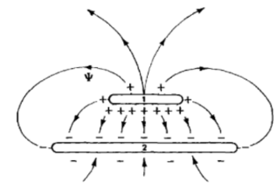
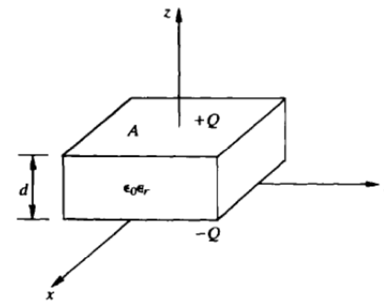
Capacitance:



Any two conducting bodies separated by free space or a dielectric material have a capacitance between them. $C = \frac{Q}{V}\ \ (F)$

1) Find the capacitance over two parallel plates as in figure.



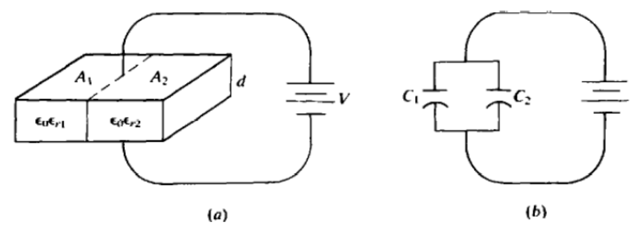
$$D = \frac{Q}{A}(-az) \qquad E = \frac{Q}{\varepsilon_0 \varepsilon_r A}(-az)$$

$$V = -\int_0^d \frac{Q}{\varepsilon_0 \varepsilon_r A}(-az).(dz\ az) = \frac{Q\ d}{\varepsilon_0 \varepsilon_r A}$$

$$C = \frac{Q}{V} = \frac{\varepsilon_0 \varepsilon_r A}{d}$$

Multiple dielectric capacitors

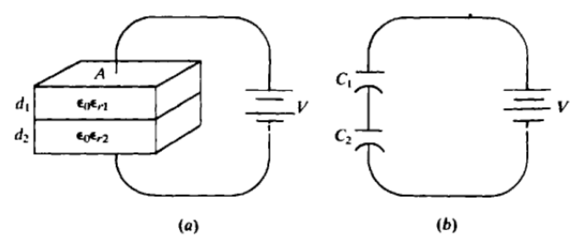
When two dielectrics are present in a capacitor with the interface parallel to **E** and **D** as shown in figure.



$$C1 = \frac{\varepsilon_0 \varepsilon_{r1} A1}{d} \qquad C2 = \frac{\varepsilon_0 \varepsilon_{r2} A2}{d}$$

$$C_{eq} = C1 + C2 = \frac{\varepsilon_0}{d}(\varepsilon_{r1} A1 + \varepsilon_{r2} A2)$$

Two capacitor in series with the interface normal to **E** and **D** as shown in figure.



$$C1 = \frac{\varepsilon_0 \varepsilon_{r1} A}{d1} \qquad C2 = \frac{\varepsilon_0 \varepsilon_{r2} A}{d2}$$

$$C_{eq} = \frac{1}{C1} + \frac{1}{C2} = \frac{\varepsilon_{r2} d1 + \varepsilon_{r1} d2}{\varepsilon_0 \varepsilon_{r1} \varepsilon_{r2} A}$$

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Example: A parallel plate capacitor with area 0.30 m^2 and separation 5.5 mm contains three dielectrics with interfaces normal E and D, as follows: $\varepsilon_{r1} = 3.0$, $d1 = 1.0\ mm$, $\varepsilon_{r2} = 4.0$, $d2 = 2.0\ mm$, $\varepsilon_{r3} = 6.0$, $d3 = 2.5\ mm$.

$$C1 = \frac{\varepsilon_0 \varepsilon_{r1} A}{d1} = \frac{\varepsilon_0 (3)(0.30)}{10^{-3}} = 7.96\ nF$$

Similarly $C2$=5.31 nF , $C3$=6.37 nF

$$\frac{1}{C_{eq}} = \frac{1}{7.96 \times 10^{-9}} + \frac{1}{5.31 \times 10^{-9}} + \frac{1}{6.37 \times 10^{-9}} = 2.12 \ nF$$