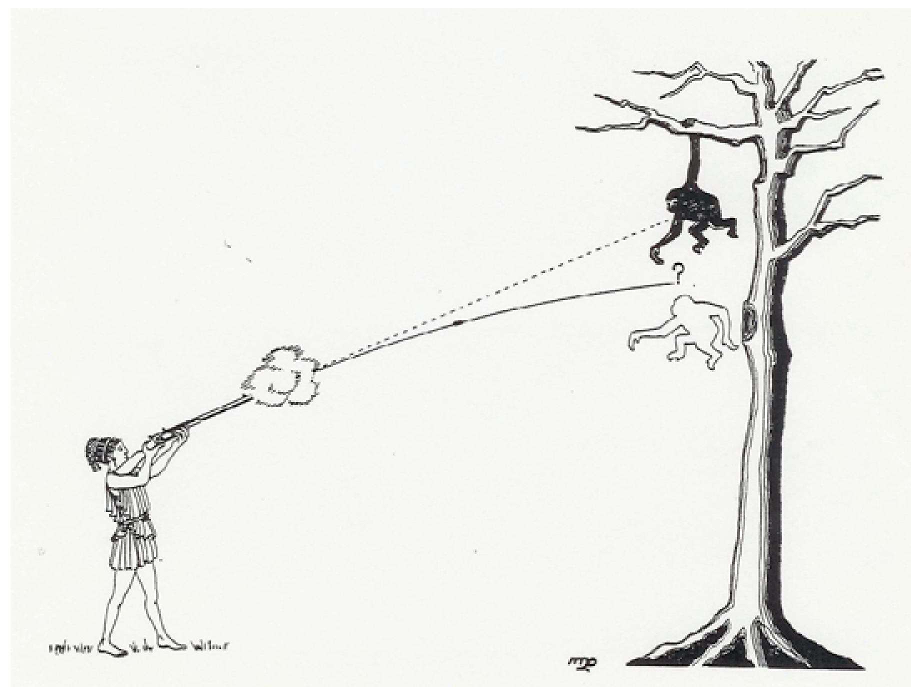
2. Motion in A Plane

Grade 11 Physics

Motion in A Plane

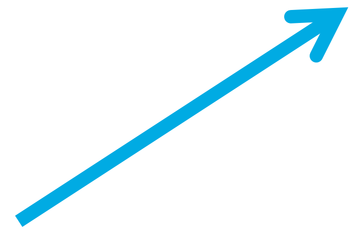
Today's Goal

- I want to shoot the monkey on the tree…
- If I shoot my tranquilizer gun, the money will be surprised by the sound, and will jump off the tree.
- How should I aim my gun?



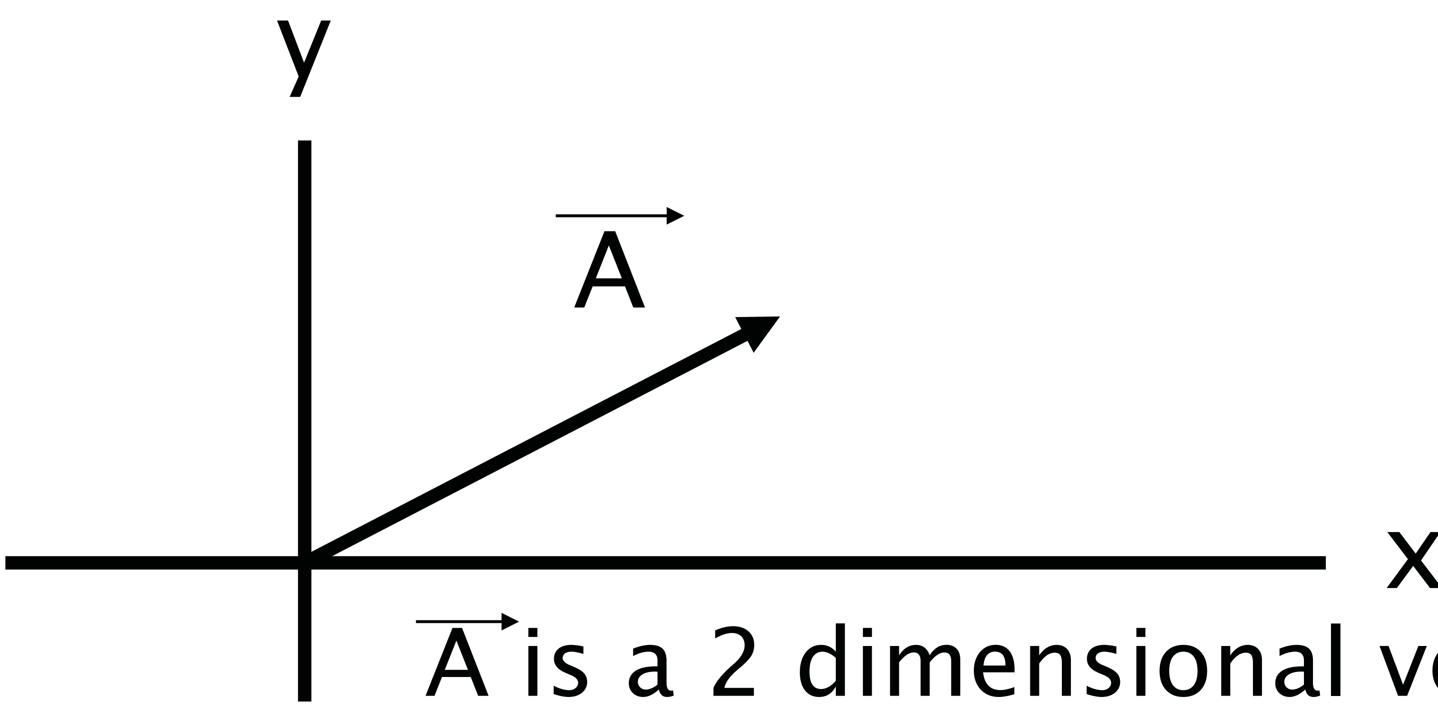
Vectors

- Vector
  - A line segment with direction



  - With two components
    - Scalar component and Vector component

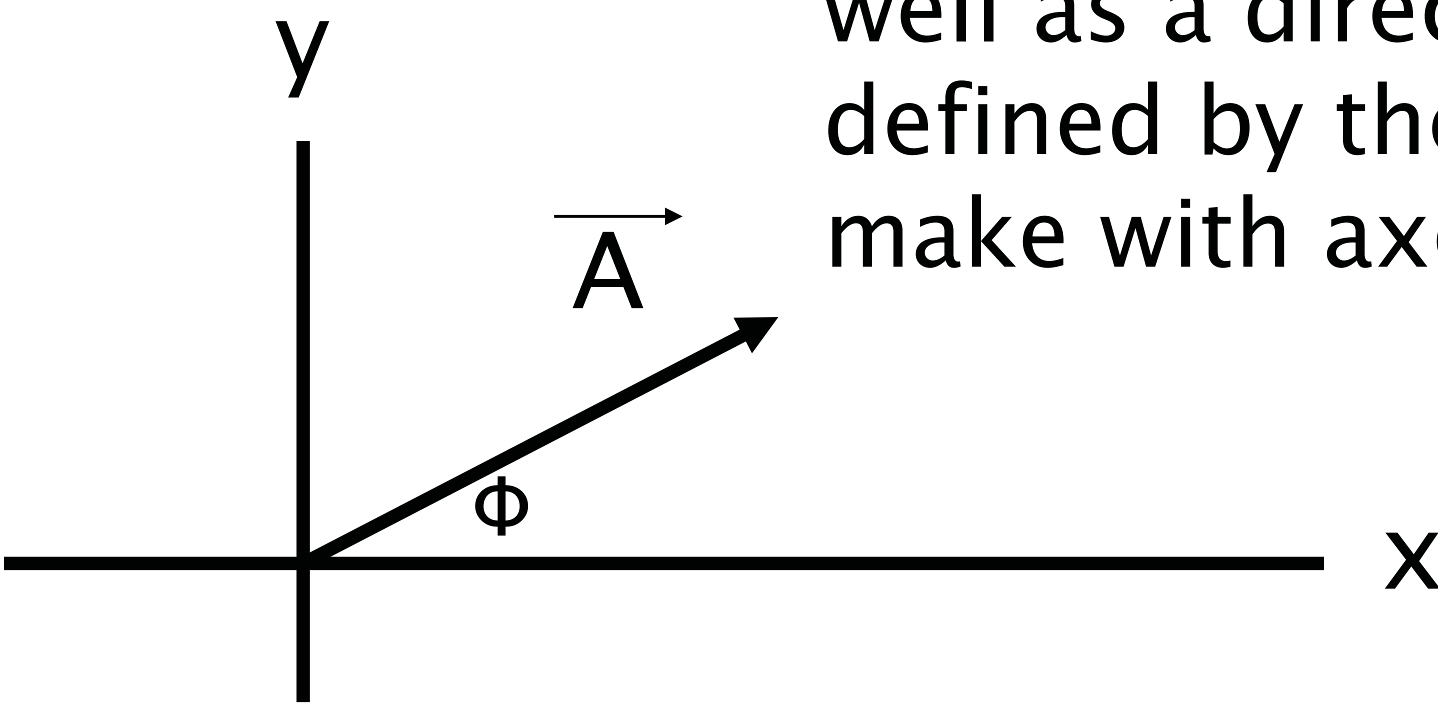
Vectors cont.



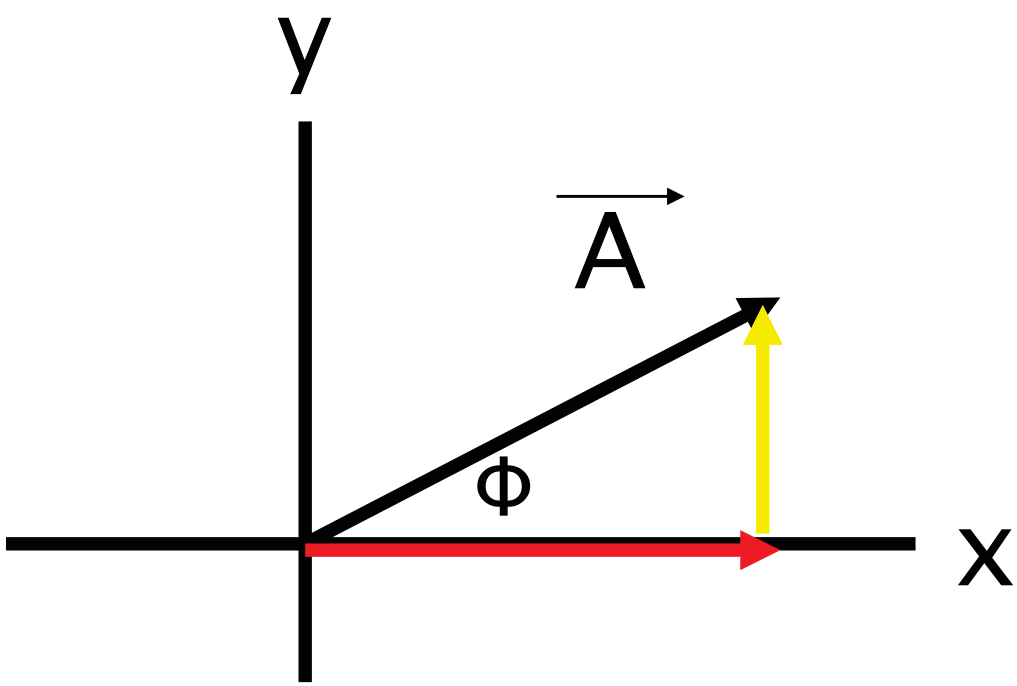
$\vec{A}$ is a 2 dimensional vector, because it moves in the x and the y direction

Vectors cont.

$\vec{A}$ has a definite length called a magnitude as well as a direction defined by the angle Φ it make with axes

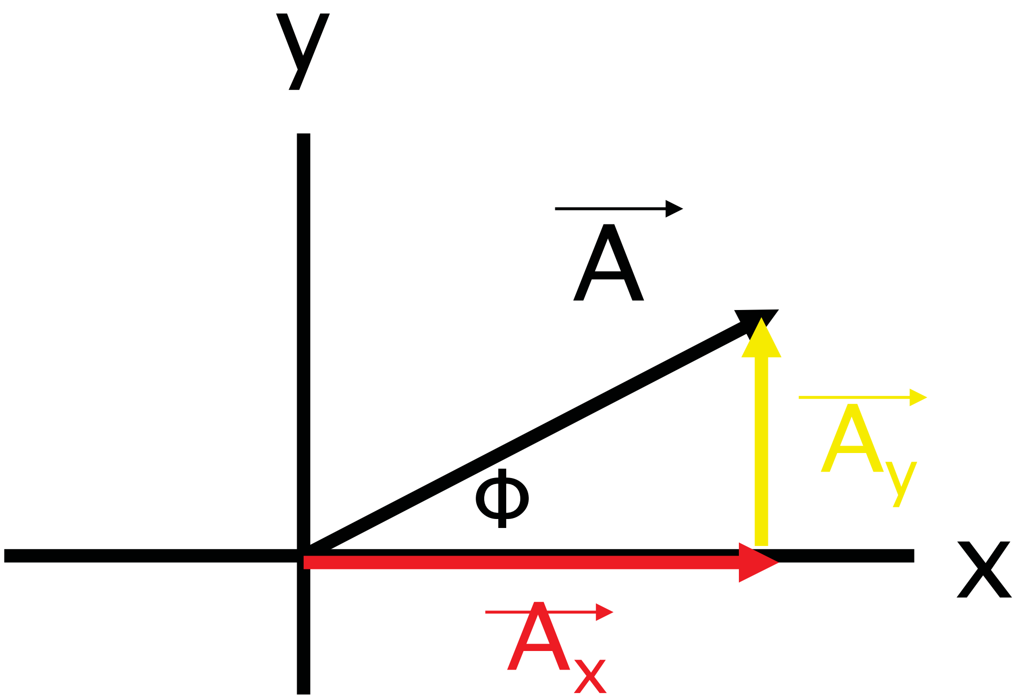


Vectors cont.



$\vec{A}$ is 2D, but made up of 1D "components" along the x and y axes these "components" are referred to as $\vec{A}_x$ and $\vec{A}_y$
It should be clear that the magnitude (length) of $\vec{A}$ is the square root of $\vec{A}_x^{\,2} + \vec{A}_y^{\,2}$ by the Pythagorean Theorem

Vectors cont.



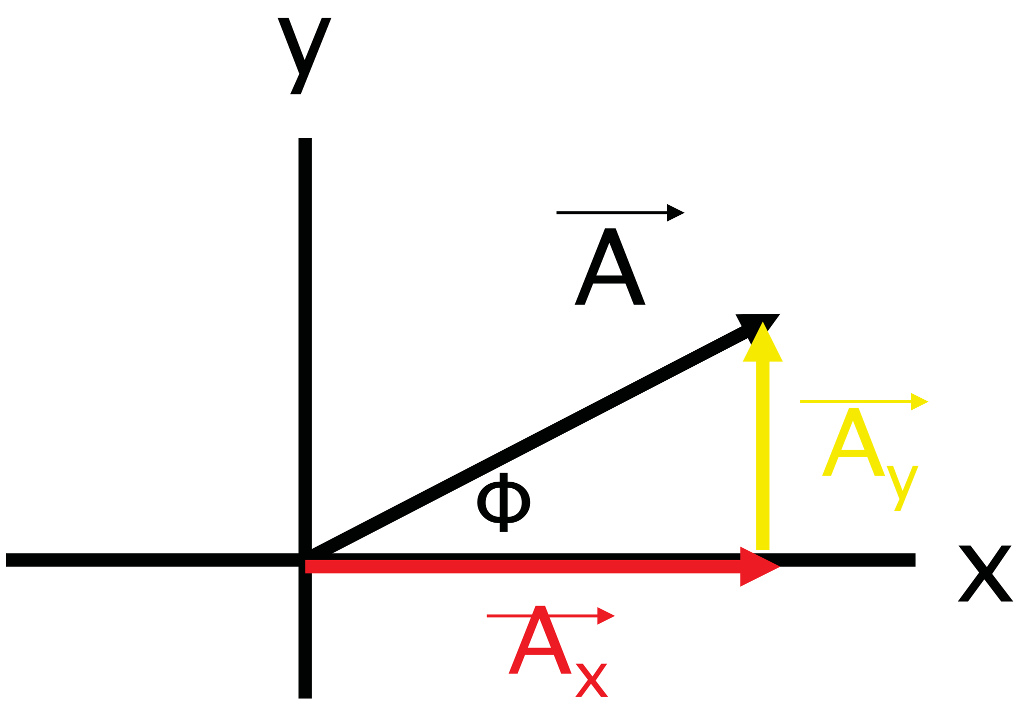
By simply using trig rules it should also be clear that

$$\vec{A}_x = \vec{A}\cos\Phi$$

and

$$\vec{A}_y = \vec{A}\sin\Phi$$

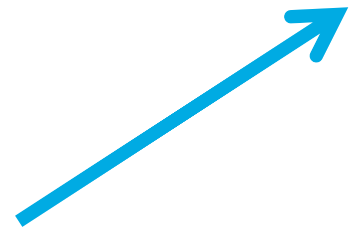
Vectors cont.



So whenever you are solving problems in two dimensions, always express a vector in terms of its components and solve each dimension separately.

Vectors

- Vector
  - A line segment with direction

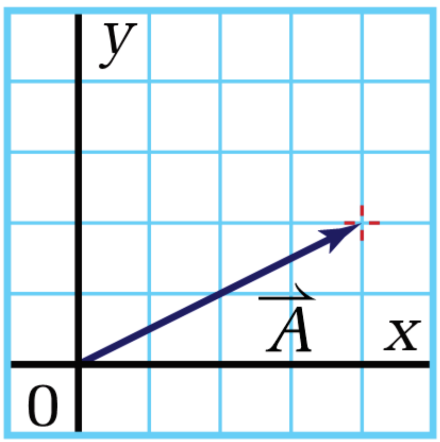


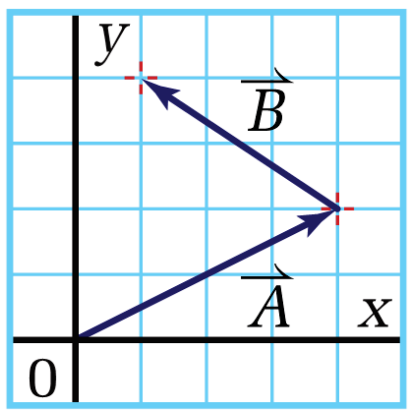
  - With two components
    - Scalar component and Vector component

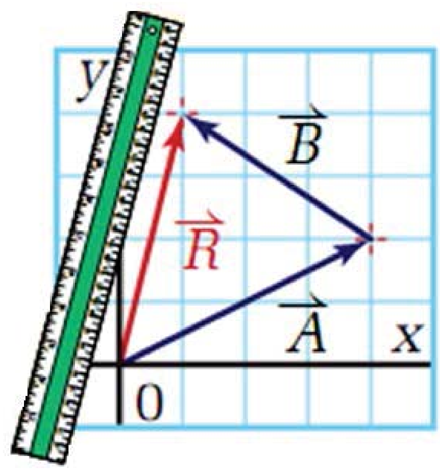
Vectors Addition

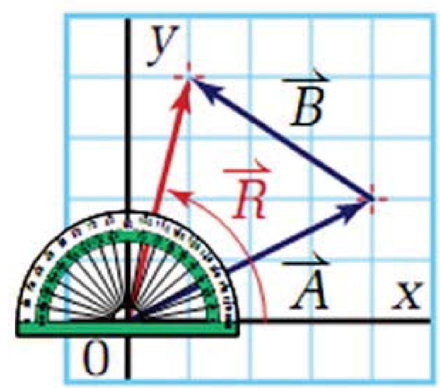
- Vectors Addition
  - Tail to Head
  - B to A

$$\vec{R} = \vec{A} + \vec{B}$$









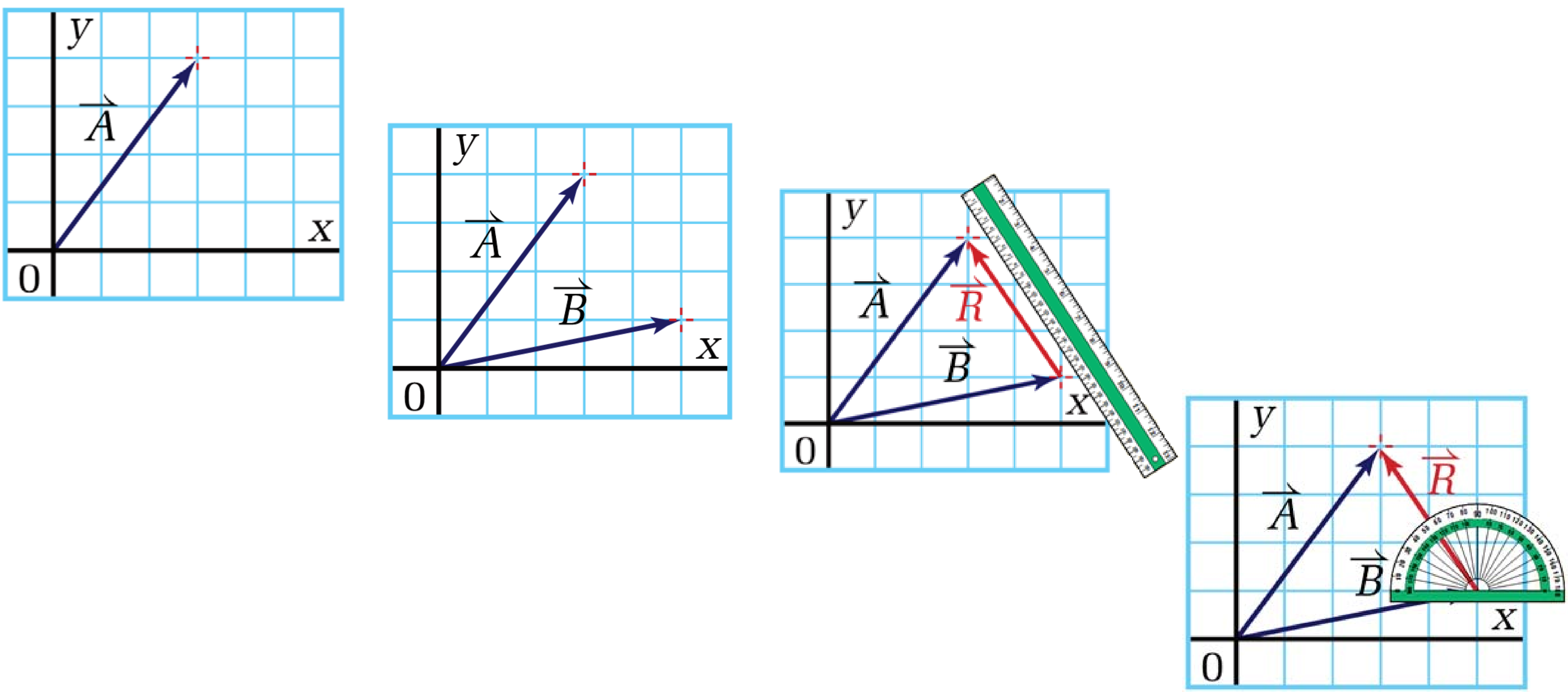
Example Problem

- EX1:
  - A kayaker sets out for a paddle on a broad stretch of water. She heads toward the west, but is blown off course by a strong wind. After a hour of hard paddling, she arrives at a lighthouse that she knows is 12km southwest of her starting point. She lands and waits for the wind to die down. She then paddles toward the setting sun and lands on a small island that is 8km west of the lighthouse. In the calm of evening, the kayaker plans to paddle straight back to her starting point. Use a vector diagram to determine her displacement from her starting point to the island. In which direction should she now head and how far will she have to paddle to go directly to the point from which she originally started paddling?

Vector Subtraction

- Vector Subtraction
  - Head to Head
  - B to A

$$\vec{R} = \vec{A} - \vec{B}$$



Example Problem

- EX2:
  - A water-skier begins his ride by being pulled straight behind the boat. Initially, he has the same velocity as the boat 50km/h [N]. Once up, the water-skier takes control and cuts out to the side. In cutting out to the side, the water-skier changes his velocity in both magnitude and direction. His new velocity is 60km/h [N60°E]. Find the water-skier's change in velocity.

Vector Multiplies or Divides Scalar

- Multiply or Divide by Scalar
  - Direction remains constant
  - Magnitude changes with respect to the scalar

Example Problem

- EX3:
  - A hiker sets out for a trek along a mountain trail. After 2 h, she checks her global positioning system and finds that she is 8km [W40^{o}N] from her starting point. What was her average velocity for the trek?

Example Problem

- EX4:
  - A hot-air balloon rises into the air and drifts with the wind at a rate of 24km/h [E40^{o}N] for 2h. The wind shifts, so that balloon changes direction and drifts south at a rate of 40km/h for 1.5h before landing. Determine the balloon's displacement for the flight.

Relative Velocity

- Relative Velocity
  - Different frame of reference into one
  - AKA early sailors
    - Account for current
    - Account for wind
    - Account for man power on the boat

Example Problem

- EX5:
  - A canoeist is planning to paddle to a campsite directly across a river that is 624m wide. The velocity of the river is 2.0m/s [S]. In still water, the canoeist can paddle at a speed of 3.0m/s. If the canoeist points her canoe straight across the river, toward the east:
    - How long will it take her to reach the other river bank?
    - Where will she land relative to the campsite?
    - What is the velocity of the canoe relative to the point on the river bank, where she left?

Example Problem

- EX6:
  - The canoeist in the previous question want to head her canoe in such a direction that she will actually travel straight across the river to the campsite.
    - In what direction must she point the canoe?
    - Find the magnitude of her velocity relative to the shore.
    - How long will it take the canoeist to paddle to the campsite?

Vector Components

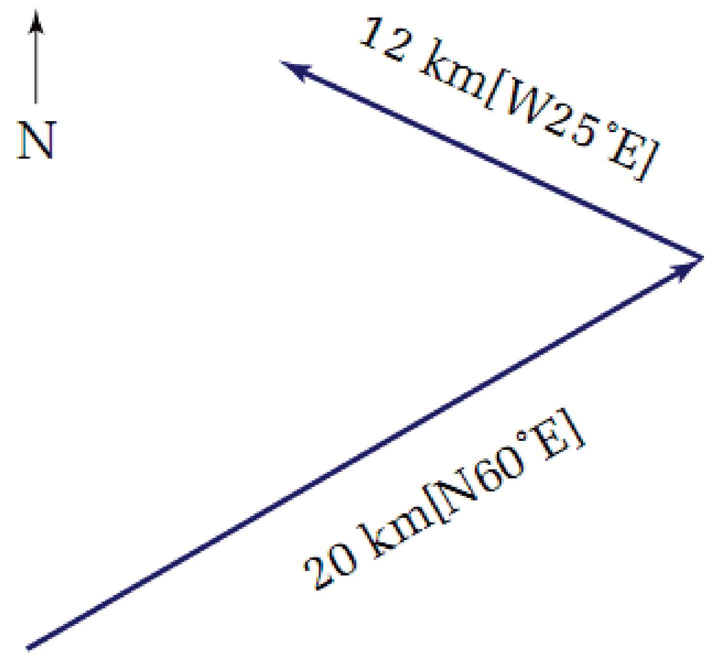
- Vector addition and subtraction
  - Not always at right angle
  - Not always the easiest way
- Vector Components
  - x-axis direction and y-axis direction
  - Applies to all vectors

Example Problem

- EX7:
  - Find the x and y components of the vector with a magnitude of 64m at an angle of 120^{o}.
- EX8:
  - Resolve the vector 56km/h [N50^{o}E], into components.

Example Problem

- EX9:
    - A sailboat sailed [N60°E] for 20.0km. A strong wind began to blow, causing the boat to travel an additional 12.0km [W25°N]. Determine the boat's displacement for the entire trip.

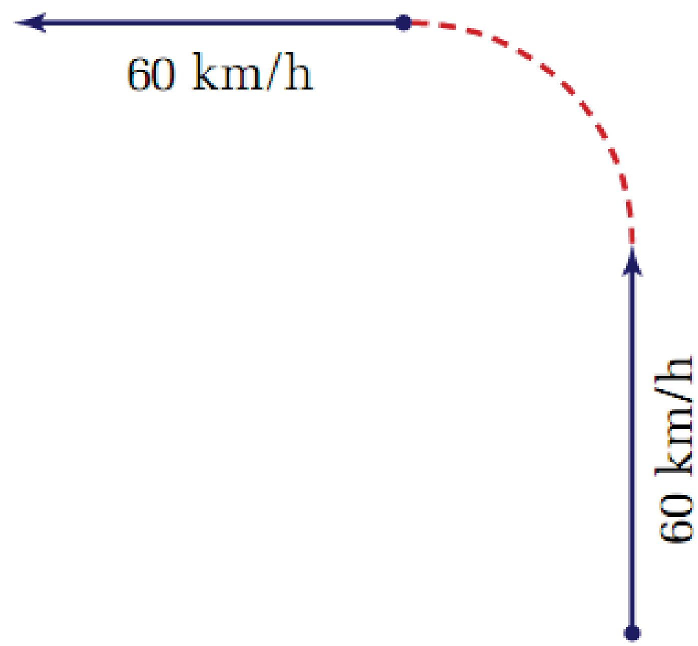


Example Problem

- EX10:
    - You are the pilot of a small plane and want to reach an airport, 600km due south, in 4.0h. A wind is blowing at 50km/h[S35^{o}E]. With what heading and airspeed should you fly to reach the airport on time?

Example Problem

- EX11:
  - Calculate the acceleration of the jet-ski as described in the following.
    - Is there an acceleration?
    - If yes, then why?
    - If no, then why?



Projectile Motion (Cont.)

- The BIG FIVE formula AGAIN:

$$\Delta d = v_1 t + \frac{1}{2} a \Delta t^2$$

$$\Delta d = v_2 t - \frac{1}{2} a \Delta t^2$$

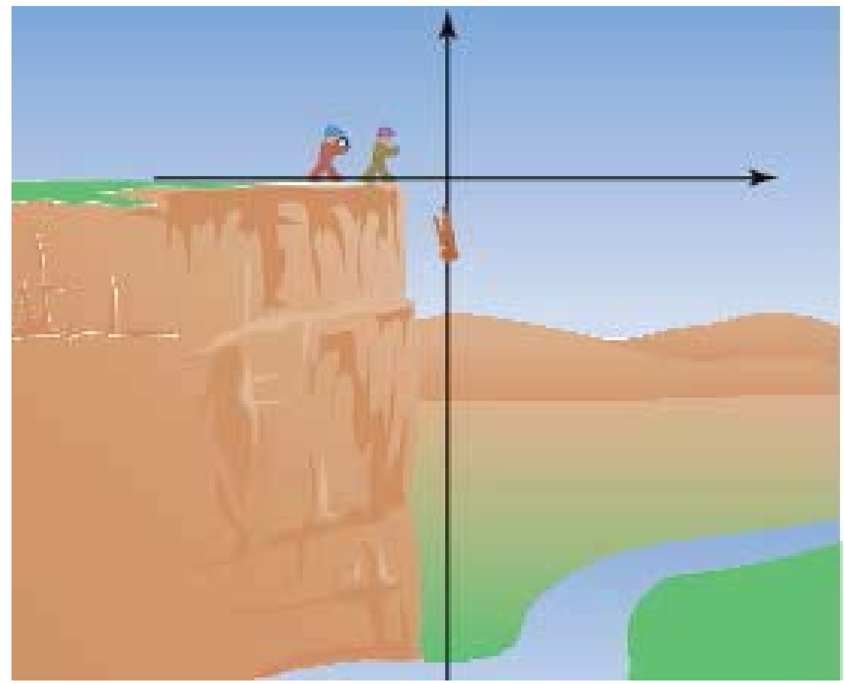
$$\Delta d = \frac{v_2 + v_1}{2} \Delta t$$

$$v_2^2 = v_1^2 + 2a\Delta d$$

$$v_2 = v_1 + a\Delta t$$

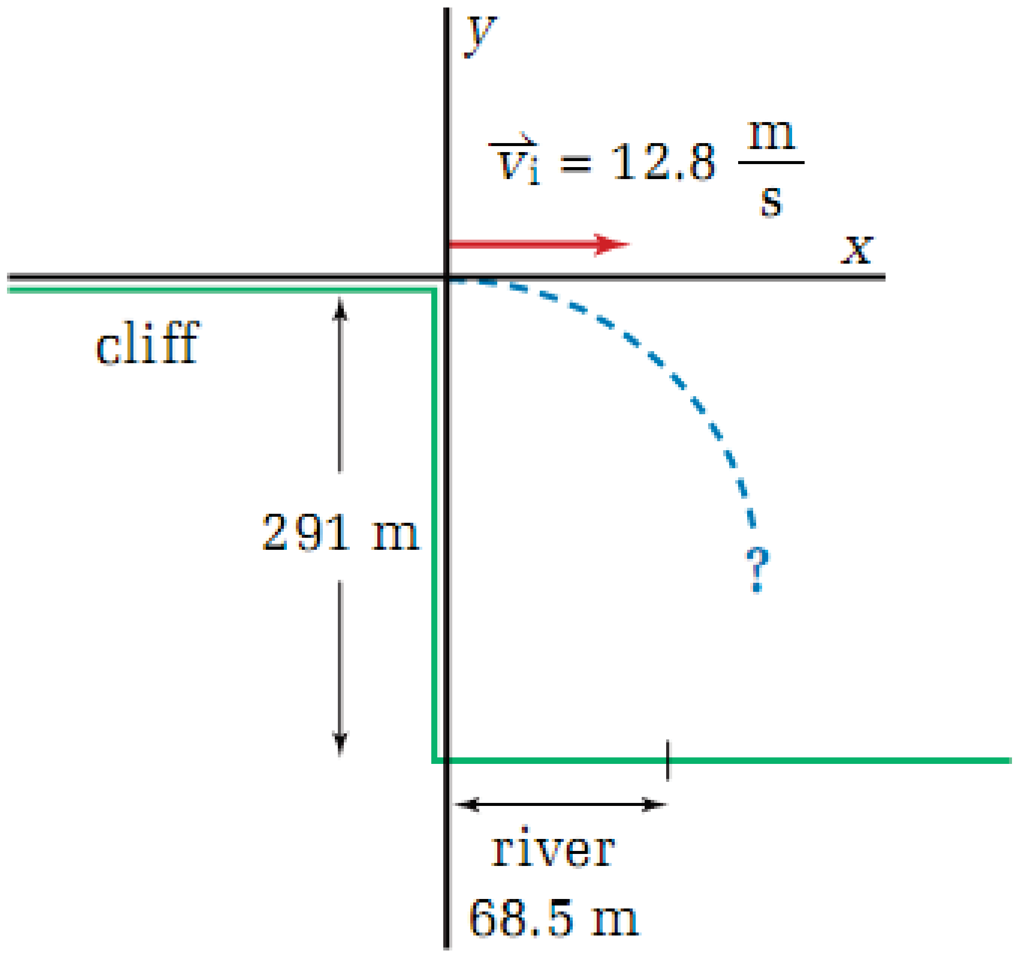
Example Problem

- EX1:
  - While hiking in the wilderness, you come to a cliff overlooking a river. A topographical map shows that the cliff is 291m high and the river is 68.5m wide at that point. You throw a rock directly forward from the top of the cliff, giving the rock a horizontal velocity of 12.8m/s



Example Problem (Cont.)

- EX1: (Cont.)
  - Did the rock make it across the river?
  - With what velocity did the rock hit the ground or water?



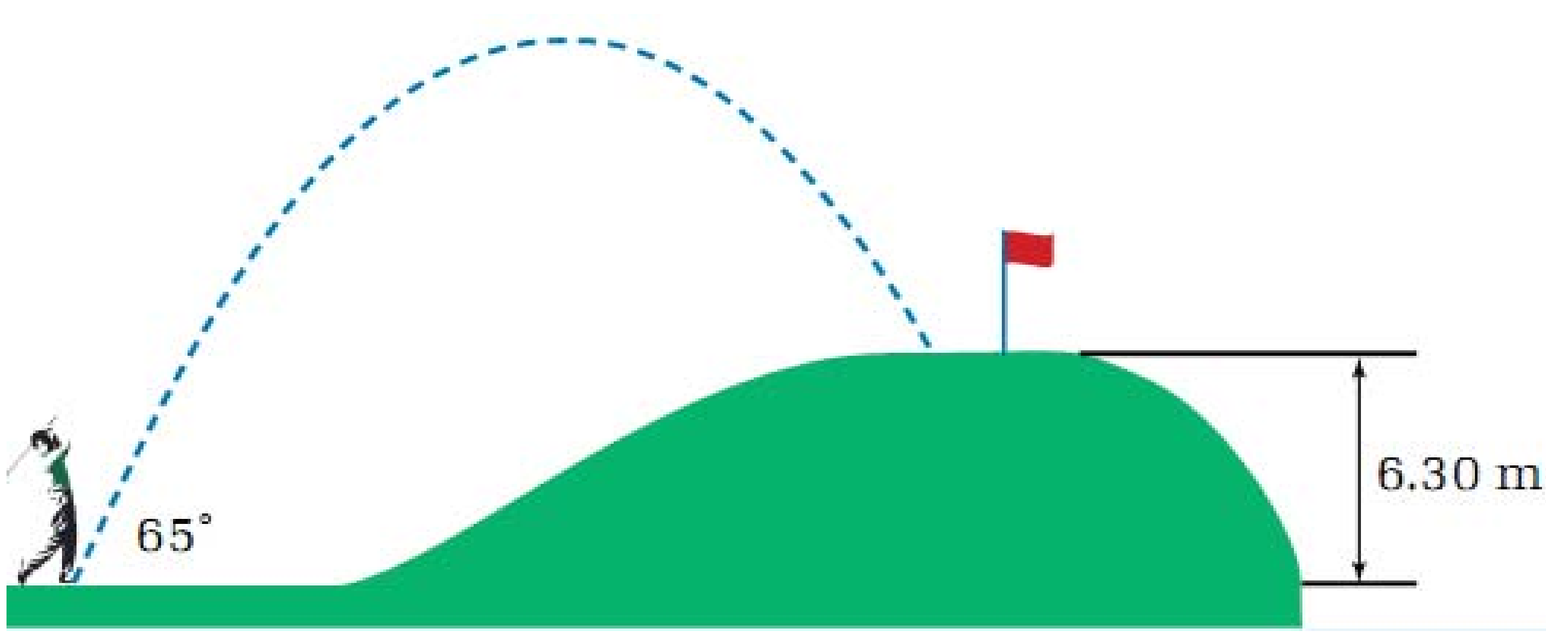
Projectiles at An Angle

- Take the angle into consideration
  - Y-axis motion (vertical) changes
  - X-axis motion (horizontal) not affected
  - Parabola

- Time is still of the essence

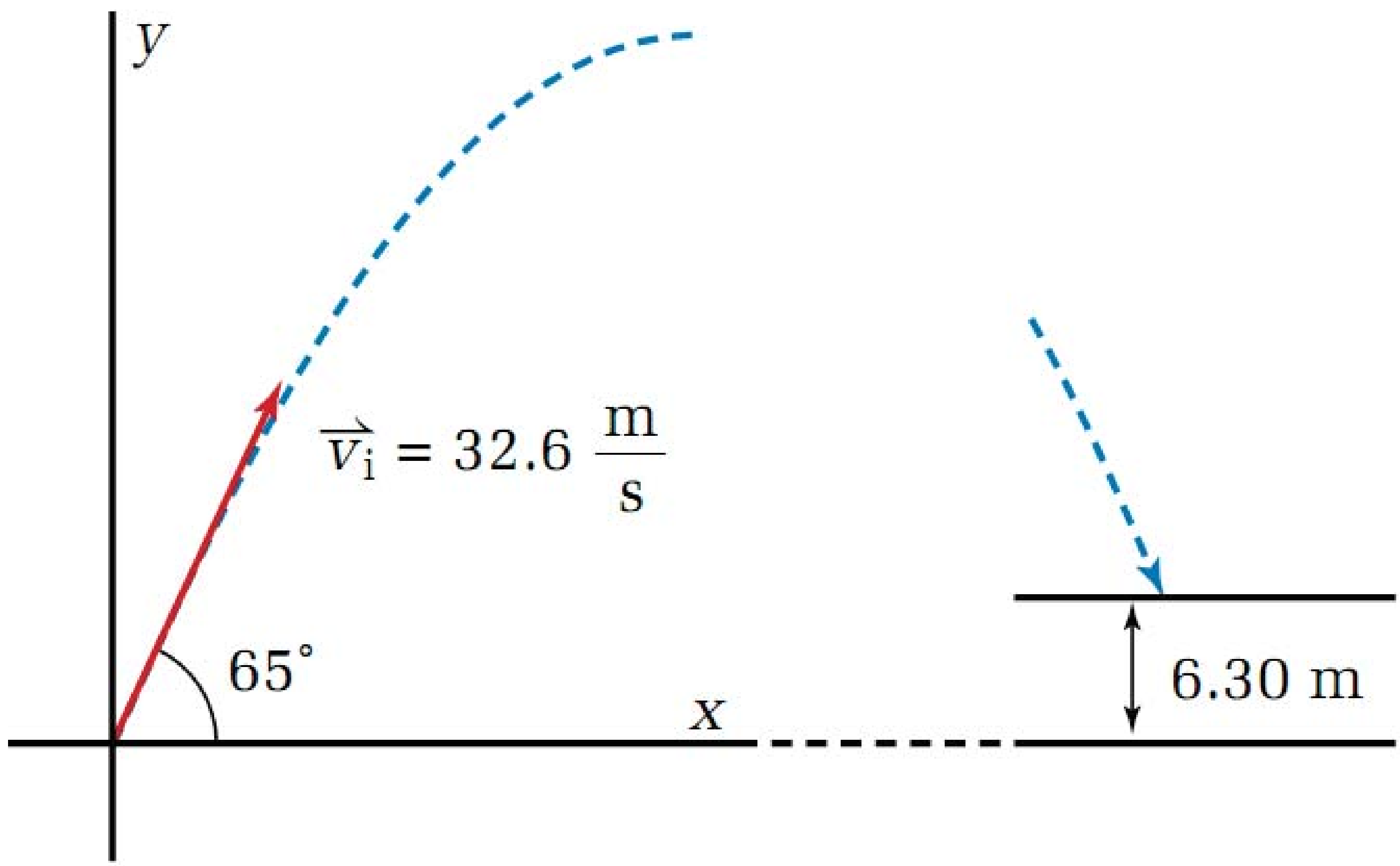
Example Problem

- EX2:
  - A golfer hits the golf ball off the tee, giving it an initial velocity of 32.6m/s at an angle of 65degree with the horizontal. The green where the golf ball lands is 6.30m higher than the tee, as shown in the illustration. Find the time interval when the golf ball was in the air.



Example Problem (Cont.)

- EX2: (Cont.)



Projectile Motion (Cont.)

- EX3:
  - You are playing tennis with a friend on tennis courts that are surrounded by a 4.8m fence. You opponent hits the ball over the fence and you offer to retrieve it. You find the ball at a distance of 12.4m on the other side of the fence. You throw the ball at an angle of 55.0^{o} with the horizontal, giving it an initial velocity of 12.1m/s. The ball is 1.05m above the ground when you release it. Did the ball go over the fence, hit the fence, or hit the ground before it reached the fence?

Today's Goal (repeated)

- I want to shoot the monkey on the tree…
- If I shoot my tranquilizer gun, the money will be surprised by the sound, and will jump off the tree.
- How should I aim my gun?