Homework Week 3

113-2 General Physics II

Due before 4:10 PM on March 10, 2025

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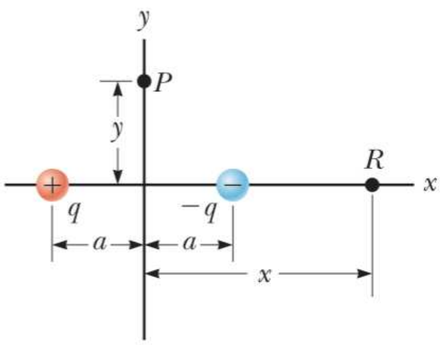
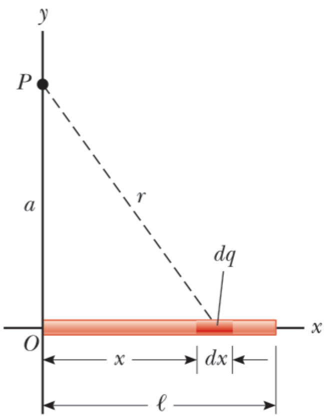
1. [30 points] **Example 24.4 The Electric Potential Due to a Dipole**

An electric dipole consists of two charges of equal magnitude and opposite sign separated by a distance 2a as shown in Figure 24.13. The dipole is along the x axis and is centered at the origin. (A) Calculate the electric potential at point P on the y axis. (B) Calculate the electric potential at point R on the positive x axis. (C) Calculate V and E_x at a point on the x axis far from the dipole.



Example 24.4



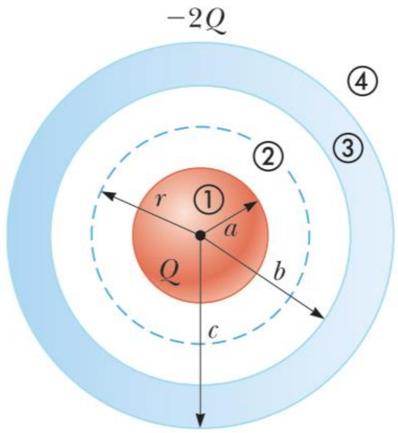
Example 24.7

2. [10 points] **Example 24.7 Electric Potential Due to a Finite Line of Charge**

   A rod of length l located along the x axis has a total charge Q and a uniform linear charge density λ. Find the electric potential at a point P located on the y axis a distance a from the origin

3. [40 points] **Example 24.8 A Sphere Inside a Spherical Shell**

   A solid insulating sphere of radius a carries a net positive charge Q uniformly distributed throughout its volume. A conducting spherical shell of inner radius b and outer radius c is concentric with the solid sphere and carries a net charge -2Q. Using Gauss's law, find the electric field in the regions labeled ①, ②, ③, and ④ in Figure 24.24 and the charge distribution on the shell when the entire system is in electrostatic equilibrium.



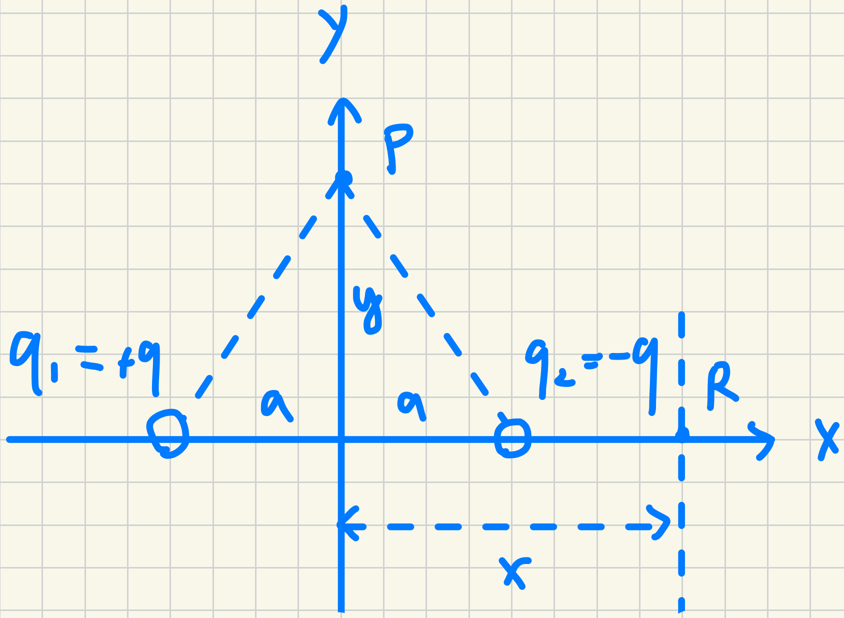
5. [20 points] 嘗試問一個生活中跟物理有關的問題。比如: 庫侖力的形式與牛頓重力相似，我們可以打開和關閉電源，調控電力。而重力似乎一直存在，我們可以調控重力嗎，可能用什麼方式調控?

有問就給分，因此盡量別使用生成式 AI 工具

勇敢地提出笨的問題，

有一天就會問到對的問題

1.



(A) $$V = \frac{kq}{r}$$

one positive charge, one negative

both at a same distance

$$\Rightarrow V = 0$$ #

(B) $$V = V_1 + V_2$$

$$= \frac{kq}{x+a} + \frac{k(-q)}{x-a}$$

$$= kq\left(\frac{1}{x+a} - \frac{1}{x-a}\right)$$

$$= \frac{-2kqa}{(x+a)(x-a)}$$ #

(c) At a distance far away from the dipole $\Rightarrow$ $x >> a$

$\Rightarrow x-a \approx x \approx x+a$

Same as (A) $\Rightarrow$ $V = 0$ ✗ #

2. 1° $dV = k\dfrac{dq}{r} = k\dfrac{\lambda\, dx}{r}$

2° $V = \int dV = k\lambda \int_0^l \dfrac{dx}{\sqrt{x^2+a^2}}$

(Question : $\int \dfrac{dx}{\sqrt{x^2+a^2}} = ?$

1° Let $x = a\sinh(\theta) \Rightarrow dx = a\cosh(\theta)\, d\theta$

$\sqrt{x^2+a^2} = \sqrt{a^2(\sinh^2(\theta)+1)}$

$= a\cosh(\theta)$

$\sinh^2(\theta)+1 = \cosh^2(\theta)$

2° Given integral $= \int \frac{a\cosh(\theta)\,d\theta}{a\cosh(\theta)}$

$= d\theta = \theta + C$

3° $x = a\sinh(\theta) \Rightarrow \theta = \sinh^{-1}\left(\frac{x}{a}\right)$

4° $\left(\int \frac{dx}{\sqrt{x^2+a^2}} = \sinh^{-1}\left(\frac{x}{a}\right) + C \right)$

$= k\lambda \left[\sinh^{-1}\left(\frac{l}{a}\right) - \sinh^{-1}\left(\frac{0}{a}\right) \right]$

$= k\lambda \sinh^{-1}\left(\frac{l}{a}\right)$ #

3. Gauss's Law: $\oint E \cdot dA = \frac{Q_{enc}}{\varepsilon_0}$

① $a < r < b$

Imagine a position inside the insulating sphere which is R away from the center

$$E\,(4\pi r^2) = \frac{Q\,r^3}{a^3} \cdot 4\pi\varepsilon_0$$

$$\Rightarrow \quad \underline{\underline{E = \frac{kQ}{a^3}\,r}} \quad \#$$

(the electric field inside the insulating sphere increases linearly with r)

② $b < r < c$

$$E \cdot (4\pi r^2) = \frac{Q}{\varepsilon_0}$$

$$\Rightarrow \quad \underline{\underline{E = \frac{kQ}{r^2}}} \quad \#$$

(the electric field decreases quadratically)

③ The E inside a conductor is always 0 in electrostatic equilibrium

$$\Rightarrow \underline{\underline{E = 0}} \quad \#$$

④

$$E(4\pi r^2) = Q \cdot 4\pi\varepsilon_0$$

$$\Rightarrow \underline{\underline{E = \frac{-kQ}{r^2}}} \quad \#$$

5. Why do some appliances continue to use electricity after powering it off.