Dr. Gregory J. Mazzaro

Spring 2015

ELEC 318 – *Electromagnetic Fields*

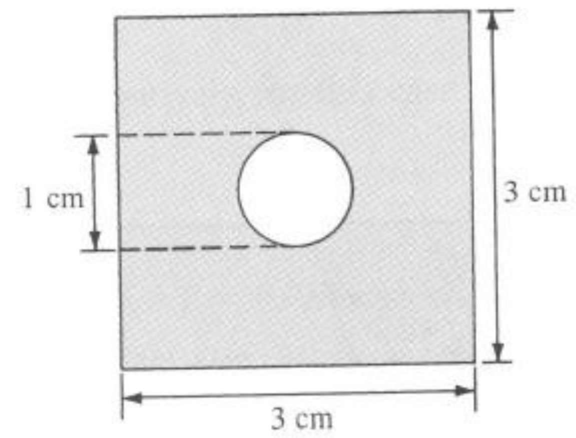
Lecture 8(b)

Review for Final Exam
Part 2

THE CITADEL, THE MILITARY COLLEGE OF SOUTH CAROLINA
171 Moultrie Street, Charleston, SC 29409

Example: Resistance

A lead bar ($\sigma = 5 \times 10^6$ 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

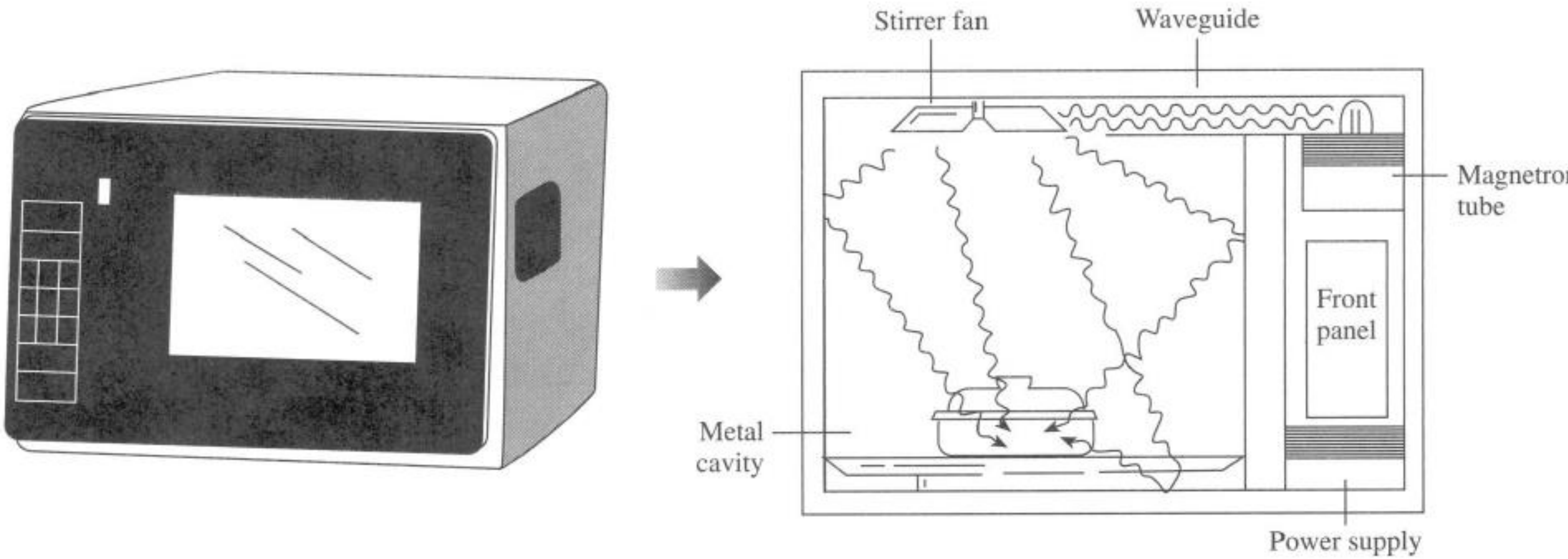


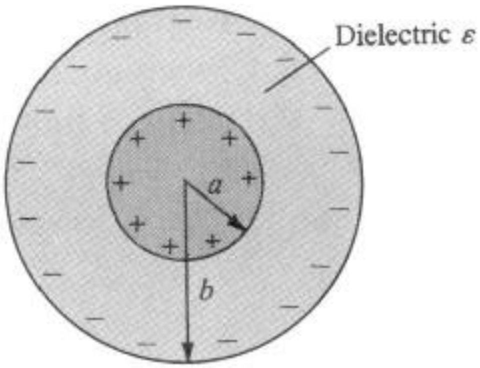
FIGURE 10.20 Microwave oven. (From N. Schlager, ed., *How Products Are Made*. Detroit: Gale Research, 1994, p. 289.)

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.



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

Van de Graaf Generator

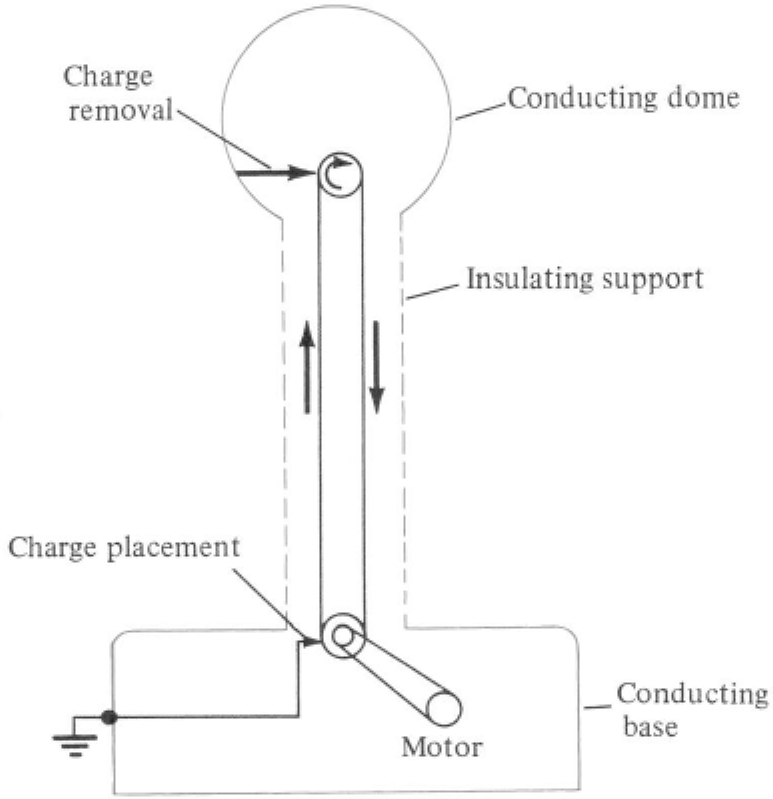
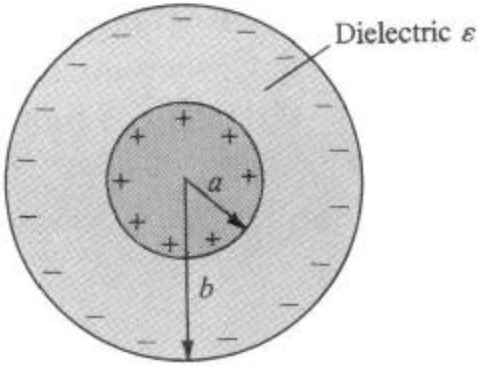


FIGURE 5.4 Van de Graaff generator; for Example 5.2.

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.



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

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

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

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

Magnetic Levitation

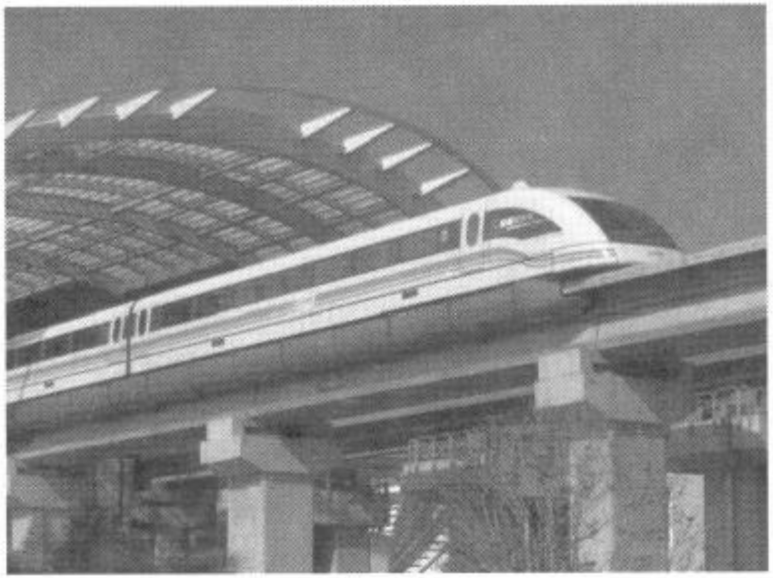
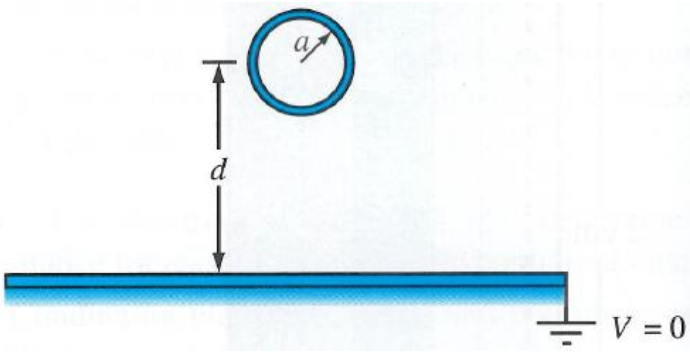


FIGURE 8.31 Maglev train.

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).



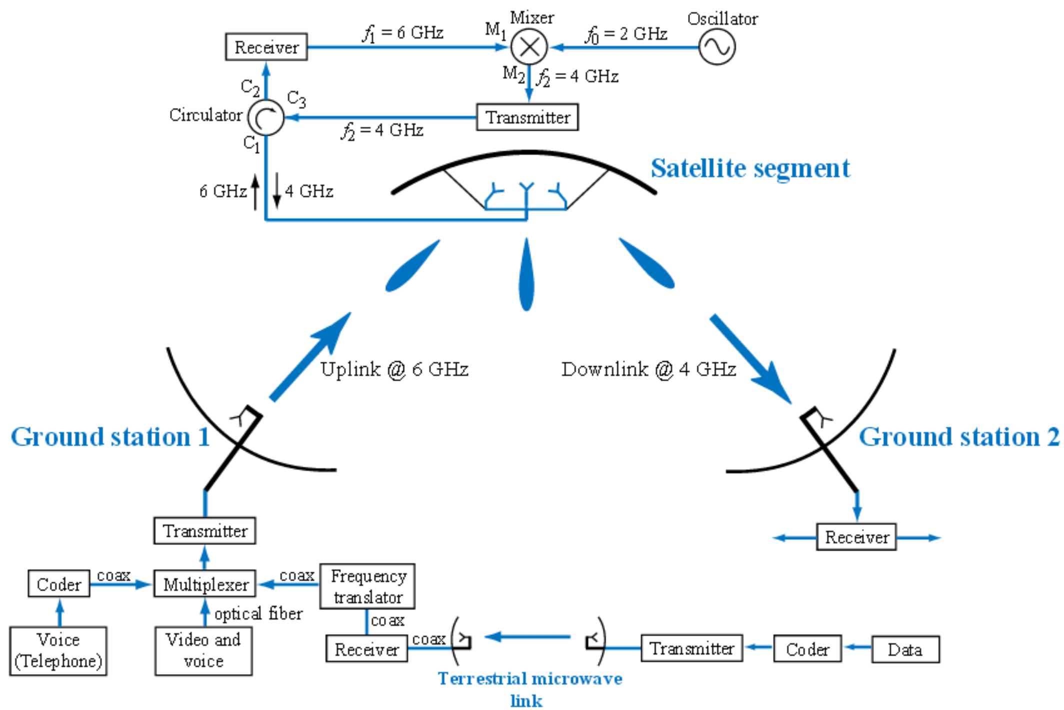
$$\mathbf{E}^{\text{infinite}}_{\text{line charge}} = \frac{\rho_l}{2\pi\varepsilon_0 r}\hat{\mathbf{r}}$$

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

Electromagnetic Fields

-- a branch of physics or electrical engineering in which electric & magnetic phenomena are studied

- microwaves
- radio frequencies, lasers
- antennas
- electrical machines
- nuclear research
- fiber optics
- interference & compatibility
- energy conversion
- radar meteorology
- remote sensing
- induction heating



$$\nabla \cdot \mathbf{D} = \rho_v \qquad \nabla \times \mathbf{E} = -\frac{\partial}{\partial t}\mathbf{B}$$

$$\nabla \cdot \mathbf{B} = 0 \qquad \nabla \times \mathbf{H} = \mathbf{J} + \frac{\partial}{\partial t}\mathbf{D}$$