THE CITADEL
THE MILITARY COLLEGE OF SOUTH CAROLINA

Department of Electrical and Computer Engineering

ELEC 318 Electromagnetic Fields **HW #4, due February 19, 2015**

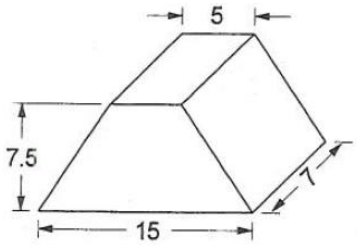
Reading Assignment: Chapter 4 (all)

Written Assignment:

1. A current density is equal to $3R^2 \cos\theta\,\hat{\mathbf{R}} - R^2 \sin\theta\,\hat{\boldsymbol{\theta}}$ $\left(\text{A}/\text{m}^2\right)$. Determine…
   (a) the current crossing the surface defined by $\theta = 30°$, $0 \le \phi \le 2\pi$, $0 \le R \le 2$ m, and
   (b) the current through the surface given by $R = 2$ m, $0 \le \theta \le 30°$, $0 \le \phi \le 2\pi$.

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

3. The block illustrated (at right), with dimensions in millimeters, is made from an aluminum alloy with a conductivity of $3.8 \text{ x } 10^7$ 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 $16\,\hat{\mathbf{x}} + 30\,\hat{\mathbf{y}} - 20\,\hat{\mathbf{z}}$ nC/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 $4x + 3y = 10$ m. The region including the origin is air, where the flux density is $2\,\hat{\mathbf{x}} - 4\,\hat{\mathbf{y}} + 6.5\,\hat{\mathbf{z}}$ nC/m^2.
   Determine the electric flux density in the second region, where the relative dielectric constant is 2.5. (The boundary is charge-free.)