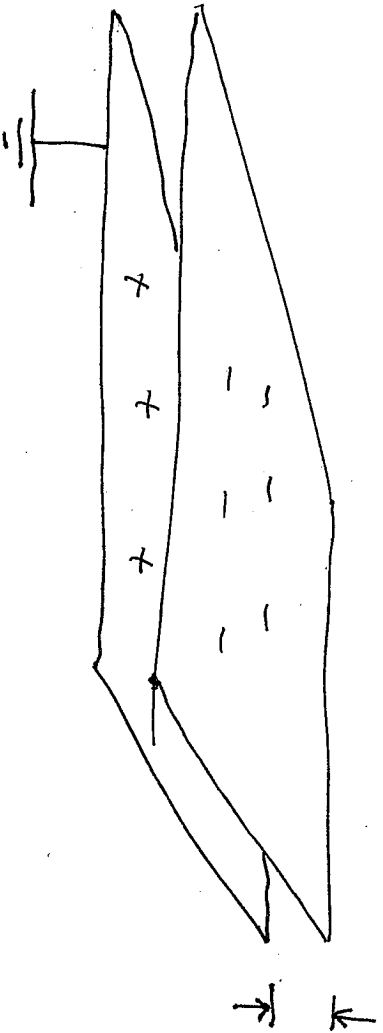


Lecture # 8

Electric Potentials (cont.)

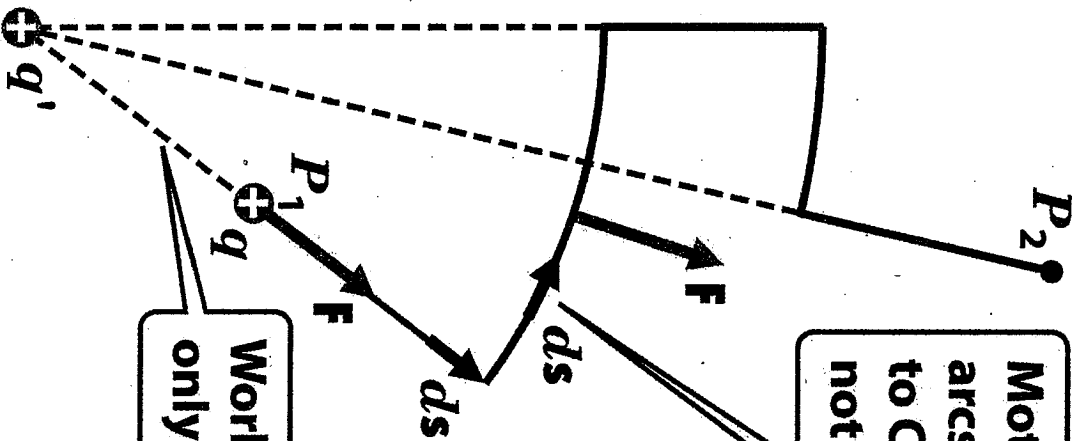
What is the Potential of the upper plate relative to Ground (E is electric field in between plates)?



- (a) $E d$
- (b) $-E d$
- (c) 0

Work needed in moving charge q' depends only on radial q distance in \vec{E} -field

Motion along circular arcs, since perpendicular to Coulomb force, does not change work done.



Work done depends only on radial distance.

$$dW = -\vec{F} \cdot d\vec{r} = -F_r dr$$

$$= -\frac{q q'}{4\pi\epsilon_0} \frac{dr}{r^2}$$

$$W = -\frac{q q'}{4\pi\epsilon_0} \int_{\infty}^r \frac{dr}{r^2}$$

$$= \frac{q q'}{4\pi\epsilon_0} \left[\frac{1}{r} \right]_{\infty}^r$$

$$= \frac{q q'}{4\pi\epsilon_0} \frac{1}{r} = U$$

Figure 25-7 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

Electric

$$V(r) = \text{Potential} = \frac{PE}{q} = \frac{q'}{4\pi\epsilon_0 r} = U(r) \equiv PE$$

$$V = \frac{q}{4\pi\epsilon_0 r}$$

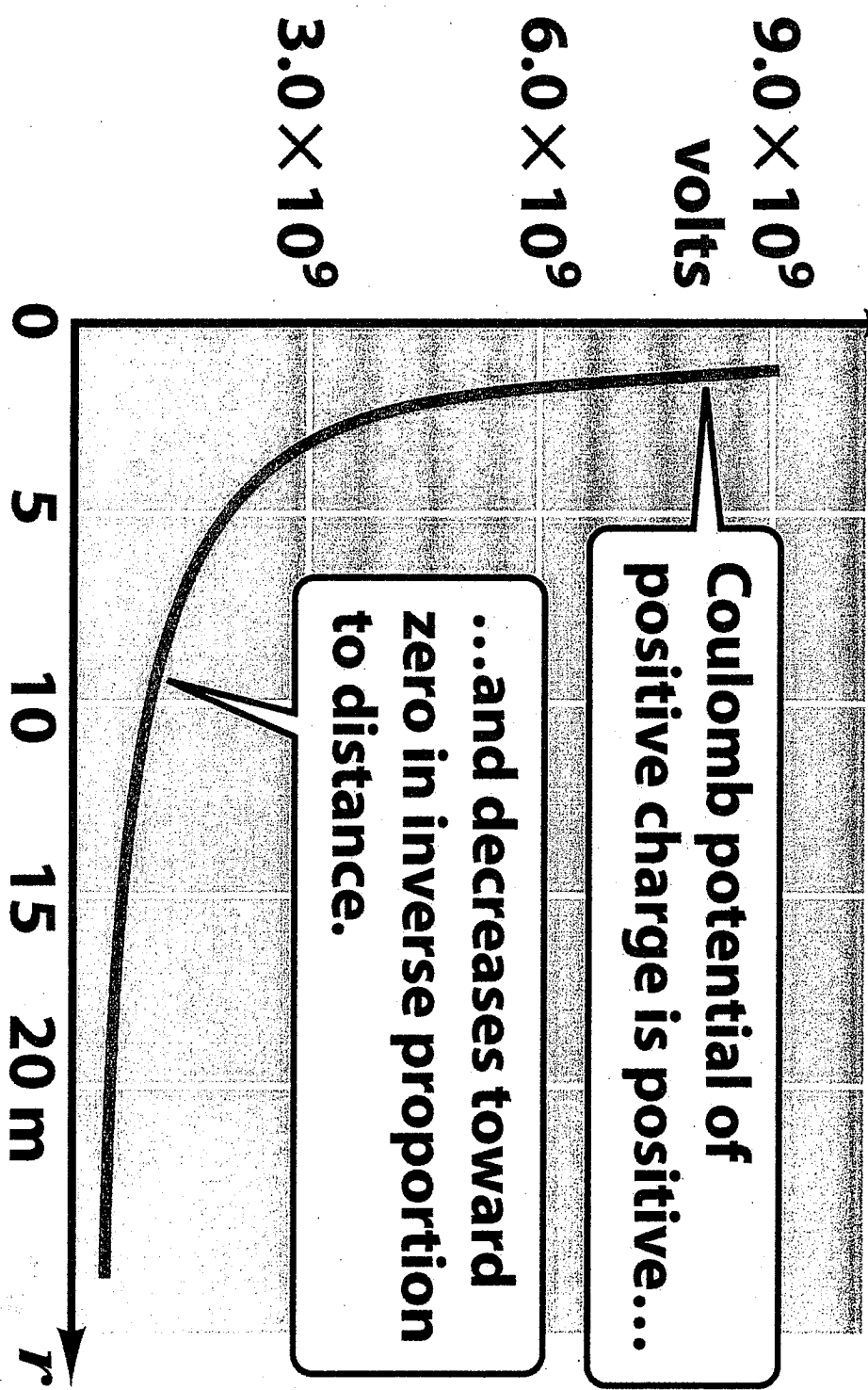


Figure 25-8a Physics for Engineers and Scientists 3/e
© 2007 W. W. Norton & Company, Inc.

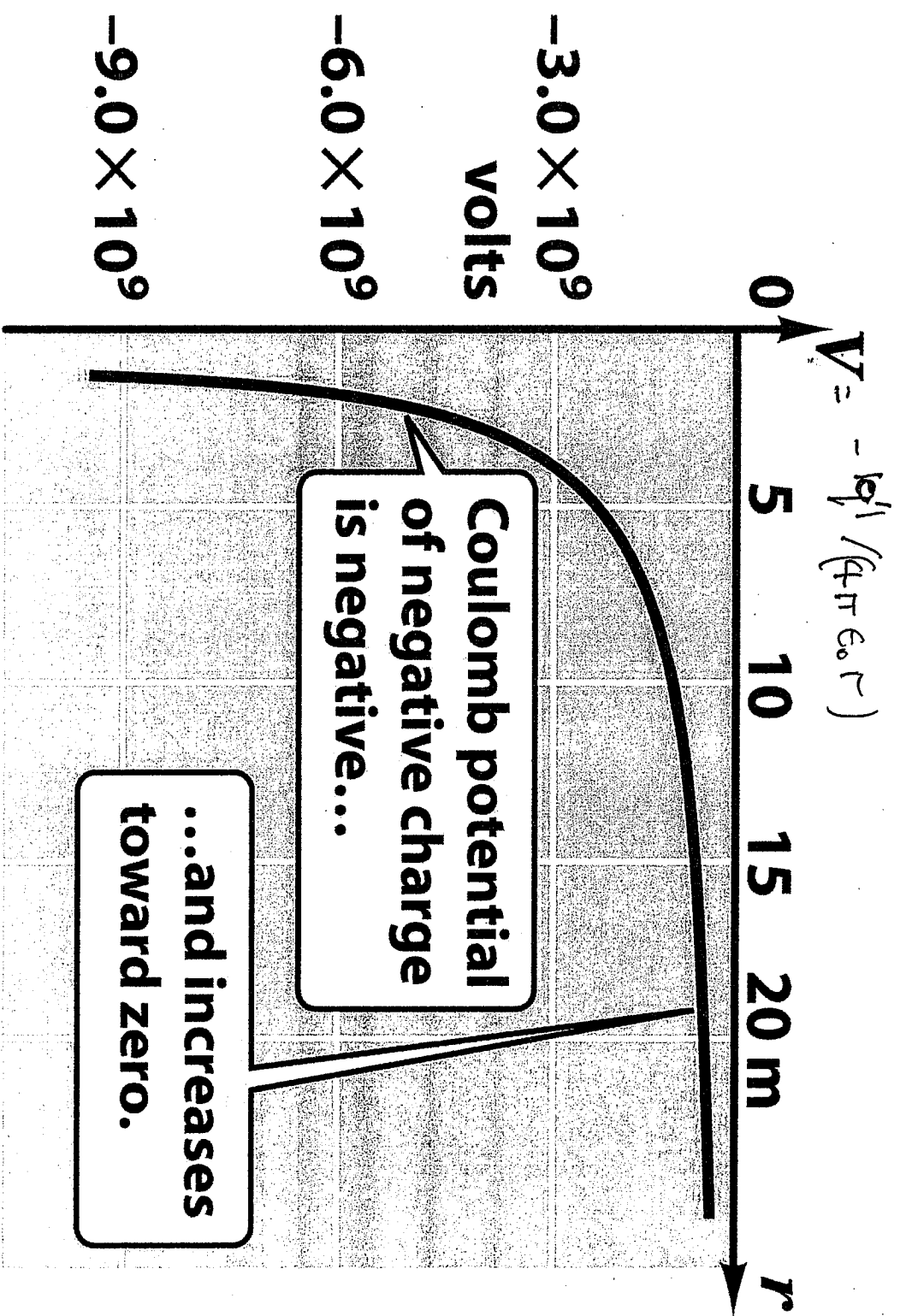
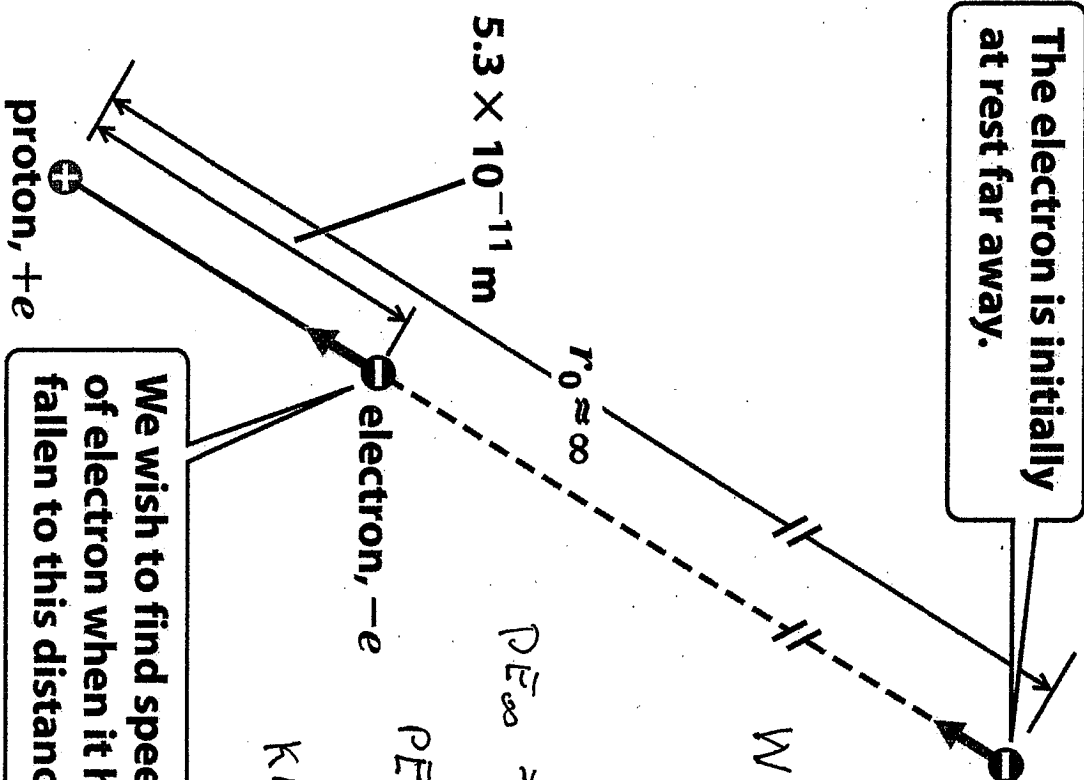


Figure 25-8b Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

The electron is initially at rest far away.



We wish to find speed of electron when it has fallen to this distance.

$$W = PE_{\infty} + KE_{\infty}$$

$$= PE_r + KE_r$$

$$PE_{\infty} = 0, \quad KE_{\infty} = 0$$

$$PE_r = (-e) \frac{e}{4\pi\epsilon_0 r}$$

$$KE_r = \frac{1}{2} m_e v^2$$

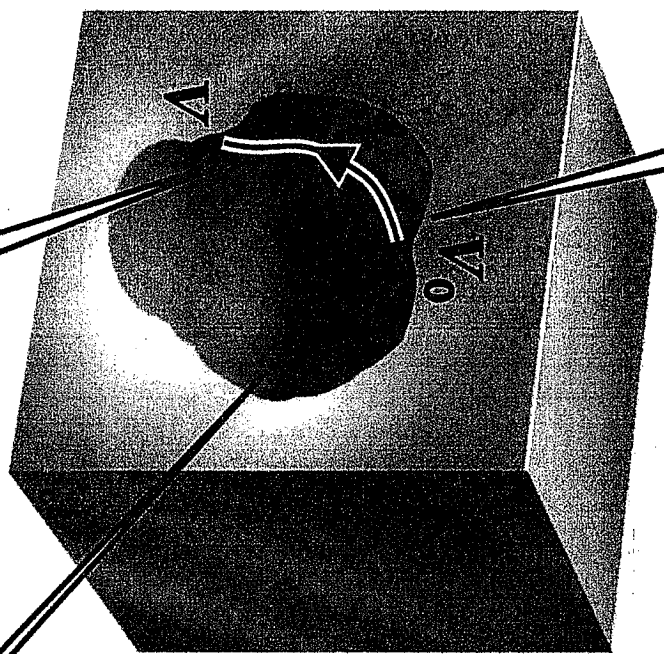
$$0 = \frac{1}{2} m_e v^2 - \frac{e^2}{4\pi\epsilon_0 r}$$

$$v = \left(\frac{e^2}{2\pi\epsilon_0 m_e r} \right)^{1/2}$$

Figure 25-11 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

Electric Field Inside Metallic Cavity

For empty cavity, any field line would have to begin and end at surface.



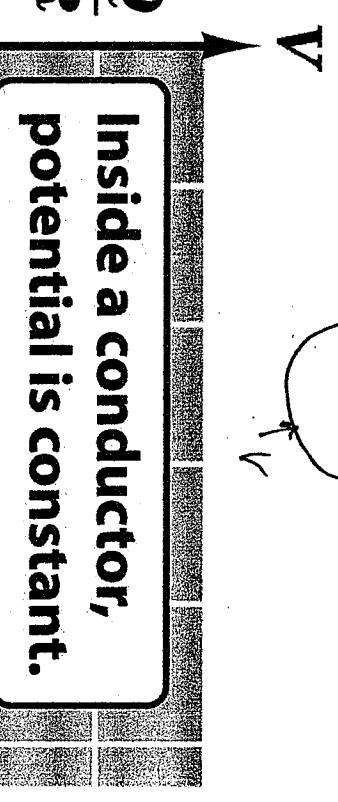
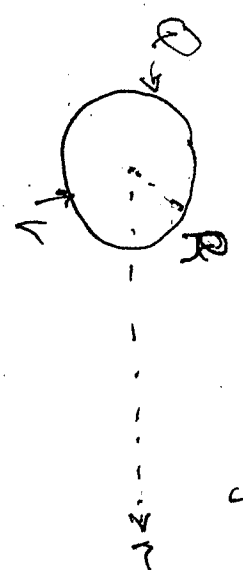
Path parallel to field line would imply a potential difference: impossible!

Electric field is zero everywhere in cavity.

conductor is
eq. w/ potential

Figure 25-19 Physics for Engineers and Scientists 3/e
© 2007 W. W. Norton & Company, Inc.

Potential from a conducting sphere



Inside a conductor, potential is constant.

Outside, potential is same as that of a point charge, inversely proportional to distance.

$$\frac{1}{4\pi\epsilon_0} \frac{3Q}{2R}$$

$$\frac{1}{4\pi\epsilon_0} \frac{Q}{R}$$

$$\frac{1}{4\pi\epsilon_0} \frac{Q}{2R}$$

$r > R$

$$V = \frac{Q}{4\pi\epsilon_0} \frac{1}{r}$$

$r \leq R$

$$V = \frac{Q}{4\pi\epsilon_0} \frac{1}{R}$$

Figure 25-18 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

$$dV = -E_r dr$$

$$= -\frac{Q}{4\pi\epsilon_0 r^2} \frac{dr}{r^2}, \quad r > R$$

$$V = -\int_{\infty}^r E_r dr$$

$$= -\frac{Q}{4\pi\epsilon_0} \int_{\infty}^r \frac{dr}{r^2}$$

$$= +\frac{Q}{4\pi\epsilon_0} \frac{1}{r} \quad (r > R)$$

$$E_r = 0, \quad r < R$$

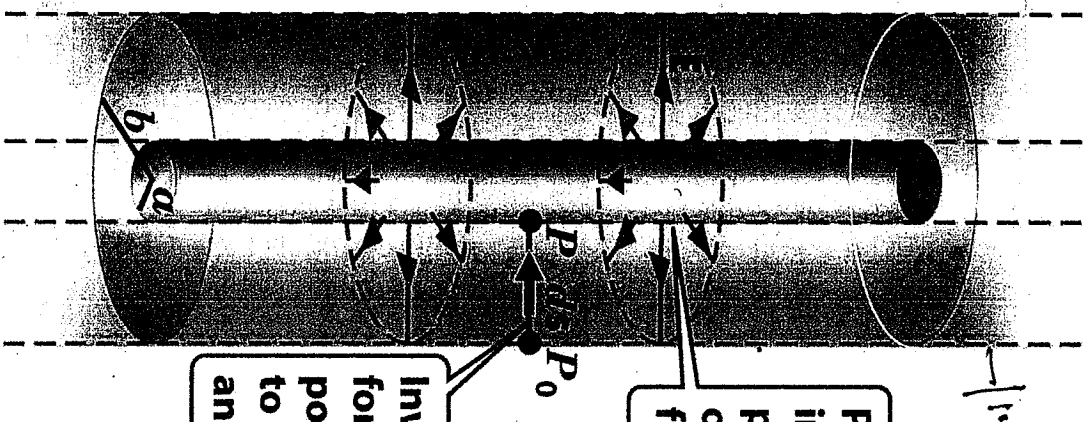
$r < a$

$$V = V(a) + \int_a^r E_r dr$$

$$= V(a)$$

Find potential difference between P and P_0

Coaxial cables with a and b shells ($a < b$)



Positive charge on inner conductor produces radially outward electric field for $a < r < b$.

Inward radial path for calculation of potential is opposite to electric field and to dr .

$$E_r = \frac{\lambda}{2\pi\epsilon_0 r}$$

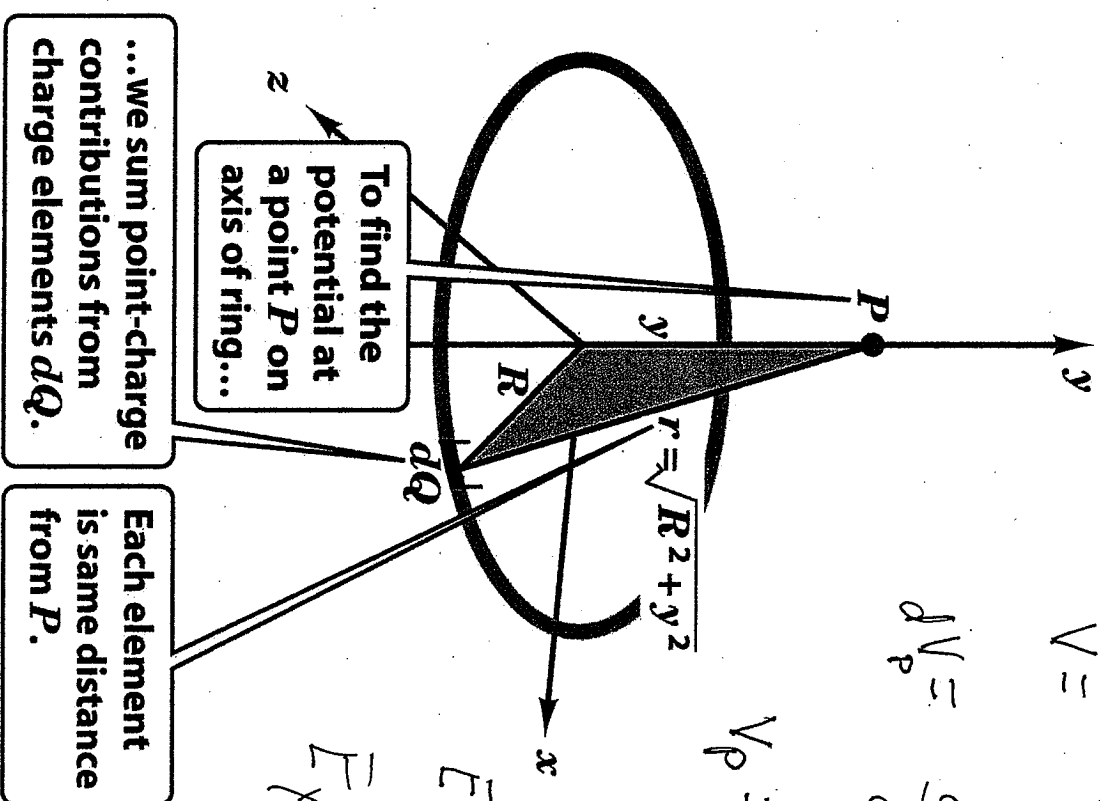
$$\int_a^b dr E_r = \frac{\lambda}{2\pi\epsilon_0} \int_a^b \frac{dr}{r}$$

$$= \frac{\lambda}{2\pi\epsilon_0} \ln\left(\frac{b}{a}\right)$$

$$V = \frac{\lambda}{2\pi\epsilon_0} \ln\left(\frac{b}{a}\right)$$

Figure 25-14 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

Find potential and electric field (new way)



$$V = \int \frac{dq}{4\pi\epsilon_0 r}$$

$$dV = \frac{dq}{4\pi\epsilon_0 \sqrt{R^2 + y^2}}$$

$$V_p = \frac{Q}{4\pi\epsilon_0} \frac{1}{\sqrt{R^2 + y^2}}$$

$$E_y = - \frac{dV}{dy}$$

$$E_y = \frac{Q}{4\pi\epsilon_0} \frac{y}{(R^2 + y^2)^{3/2}}$$

...we sum point-charge contributions from charge elements dQ .

Each element is same distance from P .

To find the potential at a point P on axis of ring...

Figure 25-22 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

How will the potential vary on each conductor?

- a. Since there are many conductors, the potential will vary on each conductor
- b. Each conductor will have its unique constant potential

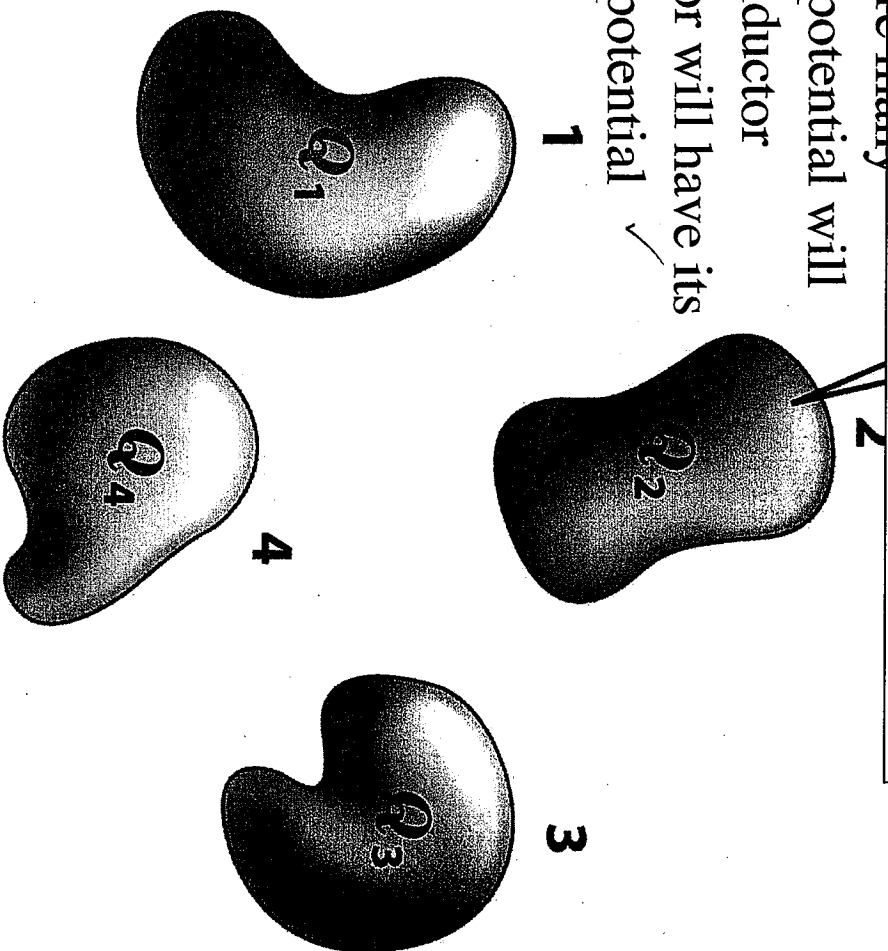


Figure 25-29 Physics for Engineers and Scientists 3/e
© 2007 W. W. Norton & Company, Inc.