University of Anbar

College of Science

Department of Applied Geology

Fourth Year

Electromagnetics

جامعة الانبار

كلية العلوم

قسم علوم الفيزياء

المرحلة الرابعة

الكهرومغناطيسية

Electrostatics

Sixth Part: Electrical Potential 2

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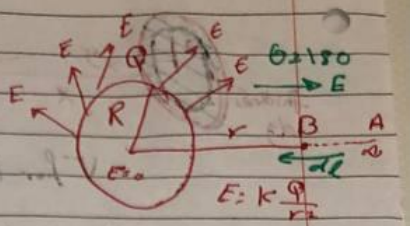
Sixth Part in this Chapter: Electrical Potential 2

Electric Potential due to a Conducting sphere.

outside ① V
inside ②
at the surface ③



1) outside $r > R$

$E_{inside} = 0$

$E = k\frac{Q}{r^2}$

Point charge (Conductor & Non-Conductor)

$$\Delta V = -\int_i^f E \cdot dl$$

$$V_f - V_i = -\int_i^F E \cdot dl$$

$$V_B - V_\infty = -\int_\infty^B E \cdot dl$$

V_∞ = Zero

$$V_B = -\int_\infty^B E \cdot dl = -\int_\infty^B \frac{kQ}{r^2} dl \cos\theta$$

$\theta = 180$, $\cos 180 = -1$

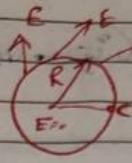
$$V_B = -\int_\infty^B k\frac{Q}{r^2} dl$$

So $dl = -dr$

$$V_B = -\int_\infty^r k\frac{Q}{r^2} dr$$

$$= -kQ \int_\infty^r \frac{dr}{r^2}$$

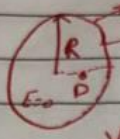
$$V_B = k\frac{Q}{r}$$



at the surface

$$V_C = k\frac{Q}{R}$$

3) inside $r<R$



What to calculate V_D

$$\Delta V = -\int_C^D E \cdot dl$$

$$V_D - V_C = -\int_C^D E \cdot dl$$

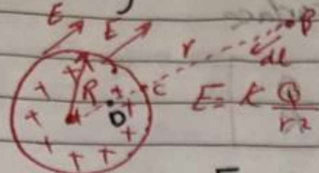
$$V_D - V_C = 0$$

$$V_D = V_C = k\frac{Q}{R}$$

Potential inside sphere is Constant

= Potential on the surface

التي قرأناها مسبقاً كانت في Conducting الآن نأخذ Non-Conducting (الشحنة موزعة على حجم Volume)



$E = k\frac{Q}{r^2}$ outside

$E_{inside} = k\frac{Q}{R^3}r$

outside $r > R$

$\Delta V = -\int E \cdot dl$

$V_B - V_\infty = -\int_\infty^B E \cdot dl$ (V_∞ = zero)

$$V_B = +k\frac{Q}{r}$$

$$V_C = k\frac{Q}{R}$$

مستنتجة بالسابق PNo 47, 48

inside $V_D - V_C = \Delta V = -\int_C^D E \cdot dl$ ($dl = -dr$)

$= +\int_R^r k\frac{Q}{R^3} r\, dr$

C/ نعوض عنها R

D/ نعوض عنها بمتغير r

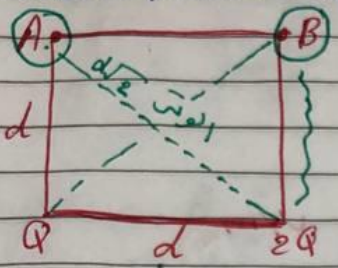
$V_D - k\frac{Q}{R} = \frac{kQ}{2R^3} r^2 \Big|_R^r$

$$V_D = k\frac{Q}{2R}\left(3 - \frac{r^2}{R^2}\right)$$

الإثباتات للاطلاع فقط
وليس مطلوب حفظ القانون التالي

Solved problems on Potential

1) The Two charges in figure are separated by a distance $d = 2$ cm and $Q = 5$ nC. Find a) The electric Potential at A b) The electric Potential at B c) the electric potential difference between B and A?



sol:-
by Using superPosition

a) $V_A = V_Q + V_{2Q}$

$= k\frac{Q}{r} + k\frac{2Q}{r}$

$= k\frac{Q}{d} + k\frac{2Q}{d\sqrt{2}}$

$\frac{kQ}{d}\left(1 + \frac{2}{\sqrt{2}}\right)$

$= \frac{9*10^9 * 5*10^{-9}}{0.02}\left(1 + \frac{2}{\sqrt{2}}\right) =$ ✓ H.W

✓ SI unit

b) $V_B = V_Q + V_{2Q}$

$= k\frac{Q}{d\sqrt{2}} + k\frac{2Q}{d}$

$= \frac{kQ}{d}\left(\frac{1}{\sqrt{2}} + 2\right)$

$=$ ✓ H.W

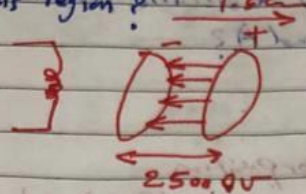
✓ SI unit

c) $V_B - V_A$

H.W

(already SI unit is ✓)

2- The difference in potential between the accelerating plates in the electron gun of a TV picture tube is about 25000 V, if the distance between these plates is 1.50 cm, what is the magnitude of the uniform electric field in this region ?



$$E = \frac{\Delta V}{d} = \frac{25000}{1.5\times10^{-2}\ m} = \_\_\_\_\ V/m$$

3- Consider Two thin, conducting spherical shells as shown in fig, the inner shell has a radius $r_1 = 15.0$ cm and a charge 10 nC, the outer shell has a radius $r_2 = 30.$ cm and a charge −15 nC Find a) the electric Field V in region A, B, C with V=0 at r= ∞

Sol:-

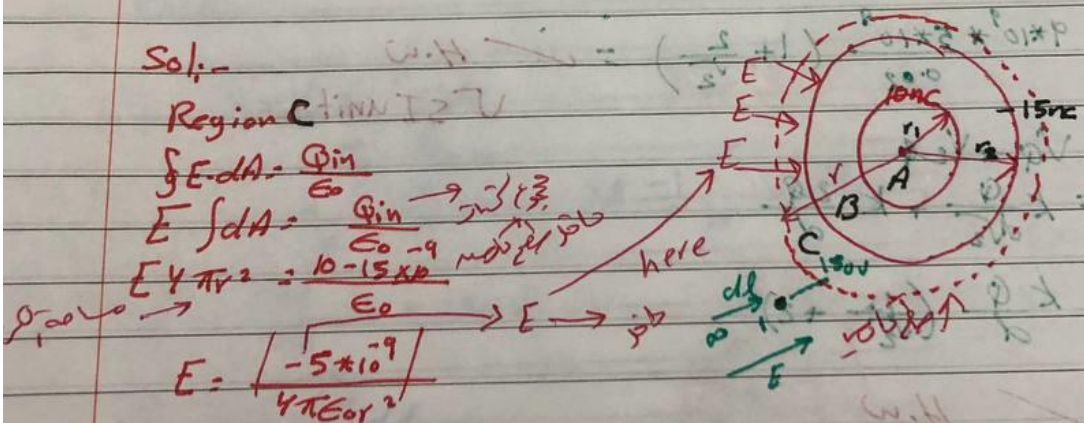
Region C

$$\oint E\cdot dA = \frac{\Phi_{in}}{\varepsilon_0}$$

$$E\oint dA = \frac{\Phi_{in}}{\varepsilon_0}$$

$$E\,4\pi r^2 = \frac{10-15\times10^{-9}}{\varepsilon_0}$$

$$E = \frac{\left|-5\times10^{-9}\right|}{4\pi\varepsilon_0 r^2}$$



$$E_C = k\,\frac{5\times10^{-9}}{r_2}$$ magnitude for E

Reference:

1) INTRODUCTION to ELECTRODYNAMICS, Third Edition, David j.Griffths