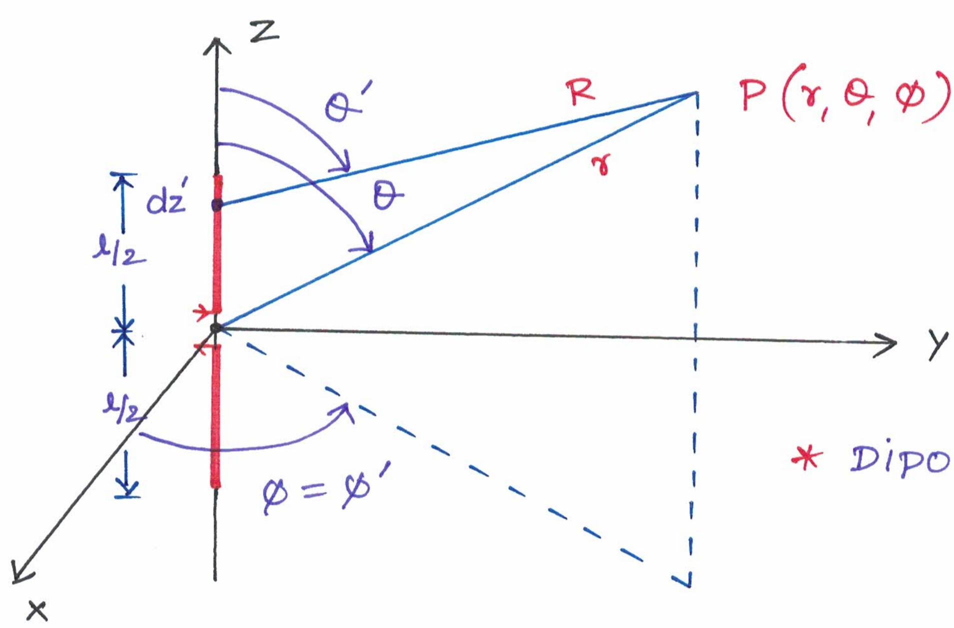
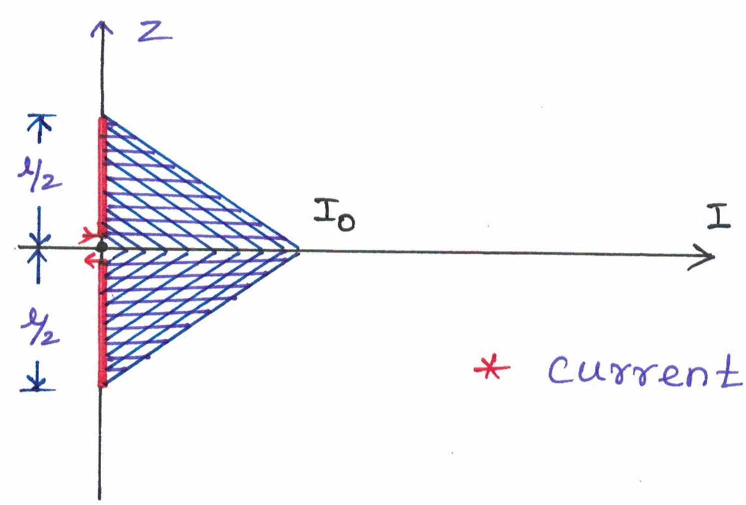
SMALL DIPOLE :- $\left(\frac{\lambda}{50} \leq l \leq \lambda/10\right)$

The current distribution of infinitesimal dipole was assumed to be constant. Although a constant current distribution is not realizable, it is a mathematical quantity that is used to represent actual current distribution of antennas that have been incremented into many small lengths.

The current distribution of wire antenna whose lengths are actually $\lambda/50 \leq l \leq \lambda/10$ is a triangular variation.



* Dipole and geometry



* current distribution

The current distribution of small dipole antenna ($\lambda/50 \le l \le \lambda/10$) is given by

$$I_e(x', y', z') = \begin{cases} \hat{a}_z \cdot I_0 \left(1 - \frac{2}{l} z'\right), & 0 \le z' \le l/2 \\ \hat{a}_z \cdot I_0 \left(1 + \frac{2}{l} z'\right), & -l/2 \le z' \le 0 \end{cases} \rightarrow (1)$$

The vector potential can be written as,

$$A(x, y, z) = \frac{\mu}{4\pi} \left[\int_{-l/2}^{0} \hat{a}_z \cdot I_0 \cdot \left(1 + \frac{2}{l} z'\right) \frac{e^{-jKR}}{R} \cdot dz' + \int_{0}^{l/2} \hat{a}_z \cdot I_0 \cdot \left(1 - \frac{2}{l} z'\right) \cdot \frac{e^{-jKR}}{R} \cdot dz' \right] \rightarrow (2)$$

$R \simeq r$

$$A(x, y, z) = \hat{a}_z \cdot A_z = \frac{\mu}{4\pi} \left[\hat{a}_z \int_{-l/2}^{0} I_0 \left(1 + \frac{2z'}{l}\right) \frac{e^{-jkr}}{r} \cdot dz' + \hat{a}_z \int_{0}^{l/2} I_0 \cdot \left(1 - \frac{2z'}{l}\right) \frac{e^{-jkr}}{r} \cdot dz' \right]$$

$$A = \frac{\mu}{4\pi} \hat{a}_z \cdot I_0 \cdot \frac{e^{-jkr}}{r} \left[\int_{-l/2}^{0} \left(1 + \frac{2z'}{l}\right) dz' + \int_{0}^{l/2} \left(1 - \frac{2z'}{l}\right) dz' \right]$$

$$= \frac{\mu}{4\pi} \hat{a}_z \cdot I_0 \frac{e^{-jkr}}{r} \left[\left[z' + \frac{\cancel{2}z'^2}{\cancel{2}l} \right]_{-l/2}^{0} + \left[z' - \frac{\cancel{2}z'^2}{\cancel{2}l} \right]_{0}^{l/2} \right]$$

$$A = \frac{\mu}{4\pi} \hat{a}_z \cdot I_0 \cdot \frac{e^{-jkr}}{r} \left[\left[z' + \frac{z'^2}{l} \right]_{-l/2}^{0} + \left[z' - \frac{z'^2}{l} \right] \right]$$

$$= \frac{\mu}{4\pi} \hat{a}_z \cdot I_0 \cdot \frac{e^{-jkr}}{r} \left[(0+0) - \left(-\frac{l}{2} + \frac{l^{\cancel{2}}}{4\cancel{l}} \right) + \left(\frac{l}{2} - \frac{l^{\cancel{2}}}{4\cancel{l}} \right) - (0-0) \right]$$

$$= \frac{\mu}{4\pi} \hat{a}_z \cdot I_0 \cdot \frac{e^{-jkr}}{r} \left[\frac{l}{2} - \frac{l}{4} + \frac{l}{2} - \frac{l}{4} \right]$$

$$A = \frac{\mu}{4\pi} \hat{a}_z \cdot I_0 \cdot \frac{e^{-jkr}}{r} \cdot \frac{l}{2}$$

$$A = \hat{a}_z \cdot A_z = \hat{a}_z \cdot \frac{1}{2} \left[\frac{\mu I_0 l . e^{-jkr}}{4\pi r} \right] \rightarrow (3)$$

Since the potential function for the triangular distribution is one-half of the corresponding one for the constant (uniform) current distribution, the corresponding fields of the former are one-half of the later. Thus we can write the E and H fields radiated by a small dipole as,

$$E_\theta \simeq j\eta \frac{K I_0 l . e^{-jkr}}{8\pi r} \sin\theta \rightarrow (4)$$

$$E_r \simeq E_\phi = H_r = H_\theta = 0 \rightarrow (5)$$

$$H_\phi \simeq j \frac{K I_0 l e^{-jkr}}{8\pi r} \sin\theta \rightarrow (6)$$

Since the directivity of an antenna is controlled by the relative shape of the field or power pattern, the directivity and maximum effective area of this antenna are the same as the ones with the constant current distribution.

Directivity,

$$D_o = 4\pi \frac{U_{max}}{P_{rad}} = \frac{3}{2} \rightarrow (7)$$

maximum effective aperture,

$$A_{em} = \frac{\lambda^2}{4\pi} \cdot D_o = \frac{3\lambda^2}{8\pi} \rightarrow (8)$$

The radiation resistance of the antenna is strongly dependent upon the current distribution. Thus radiation resistance reduces to,

$$R_r = \frac{2P_{rad}}{|I_o|^2} = 20\pi^2 \left(\frac{l}{\lambda}\right)^2 \rightarrow (9)$$