

**THE CITADEL  
THE MILITARY COLLEGE OF SOUTH CAROLINA**

**Department of Electrical and Computer Engineering**

**ELEC 318 Electromagnetic Fields**

**HW #4, due February 20, 2015**

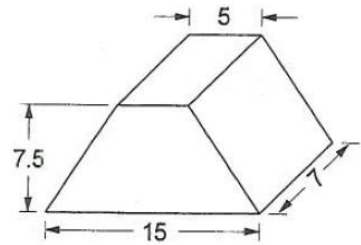
**Reading Assignment:** Chapter 4 (all)

**Written Assignment:**

1. A current density is equal to  $3R^2 \cos \theta \hat{\mathbf{R}} - R^2 \sin \theta \hat{\boldsymbol{\theta}}$  ( $\text{A}/\text{m}^2$ ). Determine...
  - (a) the current crossing the surface defined by  $\theta = 30^\circ$ ,  $0 \leq \phi \leq 2\pi$ ,  $0 \leq R \leq 2 \text{ m}$ , and
  - (b) the current through the surface given by  $R = 2 \text{ m}$ ,  $0 \leq \theta \leq 30^\circ$ ,  $0 \leq \phi \leq 2\pi$ .
2. A composite conductor 10 meters long consists of an inner core of steel of radius 1.5 cm and an outer sheath of copper whose thickness is 0.5 cm. Determine...
  - (a) the resistance of the conductor, and
  - (b) the current flowing through each metal if the total current is 60 A.

Take  $\sigma_{\text{steel}} = 8.5 \times 10^6 \text{ S/m}$  and  $\sigma_{\text{copper}} = 5.6 \times 10^7 \text{ S/m}$ .

3. The block illustrated (at right), with dimensions in millimeters, is made from an aluminum alloy with a conductivity of  $3.8 \times 10^7 \text{ S/m}$ . Compute the resistance that would be measured between the top and bottom surfaces of the block.



4. Two point charges in free space are separated by a distance  $d$  and exert a force of 2.6 nN on each other. The force becomes 1.5 nN when the free space is replaced by a homogeneous dielectric material. Determine the dielectric constant of the material.
5. The plane  $z = 0$  separates region 1 ( $z > 0$ ), which is a dielectric material with a relative dielectric constant of 4, from region 2 ( $z < 0$ ), which is another dielectric material with a relative dielectric constant of 6.5.

The electric flux density in region 1 is  $16 \hat{\mathbf{x}} + 30 \hat{\mathbf{y}} - 20 \hat{\mathbf{z}}$   $\text{nC}/\text{m}^2$ .

There is no charge at the boundary between the dielectrics.

Determine the electric flux density in region 2.

6. The boundary between two regions of space is defined by  $4x + 3y = 10 \text{ m}$ . The region including the origin is air, where the flux density is  $2 \hat{\mathbf{x}} - 4 \hat{\mathbf{y}} + 6.5 \hat{\mathbf{z}}$   $\text{nC}/\text{m}^2$ . Determine the electric flux density in the second region, where the relative dielectric constant is 2.5. (The boundary is charge-free.)