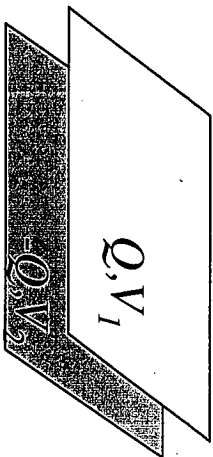


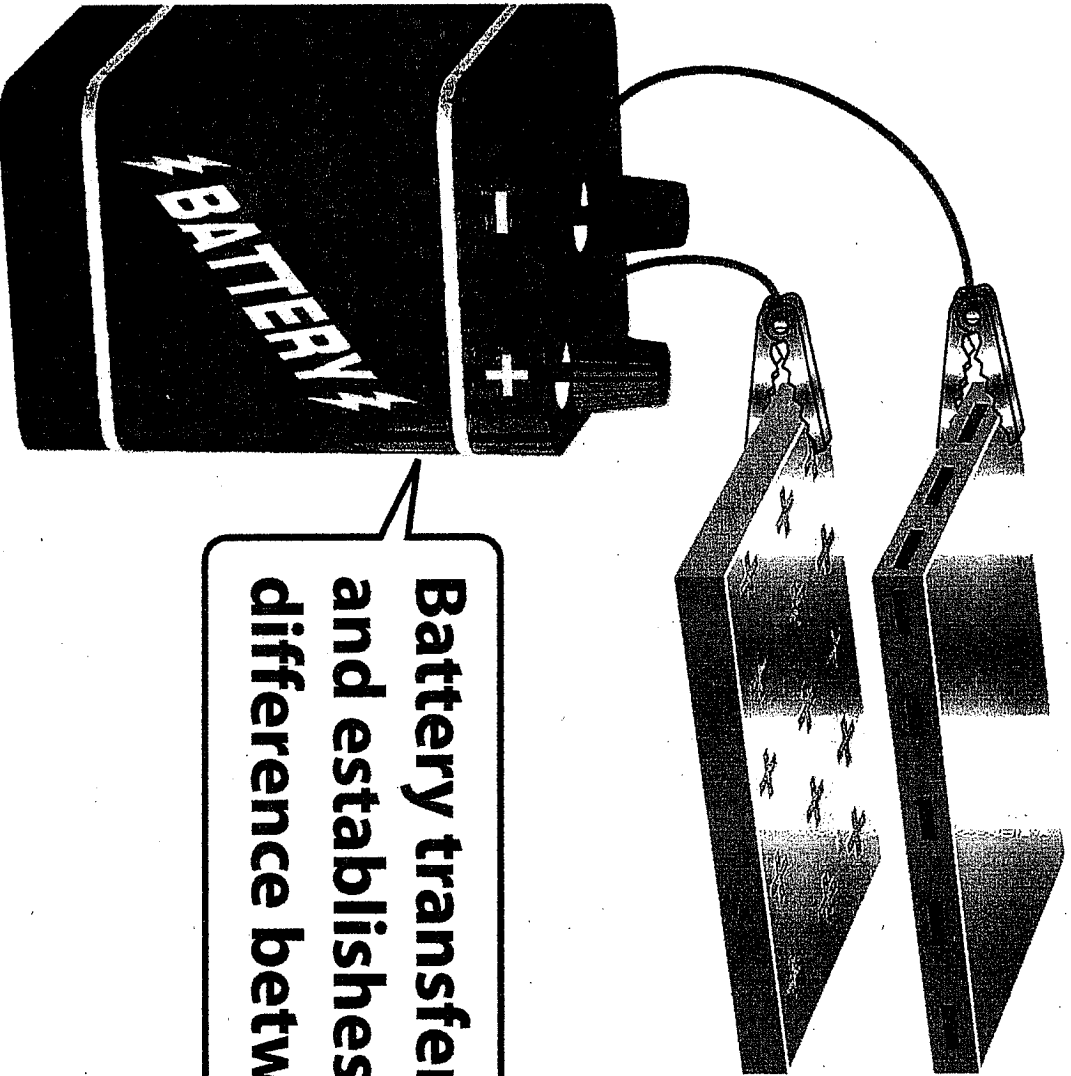
Lecture # 13

Capacitors

The definition of Capacitance is:

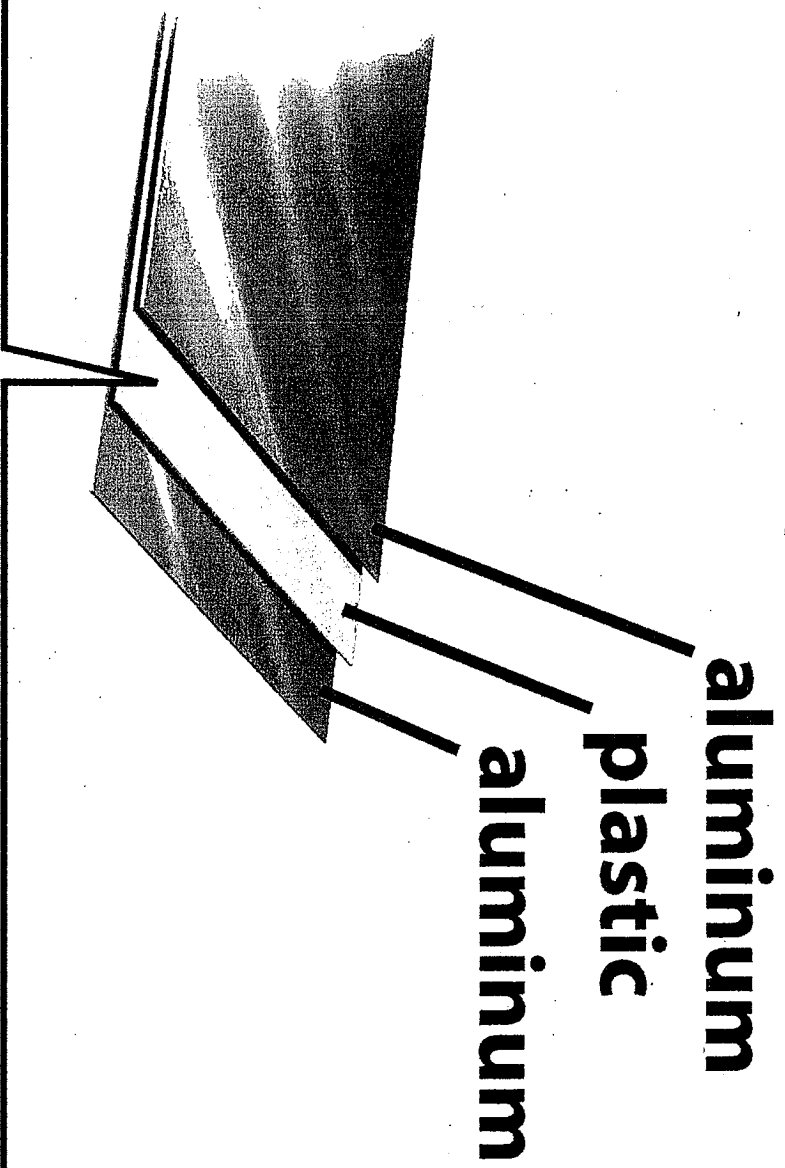


1. $C = Q/V_1$
2. $C = V_1/Q$
3. $C = V_2/Q$
4. $C = Q/(V_1 - V_2)$



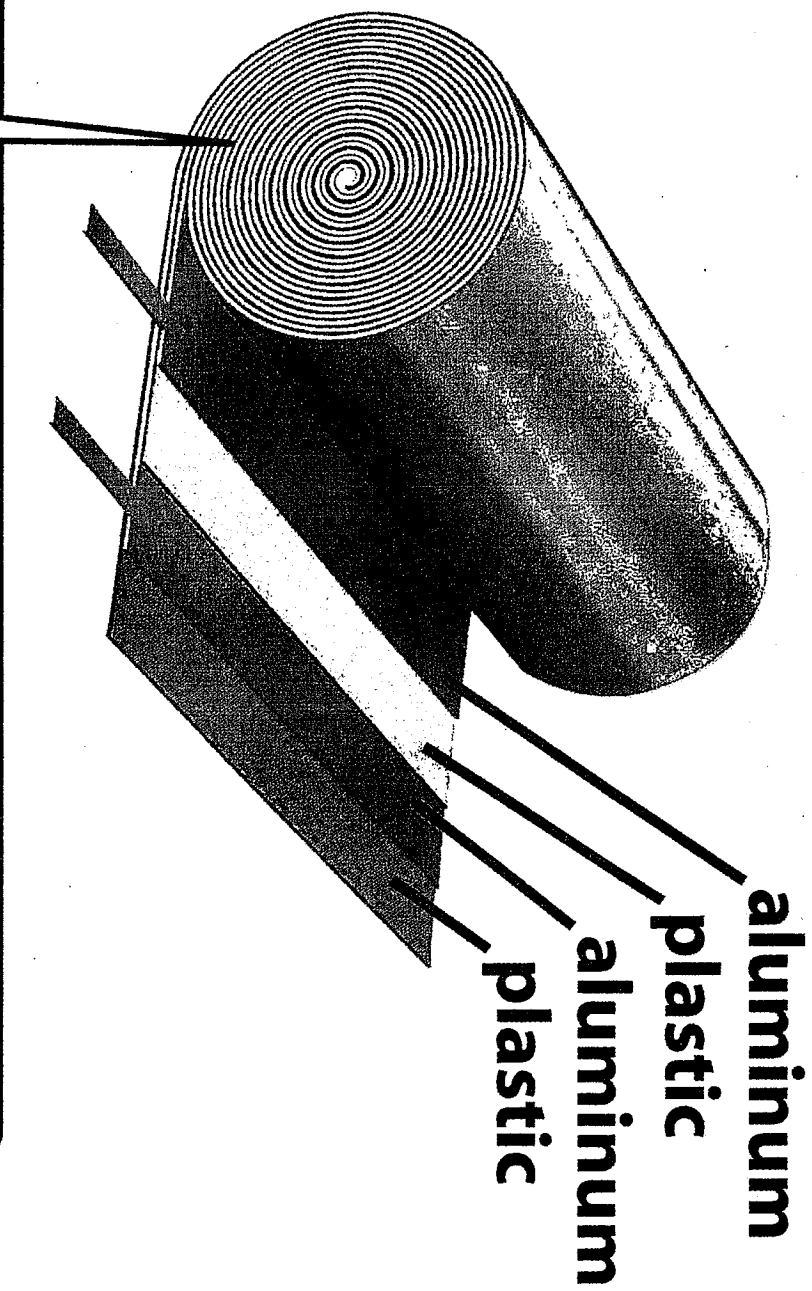
Battery transfers charge and establishes potential difference between plates.

Figure 26-4 Physics for Engineers and Scientists 3/e
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Thin insulating sheet is sandwiched between metal sheets.

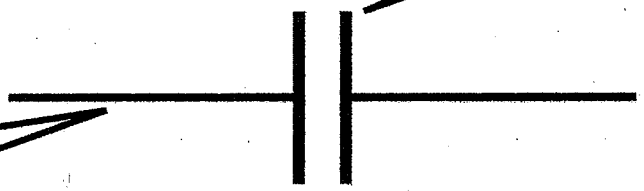
Figure 26-3a Physics for Engineers and Scientists 3/e
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To provide large capacitance in a small volume, sheets of large area are rolled up.

Figure 26-3b Physics for Engineers and Scientists 3/e
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Parallel lines represent plates of capacitor...



...and terminals attached to plates represent connecting wires.

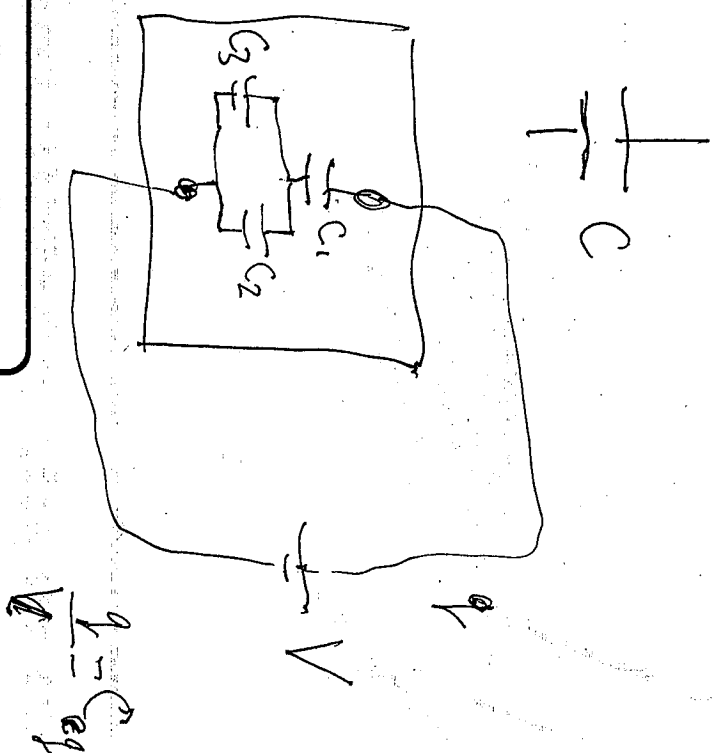


Figure 26-6 Physics for Engineers and Scientists 3/e
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Connecting wire establishes one equal potential at the two top plates...

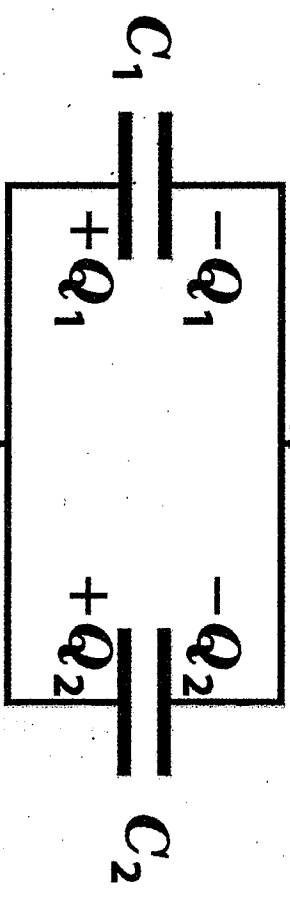
$$C_{eq} = C_1 + C_2$$

$$C_{eq} = \frac{Q_{tot}}{\Delta V}$$

$$= \frac{Q_1 + Q_2}{\Delta V}$$

$$= C_1 + C_2$$

...and another at the two bottom plates, so voltage across capacitors connected in parallel is the same.



each capacitor has same voltage across

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$$\Delta V = \frac{Q_{total}}{C_{eq}} = \frac{Q_1 + Q_2}{C_{eq}}$$

$$\frac{Q_1}{\Delta V} = C_1$$

For any number of capacitors connected in parallel, the net capacitance is the sum

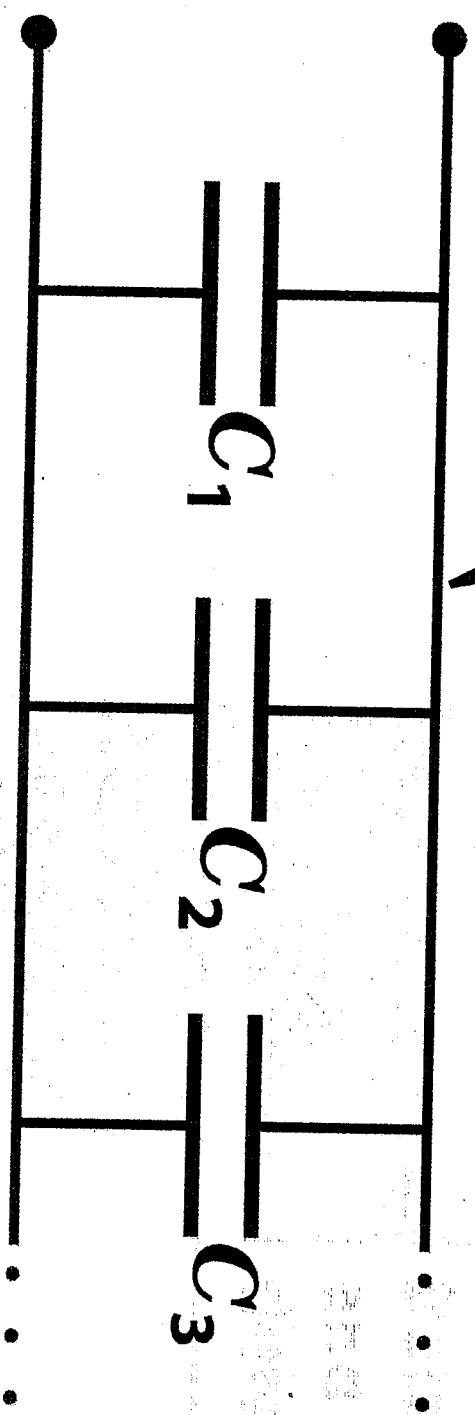
$$C = C_1 + C_2 + C_3 + \dots + C_n$$


Figure 26-8 Physics for Engineers and Scientists 3/e
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Find equivalent Capacitance C_{eq}

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$V_1 = \frac{Q}{C_1}$$

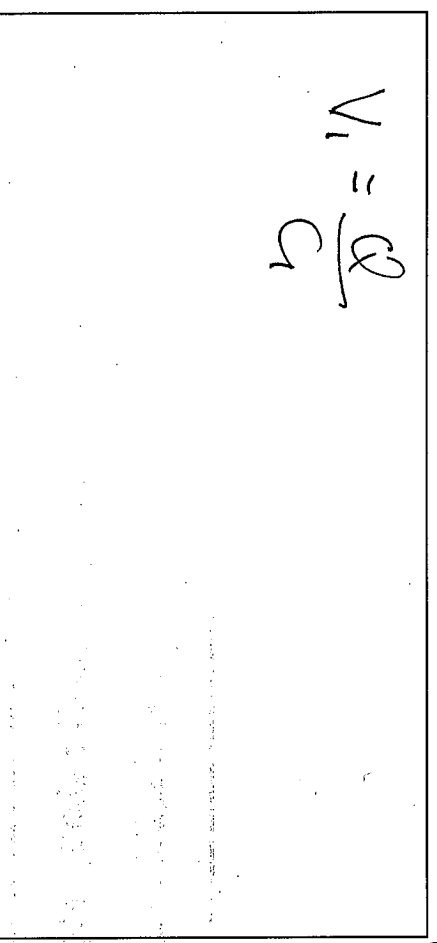
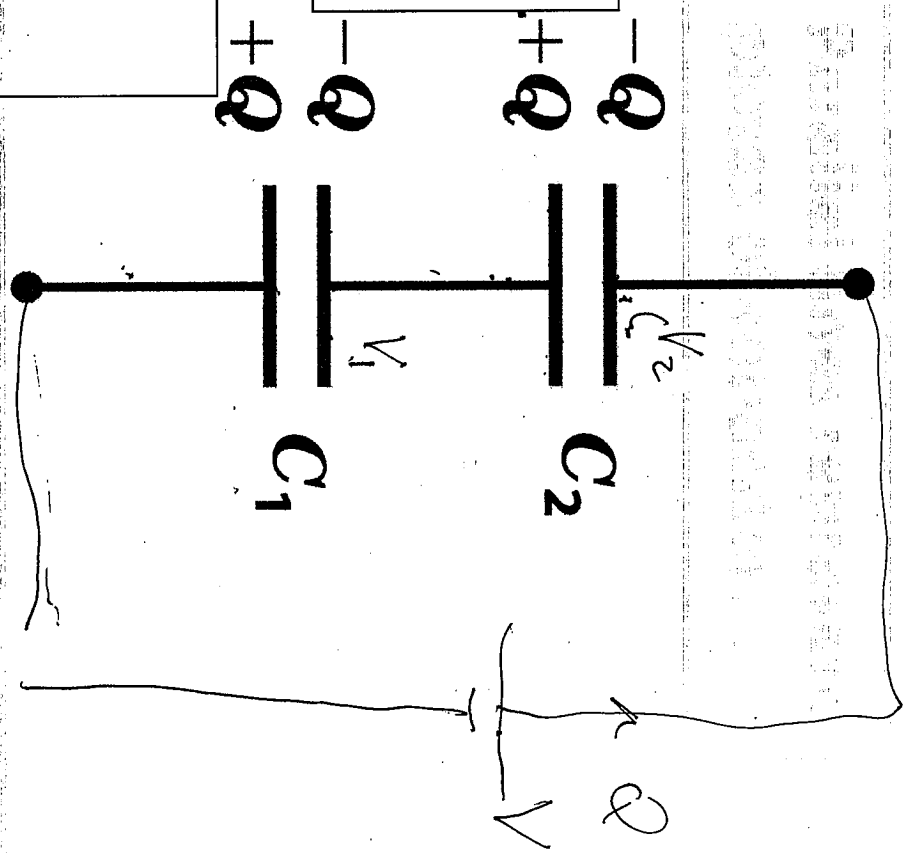
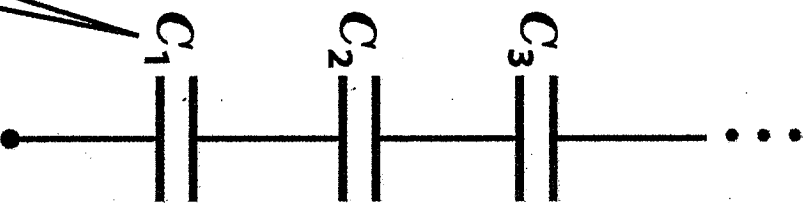


Figure 26-9 Physics for Engineers and Scientists 3/e © 2007 W. W. Norton & Company, Inc.

$$C_{eq} = \frac{Q}{V}$$

$$V = V_1 + V_2 = \frac{Q}{C_1} + \frac{Q}{C_2}$$

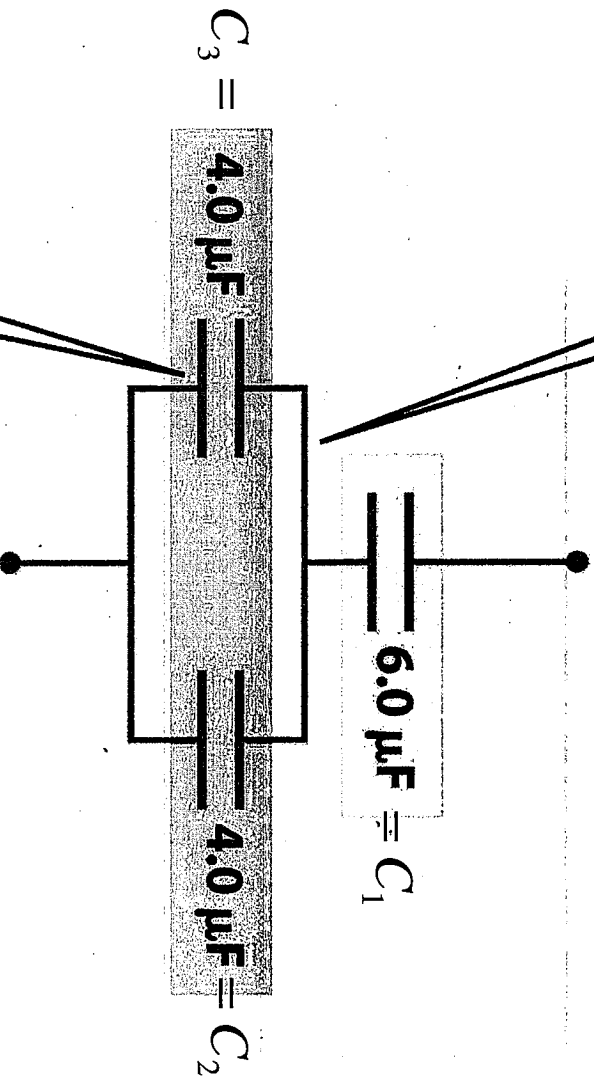


For capacitors connected in series, the inverse of the net capacitance is the sum of the inverses of individual capacitances,

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots + \frac{1}{C_N}$$

Figure 26-10 Physics for Engineers and Scientists 3/e
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To determine the net capacitance of a group of capacitors...

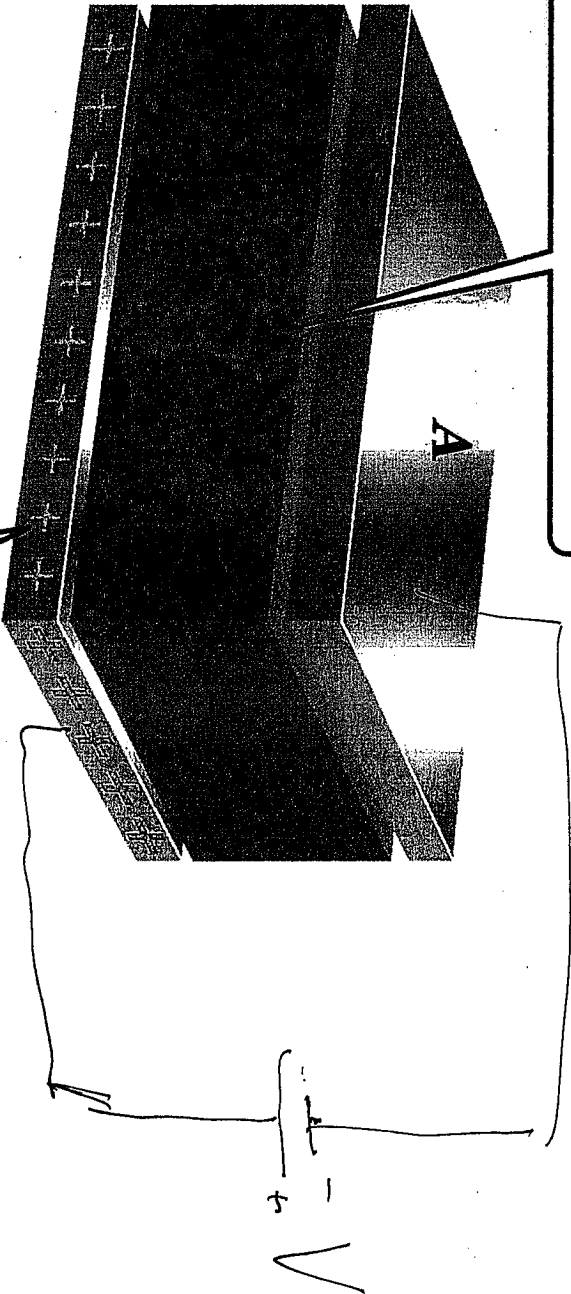


a. $C_{eq} = C_1 + C_2 + C_3$

b. $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2 + C_3}$ ✓

c. $C_{eq} = C_1 + \frac{1}{\frac{1}{C_2} + \frac{1}{C_3}}$

When a dielectric is placed between charged capacitor plates...



...charges in dielectric will respond to force exerted by electric field of charges on plates.

before

$$V = \frac{Q_{plb}}{C_0}$$

$$= \frac{Q_{plaf}}{C_0} = \frac{\kappa Q_{plb}}{C_0}$$

$$C_{\kappa} = \kappa C_0$$

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Dipoles Align Along Electric Field

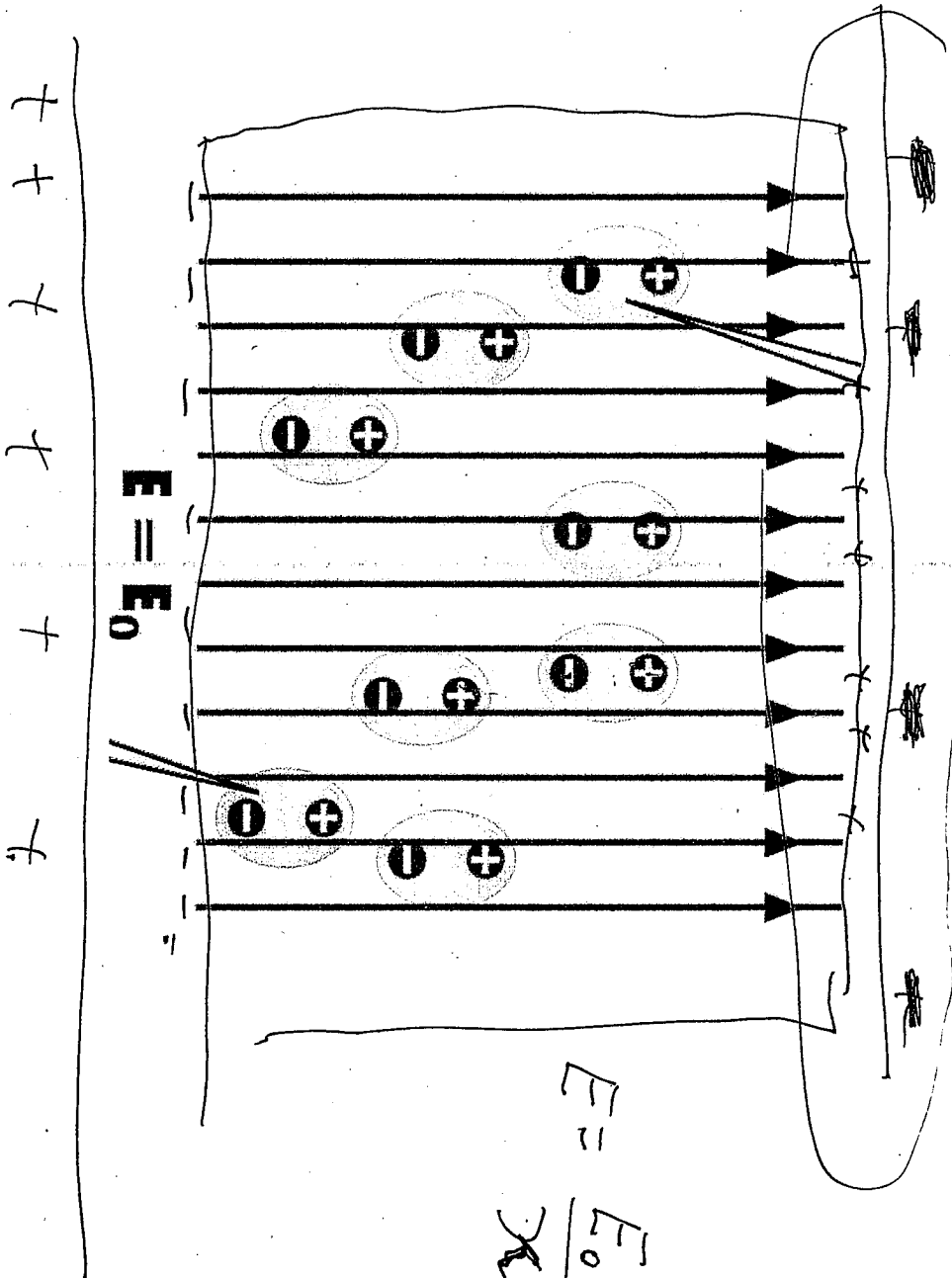
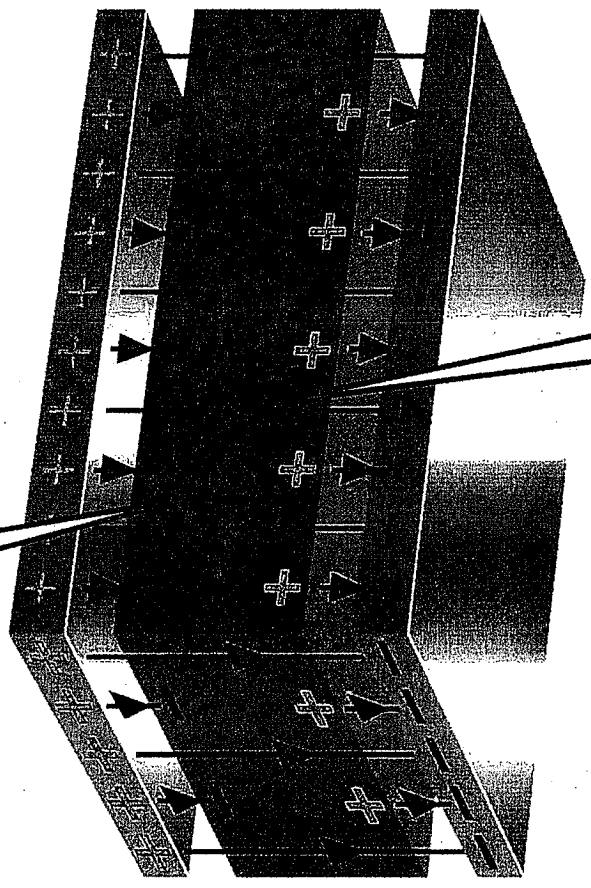


Figure 26-14b Physics for Engineers and Scientists 3/e
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Electric field of induced charge layer opposes this field from parallel plates...



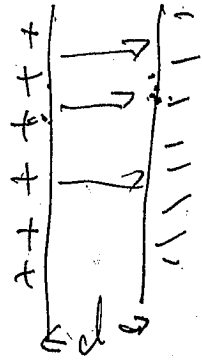
...resulting in a field inside the dielectric that is smaller than that from parallel plates alone.

$$V_0 \rightarrow \frac{V_0}{\kappa}$$

$$C_0 \rightarrow \kappa C_0$$

Figure 26-17 Physics for Engineers and Scientists 3/e
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$$W = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2} C V^2 = \frac{1}{2} QV$$



$$\frac{1}{2} QV = W$$

$$V = \frac{Q}{C}$$

$$\frac{1}{2} \frac{Q^2}{C}$$

$$Q = CV$$

$$\frac{1}{2} C V^2$$

$$\frac{Q}{\epsilon_0 A} = E$$

$$\frac{1}{2} QV = \frac{\epsilon_0 E^2}{2} Ad$$

$$Q = \epsilon_0 A E$$

$$W = \frac{\epsilon_0 E^2}{2} Vol$$

$$V = Ed$$

$$\text{Energy Density} = \frac{\text{Energy}}{\text{Volume}}$$

$$= \frac{\epsilon_0 E^2}{2}$$