

Roster ID: \_\_\_\_\_

**Physics 272 Section 1. Practice Final Exam**  
**There are 8 problems. Each is assigned 25 points.**  
**Show your work.**

Problem 1: 25 points

A very long conducting tube (hollow cylinder) has inner radius  $a$  and outer radius  $b$ . It carries charge per unit length  $+\alpha$ , where  $\alpha$  is a positive constant with units of C/m. A line of charge lies along the axis of the tube. The line of charge has charge per unit length  $+\alpha$ .

(a) Calculate the electric field in terms of  $\alpha$  and distance  $r$  from the axis of the tube for

1.  $r < a$
2.  $a < r < b$
3.  $r > b$

(b) Show your results in graph of  $E$  as a function of  $r$ , making sure to indicate the relevant radii.

(b) What is the charge per unit length on

1. the inner surface of the tube
2. the outer surface of the tube

Problem 2: 25 points

An electron (charge  $-e = 1.6 \times 10^{-19}\text{C}$ ) moves in a straight line from point  $a$  to point  $b$  inside an old Cathode Ray Tube television set, a total distance of  $d = 0.5\text{m}$ . The electric field is uniform along this line with magnitude  $E = 1.7 \times 10^4\text{N/C}$  in the direction from  $a$  to  $b$ . Determine

(a) the force on the electron?

(b) the work done on it by the field ?

(c) the potential difference  $V_a - V_b$  ?

Problem 3: 25 points

A single charged particle of charge  $q$  is moving in the  $x$  direction at time  $t = 0$  with instantaneous velocity  $\vec{v} = v\hat{i}$  in the presence of a magnetic field  $\vec{B} = B\hat{j}$ .

- (a) Sketch the motion of the charged particle.
  
  
  
  
  
  
  
  
  
  
- (b) If the magnetic field strength is increased, what will happen to the motion of the charged particle?
  
  
  
  
  
  
  
  
  
  
- (c) Will the charged particle speed up or slow down?
  
  
  
  
  
  
  
  
  
  
- (d) When the magnetic field is stable, how much work is being done on the charged particle?

Problem 4: 25 points

A conducting bar with mass  $m$  and length  $L$  slides over horizontal rails that are connected to a voltage source. The voltage source maintains a constant current  $I$  in the rails and bar, and a constant, uniform vertical magnetic field  $\vec{B}$  fills the region between the rails.

(a) Find the magnitude and direction of the net force on the conducting bar. (ignore friction, air resistance, and electrical resistance)

(b) If the bar has mass  $m$ , find the distance that the bar must move to attain speed  $v$

(c) It has been suggested that rail guns based on this principle could be used to accelerate payloads into earth orbit or beyond. Find the distance the bar must travel along the rails if it is to reach the escape speed for earth (11.2 km/s). Let  $B = 0.5$  T,  $I = 2.0 \times 10^3$  A,  $m=25$  kg, and  $L = 50$  cm.

Problem 5: 25 points

You are using a *loop antenna* with area  $0.1 \text{ m}^2$  to detect EM waves for which  $B_{rms} = 10^{-9} \text{ T}$ .

(a) If the wave frequency is 1 MHz, what is the *maximum* value of the emf induced in the antenna ?

(b) What is the *rms* E field of these waves ?

(c) What is the velocity of these EM waves ?

(d) What is the intensity of these EM waves ?

Problem 6: 25 points

Evil Mr. Laserhands has tracked him down and found Mister Bond hiding in an aquarium filled with water ( $n=1.33$ ). The window glass ( $n=1.5$ ) is 3 cm thick and our secret agent is 5m below and 10m away from the window.

(a) Sketch the scene. Our villain uses a laser in the place of his right hand to finish off his victims. At what angle should he fire to hit 007 ?

(b) How does this differ from the direction Mr. Bond appears to be ?

(c) How deep would our hero have to dive (staying same distance from window), to avoid getting blasted ?

Problem 7: 25 points

(a) Copper sphere A has radius 5 cm, while copper sphere B has a radius of 10 cm. The two spheres are connected by a conducting wire. Is the magnitude of the electric potential of sphere A (*larger than, smaller than, or the same as*) that of sphere B ? (explain).

(b) Consider a series R-L-C ( $R = 1\ \Omega$ ,  $L = 1\ \text{mH}$ , and  $C = 1\ \text{pF}$ ) circuit with an ac generator that runs at 10 kHz. Which is larger, the *resistance, capacitive reactance, inductive reactance* (pick one) ?

(c) Far away from a dipole, electric field falls off like  $1/r^2$ ,  $1/r$ ,  $1/r^3$  (*pick one*)

(d) According to Ampere's Law, the magnetic field of a long straight current-carrying wire falls off like  $1/r^2$ ,  $1/r$ ,  $1/r^3$  (*pick one*) and is in the **radial, azimuthal or along the wire** (**pick one**) direction.

Problem 8: 25 points

(a) Will total internal reflection occur for light going from air towards water ? How about from water towards air ? Explain.

(b) Why is the sky red/orange at sunset ? (give a short explanation).

(c) Given supplies/equipment you can find at a hardware store, explain how you might make a magnet to generate a 1 T magnetic field.

(d) Arrange the following types of electromagnetic radiation in order of *increasing energy*: infrared light, ultraviolet light, microwaves, x-rays, FM radio.

(e) Explain how a mass spectrometer is used to separate isotopes of different materials.