



Dr. Gregory J. Mazzaro
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ELEC 318 – *Electromagnetic Fields*

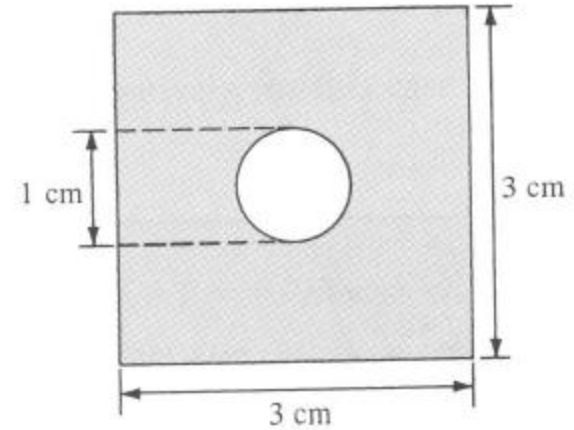
Lecture 8(b)

Review for Final Exam

Part 2

Example: Resistance

A lead bar ($\sigma = 5 \times 10^6 \text{ S/m}$) of square cross section (depicted) has a hole bored along its length of 4 m . Determine the resistance between the square ends.



$$R = \frac{\int_L \mathbf{E} \cdot d\mathbf{l}}{\iint_S \sigma \mathbf{E} \cdot d\mathbf{S}}$$

$$R_{\text{cross sec}}^{\text{uniform}} = \frac{L}{\sigma A}$$

Microwave Oven

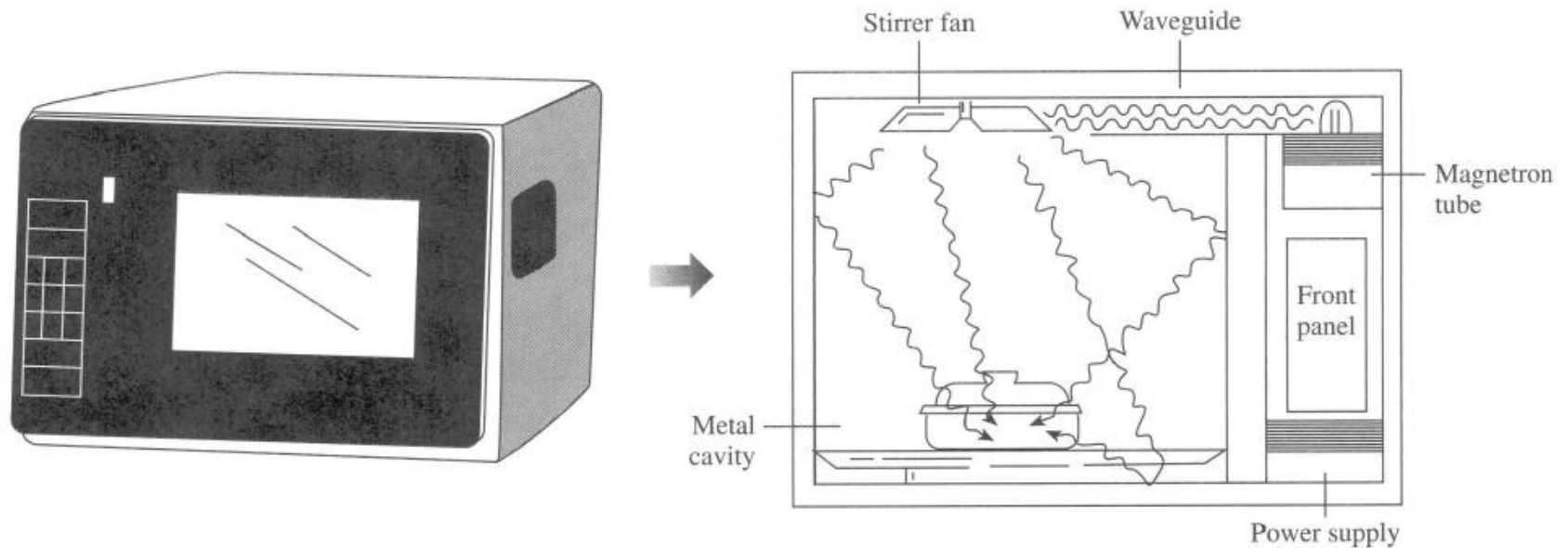


FIGURE 10.20 Microwave oven. (From N. Schlager, ed., *How Products Are Made*. Detroit: Gale Research, 1994, p. 289.)

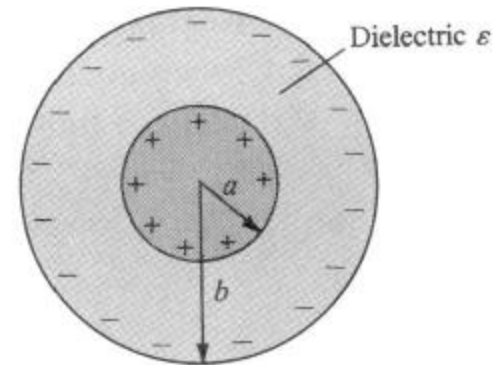
Example: Capacitance

The spherical capacitor (depicted) consists of two concentric, spherical conducting shells.

The inner radius is a and the outer radius is b .

The two radii are separated by a dielectric with permittivity ϵ .

Compute the capacitance of this geometry using Gauss's Law.



$$C = \frac{Q}{V} = \frac{\epsilon \oint_s \mathbf{E} \cdot d\mathbf{S}}{\int_L \mathbf{E} \cdot d\mathbf{l}}$$

Van de Graaf Generator

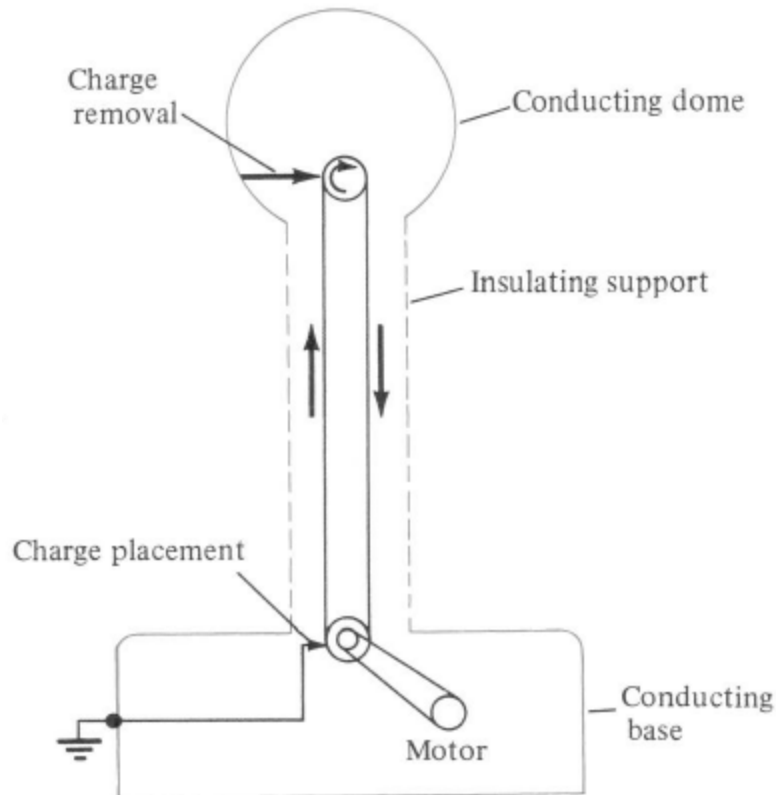


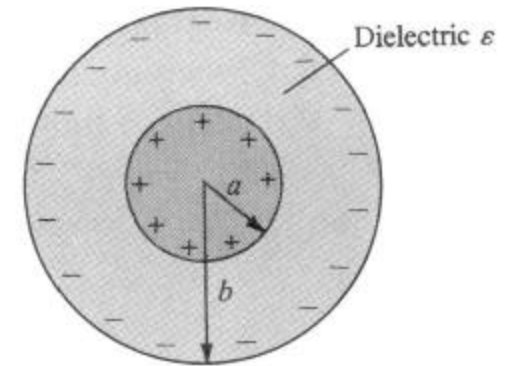
FIGURE 5.4 Van de Graaff generator; for Example 5.2.

Example: Potential; Function of Space

The spherical capacitor consists of two concentric, spherical conducting shells.

The outer shell is grounded, while the inner shell is charged to V_0 .

Determine the potential everywhere between $R = a$ and $R = b$,
and from this function determine the capacitance of the system.



$$\nabla^2 V = \frac{1}{R^2} \frac{\partial}{\partial R} \left(R^2 \frac{\partial V}{\partial R} \right) + \frac{1}{R^2 \sin \theta} \frac{\partial}{\partial \theta} \left(\sin \theta \frac{\partial V}{\partial \theta} \right) + \frac{1}{R^2 \sin^2 \theta} \frac{\partial^2 V}{\partial \phi^2}$$

$$\nabla V = \frac{\partial V}{\partial R} \hat{\mathbf{R}} + \frac{1}{R} \frac{\partial V}{\partial \theta} \hat{\boldsymbol{\theta}} + \frac{1}{R \sin \theta} \frac{\partial V}{\partial \phi} \hat{\boldsymbol{\phi}}$$

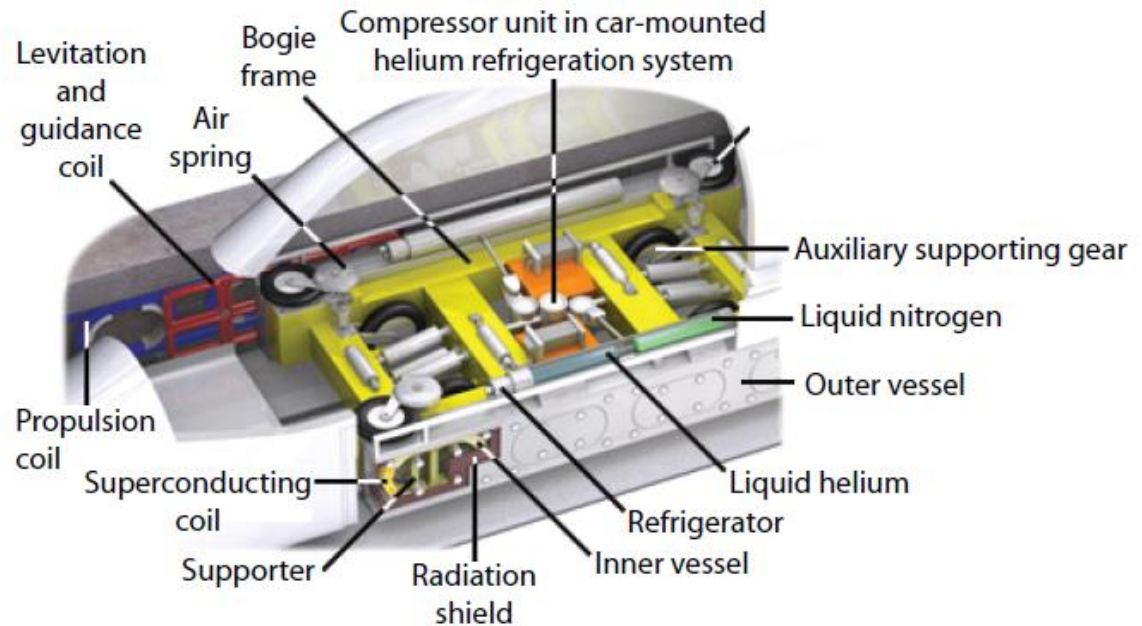
$$C = \frac{Q}{V} = \frac{\varepsilon \oint_S \mathbf{E} \cdot d\mathbf{S}}{\int_L \mathbf{E} \cdot d\mathbf{l}}$$

$$\frac{\partial}{\partial R} \left(R^2 \frac{\partial V}{\partial R} \right) = 0 \Rightarrow V = \frac{V_1}{R} + V_2$$

Magnetic Levitation



(a) Maglev train

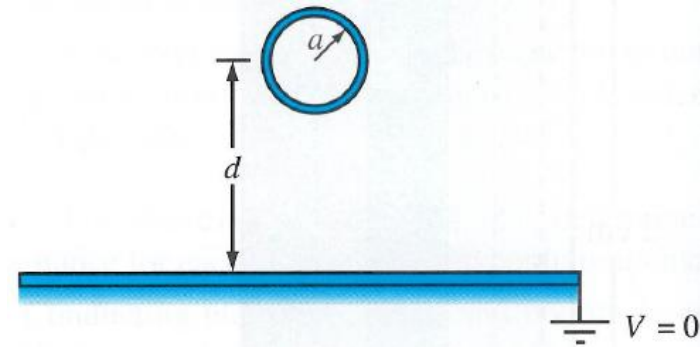


(b) Internal workings of the Maglev train

Figure TF10-5: Magnetic trains. (Courtesy Shanghai.com.)

Example: Image Theory

Determine the capacitance per unit length of an infinitely long cylinder of radius a situated at a distance d above a parallel conducting plane (as depicted).



$$\mathbf{E}_{\text{line charge}}^{\text{infinite}} = \frac{\rho_l}{2\pi\epsilon_0 r} \hat{\mathbf{r}}$$

$$C = \frac{Q}{V} = \frac{\epsilon \oiint_S \mathbf{E} \cdot d\mathbf{S}}{\int_L \mathbf{E} \cdot d\mathbf{l}}$$