Physics 4B
Fall 2022

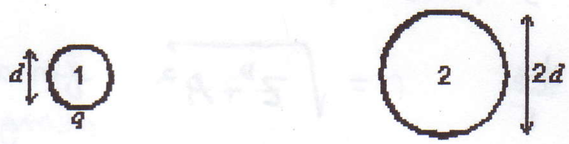
ave. = 5.7
σ = 2.6

Name: Answer Key

Lab (circle one): 8:00 am 11:15 am 2:30 pm

Quiz #4: Electric Potential

Problem 1 (2 points)
Two conducting spheres, one having twice the diameter of the other, are separated by a distance large compared to their diameters. The smaller sphere (1) has charge *q* and the larger sphere (2) is uncharged.



After the spheres are connected by a long thin conducting wire:

a) sphere 2 has twice the potential as sphere 1.
b) sphere 2 has half the potential as sphere 1.
c) sphere 2 has twice the charge as sphere 1.
d) spheres 1 and 2 have the same charge.
e) none of the above

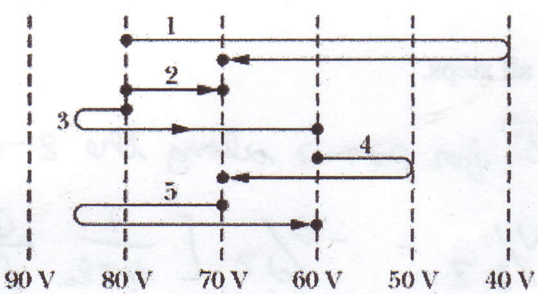
C

* when two conductors touch, all points on both conductors reach the same potential

$V_1 = V_2 \rightarrow \frac{1}{4\pi\epsilon_0}\frac{q_1}{R_1} = \frac{1}{4\pi\epsilon_0}\frac{q_2}{R_2} \rightarrow q_2 = \left(\frac{R_2}{R_1}\right) q_1$

Problem 2 (3 points)
The figure shows a family of parallel equipotential surfaces (in cross section) and five paths along which we shall move an electron from one surface to another.

$1 \rightarrow \Delta V = -10V$
$2 \rightarrow \Delta V = -10V$
$3 \rightarrow \Delta V = -20V$
$4 \rightarrow \Delta V = 10V$
$5 \rightarrow \Delta V = -10V$



a) For which of the paths is the change in potential energy of the electron positive?

paths 1, 2, 3, + 5

$\Delta U = q\Delta V \rightarrow$ since $q < 0$, we want $\Delta V < 0$

b) For which of the five paths is the work done by the electric field the greatest.

$W = -\Delta U = -(-e)\Delta V = e\Delta V$

path 4

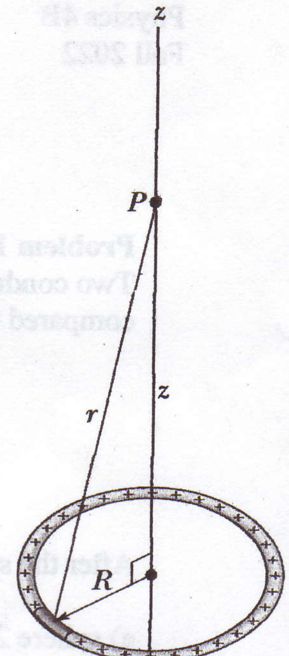
c) For which of the five paths is the work done by the electric field the least.

$W = -\Delta U = -(-e)\Delta V = e\Delta V$

path 3

Problem 3 (5 points)

(a) Derive an expression for the electric potential at point P, which is a distance z above the center of a uniformly charged ring of charge Q.



Express your answer in terms of z, R (the radius of the ring), and Q (the total charge on the ring).

Note: you must show all steps.

$$V = \int dV = \int \frac{1}{4\pi\varepsilon_0}\frac{dq}{r}$$

$$V = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r} \qquad r = \sqrt{z^2+R^2} \text{ for all points along the ring}$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{1}{\sqrt{z^2+R^2}}\int dq \qquad \int dq = Q$$

$$\boxed{V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{\sqrt{z^2+R^2}}}$$

(b) From the above result, derive an expression for the electric field magnitude E a distance z above the center of the ring.

Note: you must show all steps.

$\Rightarrow$ we want $\vec{E}$ for points along the z-axis : E_z

$$E_z = -\partial V/\partial z = -\partial/\partial z\left[\frac{1}{4\pi\varepsilon_0}\frac{Q}{\sqrt{z^2+R^2}}\right]$$

$$= \frac{-Q}{4\pi\varepsilon_0}\frac{\partial}{\partial z}(z^2+R^2)^{-1/2}$$

$$= \frac{-Q}{4\pi\varepsilon_0}\left[-\tfrac{1}{2}(z^2+R^2)^{-3/2}(2z)\right] = \frac{-Q}{4\pi\varepsilon_0}\left[-z(z^2+R^2)^{-3/2}\right]$$

$$\boxed{E_z = \frac{1}{4\pi\varepsilon_0}\frac{Qz}{(z^2+R^2)^{3/2}}}$$