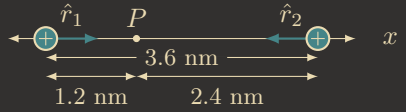
Example: Field From Two Protons

Two protons are 3.6 nm apart. Find the electric field at a point between them, 1.2 nm from one of the protons. Then find the force on an electron at this point.



The field point P is identified as being 1.2 nm from one proton. By letting the line between the protons define the x-axis, the unit vector $\hat{r}_1$ becomes $\hat{\imath}$, and $\hat{r}_2$ becomes $-\hat{\imath}$.

The charge q of both protons is the elementary charge e and the charge of an electron is $-e$, evaluating using equation 4 gives

$$\begin{aligned}\vec{E} = \vec{E}_1 + \vec{E}_2 &= \frac{k_e e}{r_1^2}\hat{\imath} + \frac{k_e e}{r_2^2}(-\hat{\imath}) = k_e e\left(\frac{1}{r_1^2} - \frac{1}{r_2^2}\right)\hat{\imath} \\ &= \left(8.99 \cdot 10^9\right)\left(1.6 \cdot 10^{-19}\right)\left(\frac{1}{1.2^2} - \frac{1}{2.4^2}\right)\hat{\imath} = 750\ \hat{\imath}\ \text{MN C}^{-1} \\ \vec{F} = q\vec{E} = -e\vec{E} &= \left(-1.6 \cdot 10^{-19}\right)\left(7.5 \cdot 10^8\right) = -1.2 \cdot 10^{-10}\hat{\imath}\ \text{N}\end{aligned}$$

Therefore, the force on an electron at point P is 0.12 nN in the $-\hat{\imath}$ direction.