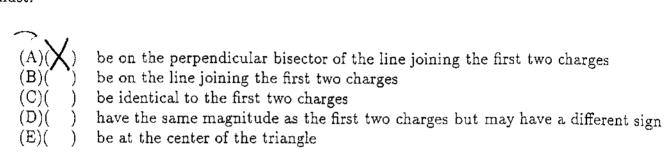
Name:	_ID#:

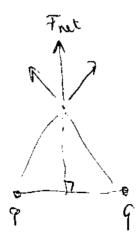
This is a closed book exam. Print and encode your name, student ID number, and recitation number on the answer sheet. Answers to all the questions are to be recorded on the answer sheet. There are 10 multiple choice questions for a total of 100 points. Do not do the problems in the order in which they are given. Do the easy problems first. There is only one correct answer to each question. No penalty for a wrong answer. However, all credit for a question will be lost if more than one choice is marked for that question. You may use your crib sheet and calculator. Fill out the op-scan card gradually, as soon as you finish a problem. Do not wait filling out the op-scan card during the last hectic five minutes!

USEFUL CONSTANTS:

```
\begin{array}{l} k_e \equiv 1/(4\pi\epsilon_0) = 8.99 \times 10^9 \; (Nm^2/C^2) \\ \epsilon_0 = 8.85 \times 10^{-12} \; (C^2/Nm^2) \\ e = 1.60 \times 10^{-19} \; (C) \\ m_e = 9.11 \times 10^{-31} \; (kg) \\ g = 9.81 \; (m/s^2) \\ m_p = 1.67 \times 10^{-27} \; (kg) \\ \text{proton charge} = \text{electron charge (in magnitude)}. \\ \mu_0/4\pi = 10^{-7} \\ c = 3.00 \times 10^8 \; \text{m/s} \\ \text{Atomic Mass Unit (AMU)} = 1.66 \times 10^{-27} \; \text{Kg} \end{array}
```

1. (10 points) Identical point charges are located at two vertices of an equilateral triangle. A third charge is placed so the electric field at the third vertex is zero. The third charge must:





2. (10 points) A spherical shell has an inner radius of 3.7 cm and an outer radius of 4.5 cm. If charge is distributed uniformly throughout the shell with a volume density of $6.1\times 10^{-4}~\bar{\rm C}/m^3$ the total charge is:

(A)(
$$\times$$
) 1.0 × 10⁻⁷ C
(B)() 1.3 × 10⁻⁷ C

(C)()
$$2.0 \times 10^{-7}$$
 C
(D)() 2.3×10^{-7} C

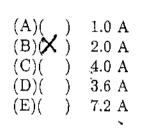
(E)()
$$4.0 \times 10^{-7}$$
 C

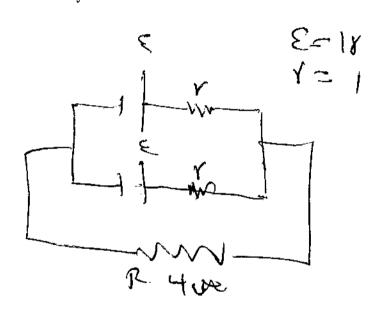
$$Q = \frac{4}{3}\pi \left(Y_0^3 - Y_1^3 \right)$$

3. (10 points) Two identical charges q are placed on the x axis, one at the origin and the other at x=5 cm. A third charge -q is placed on the x axis so the potential energy of the three charge system is the same as the potential energy at infinite separation. Its x coordinate is:

- 4. (10 points) The two capacitors shown each have a capacitance of $1\mu F$. Their total stored energy is:
 - (A)() 0.01 J (B)() 0.02 J (C)(>) 0.04 J (D)() 0.06 J
 - (E)() none of these $Q = \frac{1}{2} C_1 V_1^2 + \frac{1}{2} C_2 V_2^2$
 - = (E-6)(2m)= 0.04 T

5. (10 points) Two identical batteries, each with an emf of 18 V and an internal resistance of 1 Ω , are wired in parallel by connecting their positive terminals together and connecting their negative terminals together. The combination is then wired across a 4 Ω resistor. The current in each battery is:





Thitally worked

6. (10 points) A certain capacitor, in series with a 720 Ω resistor, is being charged. At the end of 10 ms its charge is half the final value. The capacitance is about:

(A)() 9.6
$$\mu$$
F (B)() 14 μ F (C)(X) 20 μ F (C)(X) 20 μ F (D)() 7.2 μ F (E)() 10 F (Q = $\frac{E}{R}$ (1 - $\frac{C}{R}$ - $\frac{C}{R}$)

$$Q = Q_0 \left(1 - \frac{C}{R}\right)$$

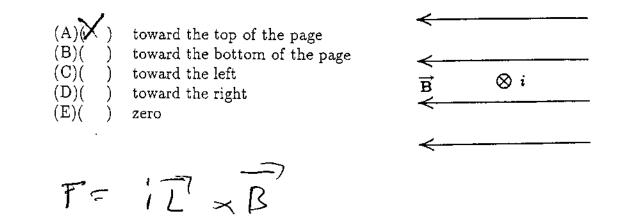
$$\frac{1}{2} = 1 - \frac{C}{R} = \frac{1}{2}$$

$$\frac{1}{2} = \frac{1}{2} - \frac{1}{2} = \frac{1}{2}$$

$$\frac{1}{2} = \frac{1}{2} = \frac{1}$$

7. (10 points) A proton (charge e), traveling perpendicular to a magnetic field, experiences the same force as an α particle (charge 2e) which is also traveling perpendicular to the same field. The ratio of their speeds, $v_{\text{proton}}/v_{\alpha}$, is:

8. (10 points) The figure shows a uniform magnetic field \vec{B} directed to the left and a wire carrying a current into the page. The magnetic force acting on the wire is:



9. (10 points) Two long parallel straight wires carry equal currents in opposite directions. At a point midway between the wires, the magnetic field they produce is:

(A)(

zero non-zero and along a line connecting the wires non-zero and parallel to the wires non-zero and perpendicular to the plane of the two wires none of the above

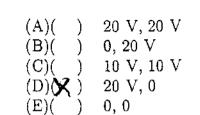
10. (10 points) A solenoid is 3.0 cm long and has a radius of 0.50 cm. It is wrapped with 500 turns of wire carrrying a current of 2.0 A. The magnetic field in tesla at the center of the solenoid is:

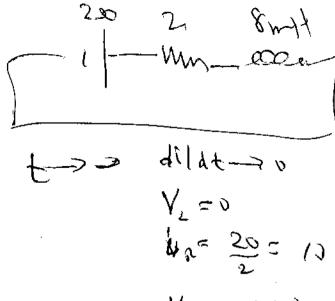
(A)()
$$9.9 \times 10^{-8}$$

(B)() 1.3×10^{-3}
(C)(X) 4.2×10^{-2}
(D)() 16
(E)() none of these

$$N_{4} = \frac{N}{L} = \frac{500}{0.03} = 16700.$$

11. (10 points) An 8.0 mH inductor and a 2.0 Ω resistor are wired in series to a 20 V ideal battery. A switch in the circuit is closed at time 0. After a long time the potential difference across the resistor and the emf of the inductor are:





12. (10 points) A capacitor in an LC oscillator has a maximum potential difference of 15 V and a maximum energy of 360 μ J. At a certain instant the energy in the capacitor is 40 μ J. At that instant what is the emf induced in the inductor?

(A)() zero
(B)()
$$5 \text{ V}$$

(C)(X) 10 V
(D)() 15 V
(E)() 20 V

When $M_{c} = 360 \text{ pW}$

When
$$V_{c} = 40 \, \text{pt}$$
 for V_{L}

When $V_{c} = 40 \, \text{pt}$ for V_{L}
 $\frac{1}{2}CV_{min} = N_{max} = \frac{1}{2}C(15)^{2} = 3.60 \, \text{E} - 4$
 $C = 3.20 \, \text{E} - 6 \, \text{F}$
 $\frac{1}{2}CV_{c}^{2} = 91$ at $l_{loo} = 4.00 \, \text{E} - 5$

$$V_{c} = 5 \text{ V}$$

$$V_{c} + V_{c} = 15$$

$$V_{L} = 10 \text{ V}$$

13. (10 points) An ac generator producing 10 V (rms) at 200 rad/s is connected in series with a 50 Ω resistor, a 400 mH inductor, and a 200 μ F capacitor. The rms voltage (in volts) across the capacitor is:

From = - Erms Siso(wt t)

$$\frac{\text{Evms Xc} = (10)(25)}{74.3} = 3.36 \text{ V}$$

14. (10 points) In a stack of three polarizing sheets the first and third ark crossed while the middle one has its axis at 45° to the axis of the other two. The fraction of the intensity of an incident unpolarized beam of light that is transmitted by the stack is:

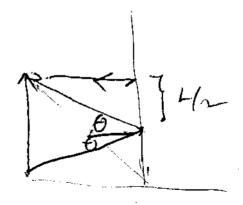
1 Cost 450 5 0, 125- 1

15. (10 points) The critical angle for total internal reflection at a diamond air interface is 25°. Suppose light is incident at an angle of θ with the normal. Total internal reflection will occur if the incident medium is: I me the who is air and $\theta = 25^{\circ}$ (A)(diamond and $\theta < 25^{\circ}$ air and $\theta > 25^{\circ}$ diamond and $\theta > 25^{\circ}$ air and $\theta < 25^{\circ}$ Medium in which the

incident beam is traveling

16. (10 points) A 5.0 ft woman wishes to see a full length image of herself in a plane mirror. The minimum length mirror required is:

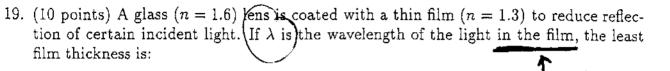
(A)() 5 ft
(B)() 10 ft
(C)(X) 2.5 ft
(D)() 3.54 ft
(E)() no answer: the farther away she stands the smaller the required mirror length



- 17. (10 points) A concave spherical mirror has a focal length of 12 cm. If an object is placed 18 cm in front of it the image position is:
 - (A)() 7.2 cm behind the mirror
 (B)() 7.2 cm in front of the mirror
 (C)() 36 cm behind the mirror
 (D)() 36 cm in front of the mirror
 (E)() at infinity

18. (10 points) In a Young's double-slit experiment the center of a bright fringe occurs wherever waves from the slits differ in the distance they travel by a multiple of:

- a fourth of a wavelength a half a wavelength
- a wavelength three-fourths of a wavelength none of the above





less than $\lambda/4$ $\lambda/4$

- 20. (10 points) Monochromatic light is normally incident on a grating that is 1 cm wide and has 10,000 slits. The first order line is deviated at a 30° angle. What is the wavelength, in nm, of the incident light?
 - (A)() 300 (B)() 400 (C)() 500 (D)() 600 (E)() 1000

$$10000 \text{ stds/cm} = 10^6/\text{m} = \frac{1}{6}$$