Physics 12

Booklet #1

- 2D Vectors
- Sine and Cosine Law
- Momentum and Impulse
- Collisions
- 2D Collisions

2D Vectors

A vector has both magnitude and direction

Example: Sketch each of the following vectors, labelling angles if necessary

5 m/s East	5 m/s South	5 m/s ,25° North of East
5 m/s, 25° above the horizontal	5 m/s, 55° below the horizontal	5 m/s 25°, East of North

To add vectors draw them tail to tip, the sum is the result of drawing a vector from start of the first vector to the end of the last vector.

Example: Roughly sketch the following additions (do not need to calculate answer)

5 m/s North + 10 m/s East	20 m/s^2 at 45° above the horizontal + 10 m/s^2 straight down
20 N East + 20 N South + 20 N 45° North of West	

To subtract vectors, change the subtracting into an addition by adding the opposite vector:

Sketch each of the vectors and their opposites:

15 m/s North	23 N, 15° North of West	45 m/s^2, 65° East of South

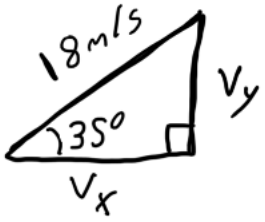
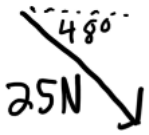
Example: Roughly sketch the following subtractions (do not need to calculate answer)

5 m/s North − 10 m/s East	20 m/s^2 at 45° above the horizontal minus 10 m/s^2 straight down
25 N, 24° North of West − 50 N, 62° South of East	

Vector Components

Any vector can be written as the sum of two vectors at 90 degrees to each other, normally these are the horizontal component and vertical components.

Example: Determine the horizontal and vertical components of the following vectors

	
25 N, 23° West of North	76 N, 51° North of East

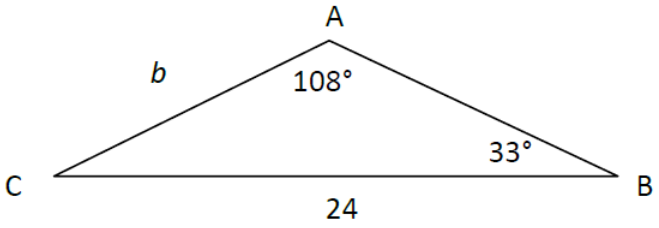
You can add (or subtract) vectors using their components.

Example: What is 25 N, 23° West of North + 76 N, 51° North of East

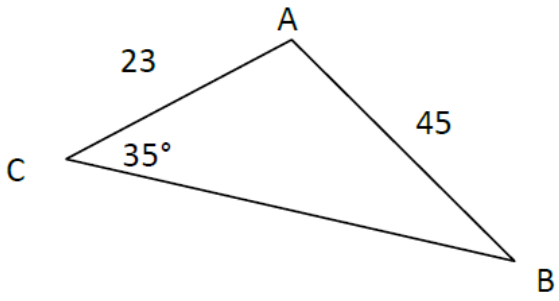
Sine Law

Sine law can be used to solve for a side or an angle in non-right triangles. We use it when we have either two angles and one side OR two sides and a non-enclosed angle

Use Sine Law to determine the length of side b:



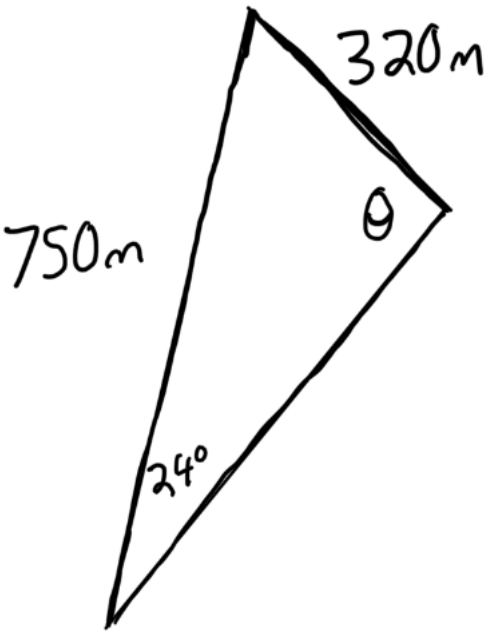
Use Sine Law to determine angle A



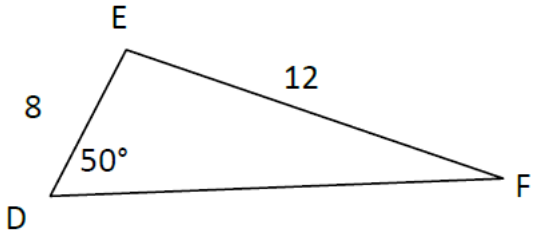
Ambiguous case warning

Using sine law to determine an angle will always return an angle between 0 and 90 degrees. If the angle you are looking for is between 90 and 180 degrees, you need to calculated the angle in second quadrant with the reference angle you found by taking 180- θ_{ref}.

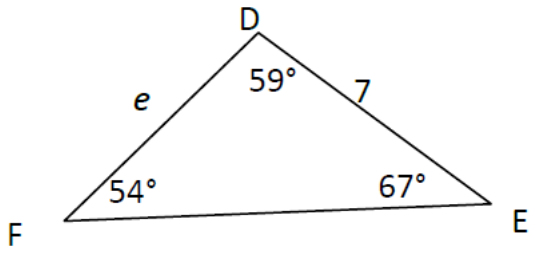
Example



Practice



Determine the measure of angle F

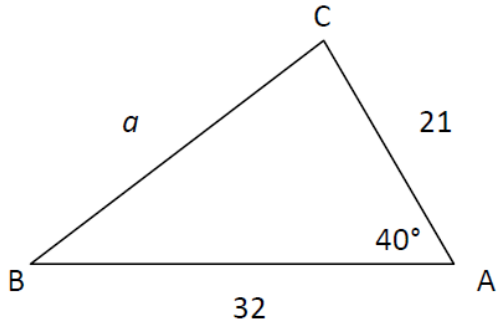


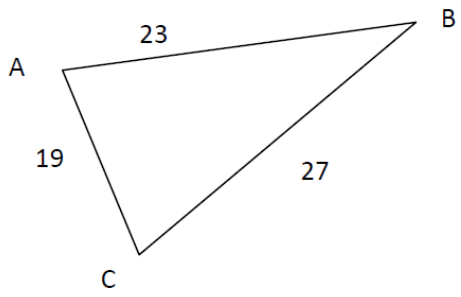
Determine the length of side e

Cosine Law

Like sine law, the cosine law can be used to solve for a side or an angle in non-right triangles. We use it when we have three sides OR two sides and the included angle.

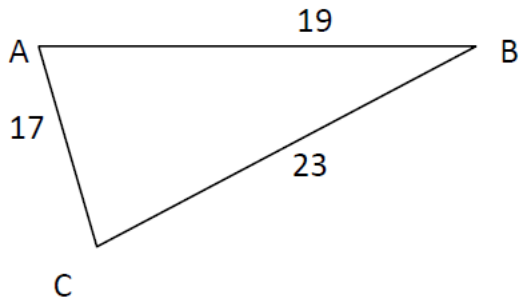
Use Cosine Law to determine the length of side a



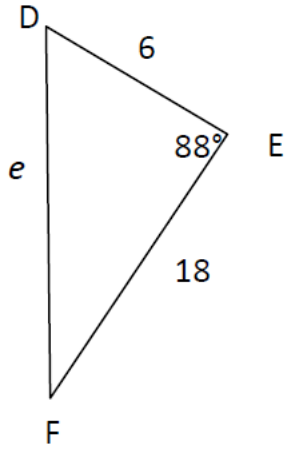


Use Cosine Law to determine angle A

Practice



Determine the measure of angle B.



Determine the length of side e

Momentum

An object in motion will tend to stay in motion. What two factors affect how difficult it is to stop an object that is moving?

The momentum of an object is:

A bullet shot from a gun has a lot of momentum because

A freight train slowly moving in the train yard has a lot of momentum because

Example 1: Calculate the momentum of a 1100 kg car travelling along the highway at 15 m/s.

Example 2: Calculate the momentum of a 1.2 kg ball thrown at 13.9 m/s.

Example 3: Determine the change in momentum of a 48 kg runner who speeds up from 5.0 m/s to 7.0 m/s.

Example 4: Determine the change in momentum of a 0.142 kg baseball that was moving at 22 m/s in one direction and is now moving 22 m/s in the opposite direction.

Impulse

Recall Newton's second law:

We can modify this to be about momentum.

Doing a slight rearrangement, we get

Impulse is defined a certain force applied for a certain amount of time, and as shown above it is equal to change in momentum.

Example 5: What is the impulse required to increase the speed of a 48 kg runner from 5.0 m/s to 7.0 m/s?

Example 6: What is the impulse if a 6.0 N force is applied for 5.0 seconds?

Example 7: What is the impulse if a 600.0 N force is applied for 0.050 seconds?

Example 8: A 25 kg ball is moving at 3.6 m/s.

a) What force would need to be applied to stop it in 0.20 seconds?

b) What force would need to be applied to stop it in 0.050 seconds?

c) How long would it take to stop by applying a 45 N force?

Collisions

A 10.0 kg block is moving at 5.0 m/s left towards a stationary 100.0 kg block.

Draw a diagram of this situation.

What is the momentum of the 10 kg block?

What is the momentum of the 100 kg block?

What is the total momentum of the system?

The 10 kg block, hits the 100 kg block and applies a 250 N force to the 100kg block for 0.25 sec.

What impulse does the 10 kg block apply to the 100kg block?

What is the change in the 100kg block's momentum?

What is the new velocity of the 100 kg block?

While the 10 kg block is applying 250 N of force to the 100 kg block, how much force is the 100 kg block applying to the 10 kg block and in what direction?

What is the impulse the 100kg block is applying to the 10 kg block?

What is the new velocity of the 10 kg block?

What is the total momentum of the system after the collision?

Since any force is applied in both directions by Newton's third law, the impulse of each object on the other is exactly the same. This is called the _____

Example: A 6 500 kg railway car initially travels at 4.0 m/s along a track, it collides with, and sticks to a stationary 4 500 kg car. After the collision how fast will the combined cars be moving?

When objects collide a few different thing can happen

Situation	**Name**	**Kinetic Energy Conserved?**
Object stick together		
Objects do not stick together, but some kinetic energy is lost.		
Objects do not stick together, and no kinetic energy is lost.		

Example: A 4.0 kg block moving at 15 m/s to the left collides with a 6.0 kg block moving at 25 m/s to the right. After the collision, the 4.0 kg block is moving at 17.5 m/s to the left. What is the velocity of the 6.0 kg block? What type of collision is this?

Collisions on 2D

A 0.5 kg ball is travelling at 5.0 m/s to the left when it strikes a stationary 0.75 kg ball at an angle, after the collision the first ball is moving at 3.5 m/s at an angle of 35° above its original path. What is the velocity of the second ball after the collision?

A 2500 kg truck is travelling at 16 m/s to the West when it is struck by a 1200 kg car travelling 36 m/s North. The vehicles stick together. What is velocity of the vehicles after the collision. What kind of collision is this? What is the change in kinetic energy of the system?

A 2.0 kg ball moving at 160 m/s 45° above right. It collides with a 3.0 kg ball moving at 140 m/s 25° above the left. After the collision, the 3.0 kg ball is moving at 25 m/s, 5.0° above the right. What is the final velocity of the 2.0 kg ball?