Week 4: **Kinematics in 2D**

SI Leader: Stephen Iota (siota001@ucr.edu)
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0 Getting Comfortable with Vectors

$$\mathbf{A} = 9\hat{x} + 18\hat{y} + 27\hat{z}$$
$$\mathbf{B} = 3\hat{x} - 4\hat{y} + 5\hat{z}$$
$$\mathbf{C} = 10\hat{y} + 4\hat{z}$$

(a) Can I add a vector and a scalar together?

(b) Compute $\mathbf{D} = \mathbf{A} - \mathbf{B} + \frac{1}{2}\mathbf{C}$.

(c) Find the magnitudes of the vectors $\mathbf{A}, \mathbf{B},$ and $\mathbf{C}$.

(d) Write $\mathbf{C}$ as a linear combination of $\mathbf{A}$ and $\mathbf{B}$, i.e. $\mathbf{C} = \alpha\mathbf{A} + \beta\mathbf{B}$.

1 Lost at Sea

A captain and his ship leave harbor A at $v_0 = 20$ m/s, traveling due north towards harbor B, which is 72 km away. 30 min into the voyage, a strong wind in the E direction blows at $v_{\text{wind}} = 5$ m/s. The captain and his crew did not adjust their course to correct for the wind, end up getting lost at sea, and do not reach their destination.
Note: Assume the shores are infinite straight lines in the EW direction, and ignore water resistance and drag.

(a) How long would it have taken the ship to cross from harbor A to B if there was no wind?

(b) How long does their journey end up taking? Assume harbor B lies along a straight, infinite coast in the EW direction.

(c) How far east from harbor B does the ship end up?

(d) At what angle should have the captain and his have steered in when the wind started to arrive at harbor B?

2 Circular Motion

(a) When working with uniform circular motion, we can describe motion in 2D with 1 independent variable. How do we do this?

(b) What is the relation between tangential velocity v_{t} and angular velocity ω?

(c) How do we express angular acceleration in terms of velocity? What about ω?

3 Cyclotron Frequency

Electrons in a constant, transverse Magnetic field undergo centripetal acceleration. If an electron has a period of oscillation $T = 2$ ms and a radius of orbit of $r = 6$ μm. Find:

(a) the electron's frequency[1] ω of oscillation

(b) the electron's speed v

(c) and the magnitude of it's acceleration a.

Notice that the electron's speed is a constant! If you think this is interesting, look into (a) Work and (b) conservative v non-conservative vector fields on Wiki.

[1] https://en.wikipedia.org/wiki/Electron_cyclotron_resonance