

# Vectors

## Vectors

- Show *magnitude* and
- Length shows magnitude =
- Arrow shows direction =
- Vector quantities include displacement, velocity,
- Resultant Vector :
  - Overall vector that represents the sum of all the vectors acting
  - The resultant vector has the same effect as all the vectors acting
- Add vectors using the "head to tail" method.
  
- Independence of Vectors
  - Vector quantities that act on an object are independent: they are not related to one another, but both vectors change the
  
- Concurrent Forces - two or more forces acting on the same point at

## Solving Vectors at 90°

- Pythagorean Theorem
  
- $R =$
  
- $\sin$
  
- $\cos$
  
- $\tan$
  
- $\theta = \tan^{-1}$

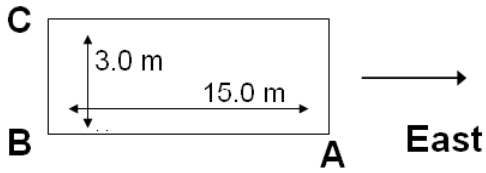
- $\theta = \cos^{-1}$
- $\theta = \sin^{-1}$
- Report the resulting angle using the  $0^\circ$  as the reference.

## Vector Resolution

- Solving for the horizontal and vertical components of a given
1. Cheetahs are, for short distances, the fastest land animals. In the course of a chase, cheetahs can also change direction very quickly. Suppose a cheetah runs straight north for 5.0 s, quickly turns and runs 300.0 m west. If the magnitude of the cheetah's resultant displacement is 335 m, what is the cheetah's displacement and velocity during the first part of its run?
  2. Certain iguanas have been observed to run as fast as 10.0 m/s. Suppose an iguana runs in a straight line at this speed for 5.00 s. The direction of the motion makes an angle of  $30.0^\circ$  to the east of north. Find the value of the iguana's northward displacement.



6. A man hops a freight train car that is 15.0 m long and 3.0 m wide. The car is moving east at 2.5 m/s. Exploring the surroundings, the man walks from corner A to corner B in 20 seconds, then from corner B to corner C in 5.0 sec. Calculate the man's displacement relative to the ground.



### More Vectors

- Adding vectors that are not at right angles.
- You have to split each individual vector into its horizontal (x) and vertical (y) components.
- Then you can find the resultant vector using the Pythagorean theorem.
- Adding

- Break down all the original vectors into horizontal components.

- $A_x = A$
- $B_x = B$

- If the horizontal component is "left," make it negative.

- $-A_x = A$
- $-B_x = B$

- Break down all the original vectors into vertical components.

- $A_y = A$
- $B_y = A$

- If the vertical component is "down," make it negative.

- $-A_y = A$
- $-B_y = A$

- The sum of all the horizontal components equals the horizontal component of the resultant vector.

- $R_x = A_x + B_x$

- The sum of all the vertical components equals the vertical component of the resultant vector.

- $R_y = A_y + B_y$

- Then put these components together to find the resultant vector. Don't forget to find the angle!

- $R =$

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- Adjust the angle so it is measured from the  $0^\circ$ .
8. The record for the longest nonstop closed-circuit flight by a model airplane was set in Italy in 1986. The plane flew a total distance of 1239 km. Assume that at some point the plane traveled 1250 m to the east, then 1250 m to the north, and finally 1100 m to the southeast ( $315^\circ$ ). Calculate the total displacement for this portion of the flight.
  9. A hiker begins a trip by first walking 25.0 km  $330^\circ$  from her base camp. On the second day she walks 40.0 km in a direction  $240.0^\circ$ , ( at which point she discovers a forest ranger's tower. Find the magnitude and direction of her displacement from base camp.
  10. In 1976, the Lockheed SR-71A Blackbird set the record speed for any airplane: 3530 km/hr. Suppose you observe this plane ascending at this speed. For 20.0 s, it

flies at an angle of  $15.0^\circ$  above the horizontal, then for another 10.0 s its angle of ascent is increased to  $35.0^\circ$ . Calculate the plane's total gain in altitude, its total horizontal displacement, and its resultant displacement.

# Projectiles

## Horizontally Shot Projectiles

- Objects launched or shot are called
- Their path is curved and called a
- Gravity causes the object to fall vertically, so  $v_y$
- The projectile moves horizontally because
- If you ignore air resistance, the horizontal velocity is constant;  $v_x$  is
- The horizontal and vertical velocities are
- Together they cause the path of the projectile to be curved :
- An object dropped at the same time another is shot horizontally will hit the ground
- Only gravity causes it to
- Assume
- If your reference is moving with the projectile, the projectile appears to

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- $v_y$  for horizontal motion is

## Projectiles shot at an Angle!

- You are giving the object an initial velocity,
- This velocity has two components,
- $v_x =$
  
- $v_y =$

- The final vertical velocity is equal to the initial vertical velocity but opposite
- The horizontal velocity,  $v_x$ , is
- Assume air resistance =
- Rising time =
- Distance up =
- $D_y=0$  at the start

- Max height,  $D_{y\max}$  happens at
- $D_{y\max}$  at

- Maximum range is
  - $\sin$
  - Angles more than
- Angles less than

11. A bridge is 176.4 m above a river. If a lead-weighted fishing line is thrown from the bridge with a horizontal velocity of 22.0 m/s, how long does it take to hit the water? How far has it moved horizontally when it hits the water?

12. A discus is released at an angle of  $40^\circ$  and a velocity of 24.0 m/s.

- a. How long does it stay in the air?
- b. What horizontal distance does it travel?

13. A shot put is released with a velocity of 12 m/s and stays in the air for 2.0 s.
- At what angle with the horizontal was it released?
  - What horizontal distance did it travel?

14. A football is kicked at  $55^\circ$  and travels 82 m before hitting the ground.
- What was its initial velocity?
  - How long was it in the air?
  - How high did it go?

15. A golf ball is hit with a velocity of 24.5 m/s at  $35.0^\circ$  above the horizontal from a cliff that is 152 m high. Find the time of flight of the ball and the range of the ball.