Take-Home Final Examination of Fundamentals of Electromagnetism

日期____________ **評分**____________
系級 **學號** **姓名**

The first two problems will be your extra credit of 20% in your final examination on June 16.

1. (10%) An RC direct-current Circuit is consist of a resistor $R = 5$ kΩ, a capacitor $C = 10000$ μF, and a constant-voltage power supply, $V = 5$ (V), in series. Initially, the capacitor is empty of electric charges and the power supply turns on at $t = 0$. After a long time when the electric capacitor is fully charged, the power supply is automatically turned off and the electric capacitor is discharging until there is no more electric voltage on the capacitor. You will write a computer program with Kirchhoff's law and plot a curve of voltage on the electric capacitor versus time from $t = 0$ to the capacitor is fully charged and then fully discharged.

   The mandatory conditions are to use two undetermined loops in your computer program. The first loop will be automatically terminated when the capacitor is fully charged and your will state the condition with your physics knowledge. And then, your computer program will immediately move to the second loop. The second undetermined loop will also be automatically stopped until the capacitor is fully discharged and your will state the condition with your physics knowledge.

2. (10%) A charged particle of mass $m = 1.67\ \times 10^{-27}$ (kg) and charge $q = 1.6\ \times 10^{-19}$ (Coul) is inside a uniform magnetic field $\vec{B} = 2\hat{z}$ (Tesla) and a uniform electric field $\vec{E} = 1\hat{y}$ (N/C), with initial velocity $\vec{v}_0 = (0, 0, 0)$ (m/s). Write a computer program with Newton's second law of motion and find the particle's trajectory of $\vec{r}\,(t) = \hat{x}r_x\,(t) + \hat{y}r_y\,(t) + \hat{z}r_z\,(t)$. You will plot the trajectory in 3-Dimensional diagram starting with $t = 0$ and along its progress in time.

   The recommendation is to assume a very small time increment such as $\Delta t = 0.001$ (sec). Within a small time interval the particle is moving similar to a constant acceleration motion. You may assume its initial position arbitrarily, for instance, $\vec{r}_0 = (0, 0, 0)$ (m). Calculate the initial acceleration of particle from the initial magnetic force. You may then calculate the vectors of velocity $\vec{v} = (v_x, v_y, v_z)$ and position $\vec{r} = (r_x, r_y, r_z)$ after one time step, and find the corresponding magnetic force, $\vec{F} = (F_x, F_y, F_z)$, and acceleration, $\vec{a} = (a_x, a_y, a_z)$, and so on and so forth. You may use a fixed loop of 1000 or 10000 steps to simulate the particle's trajectory. Adjust any given initial values if you see fit.

The other problems will be scores of your practice tests. You obtain one more point of your semester grade if you can complete one of the following assigned programming problems.

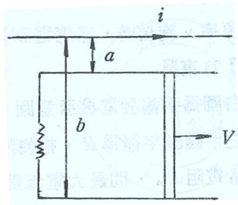
1. (1% for the semester) A charged particle of mass $m = 1.67\ \times 10^{-27}$ (kg) and charge $q = 1.6\ \times 10^{-19}$ (Coul) is inside a uniform magnetic field $\vec{B} = 2\hat{z}$ (Tesla), with initial velocity $\vec{v}_0 = 1.0\hat{y} + 2.0\hat{z}$(m/s). Write a computer program with Newton's second law of motion and find the particle's trajectory of $\vec{r}\,(t) = \hat{x}r_x\,(t) + \hat{y}r_y\,(t) + \hat{z}r_z\,(t)$. You will plot the trajectory in 3-Dimensional diagram starting with $t = 0$ and along its progress in time.

   This is a problem extracted and revised from the Transferring Examination of Nation Taiwan University in 1985.

   The recommendation is to assume a very small time increment such as $\Delta t = 0.001$ (sec). Within a small time interval the particle is moving similar to a constant acceleration motion. You may assume its initial position arbitrarily, for instance, $\vec{r}_0 = (0, 0, 0)$ (m).

Calculate the initial acceleration of particle from the initial magnetic force. You may then calculate the vectors of velocity $\vec{v} = (v_x, v_y, v_z)$ and position $\vec{r} = (r_x, r_y, r_z)$ after one time step, and find the corresponding magnetic force, $\vec{F} = (F_x, F_y, F_z)$, and acceleration, $\vec{a} = (a_x, a_y, a_z)$, and so on and so forth. You may use a fixed loop of 1000 or 10000 steps to simulate the particle's trajectory. Adjust any given initial values if you see fit.

2. (1% for the semester) The figure shows a copper rod moving on conducting rails with constant velocity v parallel to a very long straight wire carrying a constant current i. (a) Calculate the induced Electric Motive Force $\mathscr{E}$ in the rod; (b) Calculate the force required to keep the rod in motion. You may assume that $v = 8.00$ (m/s), $i = 100$ (Ampere), $a = 0.50$ (cm), $b = 25.0$ (cm), and $R = 10.0\ \Omega$.



This is a problem extracted from the Transferring Examination of Nation Taiwan University in 1980.

You will obtain the answers either with mathematics in details or with a computer program simulating the necessary integrals with the concepts of Faraday's law of electromagnetic induction and the magnetic force on a moving current-carrying wire in a magnetic field.

3. (2% for the semester) Two stationary point charges +3.00 nC and +2.00 nC are separated by a distance of 50.0 cm. An electron is released from rest at a point midway between the two charges and moves along the line connecting the two charges. Find the speed of the electron when it is 10.0 cm from the charge +3.00 nC.

You will write a computer program with concepts of Newton's second law of motion and the constant-acceleration motion in a very short time increment, to calculate the whole process of the electron's movement from rest. You will obtain 1% point for a computer language you choose and totally 2% points if you submit one more computer program in a different computer language. You are to plot the curve of velocity versus time and identify the total traveling time, the final position and acceleration of the flying electron.