## Chapter 5

Forces In Two Dimensions

## Vectors

- One force = one vector
- Length of vector = magnitude of force
- Direction of force represented by
- Sum of vectors is shown by resultant vector


## Vectors In Multiple Dimensions

- Solving Graphically
- Use a PROTRACTOR
- Correct angles
- Direction and Magnitude of Resultant Vector
- Add Vectors by . . .
- placing them tip to tail
- draw the resultant vector by connecting the tail of the first vector to the tip of the second vector.
- use a protractor to measure the direction of the resultant vector.
- determine the length or direction of resultant vector
- Pythagorean Theorem - Vector $A$ is at right angle to Vector B

$$
R^{2}=A^{2}+B^{2}
$$

- If the two Vectors are at angles other than $90^{\circ}$
» Law of Cosines - $R^{2}=A^{2}+B^{2}-2 A B \cos \theta$
» Law of Sines - $\underset{\sin \theta}{\underline{R}}=\underline{A}=\underline{B}$


## Practice Problems

$$
\begin{aligned}
& \text { pg. } 121 \\
& \text { \#'s 1-4 }
\end{aligned}
$$

## Components of Vectors

- Choosing the direction of the x-axis
- When dealing with problems of Earth
- x-axis points to the East
- y-axis points to the North
- When dealing with objects moving through the air
- Positive x-axis is Horizontal
- Positive y-axis is Vertical (Upward)
- Components - a vector parallel to the $x$-axis and another parallel to the $y$-axis.
- Fig. 5-3 b pg. 122
- Adding these components will give you the resultant vector (hypotenuse).

$$
A=A_{x}+A_{y}
$$

- Vector Resolution - breaking a vector into its components


## Components of Vectors

- Direction of a vector - the angle the vector makes with the $x$-axis measured counterclockwise. ( $\theta$ )
- In algebraic calculations only involve positive components
- Using trigonometry to find components
- In algebraic calculations only involve positive components
- Equations to use

$$
\begin{aligned}
& \cos \theta=\frac{\text { adjacent side }}{\text { hypotenuse }}=\frac{A_{\underline{x}}}{A} ; \text { therefore, } A_{x}=A \cos \theta \\
& \sin \theta=\frac{\text { opposite side }}{\text { hypotenuse }}=\frac{A_{x}}{A} ; \text { therefore, } A_{y}=A \sin \theta
\end{aligned}
$$

## Algebraic Addition of Vectors

- By breaking down vectors into their components makes adding vectors together much easier.
$-X$ components are added to form the x-component of the resultant: $R_{x}=A_{x}+B_{x}+C_{x}$
- $Y$ components are added to form the $y$-component of the resultant: $R_{y}=A_{y}+B_{y}+C_{y}$
- By doing this, your are presenting them at right angles and now can use the Pythagorean theorem to calculate the magnitude of the resultant vector.

$$
R^{2}=R_{x}{ }^{2}+R_{y}{ }^{2}
$$

- To find the angle and direction of the resultant vector,

$$
\theta=\tan ^{-1}\left[\underline{R}_{y}\right]
$$

## Problem Solving Strategies

- Vector Addition
- Choose a coordinate system
- Resolve vectors into
- X-components using $A_{x}=A \cos \theta$
- Y-components using $A_{y}=A \sin \theta$

Where $\boldsymbol{\theta}$ is the angle measured counter clockwise from the positive x -axis

Choose a coordinate system

- Add or Subtract the component vectors in the x-direction
- Add or Subtract the component vectors in the $y$-direction
- Use the Pythagorean theorem to find the magnitude of the resultant vector.

$$
\mathrm{R}=\sqrt{R_{x}{ }^{2}+R_{y}{ }^{2}}
$$

- Find the angle of the resultant vector by using

$$
\begin{array}{r}
\theta=\tan ^{-1}\left[\underline{R}_{y}\right] \\
R_{x}
\end{array}
$$

## Practice Problems

pg. 125<br>\#'s 5-10

## Section Review

> pg. 125
> \#'s $11-14$

## Friction

- Friction - acceleration opposite to that of motion.
- Kinetic Friction - force exerted on one surface by another when the two surfaces rub against each other because one or both are moving.
- Static Friction - force exerted on one surface by another when there is NO motion between the surfaces.
- There is a limit to how large this force can be; when it is over come and the object moves.
- Friction force depends on. . .
- Surface material
- Normal force between two objects
- Harder the object is pushed against the other, the greater the force of friction.
- DOES NOT depend on. . .
- Surface area
- Speed
- The relationship between kinetic friction force and normal force.
- Linear relationship (greater = greater)
- Coefficient of Kinetic Friction - relates the frictional force to the normal force.
- Equal to the product of the coefficient of the kinetic friction and normal force.

- The relationship between static friction force and normal force.
- If no force acts on an object, static friction force is zero
- Force applied; static friction force increases linear, until overcome.
- Less than or equal to the product of the coefficient of static friction and normal force.
- Coefficient of Static Friction - relates the frictional force to the normal force.



## Practice Problems

pg. 128<br>\#'s 17-21

- Equations for solving kinetic and maximum static friction only involve magnitude.
- The direction of the forces themselves $\left(F_{f}\right.$ and $\left.F_{N}\right)$ are at right angles to one another.

Practice Problems

pg. 130
\#'s 22-26

## Frictional Situations

- Friction always acts in a direction opposite to the motion.
- Magnitude of the force of friction depends on the magnitude of the normal force between the two rubbing surfaces; NOT necessarily the weight of the objects.
- Multiplying the coefficient of static friction and the normal force gives you the maximum static friction force.


## Section Review

## pg. 130 <br> \#'s 27-30

## Forces at Angles Other Than $90^{\circ}$

- Equilibrium
- Net force = zero
- Motionless or Moves at a Constant Velocity
- Occurs No Matter How Many Forces Act On It; As long as the Resultant is 0
- An object is in equilibrium when all forces add to 0
- Two forces act on an object and sum is NOT 0
- Add the two forces.
- This answer is the Resultant Force
- The missing force will have the same magnitude as the Resultant Force, but Opposite direction.
- The force that puts an object into equilibrium is called the equilibrant.

CHALLENGE PROBLEM
Pg. 132

## Motion Along an Inclined Plane

- Identify the forces acting on the object
- Sketch a free body diagram with those forces
- The x-axis will be represented by the accelerated motion
- The $y$-axis will be perpendicular to the $x$-axis
- Weight of the object on an inclined plane represented by Normal Force. But because of slope, Weight will not be equal the magnitude of the Normal Force.
- Apply Newton's Laws once in the x-direction and once in the $y$-direction by breaking them into components.


## Practice Problems

$$
\begin{aligned}
& \text { pg. 133 } \\
& \text { \#'s 33-37 }
\end{aligned}
$$

## Section Review

$$
\begin{gathered}
\text { pg. } 135 \\
\text { \#'s } 42-45
\end{gathered}
$$

