VECTOR WORKSHEET

NAME: Answer Key

1. An object moves in 2D space. Its position at three points in time are given as $\vec{r}_1$, $\vec{r}_2$, and $\vec{r}_3$. Find the magnitude and direction (as an angle between 0° and 360°) of each of the position vectors:

$\vec{r}_1 = \langle -7, \quad -6 \rangle$ m mag: $r_1 =$ 9.2 m; dir: $\theta_1 =$ 221 °

$\vec{r}_2 = \langle -9, \quad 2 \rangle$ m mag: $r_2 =$ 9.2 m; dir: $\theta_2 =$ 167 °

$\vec{r}_3 = \langle 4, \quad -7 \rangle$ m mag: $r_3 =$ 8.1 m; dir: $\theta_3 =$ 300 °

use Pythagoreans theorem and $\tan^{-1}$ (add 180° or 360° as needed)

2. Find the displacement between each of the following sets of position vectors. Give your answer as both a vector and magnitude/direction:

$\Delta\vec{r}_{12} = \Delta\vec{r}_{1\to2} = \vec{r}_2 - \vec{r}_1 = \langle -2, 8 \rangle$ m; mag: $r_{12} =$ 8.2 m; dir: $\theta_{12} =$ 104 °

$\Delta\vec{r}_{23} = \Delta\vec{r}_{2\to3} = \vec{r}_3 - \vec{r}_2 = \langle 13, -9 \rangle$ m; mag: $r_{23} =$ 15.8 m; dir: $\theta_{23} =$ 325 °

$\Delta\vec{r}_{13} = \Delta\vec{r}_{1\to3} = \vec{r}_3 - \vec{r}_1 = \langle 11, -1 \rangle$ m; mag: $r_{13} =$ 11.0 m; dir: $\theta_{13} =$ 355 °

3. What is the total distance traveled if the movement happens in a straight line from position #1 to position #2, then on to position #3? How is this different from the displacement from position #1 to position #3?

$d_{total} = r_{12} + r_{23} =$ 24.0 m

$d_{total} - r_{13} =$ 13.0 m d_{total} and r_{13} are not the same

4. The object was at positions 1, 2, and 3 at times 9, 12, and 16 seconds, respectively. Find the average velocity between each set of position vectors. Give your answer as both a magnitude/direction:

Δt is a scalar; every component of $\Delta\vec{r}$ gets divided by Δt

$\bar{\vec{v}}_{12} = \frac{\Delta\vec{r}_{12}}{\Delta t_{12}} = \langle -\frac{2}{3}, \frac{8}{3} \rangle$ m/s; mag: $\bar{v}_{12} =$ 2.7 m/s; dir: $\theta_{12} =$ 104 °

$\bar{\vec{v}}_{23} = \frac{\Delta\vec{r}_{23}}{\Delta t_{23}} = \langle \frac{13}{4}, -\frac{9}{4} \rangle$ m/s; mag: $\bar{v}_{23} =$ 4.0 m/s; dir: $\theta_{23} =$ 325 °

$\bar{\vec{v}}_{13} = \frac{\Delta\vec{r}_{13}}{\Delta t_{13}} = \langle \frac{11}{7}, -\frac{1}{7} \rangle$ m/s; mag: $\bar{v}_{13} =$ 1.6 m/s; dir: $\theta_{13} =$ 355 °

note that avg. velocity and displacement have the same direction; verify using $\tan^{-1}$

5. After reaching position #3, the object experiences a constant acceleration of $\vec{a} = \langle -5, \quad 2 \rangle$ m/s². What is the object's new position and velocity 3 seconds after leaving position #3?

$\Delta\vec{r}_4 = \vec{r}_3 + \bar{\vec{v}}_{23}\Delta t_{34} + \frac{1}{2}\vec{a}(\Delta t_{34})^2 = \langle -8.75, 8.75 \rangle$ m; mag: $r_{34} =$ 12.4 m; dir: $\theta_{34} =$ 135 °

$\vec{v}_4 = \vec{v}_3 + \vec{a}t = \langle -11.75, 3.75 \rangle$ m/s; mag: $\bar{v}_{34} =$ 12.3 m/s; dir: $\theta_{34} =$ 162 °

instantaneous velocity + position do not necessarily have the same direction

Note: Compare these equations with the kinematic equations by substituting vectors for all of the variables (except for time).