Common exam #1: 8:30-9:45am on Feb. 9th(Fri.) at 205 Kupfrian Hall
(arrive by 8:15am, Proctor: Yixuan Li)
Chapters 1, 2, 3. Bring scientific calculators

HW#3 due Feb. 9

Quiz#3 today

http://geocities.com/kenahn7/

Today in this class...

Chapter 4. Motion in Two and Three Dimensions

Position and Displacement
Average Velocity and Instantaneous Velocity
Average Acceleration and Instantaneous Acceleration
Examples:
Projectile Motion → Partly, on Monday
Uniform circular motion → On Monday

Very brief review of Ch.1, 2, 3
Quiz for Ch.3
Motion along the straight line + Vectors

**One dimension (1D)**

- Position: \( x(t) \) m
- Velocity: \( v(t) \) m/s
- Acceleration: \( a(t) \) m/s\(^2\)

All are vectors: have direction and magnitude.

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**Three dimension (2D)**

- Position: \( \vec{r}(t) \) m
- Velocity: \( \vec{v}(t) \) m/s
- Acceleration: \( \vec{a}(t) \) m/s\(^2\)

**Motion in 3D:**

\[
\vec{r} = xi + yj + zk
\]

- \( t = 0 \) beginning of the process
- \( \vec{r} = 0 \) is arbitrary; can set where you want it
- \( \vec{r}_0 = \vec{r}(t=0) \) position at \( t=0 \);

\[
\vec{r} = \vec{r}_x + \vec{r}_y + \vec{r}_z = x\hat{i} + y\hat{j} + z\hat{k}
\]
\[ \vec{r}_1 = (-3.0m)\hat{i} + (2.0m)\hat{j} + (5.0m)\hat{k} \]

**Position and Displacement**

\[
\begin{align*}
\vec{r} &= x\hat{i} + y\hat{j} + z\hat{k} \\
\Delta\vec{r} &= \vec{r}_2 - \vec{r}_1 \\
\Delta\vec{r} &= (x_2\hat{i} + y_2\hat{j} + z_2\hat{k}) - (x_1\hat{i} + y_1\hat{j} + z_1\hat{k}) \\
&= (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j} + (z_2 - z_1)\hat{k} \\
&= \Delta x\hat{i} + \Delta y\hat{j} + \Delta z\hat{k}
\end{align*}
\]
Average and Instantaneous Velocity

\[ \vec{v}_{\text{avg}} = \frac{\Delta \vec{r}}{\Delta t} = \frac{\Delta x \hat{i} + \Delta y \hat{j} + \Delta z \hat{k}}{\Delta t} \]

\[ \vec{v} = \frac{d\vec{r}}{dt} = \frac{dx}{dt} \hat{i} + \frac{dy}{dt} \hat{j} + \frac{dz}{dt} \hat{k} \]

\[ v_x = \frac{dx}{dt}, \quad v_y = \frac{dy}{dt}, \quad \text{and} \quad v_z = \frac{dz}{dt} \]

Average and Instantaneous Acceleration

\[ \vec{a}_{\text{avg}} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \frac{\Delta \vec{v}}{\Delta t} \]

\[ \vec{a} = \frac{d\vec{v}}{dt} = \frac{d}{dt} (v_x \hat{i} + v_y \hat{j} + v_z \hat{k}) \]

\[ = \frac{dv_x}{dt} \hat{i} + \frac{dv_y}{dt} \hat{j} + \frac{dv_z}{dt} \hat{k} \]

\[ a_x = \frac{dv_x}{dt}, \quad a_y = \frac{dv_y}{dt}, \quad \text{and} \quad a_z = \frac{dv_z}{dt} \]
Sample Problem 4-2

For a running rabbit in a parking lot with a set of coordinate axes

\[ x = -0.31t^2 + 7.2t + 28 \]
\[ y = 0.22t^2 - 9.1t + 30 \]

\[ \vec{r} = x(t)\hat{i} + y(t)\hat{j} \]
Plot of position from $t=0$ sec. to $t=25$ sec.

Instantaneous Velocity

$$\ddot{\mathbf{r}} = \frac{d\mathbf{r}}{dt} = \frac{d}{dt}(x\mathbf{i} + y\mathbf{j} + z\mathbf{k}) = \frac{dx}{dt}\mathbf{i} + \frac{dy}{dt}\mathbf{j} + \frac{dz}{dt}\mathbf{k}$$

$$v_x = \frac{dx}{dt}, \quad v_y = \frac{dy}{dt}, \quad \text{and} \quad v_z = \frac{dz}{dt}$$
\[ x = -0.31t^2 + 7.2t + 28 \]
\[ y = 0.22t^2 - 9.1t + 30 \]
\[ v_x = -0.62t + 7.2 \]
\[ v_y = 0.44t - 9.1 \]

**Instantaneous Acceleration**
While describing any 2-D motion one can represent it as a superposition (a vector sum) of two 1-D motions!

**Example:** A turtle 2-D motion can be represented as its simultaneous motion in x direction and in y direction. Notice, the velocity is a vector and it has two components: $v_x$ and $v_y$!
A turtle starts at the origin and moves with the speed of $v_0 = 10$ cm/s in the direction of $25^\circ$ to the horizontal.

(a) Find the coordinates of a turtle 10 seconds later.
(b) How far did the turtle walk in 10 seconds?

**Example 1: Motion of a Turtle**

**COMMENT:**
Notice, you can solve the equations independently for the horizontal ($x$) and vertical ($y$) components of motion and then combine them!

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**Sign on the attendance sheet, if you haven’t today!**