PHYSICS 341, Assignment # 1
Due: Friday, September 22, 2017

(1) Two insects are initially located at the same position on a flat horizontal table. Insect A begins walking in a straight line at 60° North of East and Insect B begins walking (also in a straight line) at 25° North of East from the initial position. After a certain time period, Insect A has covered 3.00 cm and Insect B has covered 5.00 cm.
(a) Sketch a diagram showing the displacement vectors of the two insects. Assume East lies on the x-axis and N on the y-axis.
(b) If $\mathbf{A}$ is the displacement vector for Insect A and $\mathbf{B}$ is the displacement vector for Insect B what is the sum $\mathbf{A} + \mathbf{B} = \mathbf{C}$? What is the length of $\mathbf{C}$?
(c) What is the difference $\mathbf{A} - \mathbf{B} = \mathbf{D}$? What is the length of $\mathbf{D}$?
(d) What angle does the vector $\mathbf{C}$ make with the easterly direction?
(e) What angle does the vector $\mathbf{D}$ make with the easterly direction?

(2) Assuming the $\mathbf{O}$ is the additive identity vector and that $\mathbf{A}$ and $\mathbf{B}$ are two arbitrary three dimensional vectors:
(a) Prove both algebraically and geometrically that:

$$\mathbf{O} + \mathbf{A} = \mathbf{A} + \mathbf{O} = \mathbf{A}$$

(b) Prove algebraically that $\mathbf{A} + (-\mathbf{A}) = \mathbf{O}$.
(c) Prove algebraically and geometrically that $\mathbf{A} - (-\mathbf{B}) = \mathbf{A} + \mathbf{B}$.
In all algebraic proofs explicitly justify each step you make.

(3) A certain force is given in a Cartesian coordinate system as:

$$\mathbf{F} = F_0 \frac{x\hat{\boldsymbol{\imath}} + y\hat{\boldsymbol{\jmath}}}{\sqrt{(x^2 + y^2)}}.$$

Find the total work done on a particle by that force if it moves the particle from point P on the x-axis at $x = 2$ to a point Q with Cartesian coordinates $(x_Q, y_Q) = (2, L)$.

(4) Find a unit vector that is perpendicular to both $\mathbf{A} = \hat{\boldsymbol{\imath}} + \hat{\boldsymbol{\jmath}} - \hat{\boldsymbol{k}}$ and $\mathbf{B} = 2\hat{\boldsymbol{\imath}} - \hat{\boldsymbol{\jmath}} + 3\hat{\boldsymbol{k}}$.

(5) A rectangular block with sides of length 3ℓ, 2ℓ and ℓ in x, y and z coordinates has a face diagonal vector $\mathbf{A} = 3\ell\hat{\boldsymbol{\imath}} + \ell\hat{\boldsymbol{k}}$ and body diagonal vector $\mathbf{B} = 3\ell\hat{\boldsymbol{\imath}} + 2\ell\hat{\boldsymbol{\jmath}} + \ell\hat{\boldsymbol{k}}$
(a) Using the coordinate system shown below, sketch the block and the two vectors $\mathbf{A}$ and $\mathbf{B}$
(b) What is the angle between vectors $\mathbf{A}$ and $\mathbf{B}$?