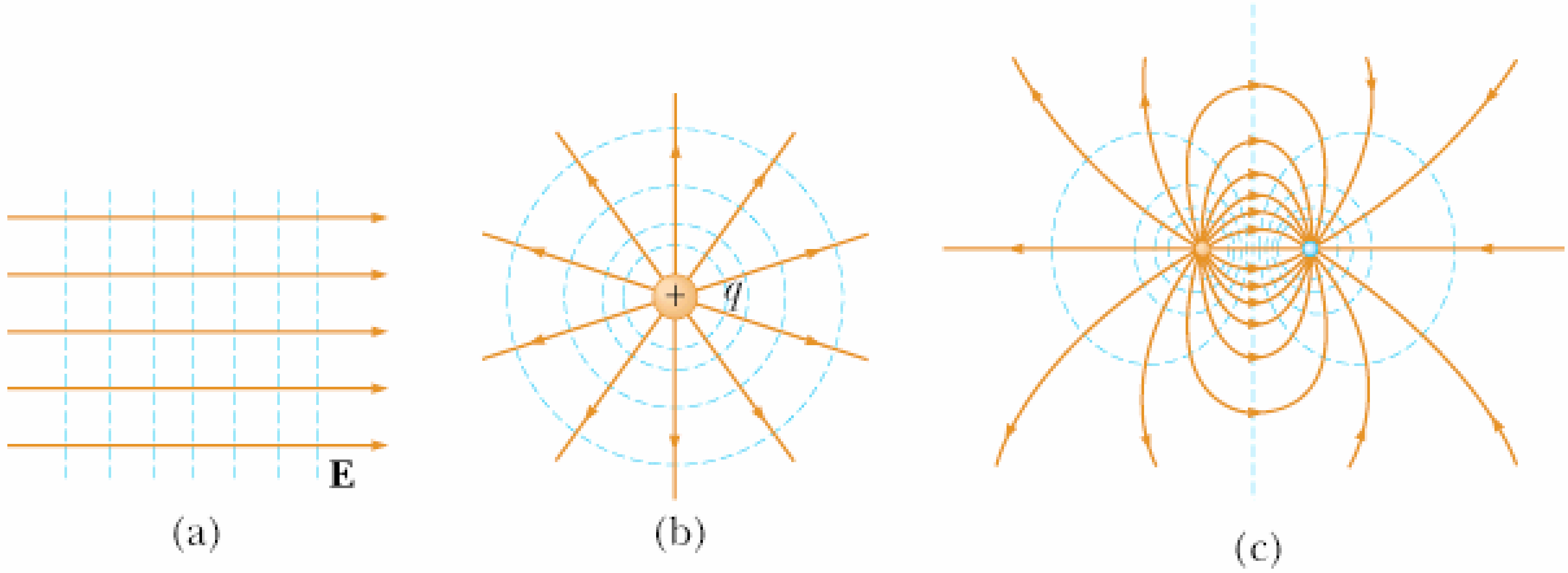
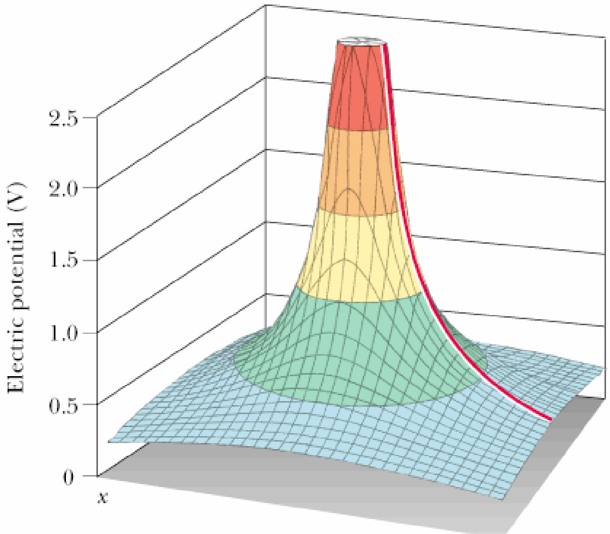
Electric Potential



Serway, Physics for Scientists and Engineers, 5/e
Figure 25.7a



(a)

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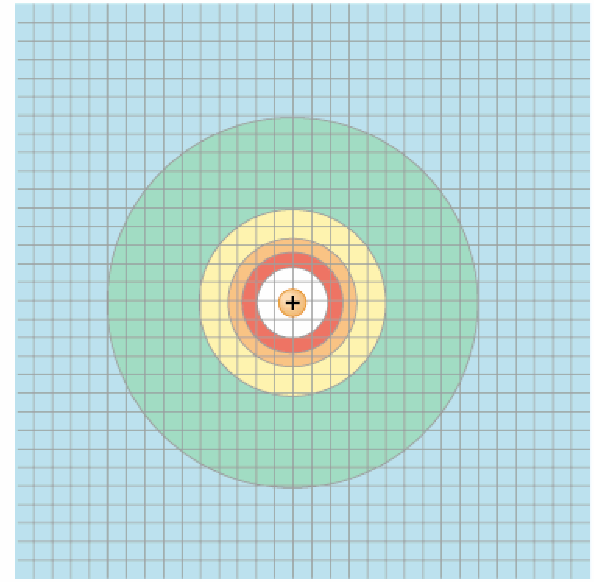
Figure 25.7b



(b)

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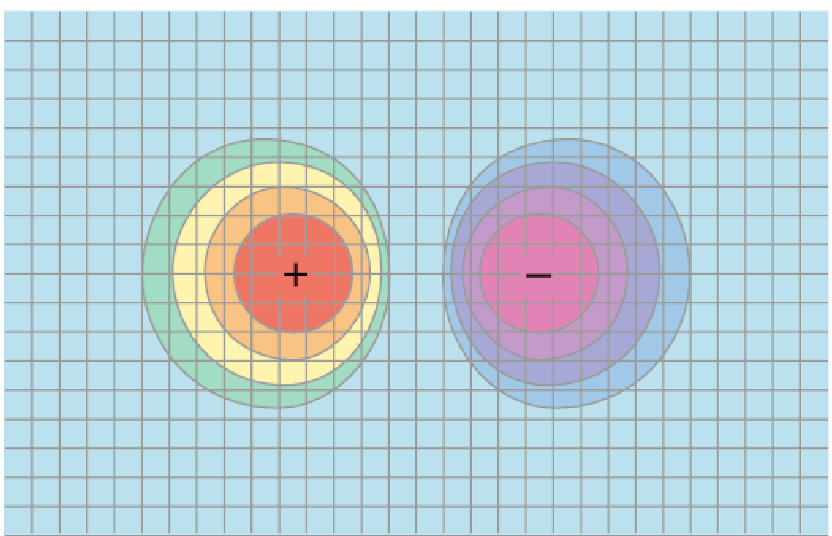
Figure 25.8b



(b)

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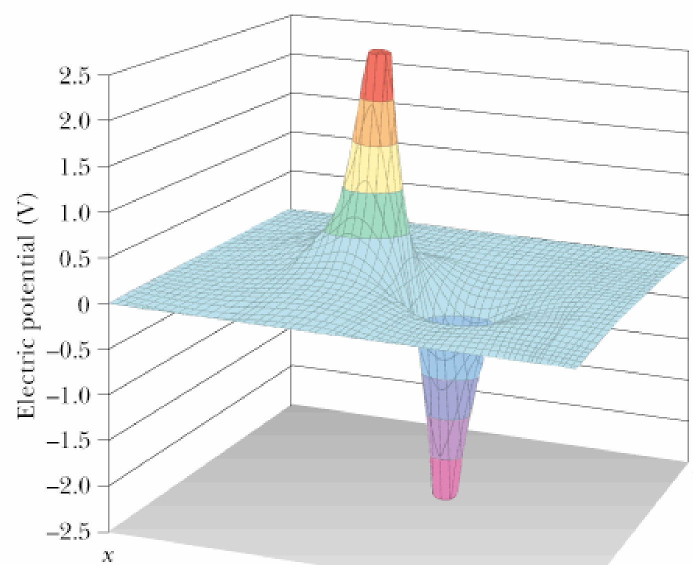
25.8a



(a)

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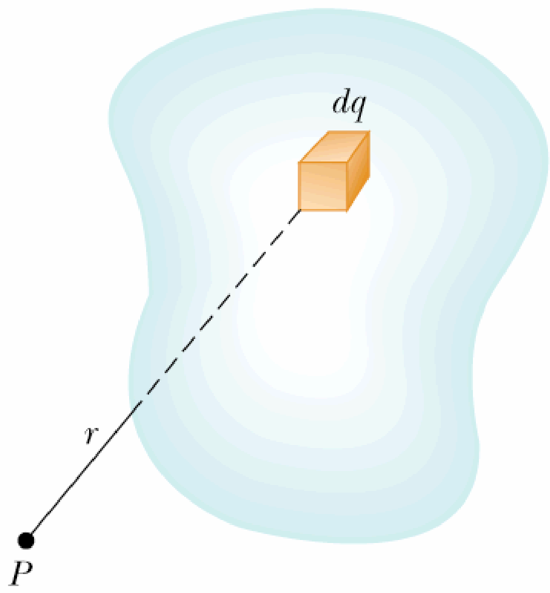
Figure 25.14



electric Potential due to a continuous charge distribution

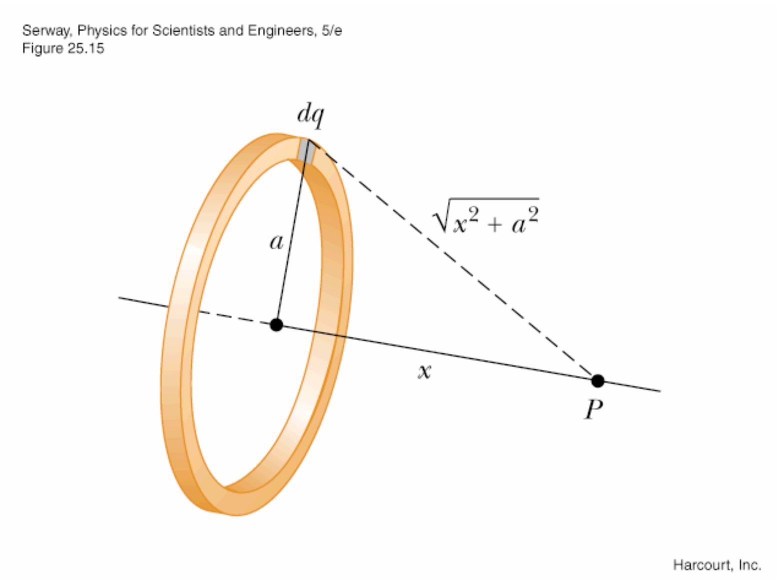
$$dV = k_e \frac{dq}{r} \tag{20}$$

$$V = k_e \int \frac{dq}{r} \tag{21}$$

Example 25.5:

- Find the electric potential at a point P located on the perpendicular axis of uniformly charged ring of radius a and total charge Q.

  Let us orient the ring so that the perpendicular axis is along the x direction and point P is at a distance x from the center of the ring.



$$V = k_e \int \frac{dq}{r} \tag{22}$$

$$= k_e \int \frac{dq}{\sqrt{(x^2 + a^2)}} \tag{23}$$

x, and a are constants
$$= \frac{k_e}{\sqrt{(x^2 + a^2)}} \int dq \tag{24}$$

$$= \frac{k_e Q}{\sqrt{(x^2 + a^2)}} \tag{25}$$

Find the electric field at point P

$$\mathbf{E} = -\frac{dV}{dx}\hat{\mathbf{i}} - \frac{dV}{dy}\hat{\mathbf{j}} - \frac{dV}{dz}\hat{\mathbf{j}} \tag{26}$$

$$\frac{dV}{dx} = -\frac{k_e Q x}{(x^2 + a^2)^{3/2}} \tag{27}$$

$$\frac{dV}{dy} = 0 \tag{28}$$

$$\frac{dV}{dx} = 0 \tag{29}$$

$$\Rightarrow \mathbf{E} = -\frac{dV}{dx} = \frac{k_e Q x}{(x^2 + a^2)^{3/2}}\hat{\mathbf{i}} \tag{30}$$

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Figure 25.20

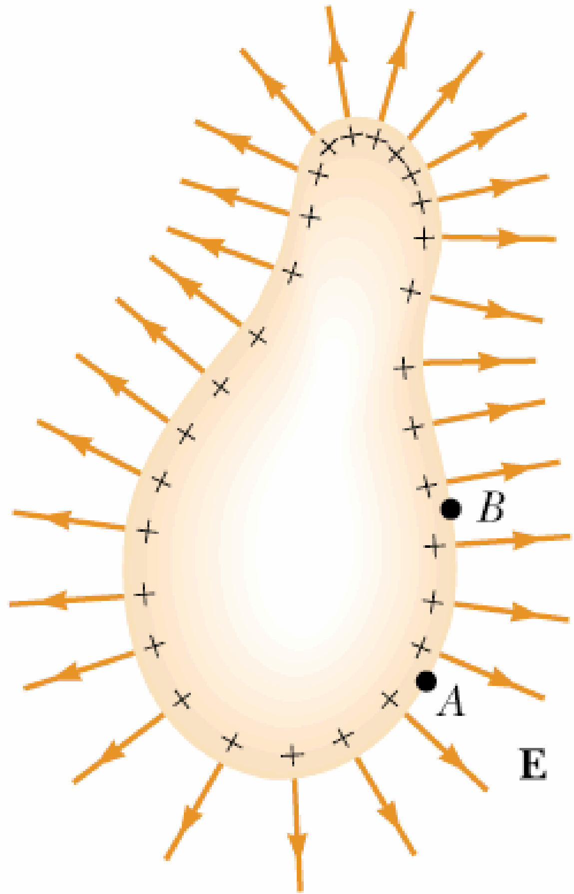

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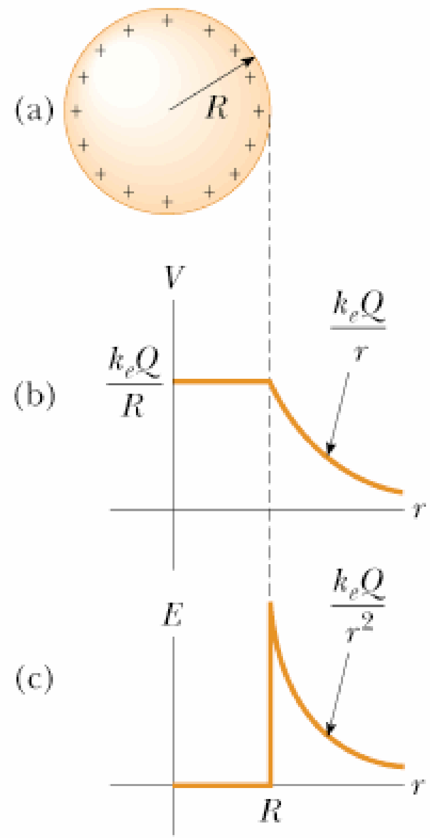
Figure 25.21



Example 25.9

Two spherical conductors are separated by a large distance and have the indicated charges. They are connected by a thin conducting wire. Find the magnitudes of the electric fields at the surface of the spheres.

- Since they are connected by a conductor, the two spheres are at the same potential:

$$V = k_e \frac{q_1}{r_1} = k_e \frac{q_2}{r_2} \tag{2}$$

$$\Rightarrow \frac{q_1}{q_2} = \frac{r_1}{r_2} \tag{3}$$

but,

$$E_1 = k_e \frac{q_1}{r_1^2} \quad ; \quad E_2 = k_e \frac{q_2}{r_2^2} \tag{4}$$

$$\Rightarrow \frac{E_1}{E_2} = \frac{q_1}{q_2} \frac{r_2^2}{r_1^2} \tag{5}$$

$$\frac{E_1}{E_2} = \frac{r_2}{r_1} \tag{6}$$

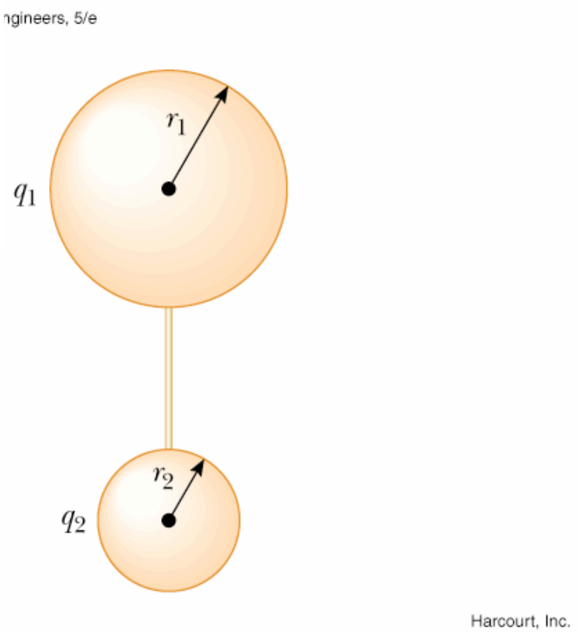


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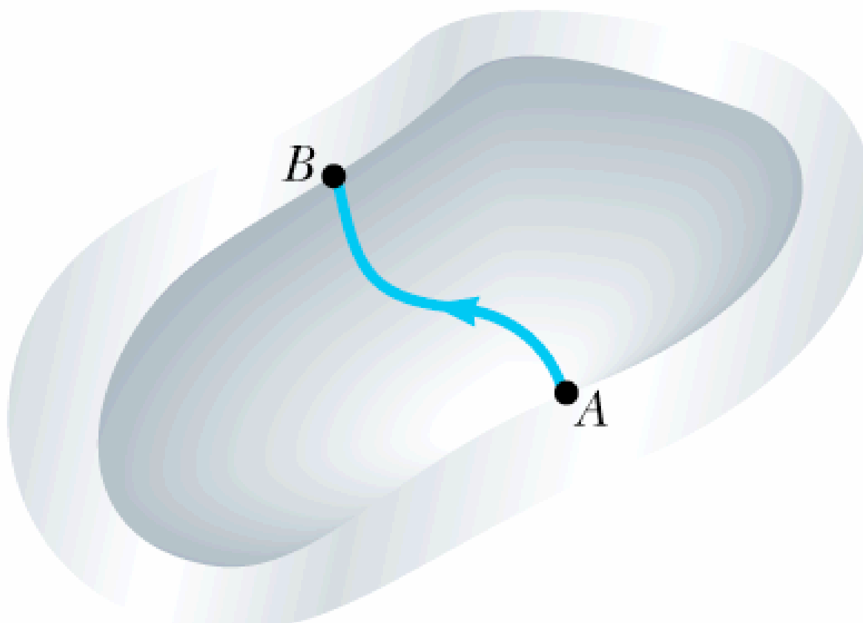
Figure 25.24



Problem 25.43:

25.43 (a) $[\alpha] = \left[\frac{\lambda}{x}\right] = \frac{\text{C}}{\text{m}} \cdot \left(\frac{1}{\text{m}}\right) = \boxed{\frac{\text{C}}{\text{m}^2}}$

(b) $V = k_e \int \frac{dq}{r} = k_e \int \frac{\lambda\, dx}{r} = k_e \alpha \int_0^L \frac{x\, dx}{(d+x)} = \boxed{k_e \alpha \left[L - d \ln\left(1 + \frac{L}{d}\right)\right]}$