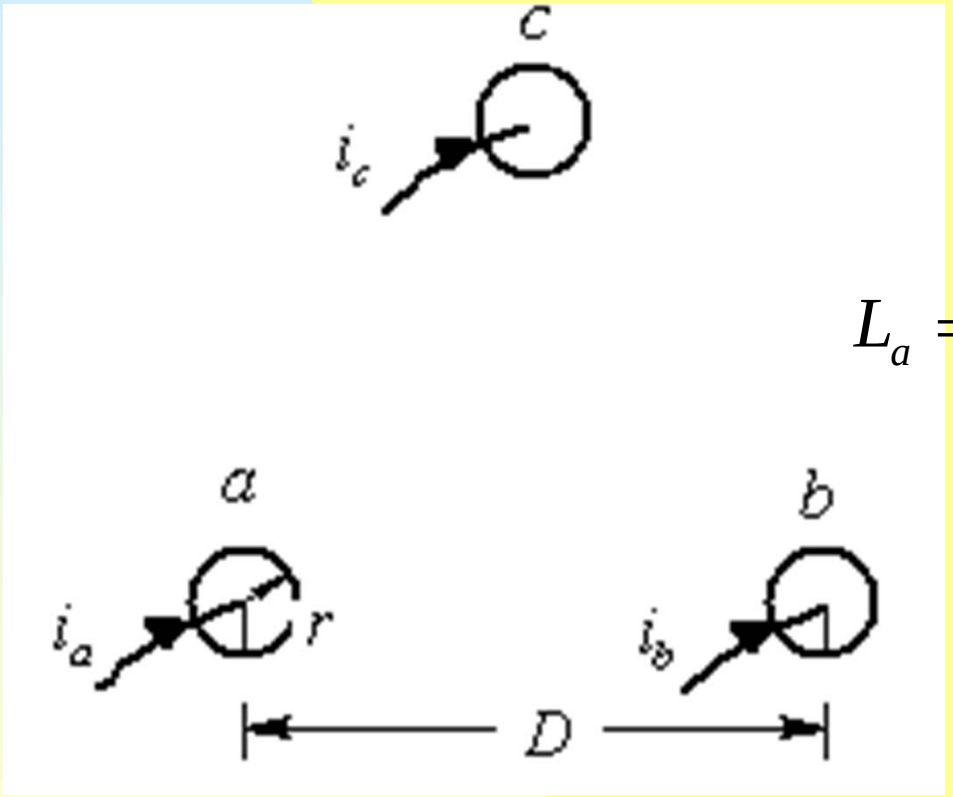
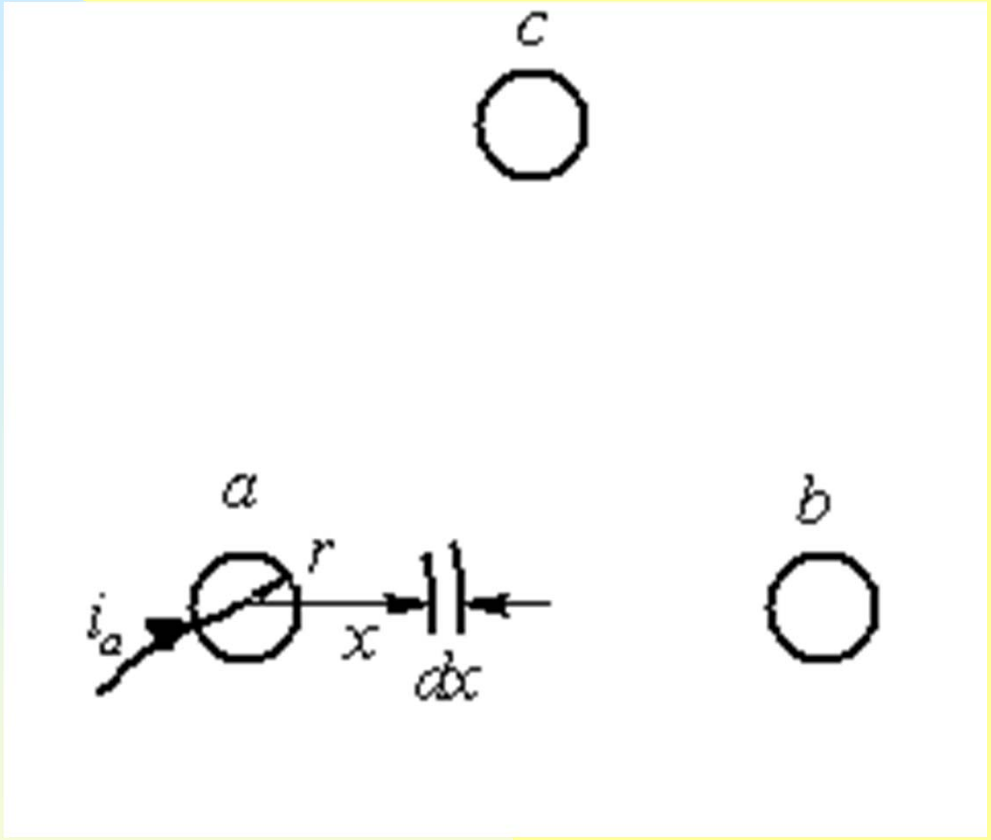
Calculation of Transmission Line Inductance



$$i_a + i_b + i_c = 0$$

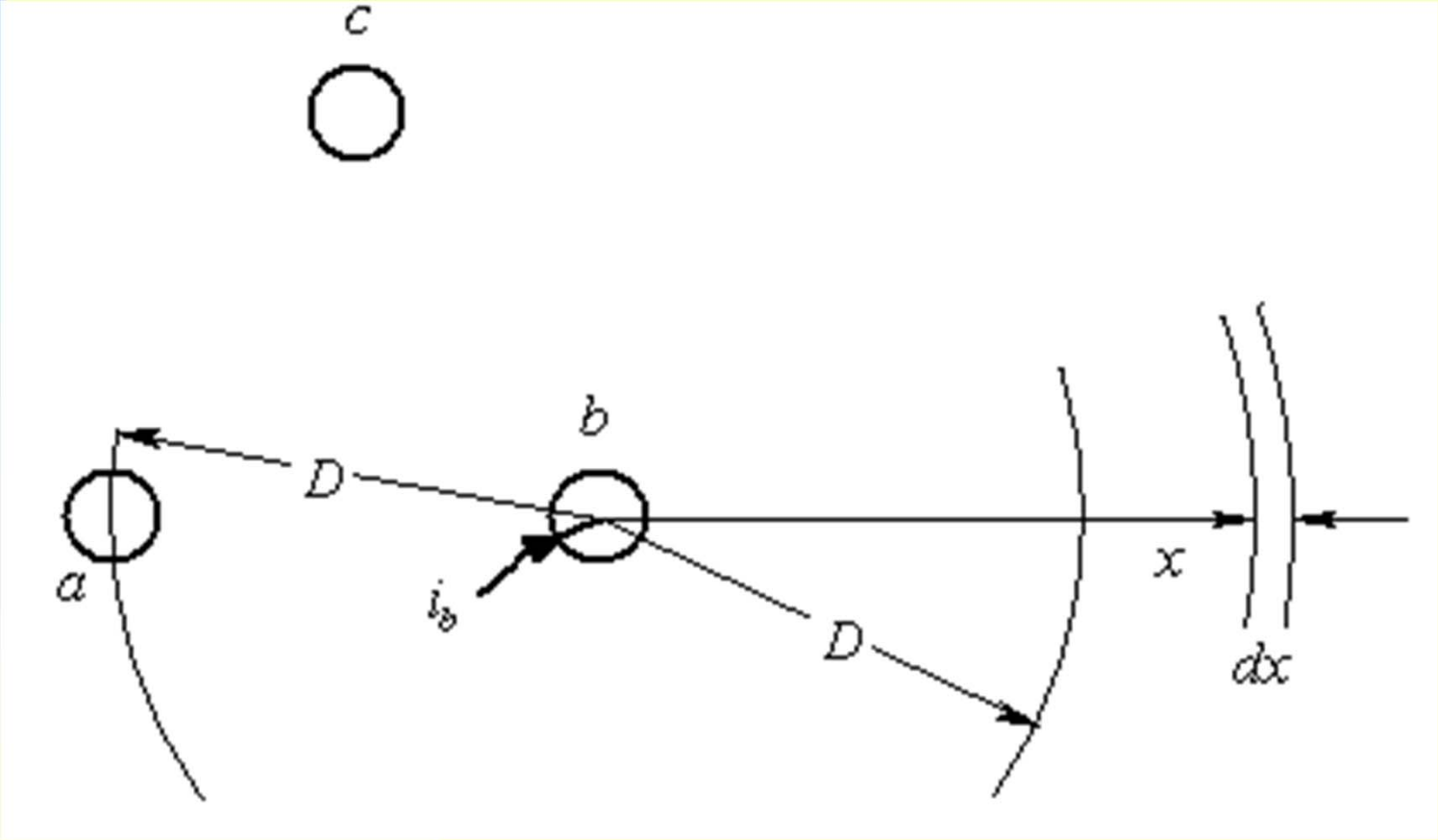
$$L_a = \frac{\lambda_{a,total}}{i_a} = \frac{1}{i_a}\left(\lambda_{a,i_a} + \lambda_{a,i_b} + \lambda_{a,i_c}\right)$$

Use of Superposition – self-current:



$$\lambda_{a,i_a} = \int_r^{\infty} d\lambda_{x,i_a} = \left(\frac{\mu_0}{2\pi}\right) i_a \ln\frac{\infty}{r}$$

Due to other two currents:



$$\lambda_{a,i_b} = \left(\frac{\mu_0}{2\pi}\right) i_b \ln\frac{\infty}{D} \qquad \lambda_{a,i_c} = \left(\frac{\mu_0}{2\pi}\right) i_c \ln\frac{\infty}{D}$$

Superposition –

$$\lambda_{a,total} = \lambda_{a,i_a} + \lambda_{a,i_b} + \lambda_{a,i_c} = \left(\frac{\mu_0}{2\pi}\right)\left[i_a \ln\frac{\infty}{r} + \left(i_b + i_c\right)\ln\frac{\infty}{D}\right]$$

$$i_a + i_b + i_c = 0$$

$$\lambda_{a,total} = \left(\frac{\mu_0}{2\pi}\right) i_a \ln\frac{D}{r}$$

$$L = \left(\frac{\mu_0}{2\pi}\right)\ln\frac{D}{r}$$

GMD $D = \sqrt[3]{D_1 D_2 D_3}$

Effect of Bundling on Inductance –

- 0.7 times for 3-conductor bundle
- 0.8 times for 2-conductor bundle

Electric Field Due to Transmission Line Voltage

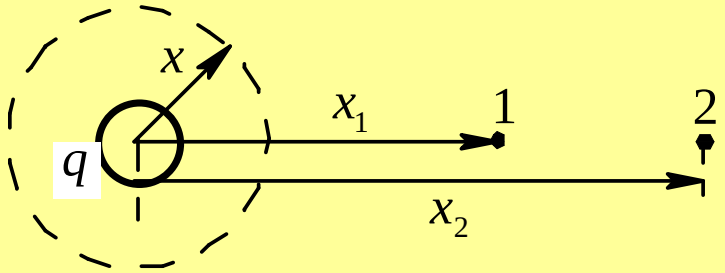
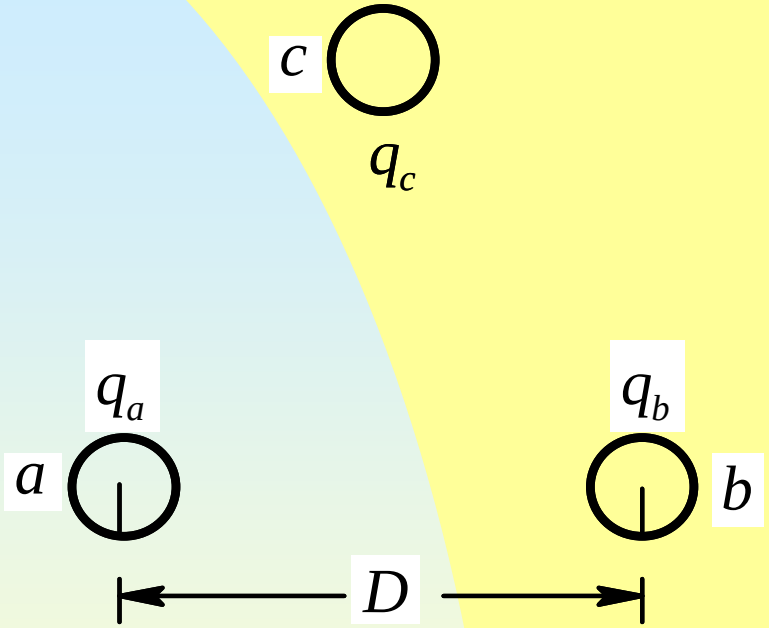


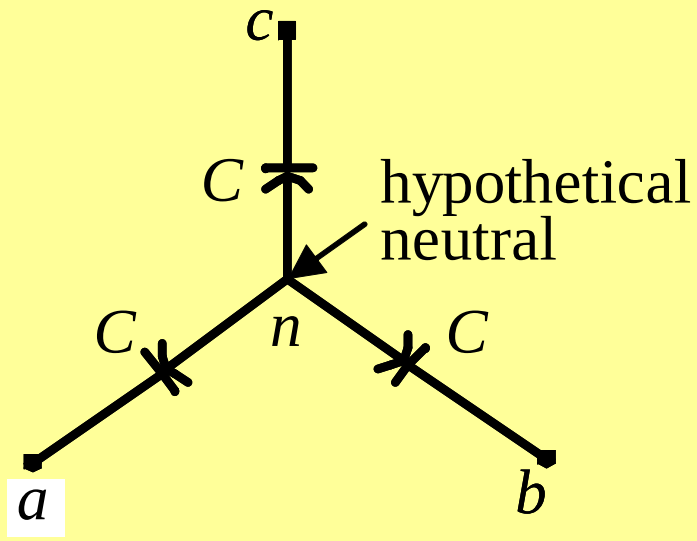
Fig. 4-6 Electric field due to a charge.

$$v_{12} = -\int_{x_2}^{x_1} E(x) \cdot dx = \left(\frac{q}{2\pi\varepsilon_0} \right) \ln \frac{x_2}{x_1}$$

Calculation of Transmission Line Capacitance



(a)



(b)

$$C = \frac{2\pi\varepsilon_0}{\ln \frac{D}{r}}$$

$$D = \sqrt[3]{D_1 D_2 D_3}$$

Effect of Bundling on Shunt Capacitance –

- 1.4 times for 3-conductor bundle
- 1.25 times for 2-conductor bundle

Typical Parameters for various Voltage Transmission Lines

Table 4-1

Transmission Line Parameters with Bundled Conductors (except at 230 kV) at 60 Hz [2, 6]

Nominal Voltage	$R(\Omega/km)$	$\omega L(\Omega/km)$	$\omega C(\mu\mho/km)$
230 kV	0.055	0.489	3.373
345 kV	0.037	0.376	4.518
500 kV	0.029	0.326	5.220
765 kV	0.013	0.339	4.988

Calculating Transmission Line Parameters using EMTDC

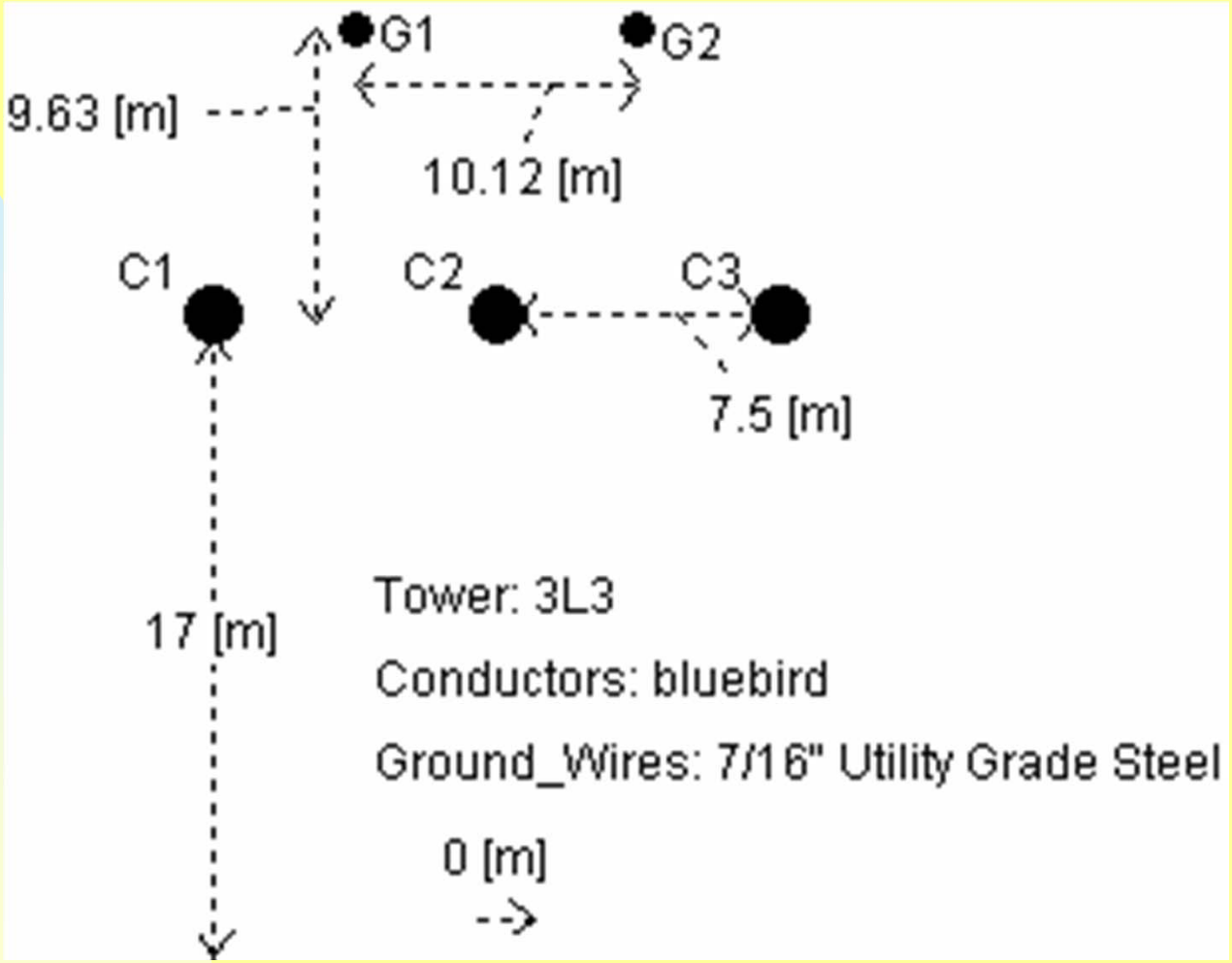


Fig. 4-8 A 345-kV, single-conductor per phase, transmission system.