PHYS 1B-1 Winter 2022 – Midterm 2

Name:

UID:

Discussion session:

– Length: 90 mins.

– Closed book.

– Web search and discussions are not allowed.

– Simple calculators are allowed.

– A formula sheet is allowed.

Problem 1:	/10
Problem 2:	/10
Problem 3:	/10
Problem 4:	/10
Total:	/40

Problem 1

A point charge $q_1 = 7\text{nC}$ is located on the x-axis at $x = 3.6\text{m}$ and a second point charge $q_2 = -3\text{nC}$ is on the y-axis at $y = 2.7\text{m}$.

(a) What is the total electric flux due to these two point charges through a spherical surface centered at the origin and with radius $r_1 = 0.1\text{m}$?

(b) What if the spherical surface has radius $r_2 = 10$ m?

(c) What if the surface is cubic (still centered at the orign) with side length $L = 10$ m?

Problem 2

Two positive point charges q are placed on the x-axis, one at $x = a$ and the other at $x = -a$.

(a) Find the magnitude and direction of the electric field at $x = 0$.

(b) Derive an expression for the electric field at any point on the x-axis.

(c) Find and comment on the answer for $x \gg a$.

Problem 3

A charged paint is spread in a very thin uniform layer over the surface of a plastic sphere of diameter $R = 10\text{cm}$, giving it a charge $Q = -30\mu\text{C}$.

(a) Find the electric field just inside the paint layer.

(b) Find the electric field just outside the paint layer.

(c) Repeat (a) and (b) for a metal sphere.

Problem 4

An electron is projected with an initial speed $v_0 = 3.2 \times 10^5\text{m/s}$ into the uniform field between two parallel plates (see Fig.1 on page 3). Assume that the field between the plates is directed vertically downward and that the field outside the plates is zero. The electron enters the field at a point midway bewteen the plates.

(a) If the electron just misses the upper plate as it emerges from the field, find the magnitude of the electric field.

(b) Supppose that the electron is replaced by a proton with the same initial speed v_0. Would the proton hit one of the plates? If not, what would be the magnitude and direction of its vertical displacement as it exits the region between the plates?

(c) Compare the paths traveled by the electron and the proton, and explain the differences.

(d) Discuss whether it is reasonable to neglect the effect of gravity for each of the particle.

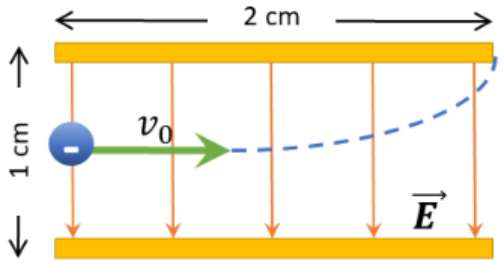

FIG. 1: Setup of Problem 4.

Equation sheet

Possibly useful constants

$$\epsilon_0 = 8.85 \cdot 10^{-12}\ C^2/Nm^2$$

$$k = \frac{1}{4\pi\epsilon_0} = 9.0 \cdot 10^9\ Nm^2/C^2$$

$$e = 1.60 \cdot 10^{-19}\ C$$

$$G = 6.67 \times 10^{-11} m^3/kg \cdot s^2$$

m_electron = 9.11 × 10-31 kg
m_proton = 1.67 × 10-27 kg

Possibly useful equations

$$\vec{F} = q\vec{E}$$

$$\vec{E} = \sum k\frac{q_i}{r^2}\hat{r} \rightarrow \overrightarrow{E} = k\int \frac{dq}{r^2}\hat{r}\text{ , where } \hat{r} \equiv \frac{\vec{r}}{r}$$

$$\vec{p} \equiv q\vec{d}$$

$$\vec{\tau} = \vec{p} \times \vec{E} \text{ and } U = -\vec{p} \cdot \vec{E}$$

$$\Phi_E \equiv \int \vec{E} \cdot \overrightarrow{dA}$$

$$\oint \vec{E} \cdot \overrightarrow{dA} = {}^{Q_{enc}}/_{\epsilon_0}$$