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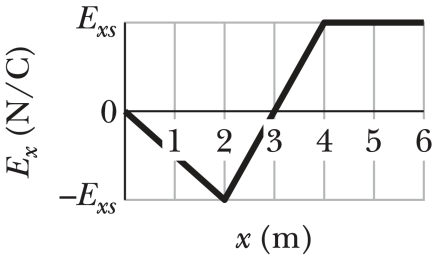
Institution: Beijing-Dublin International College
Module: University Physics 2 (BDIC2008J)
Lecturer: Dr. Hao Zhu

Problem Set 3

Electric Potential

Problem 1. *Suppose that in a lightning flash the potential difference between a cloud and the ground is* 1.0×10^9V *and the quantity of charge transferred is* 30C. ***(a)*** *What is the change in energy of that transferred charge?* ***(b)*** *If all the energy released could be used to accelerate a* 1000kg *car from rest, what would be its final speed?*

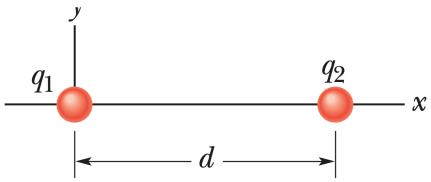
Problem 2. *A graph of the x component of the electric field as a function of x in a region of space is shown in the figure. The scale of the vertical axis is set by $E_{xs} = 20.0\text{N/C}$. The y and z components of the electric field are zero in this region. If the electric potential at the origin is* 10V, ***(a)*** *what is the electric potential at $x = 2.0\text{m}$,* ***(b)*** *what is the greatest positive value of the electric potential for points on the x axis for which $0 \leq x \leq 6.0\text{m}$, and* ***(c)*** *for what value of x is the electric potential zero?*



Problem 3. *An infinite nonconducting sheet has a surface charge density* $\sigma = +5.80\text{pC/m}^2$. ***(a)*** *How much work is done by the electric field due to the sheet if a particle of charge* $q = +1.60 \times 10^{-19}\text{C}$ *is moved from the sheet to a point* P *at distance* $d = 3.56\text{cm}$ *from the sheet?* ***(b)*** *If the electric potential* V *is defined to be zero on the sheet, what is* V *at* P*?*

Problem 4. *A spherical drop of water carrying a charge of* 30pC *has a potential of* 500V *at its surface (with* $V = 0$ *at infinity).* ***(a)*** *What is the radius of the drop?* ***(b)*** *If two such drops of the same charge and radius combine to form a single spherical drop, what is the potential at the surface of the new drop?*

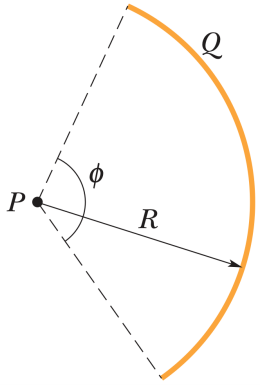
Problem 5. *In the figure below, particles with the charges* $q_1 = +5e$ *and* $q_2 = -15e$ *are fixed in place with a separation of* $d = 24.0\text{cm}$. *With electric potential defined to be* $V = 0$ *at infinity, what are the finite* ***(a)*** *positive and* ***(b)*** *negative values of* x *at which the net electric potential on the* x *axis is zero?*



Problem 6. *The ammonia molecule* NH_3 *has a permanent electric dipole moment equal to* 1.47D*, where* 1D = 1 *debye unit* $= 3.34 \times 10^{-30} \mathrm{C} \cdot \mathrm{m}$*. Calculate the electric potential due to an ammonia molecule at a point* 52.0nm *away along the axis of the dipole. (Set* $V = 0$ *at infinity.)*

(Hint: The electric potential for electric dipole is $V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{p\cos\theta}{r^2}$*, in which* p $(= qd)$ *is the magnitude of the electric dipole moment* $\vec{p}$*. The vector* $\vec{p}$ *is directed along the dipole axis, from the negative to the positive charge. Thus,* θ *is measured from the direction of* $\vec{p}$*.)*

Problem 7. *In the figure below, a plastic rod having a uniformly distributed charge* $Q = -25.6\text{pC}$ *has been bent into a circular arc of radius* $R = 3.71\text{cm}$ *and central angle* $\phi = 120°$. *With* $V = 0$ *at infinity, what is the electric potential at* P, *the centre of curvature of the rod?*



Problem 8. *What is the magnitude of the electric field at the point* $(3.00\vec{i} - 2.00\vec{j} + 4.00\vec{k})\text{m}$ *if the electric potential in the region is given by* $V = 2.00xyz^2$*, where* V *is in volts and coordinates* x*,* y*, and* z *are in meters?*

Problem 9. *What is the "escape speed" for an electron initially at rest on the surface of a sphere with a radius of* 1.0cm *and a uniformly distributed charge of* 1.6×10^{-15}C*? That is, what initial speed must the electron have in order to reach an infinite distance from the sphere and have zero kinetic energy when it gets there? (Hint:* $m_e = 9.11 \times 10^{-31}$kg, $e = 1.60 \times 10^{-19}$C.*)*

Problem 10. *Two metal spheres, each of radius* 3.0cm*, have a center-to-center separation of* 2.0m*. Sphere 1 has charge* $+1.0 \times 10^{-8}$C*; sphere 2 has charge* -3.0×10^{-8}C*. Assume that the separation is large enough for us to say that the charge on each sphere is uniformly distributed (the spheres do not affect each other). With* $V = 0$ *at infinity, calculate* ***(a)*** *the potential at the point halfway between the centres and the potential on the surface of* ***(b)*** *sphere 1 and* ***(c)*** *sphere 2.*