Phys 111: Lecture 4

"The Four Who Are There"

University of Idaho

September 05, 2019

Today's Announcements

Homework Wk #2 Due Today

Today's Topics

1. 2D Motion/Kinematics
2. Vectors
3. Example Problems

Concept Check

C&J 1.6.24 A force vector $\vec{\mathbf{F}}_1$ points due east and has a magnitude of 200 newtons. A second force $\vec{\mathbf{F}}_2$ is added to $\vec{\mathbf{F}}_1$. The resultant of the two vectors has a magnitude of 400 newtons and points along the east/west line. Find the magnitude and direction of $\vec{\mathbf{F}}_2$. Note that there are two answers.

C&J 1.6.25 Consider the following four force vectors:

$$\vec{\mathbf{F}}_1 = 50.0\ N\ dueeast$$
$$\vec{\mathbf{F}}_2 = 10.0\ N\ dueeast$$
$$\vec{\mathbf{F}}_3 = 40.0\ N\ duewest$$
$$\vec{\mathbf{F}}_4 = 30.0\ N\ duewest$$

Which two vectors

a. add to give a resultant with the smallest magnitude?

b. add to give a resultant with the largest magnitude?

In each case specify the magnitude and direction of the resultant.

Necessary Info?

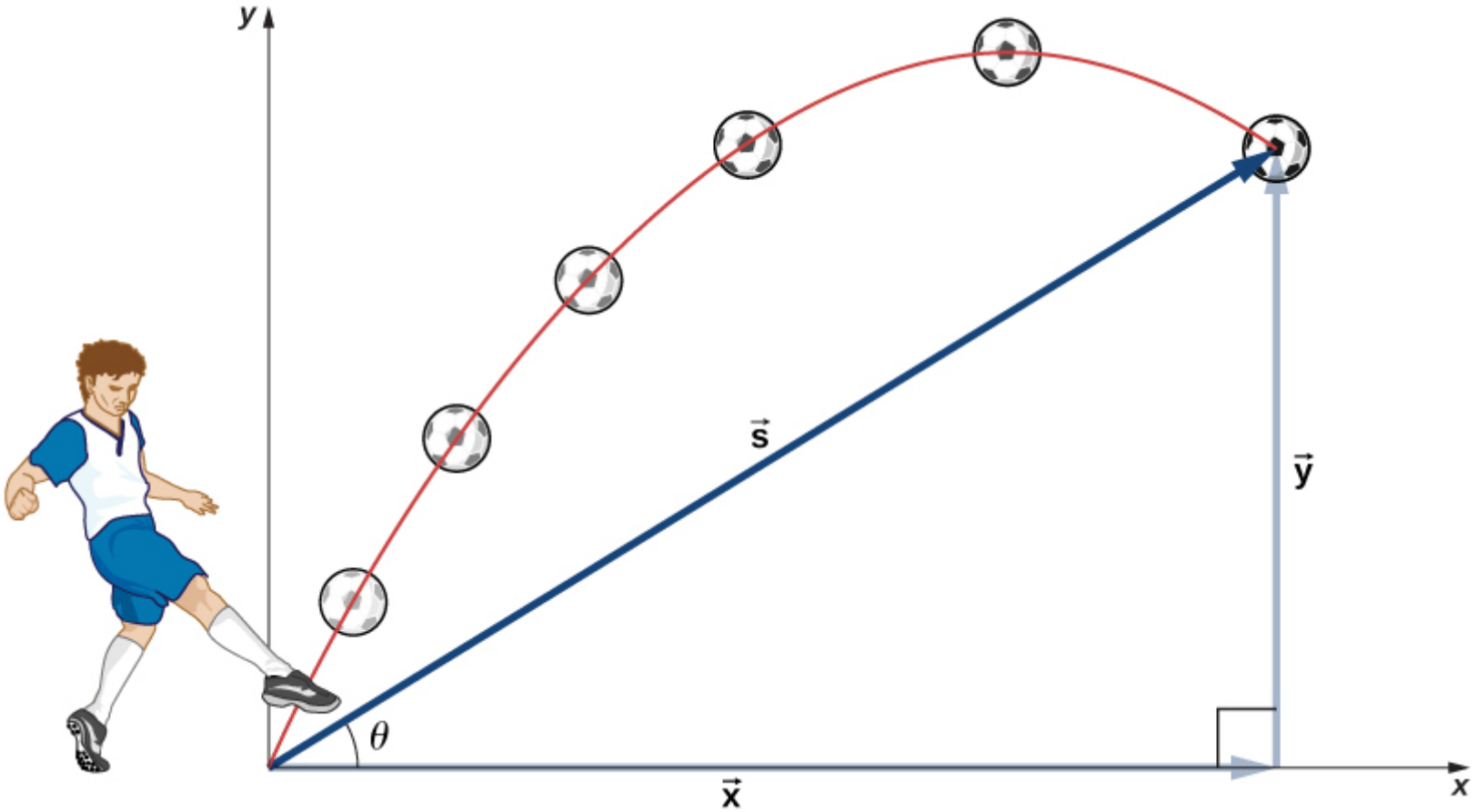

Figure: 4.1 Can you quantify this motion?

2D Vectors

Vector: A quantity that inherently deals with a magnitude and a direction is called a vector quantity.

Examples position, displacement, velocity, acceleration, force, momentum, torque, etc.

Notation

$$\vec{\mathbf{r}} = x\,\hat{\mathbf{i}} + y\,\hat{\mathbf{j}}$$

$$\vec{\mathbf{v}} = v_x\,\hat{\mathbf{i}} + v_y\,\hat{\mathbf{j}}$$

$$\vec{\mathbf{a}} = a_x\,\hat{\mathbf{i}} + a_y\,\hat{\mathbf{j}}$$

Exercise #1

General 2D Vectors Calculate the magnitude of a general two dimensional vector with cartesian components.

$$\vec{\mathbf{A}} = A_x\,\hat{\mathbf{i}} + A_y\,\hat{\mathbf{j}}$$

$$A = |\vec{\mathbf{A}}| = \sqrt{A_x^2 + A_y^2}$$

Examples

$$r = |\vec{\mathbf{r}}| = \sqrt{x^2 + y^2}$$

$$v = |\vec{\mathbf{v}}| = \sqrt{v_x^2 + v_y^2}$$

$$a = |\vec{\mathbf{a}}| = \sqrt{a_x^2 + a_y^2}$$

Exercise #2

C&J 1.7.35 Vector $\vec{\mathbf{A}}$ points along the +y axis and has a magnitude of 100.0 units. Vector $\vec{\mathbf{B}}$ points at an angle of 60.0 above the +x axis and has a magnitude of 200.0 units. Vector $\vec{\mathbf{C}}$ points along the +x axis and has a magnitude of 150.0 units.

Which vector has

a. the largest x component?

b. the largest y component?

Exercise #3

Displacement What are the x and y components of the 2D displacement vectors for the following?

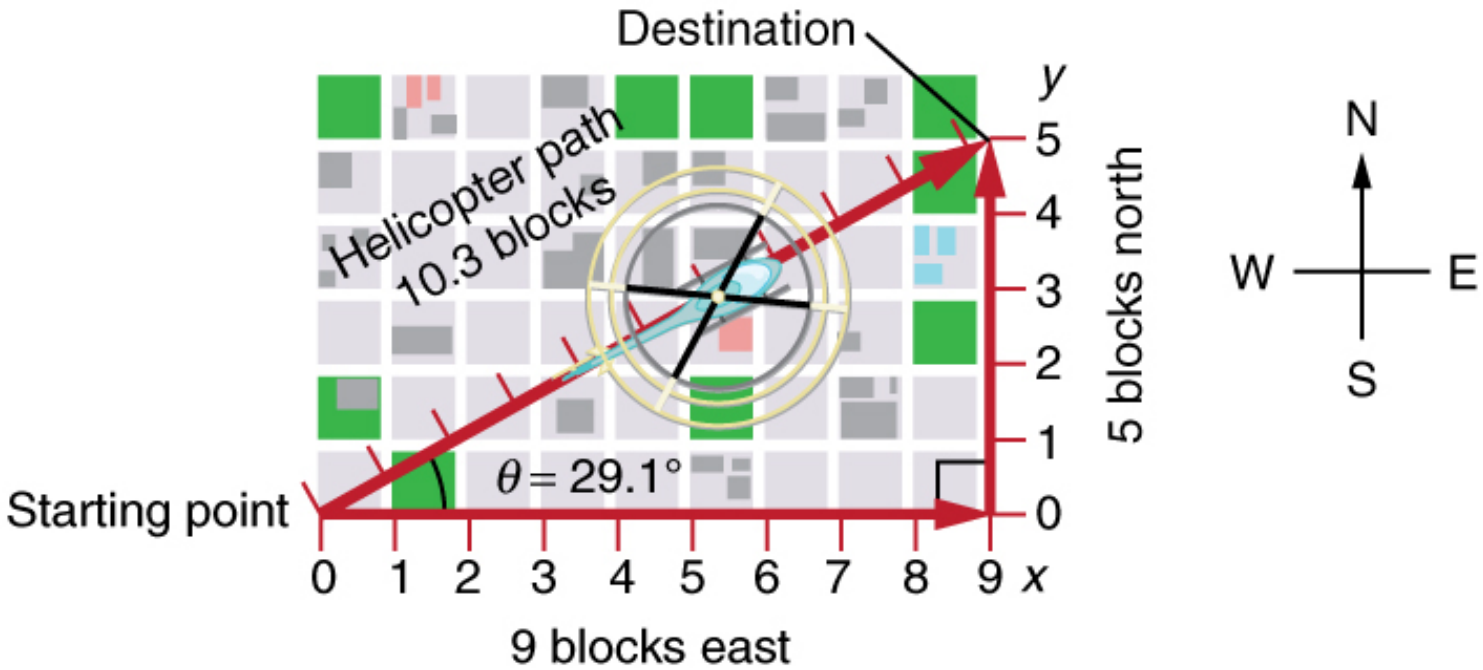

Figure: 4.2 Different paths, same displacement

Exercise #4

C&J 1.6.31 A car is being pulled out of the mud by two forces that are applied by the two ropes shown in the drawing. The dashed line in the drawing bisects the 30.0° angle. The magnitude of the force applied by each rope is 2900 newtons. Arrange the force vectors tail to head and use the graphical technique to answer the following questions.

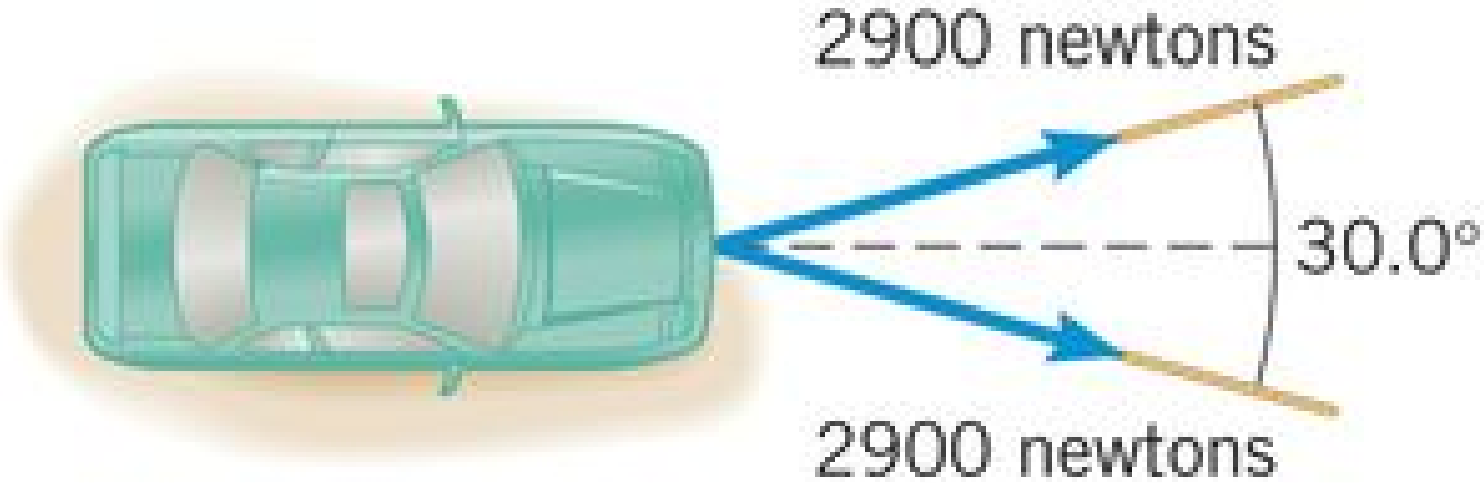

Figure: 4.3 Pulling in 2 directions.

Exercise #4

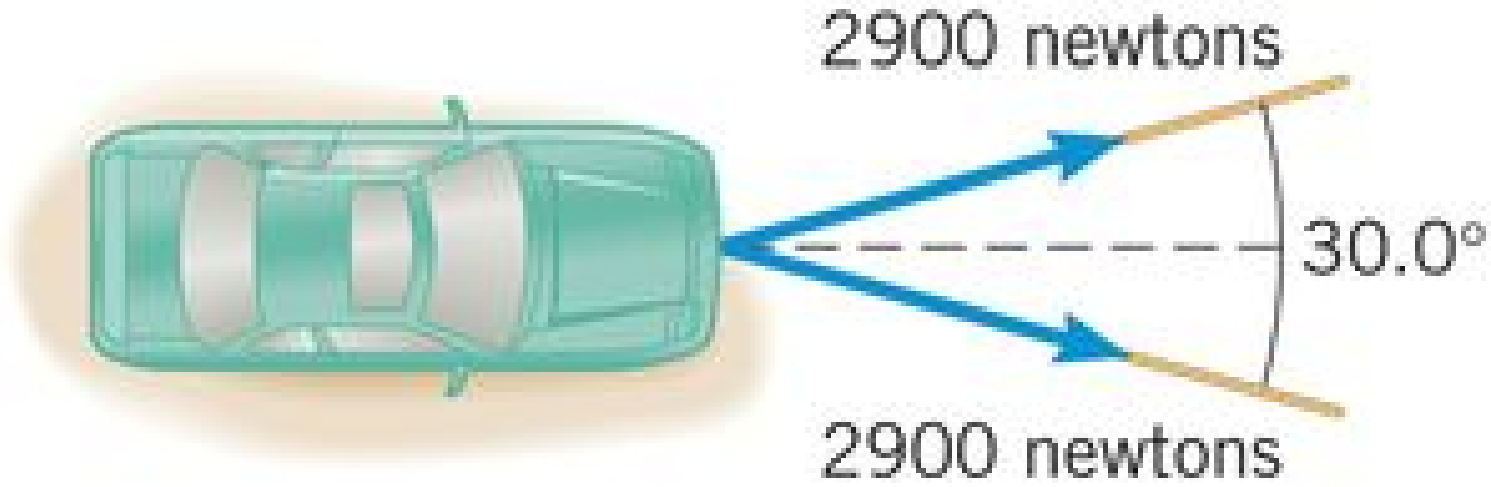

Figure: 4.3 Pulling in 2 directions.

a. How much force would a single rope need to apply to accomplish the same effect as the two forces added together?

b. How would the single rope be directed relative to the dashed line?

Exercise #5

C&J 3.1.1 Two trees have perfectly straight trunks and are both growing perpendicular to the flat horizontal ground beneath them. The sides of the trunks that face each other are separated by 1.3 m. A squirrel makes three jumps in rapid succession.

First, he leaps from the foot of one tree to a spot that is 1.0 m above the ground on the other tree. Then, he jumps back to the first tree, landing on it at a spot that is 1.7 m above the ground. Finally, he leaps back to the other tree, now landing at a spot that is 2.5 m above the ground.

What is the magnitude of the squirrel's displacement?

Constant Acceleration

$$s(t) = s_o + v_o t + \frac{1}{2} a t^2$$

$$v(t) = v_o + at$$

$$v_f^2 = v_o^2 + 2a\Delta s$$

Constant Acceleration in 2D

Extend 1D Case

$$\vec{\mathbf{r}}_f = \vec{\mathbf{r}}_o + \vec{\mathbf{v}}_o t + \frac{1}{2}\vec{\mathbf{a}}t^2$$

$$\vec{\mathbf{v}}(t) = \vec{\mathbf{v}}_o + \vec{\mathbf{a}}t$$

$$|\vec{\mathbf{v}}_f|^2 = |\vec{\mathbf{v}}_o|^2 + 2\vec{\mathbf{a}} \cdot \Delta\vec{\mathbf{r}}$$

Projectile Motion

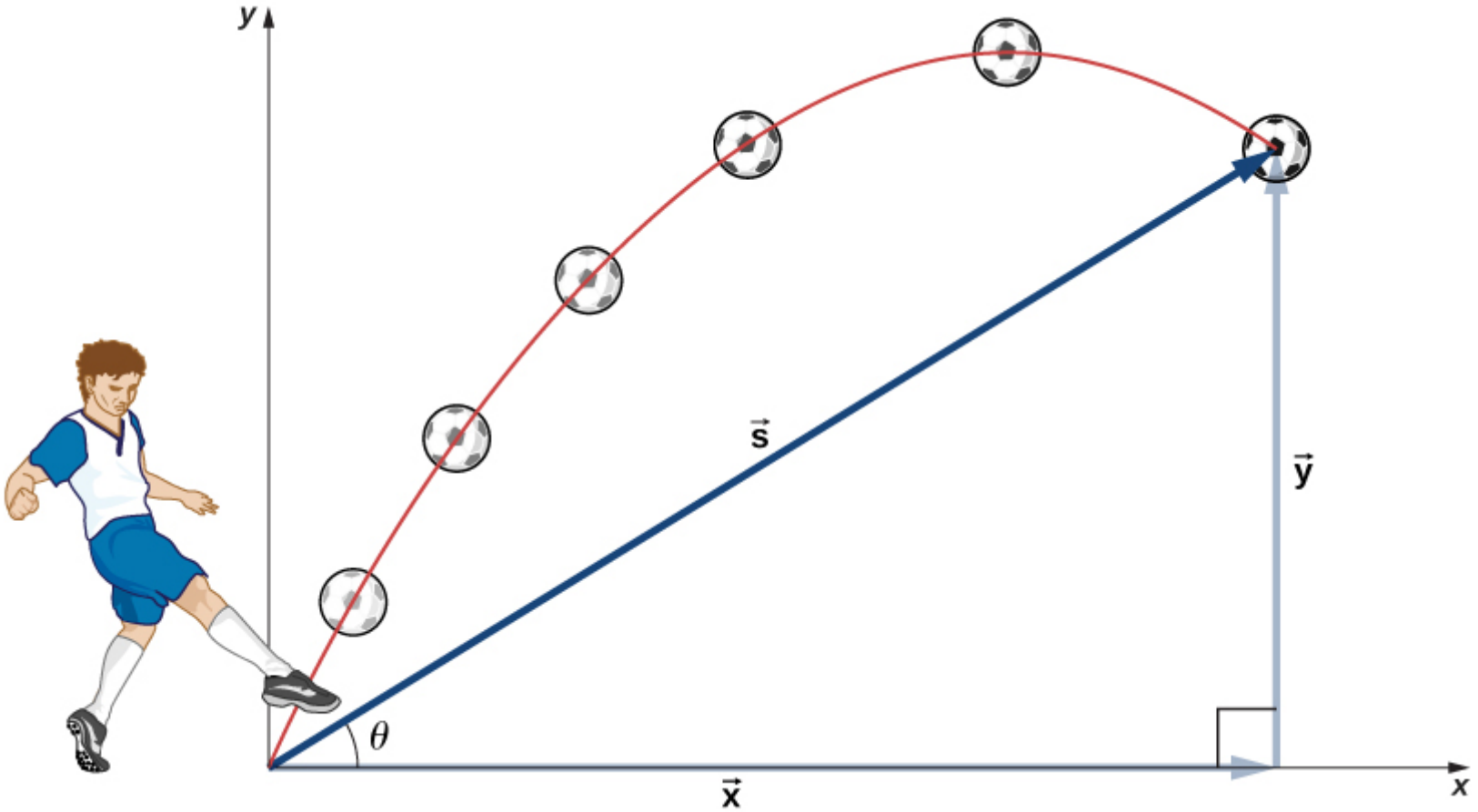

Figure: 4.1 Projectile motion of a soccer ball.

Exercise #6 (Collecting)

C&J 3.3.14 As a tennis ball is struck, it departs from the racket horizontally with a speed of 28.0 m/s. The ball hits the court at a horizontal distance of 19.6 m from the racket. How far above the court is the tennis ball when it leaves the racket?

Exercise #7

C&J 3.3.15 A skateboarder shoots off a ramp with a velocity of 6.6 m/s, directed at an angle of 58.0° above the horizontal. The end of the ramp is 1.2 m above the ground. Let the x axis be parallel to the ground, the +y direction be vertically upward, and take as the origin the point on the ground directly below the top of the ramp.

a. How high above the ground is the highest point that the skateboarder reaches?

b. When the skateboarder reaches the highest point, how far is this point horizontally from the end of the ramp?