Physics 3344 **Professor Scalise**
Fall 2006 **Assignment #2**

Due: 31 August 2006

Read Marion (& Thornton) Chapters 1 and 2.

1. Use MKS units throughout and give the answers both analytically and numerically. From the following four fundamental constants (and only these)

$$G = 6.67259 \times 10^{-11}\ \tfrac{\mathrm{N \cdot m^2}}{kg^2} \qquad c = 2.99792458 \times 10^{8}\ \mathrm{m/s}$$
$$\hbar = 1.05457266 \times 10^{-34}\ \mathrm{J \cdot s} \qquad k_B = 1.380658 \times 10^{-23}\ \mathrm{J/K}$$

   using dimensional analysis, construct quantities with the dimensions of:

   (a) length
   (b) time
   (c) velocity
   (d) mass
   (e) energy
   (f) temperature

2. (a) In the matrix equation $\underline{\underline{\mathrm{D}}} = \underline{\underline{\mathrm{A}}}\ \underline{\underline{\mathrm{B}}}\ \underline{\underline{\mathrm{C}}}$, if $\underline{\underline{\mathrm{D}}}$ is a 2×2 matrix, $\underline{\underline{\mathrm{A}}}$ is a 2×5 matrix, and $\underline{\underline{\mathrm{C}}}$ is a 2×2 matrix, what are the dimensions of $\underline{\underline{\mathrm{B}}}$? How many rows and how many columns?

   (b) Write the matrix equation $\underline{\underline{\mathrm{D}}} = \underline{\underline{\mathrm{A}}}\ \underline{\underline{\mathrm{B}}}\ \underline{\underline{\mathrm{C}}}$ in index notation. Include limits on the sums.

3. If $\boldsymbol{x}$ is the column vector $\begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}$, what is the result of the following matrix multiplications?

   (a) $\boldsymbol{x}\ \boldsymbol{x^T}$
   (b) $\boldsymbol{x^T}\ \boldsymbol{x}$

4. If two lines have direction cosines (α, β, γ) and (α', β', γ'), show that the angle θ between these lines satisfies:

$$\cos\theta = \cos\alpha\cos\alpha' + \cos\beta\cos\beta' + \cos\gamma\cos\gamma'$$

5. Rotate the vector $\begin{pmatrix} 2 \\ 1 \\ 0 \end{pmatrix}$ about the axis $\begin{pmatrix} \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \\ \frac{1}{\sqrt{3}} \end{pmatrix}$ by 30° counterclockwise as seen by looking down the axis from the tip to the origin.

   (a) Find the 3×3 rotation matrix $\underline{\underline{\lambda}}$.

   (b) Find the image of $\begin{pmatrix} 2 \\ 1 \\ 0 \end{pmatrix}$ under the transformation.

   (c) Verify that the axis does not change direction under the rotation. $\underline{\underline{\lambda}} \frac{1}{\sqrt{3}} \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} = ?$

   (d) Find $\det(\underline{\underline{\lambda}})$

   (e) What is the image of the moment of inertia tensor below under the transformation? (Hint: remember to use two λ's.)

$$\begin{pmatrix} 1 & 1 & 3 \\ 2 & 2 & 1 \\ 1 & 2 & 3 \end{pmatrix}$$