Applied Physics BS 101

Electric Potential

Problem 1: In a typical lightening flash, the potential difference between cloud and ground is $1 \times 10^9 V$ and the quantity of charge transferred is 30C. (a) What is the decrease in energy of that transferred charge? (b) If all that energy could be used to accelerate a 1000kh automobile from rest, what would be the automobile final speed?
Ans.: (a) $3 \times 10^{10} V$ (b) $7.7 \times 10^3 m/s$

Problem 2: What potential difference is needed to stop an electron having an initial speed of $4.20 \times 10^5\ m/s$?
Ans.: $-0.5V$

Problem 3: The difference in potential between the accelerating plates in the electron gun of a TV picture tube is about 25 000 V. If the distance between these plates is 1.50 cm, what is the magnitude of the uniform electric field in this region?
Ans.: $1.6 \times 10^6 N/C$

Problem 4: The potential in a region between *x* = 0 and *x* = 6.00 m is $V = a + bx$, where *a* = 10.0 V and *b* =-7.00 V/m. Determine the magnitude and direction of the electric field at *x* = 0, 3.00 m, and 6.00 m.
Ans.: $7\ \frac{N}{C}\ along + xaxis$

Problem 5: Over a certain region of space, the electric potential is $V = 5x - 3x^2y + 2yz^2$.
(a) Find the expressions for the electric field $\vec{E}$ over this region. (b) What is the magnitude of the field at the point *P* that has coordinates (1, 0, -2) m?
Ans.: $(a)\vec{E} = (-5 + 6xy)i + (3x^2 - 2z^2)j - 4yzk\ , (b)7.07\frac{N}{C}$

Problem 6: When an uncharged conducting sphere of radius *a* is placed at the origin of an *xyz* coordinate system that lies in an initially uniform electric field $E = E_0\boldsymbol{k}\hat{}$, the resulting electric potential is $V(x, y, z) = V_0$ for points inside the sphere and

$$V = V_0 - E_0 z + \frac{E_0 a^3 z}{(x^2 + y^2 + z^2)^{3/2}}$$

for points outside the sphere, where *V*0 is the (constant) electric potential on the conductor. Use this equation to determine the expressions for the resulting electric field $\vec{E}$ both inside and outside the conducting sphere.
Ans.: $E_{1n} = 0, E_{out} = 3E_0a^3xz(x^2 + y^2 + z^2)^{-5/2}\ i + 3E_0a^3yz(x^2 + y^2 + z^2)^{-5/2}j +$
$\{E_0 + E_0a^3(2z^2 - x^2 - y^2)(x^2 + y^2 + z^2)^{-\frac{5}{2}}\}$k

Problem 7: Two very large flat metal plates 1 and 2 having charge densities +σ and -σ are parallel and separated by distance D as shown in fig.(a). Find the potential difference between plates 1 and 2. (b) Now if we bring two plates closer until distance between them is d as shown in fig. (b), what will be the potential; difference between plates now?

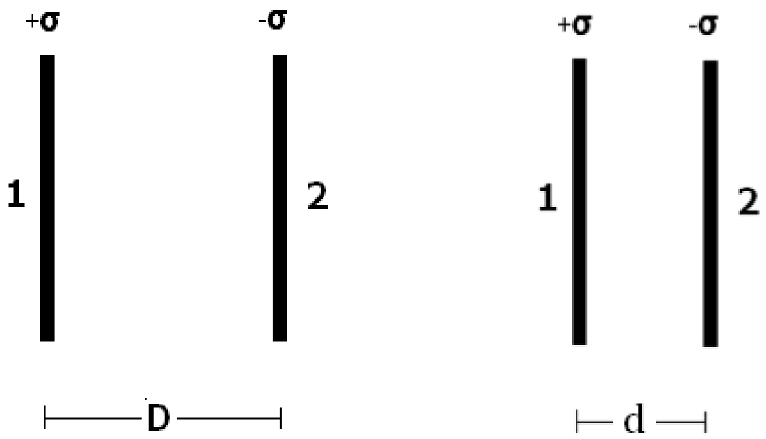

fig.(a)   fig.(b)

Ans.: $(\boldsymbol{a})V = \frac{\sigma D}{\varepsilon_0}$, $(\boldsymbol{a})V = \frac{\sigma d}{\varepsilon_0}$

Problem 8: A spherical conductor has a radius of 14.0 cm and charge of 26.0 μC. Calculate the electric field and the electric potential (a) *r* = 10.0 cm, (b) *r* = 20.0 cm, and (c) *r* = 14.0 cm from the center.

Ans.: $(\boldsymbol{a})E = 0, V = 1.67MV\ (b)E = 5.84MN/C,\ V = 1.17MV$
$(c)E = 11.9MN/C,\ V = 1.67MV$

Problem 9: Over a certain region, the electric field is

$$\vec{E} = 3x^2 i.$$

Find the electric potential at x = 3m

Problem 10: Over a certain region, the electric field is

$$\vec{E} = 5xi - 3x^2yj.$$

Find the electric potential at point P(2,3).

Problem 11: Over a certain region of space, the electric field is

$$\vec{E} = 2x^3i - 3x^2yj + 2yz^2k.$$

Find the electric potential at point P(1,3,-1).