight edge. (No credit for crooked lines!)

Characterize the image above by using the words: real or virtual, upright or inverted, reduced or enlarged: (3 points)

Problem 19 Suppose that a computer screen has a pixel spacing of 0.26 mm between the dots on the screen. Assume a wavelength of light of 530 nm for viewing.

a) Calculate the best possible angular resolution for the human eye with a pupil diameter of 2.0 mm. (Ignore the index of refraction of the eye.) (5 points)

angle = radian

b) How close to the screen would you have to sit in order to barely distinguish the individual pixels? (5 points)

Distance from screen = cm

Problem 20 A beam of light traveling in vacuum is incident on a smooth, flat slab of unknown plastic as shown in the figure.

b) What is the index of refraction of the unknown plastic?

(b) What is the speed of light in the unknown plastic?

Bonus question (5 points for either answer) Which of the two homework types did you prefer? (check one)

I preferred the homework from the textbook with the solutions on the internet

I preferred the UT online homework

