University of Anbar

College of Science

Department of Applied Geology

Fourth Year

Electromagnetics

جامعة الانبار

كلية العلوم

قسم علوم الفيزياء

المرحلة الرابعة

الكهرومغناطيسية

Electrostatics

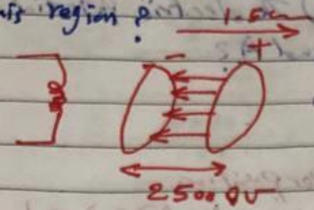
Seventh Part: Electrical Potential 3

Dr. Israa Kamil Ahmed

د . اسراء كامل احمد

Seventh Part in this Chapter: Electrical Potential 3

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?



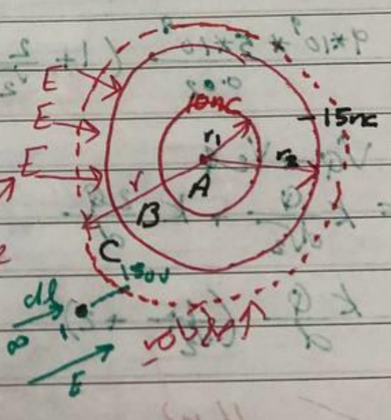
. Two plates

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

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 ~~radius~~ 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



$$\oint E\cdot dA = \frac{Q_{in}}{\epsilon_0}$$

$$E\int dA = \frac{Q_{in}}{\epsilon_0}$$ [illegible]

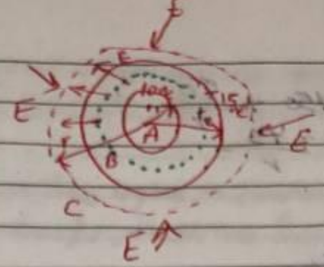
$$E\,4\pi r^2 = \frac{10-15\times10^{-9}}{\epsilon_0}$$

[illegible] → E → [illegible]

$$E = \left|\frac{-5*10^{-9}}{4\pi\epsilon_0 r^2}\right|$$

$$E_C = K\,\frac{5*10^{-9}}{r^2}$$ magnitude for E

2) Region B



Gaussian surface

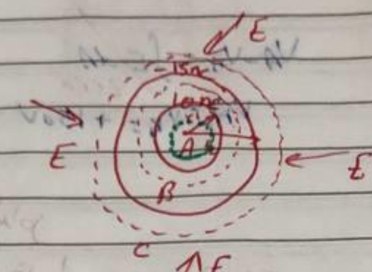
اختار بالوسط نصف قطر

$$\oint E\cdot dA = \frac{Q_{in}}{\epsilon_0}$$

$$E\,4\pi r^2 = \frac{10\times10^{-9}}{\epsilon_0}$$

$$E_B = K\,\frac{10\times10^{-9}}{r^2}$$

3) at Region A



بالوسط أصغر من أصغر الباقي

$E_A = 0$ There is No charge

$$E_C = K\,\frac{|-5\times10^{-9}|}{r^2} = \frac{45}{r^2}$$

$$E_B = K\,\frac{10\times10^{-9}}{r^2} = \frac{90}{r^2}$$

$E_A = 0$

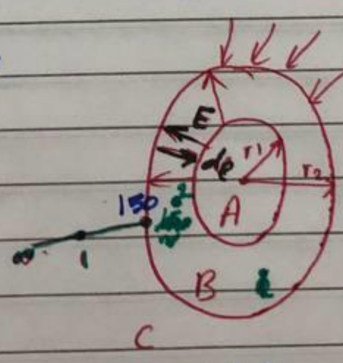
$$V_C = V_1 - V_\infty = \int_\infty^1 E\cdot dl \quad (\cos 0)$$

رجع لرسم الأول

$$= \int_\infty^r \frac{45}{r^2}\,dr = 45\left.\frac{-1}{r}\right|_\infty^r = \boxed{\frac{45}{r}}$$

بعد التعويض بحدود التكامل

$$V_{r=r_2} = \frac{-45}{0.3} = -150\ V$$



$$V_2 - V_{r_2} = -\int_{r_2}^{2} E\cdot dl \quad (\cos 180)$$

$E \rightarrow$ بس خارج السطح و dl داخل السطح

$$= -\int_{r_2}^{r} \frac{90}{r^2}\,dr = -90\left(-\frac{1}{r}\right) = 90\left.\left(\frac{1}{r}\right)\right|_{0.3}^{r}$$

$$V_2 + 150 = 90\left(\frac{1}{r} - \frac{1}{0.3}\right)$$

$$V_2 = -150 + \frac{90}{r} - \frac{900}{3} \Longrightarrow \boxed{V_2 = -450 + \frac{90}{r}} = V_B$$

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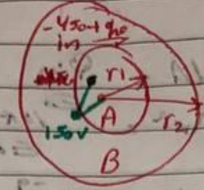
$V_B = -450 + \frac{90}{r}$

$V_C = \frac{-45}{r}$



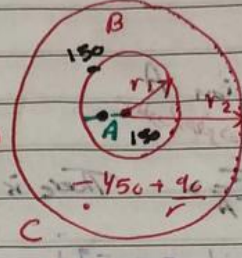
$r_1 = 15cm$

$V_{r_1} = -450 + \frac{90}{0.15}$

$= +150V$

$V_A - V_{r_1} = \int \cancel{E \cdot dA}_{zero}$

$V_A - V_{r_1} = +150V$



يوصلك الـ potential في الداخل

تحت الدائرة الى نقطة قطع وعوض في المعادلة

$-450 + \frac{90}{r}$

$r_1 = 0.15cm$

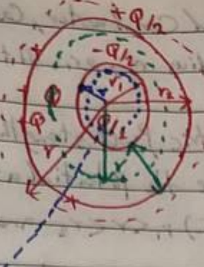
هذا كله هو V_{r_1}

V_A ثابت لو $E =$ صفر

So potential is Constant

2) $r_1 < r < r_2$

الحل: نأخذ سطح كاوسي مناسب



$$\oint E\,dA = \frac{Q_{in}}{\epsilon_0}$$

$$E\,4\pi r^2 = \frac{-Q/2 + Q/2}{\epsilon_0}$$

$$E\,4\pi r^2 = \frac{0}{\epsilon_0}$$

$$\boxed{E = 0} \text{ --- } ②$$

ملاحظة هامة :

Electric field inside any conductor is equal to zero

3) $r_1 < r$

$$\oint E \cdot dA = \frac{Q_{in}}{\epsilon_0}$$

$$E\,4\pi r^2 = \frac{Q/2}{\epsilon_0}$$

$$\boxed{E = \frac{1}{2} k \frac{Q}{r^2}} \text{ --- } ③$$

4 A spherical conductor, carrying a net charge $+Q$ has inner radius r_1 and outer radius $r_2 = 2r_1$. At the center of the sphere is a point charge $+Q/2$

a) Write the electric field strength E in all three regions as function of r

then b) Determine the potential as a function of r, the distance from the center for (b) $r > r_2$ c) $r_1 < r < r_2$ and d) $0 < r < r_1$?

Sol:

$r > r_2$

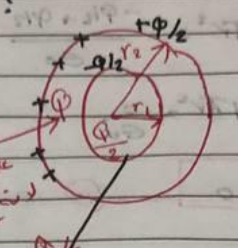
by using Gauss law

$$\oint E \cdot dA = \frac{Q_{in}}{\epsilon_0}$$

Q_{in} الشحنة داخل السطح الجاوسي

ناخذ سطح كروي متماثل ويكون high symmetry

كما في الرسم

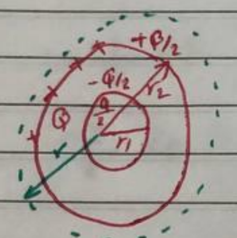


عشان تتوزع على السطح الخارجي لأن conductor

$\frac{Q}{2}$ الداخلية في الـ conductor قبل induction على السطح الخارجي $-\frac{Q}{2}$ و conduction على السطح الداخلي $+Q/2$

So: السطح الخارجي فيه $-\frac{Q}{2} + \frac{Q}{2}$, $+Q$ الأصلية

وفي الـ Center يوجد $Q/2$



always E prependicular on the surface

E دائماً يكون عمودي على السطح لذلك بالأخير . نضع $\cos\theta$

$$\oint E \cos\theta \, dA = \frac{Q_{in}}{\epsilon_0}$$

$$E \oint dA = \frac{Q_{in}}{\epsilon_0}$$

$$E \, 4\pi r^2 = \frac{3Q/2}{\epsilon_0} = \frac{3Q}{2\epsilon_0}$$

مجموع الشحنات الداخلية

$-Q/2 + Q/2 + Q + Q/2 = 3Q/2$

$$E = \frac{1}{4\pi\epsilon_0} \frac{3}{2} \frac{Q}{r^2} \Rightarrow \boxed{E = \frac{3}{2} k \frac{Q}{r^2}} \quad (1)$$

Now potential in every Regions in (pages 4, 55)

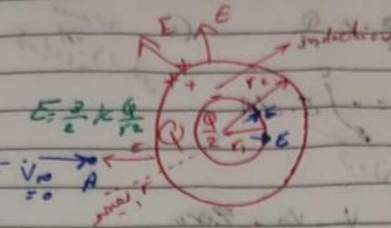
Va) $r < r_2$

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

منتقطه

أخذ نقطه واحدة من ملا نهاية

إلى نقطة أخرى



$$V_A - \cancel{V_\infty} = -\int_\infty^A E \cdot dl$$

zero

$$V_A = -\int_\infty^A E\,dl \cos 180$$

سالب×سالب

$$= \int_\infty^A E\,dl$$

$dl = -dr$ دائماً

$$= -\int_\infty^r E\,dr$$

$$V_A = -\int \frac{3}{2} k \frac{Q}{r^2}\,dr$$

$$= \frac{-3}{2} kQ \int \frac{dr}{r^2}$$

$$= \frac{-3}{2} kQ \left. \left(\frac{-1}{r} \right) \right|_\infty^r$$

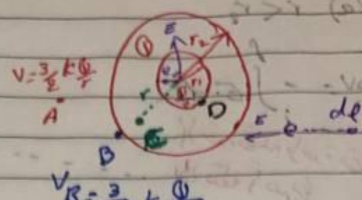
$$=$$

بعد التعويض بحدود التكامل

$\frac{1}{\infty} = 0$

$$\boxed{V_A = \frac{3}{2} k \frac{Q}{r} \qquad r > r_2}$$

$V_B = \frac{3}{2} k \frac{Q}{r_2}$ --- (1) [illegible]



$V_C - V_B = -\int_B^C E \cdot dA$

Zero = [illegible]

$V_C - V_B = \text{Zero}$

$V_C = V_B = \frac{3}{2} k \frac{Q}{r_2}$ --- (2)

كذلك

$V_D = V_C = \frac{3}{2} k \frac{Q}{r_2}$ --- (3)

Now calculate V_e

$V_e - V_D = -\int_D^e E \cdot dl$

$V_e - V_D = -\int_D^e E \cdot \cos 180 \, dl$

$= -\int_{r_1}^{r} E \, dl \quad = -\int_{r_1}^{r} E \, dr \quad \rightarrow dl = -dr$

$= -\int_{r_1}^{r} \frac{1}{2} k \frac{Q}{r^2} \, dr$

$= -\frac{1}{2} k Q \int_{r_1}^{r} \frac{dr}{r^2}$

$= \frac{1}{2} k \frac{Q}{r} \Big|_{r_1}^{r} = \frac{1}{2} k Q \left(\frac{1}{r} - \frac{1}{r_1}\right)$

$V_e - \frac{3}{2} k \frac{Q}{r_2} = \frac{1}{2} k Q \left(\frac{1}{r} - \frac{1}{r_1}\right) \qquad r_2 = 2r_1$

$V_e - \frac{3}{2} k \frac{Q}{2r_1} = \frac{1}{2} k \frac{Q}{r} - \frac{1}{2} k \frac{Q}{r_1}$

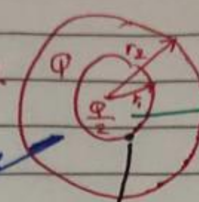
$V_e = \frac{1}{2} k \frac{Q}{r} - \frac{1}{2} k \frac{Q}{r_1} + \frac{3}{2} k \frac{Q}{r_1}$

[illegible]

$$= \frac{1}{2} k \frac{Q}{r} + k \frac{Q}{r_1} \underbrace{\left(-\frac{1}{2} + \frac{3}{4}\right)}_{\frac{1}{4}}$$

$$\boxed{V_e = \frac{1}{2} k \frac{Q}{r} + \frac{1}{4} k \frac{Q}{r_1}}$$

$* V = \frac{3}{2} k \frac{Q}{r}$



$V = \frac{1}{2} k \frac{Q}{r} + \frac{1}{4} k \frac{Q}{r_1}$

here

$r = r_2$

$$\boxed{V = \frac{3}{2} k \frac{Q}{r_2}}$$

في هذه النقطة

$r = r_1$

$$V = \frac{1}{2} k \frac{Q}{r_1} + \frac{1}{4} k \frac{Q}{r_1}$$

$$= \frac{3}{4} k \frac{Q}{r_1}$$

$r_1 = \frac{1}{2} r_2$

$$\boxed{= \frac{3}{2} k \frac{Q}{r_2}}$$

in The same
Potential
and The same magnitude
in The Center *

thats all

Dr. Isra. K
2022

Reference:

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