

## 8.02X Electricity and Magnetism

### Problem Set 3

Issued: Wed, Feb 16

~~Due: Fri, Feb 25, 4PM < note Date + Time!~~

#### ~~Reading suggestions (from Young & Freedman)~~

~~Fri, 2/18 : Quiz 1 Review~~

~~Tue, 2/22: Quiz~~

~~Wed, 2/23: Electric Potential contd 23-3, 23-4~~

~~Fri, 2/25: Capacitance 24-1~~

#### ~~Homework Problems (30 points total)~~

~~**Problem 1 (10 points)** Two pointlike test charges  $+q$  and  $-q$  are brought separately into the vicinity of a pointlike charge  $+Q$ . First charge  $+q$  is brought to a distance  $r$  from  $+Q$  and then  $+q$  is removed and  $-q$  is brought to the same distance  $r$ .~~

~~(a) At distance  $r$  from  $+Q$ , which of the two charges  $+q$  or  $-q$  has the greater potential energy  $U$ , relative to  $U(\text{infinity}) = 0$ ?~~

~~(b) How big is the difference in potential energy for  $+q$  and  $-q$ ?~~

~~(c) What can you say about the electric potential in the two cases?~~

~~**Problem 2 (10 points)** A proton is shot towards a lead nucleus from very far away. The proton reaches a closest distance to the nucleus of 10 fermi before being pushed back. What is the initial speed of the proton?~~

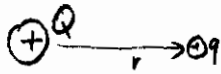
~~**Problem 3 (10 points)** Consider two spherical conductors with radii  $A$  and  $B$  ( $A \gg B$ ), that are connected by a conducting rod. The spheres carry a combined net charge  $+Q$ .~~

~~(a) Explain why the electric potential of the surface of both spheres will be the same~~

~~(b) Determine the ratio of the electric field strengths near the surfaces of the two spheres.~~

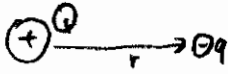
# 8.02X PSET 3 SOLUTIONS

## PROBLEM 1



$$U_+ = \frac{kQq}{r}$$

$$U_{\infty} = 0$$



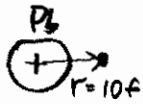
$$U_- = -\frac{kQq}{r}$$

a) the charge  $+q$  has greater potential energy at  $r$  than at  $\infty$ .

b)  $U_+ - U_- = 2\frac{kQq}{r}$

c) the electric potential doesn't depend on  $q$ ,  $V = \frac{U_+}{q} = k\frac{Q}{r} = \left(-\frac{U_-}{q}\right)$

## PROBLEM 2



conservation of energy:

at infinity  $E_k = \frac{1}{2}mv^2$

at closest distance  $E_p = k\frac{Qq}{r}$

$$E_{k(\infty)} = E_{p(r)}$$

giving  $v = \sqrt{\frac{2kQq}{mr}}$

take  $q = 1.6 \times 10^{-19} \text{ C}$

$m = 1.7 \times 10^{-27} \text{ kg}$

$k = 9.0 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}$

$Q = 82q$

$r = 10^{-15} \text{ m}$

we obtain  $v \approx 1.5 \times 10^8 \text{ m/s}$

## PROBLEM 3



$$Q = Q_A + Q_B$$

a) the potential of both spheres is constant, because the charge distribution is static now. If there was a place with lower potential, the charge would flow there freely. It doesn't  $\Rightarrow V = \text{const}$ .

b) The potentials of the spheres are equal  $V_A = k\frac{Q_A}{A}$   $V_B = k\frac{Q_B}{B} \Rightarrow \frac{Q_A}{Q_B} = \frac{A}{B}$

The ratio of electric field strengths is

$$\frac{E_A}{E_B} = \frac{k\frac{Q_A}{A^2}}{k\frac{Q_B}{B^2}} = \frac{Q_A}{Q_B} \frac{B^2}{A^2} = \frac{B}{A}$$

The electric field is stronger near the smaller sphere.