Review for Exam 1

Practice Problem Solving !

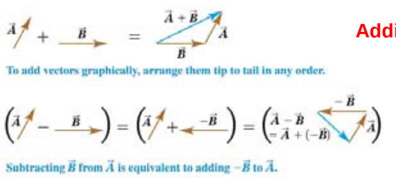
Homework Problems

Recitation Problems

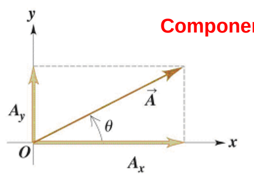
Examples from Class

- **Ch 1 Mathematical Concepts**
  - Dimensional Analysis
  - Trigonometry
  - Vectors, Addition and Subtraction, Components
  - Addition of Vectors by Means of Components
- **Ch 2 Kinematics in One Dimension**
  - Displacement, Speed, Velocity, Acceleration
  - Equations of Kinematics for Constant Acceleration
  - Applications; Freely Falling Bodies
- **Ch 3 Kinematics in Two Dimensions**
  - Displacement, Velocity, Acceleration (Vectors !)
  - Equations of Kinematics in Two Dimensions
  - Projectile Motion
  - Relative Velocity

Adding Vectors



Components of Vectors



$A_x = A\cos\theta;\quad A_y = A\sin\theta;\quad A = \sqrt{A_x^2 + A_y^2};\quad \theta = \tan^{-1}\frac{A_y}{A_x}$

Example: Displacement of a cross-country skier

On a cross-country ski trip you travel 1.00 km north and then 2.00 km east.
a) How far and in what direction are you from your starting point ?

$$d = \sqrt{(1.00\,\text{km})^2 + (2.00\,\text{km})^2} = 2.24\ \text{km}$$

(magnitude of the displacement vector)

$$\tan\phi = \frac{\text{opposite side}}{\text{adjacent side}} = \frac{2.00\ \text{km}}{1.00\ \text{km}} \qquad \phi = 63.4^\circ$$

(direction of the displacement vector)

Equations of Kinematics in One Dimension

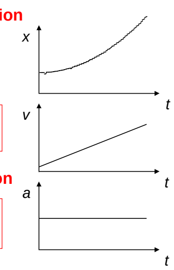
Position

Velocity

$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t}$

Acceleration

$\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t}$



For constant acceleration we find:

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$v = v_0 + at$$

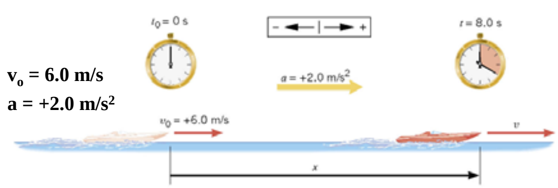
$$a = const$$

$$v^2 - v_0^2 = 2a\,(x - x_0)$$

$$g = 9.8\ \text{m}/\text{s}^2$$

Equations of kinematics for constant acceleration

v_o = 6.0 m/s
a = +2.0 m/s²



Find the position of the accelerating speedboat at t = 8.0 s.

$$x = v_o t + \tfrac{1}{2}at^2$$
$$= (6.0\,\text{m/s})(8.0\,\text{s}) + \tfrac{1}{2}(2.0\,\text{m/s}^2)(8.0\,\text{s})^2$$
$$= +110\ \text{m}$$

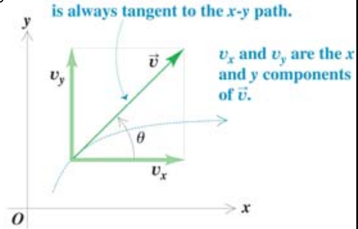
Velocity in two dimensions

Definition of average velocity

$$\vec{v}_{av} = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \frac{\Delta \vec{r}}{\Delta t}$$

Definition of instantaneous velocity

$$\vec{v} = \lim \frac{\Delta \vec{r}}{\Delta t}$$



Acceleration in two dimensions

Definition of average acceleration

$$\vec{a}_{av} = \frac{\vec{v}_2 - \vec{v}_1}{t_2 - t_1} = \frac{\Delta \vec{v}}{\Delta t}$$

Definition of instantaneous acceleration

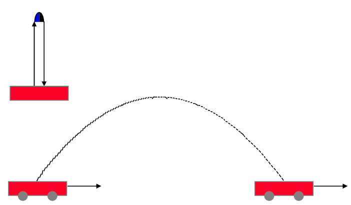
$$\vec{a} = \lim \frac{\Delta \vec{v}}{\Delta t}$$

Most important concept in two-dimensional motion

- two-dimensional motion can be decomposed into motion in x-direction and motion in y-direction

"x" and "y" components of motion are independent

- **Person on a cart throws ball vertically upwards**
  - **Seen from two different frames of reference**



Constant-Acceleration Equations of Motion in Two-Dimensions

Equations for Projectile Motion (assuming that $a_x = 0$, $a_y = -g$)

$v_x = v_{0x} + a_x t$

$x = x_0 + v_{0x} t + (½) a_x t^2$

$v_x = v_{0x}$ (1)

$x = x_0 + v_{0x} t$ (2)

$v_y = v_{0y} + a_y t$

$y = y_0 + v_{0y} t + (½) a_y t^2$

$v_y = v_{0y} - gt$ (3)

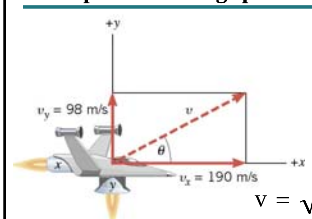
$y = y_0 + v_{0y} t - (½) g t^2$ (4)

$$v_x^2 - v_{0x}^2 = 2a_x (x - x_0)$$

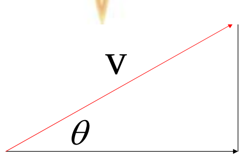
$$v_y^2 - v_{0y}^2 = 2a_y (y - y_0)$$

$$v_y^2 - v_{0y}^2 = -2g (y - y_0)$$

Example: A moving spacecraft



$$v = \sqrt{(190 \text{ m/s})^2 + (98 \text{ m/s})^2} = 210 \text{ m/s}$$



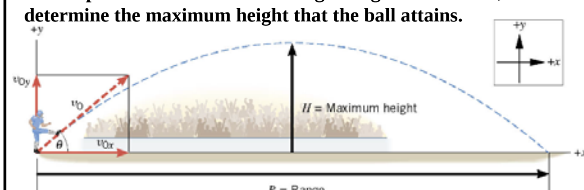
$v_y = 98$ m/s

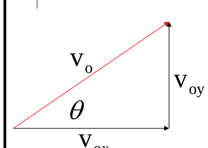
$v_x = 190$ m/s

$$\theta = \tan^{-1}(98/190) = 27^\circ$$

Example: The height of a kickoff

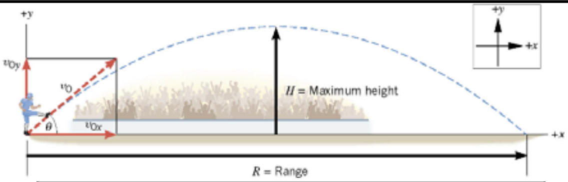
A placekicker kicks a football at and angle of 40.0 degrees and the initial speed of the ball is 22 m/s. Ignoring air resistance, determine the maximum height that the ball attains.





$$v_{ox} = v_o \cos\theta = (22 \text{ m/s})\cos 40^\circ = 17 \text{ m/s}$$

$$V_{oy} = V_o \sin\theta = (22 m/s)(\sin 40^\circ) = 14\ m/s$$



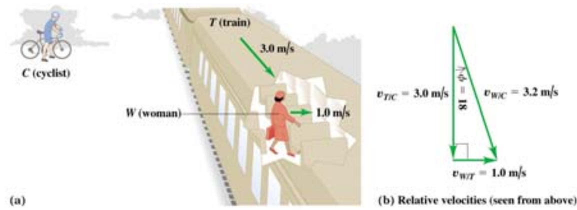
y	a_y	v_y	v_{oy}	t
?	-9.80 m/s^2	0	14 m/s	

$$v_y^2 = v_{oy}^2 + 2a_y y \quad \Rightarrow \quad y = \frac{v_y^2 - v_{oy}^2}{2a_y}$$

$$y = \frac{0 - (14\,\mathrm{m/s})^2}{2(-9.8\,\mathrm{m/s^2})} = +10\,\mathrm{m}$$

Relative velocity in 2-dim

The concept of relative velocity can be extended from 1-dim to 2-dim



Velocities can carry multiple values depending on the position and motion of the object and observer