Conceptual Physics I
Classical Mechanics

Lesson 2A – Vectors and Scalars

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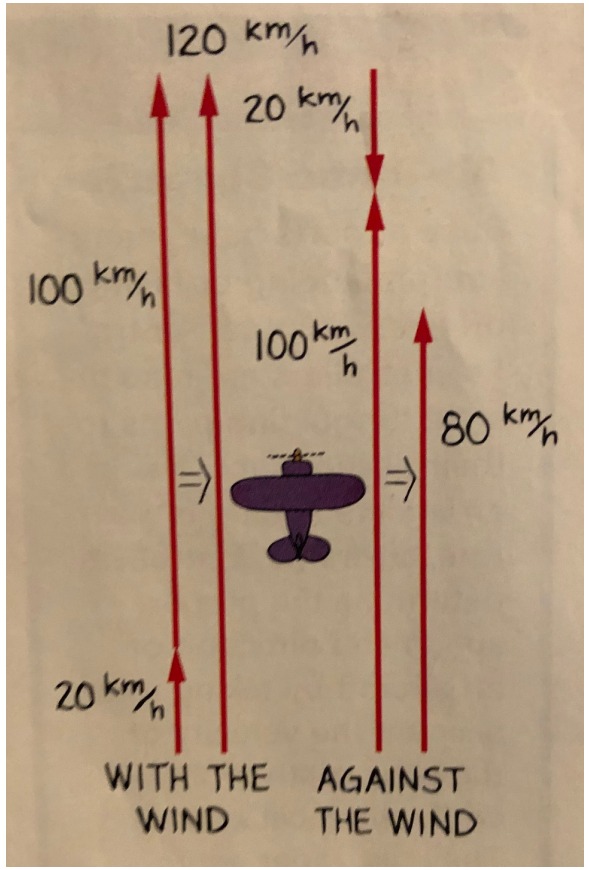
- We will now extend the discussion of motion beyond one-dimensional (along a straight line) to non-linear (along a curved path)
- We need a way to giving the notion of direction to our quantities (remember the difference between speed and velocity?)
- Let's define two types of quantities: a vector and a scalar quantity
- A vector quantity requires both magnitude and direction for a complete description. (Think of magnitude as just a number denoting strength, just like in English.)
- A scalar quantity requires only a magnitude.

Lesson 2A - Vectors and Scalars

- Many quantities in physics are scalars, such as mass, volume, speed, and time.
- Other quantities require a direction as well, and are described by vectors, such as velocity and acceleration. We will learn later about a very important additional vector called force.
- Scalar/Vector pairs: speed and velocity; distance and displacement
- Scalars can be added, subtracted, multiplied and divided like ordinary numbers. For example, 3 kg of sand added to 1 kg of cement will give a mixture of 4 kg (3 + 1 = 4).
- Vectors are a little trickier because of the directional nature. For example, we could NOT say that 10 mi/h south + 20 mi/h east = 30 mi/h !

Lesson 2A - Vectors and Scalars



- A velocity vector is represented by an arrow. The length of the arrow represents the magnitude, the direction of the represents the direction of the action or force.
- Adding vectors is easy when the directions are along a straight line. For example, if an airplane is flying at 100 km/h but has a tailwind of 20 km/h, the resultant (addition) velocity is 120 km/h along its direction of motion.

  If the same airplane is flying into a 20 km/h wind, the resultant velocity is 80 km/h along its direction of motion.

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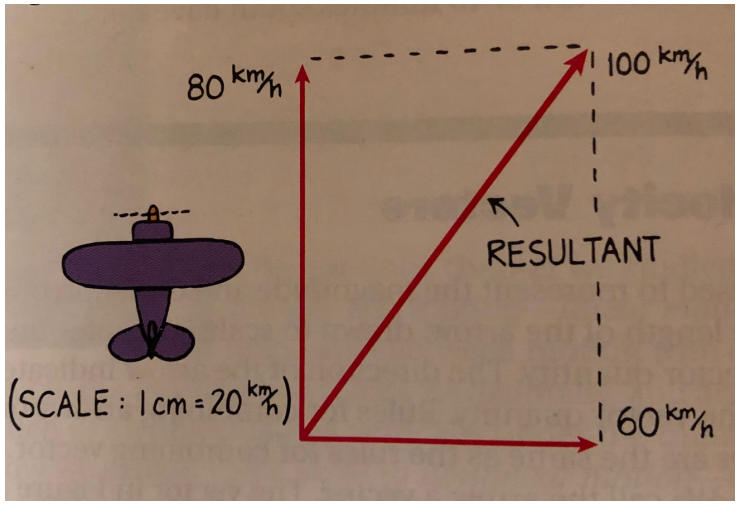

- What if the wind blows at a 90 degree angle from the direction of the airplane? The airplane would veer off its direct course.
- The resultant vector would be determined by making a rectangle out of the two vectors and measuring/calculating the diagonal.

- You can determine the resultant by two methods: Measurement and Pythagorean Theorem.
- Measurement is done using graph paper. Pythagorean Theorem says: The square of the hypotenuse of a right-triangle is equal to the sum of the squares of the other two sides.

$$a^2 + b^2 = c^2$$

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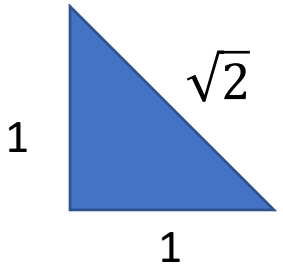
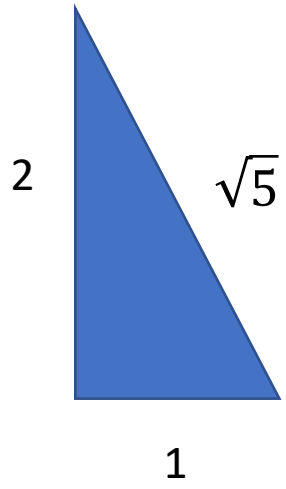
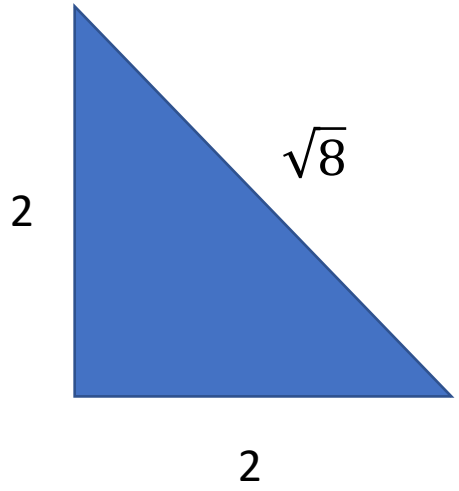
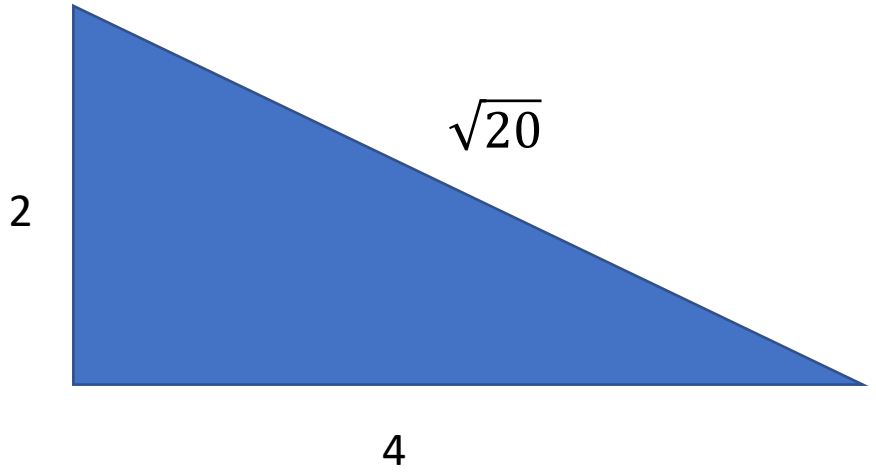
Calculate the length of the missing side









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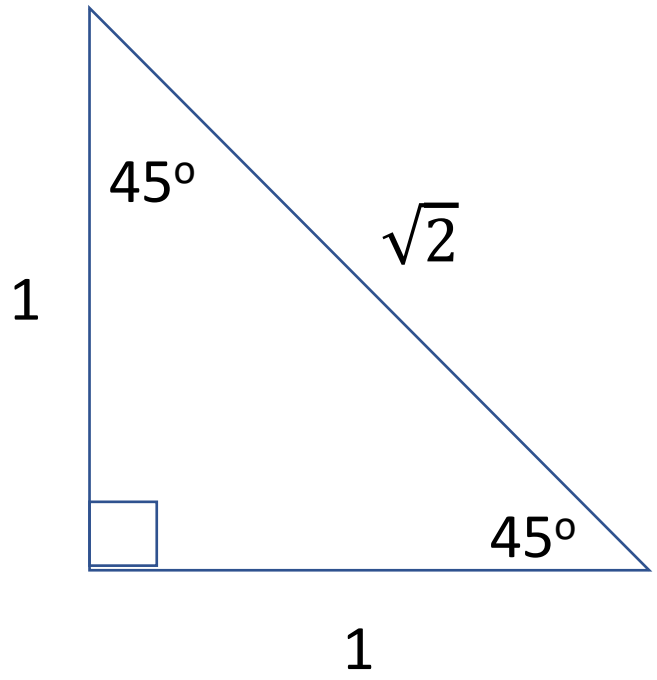
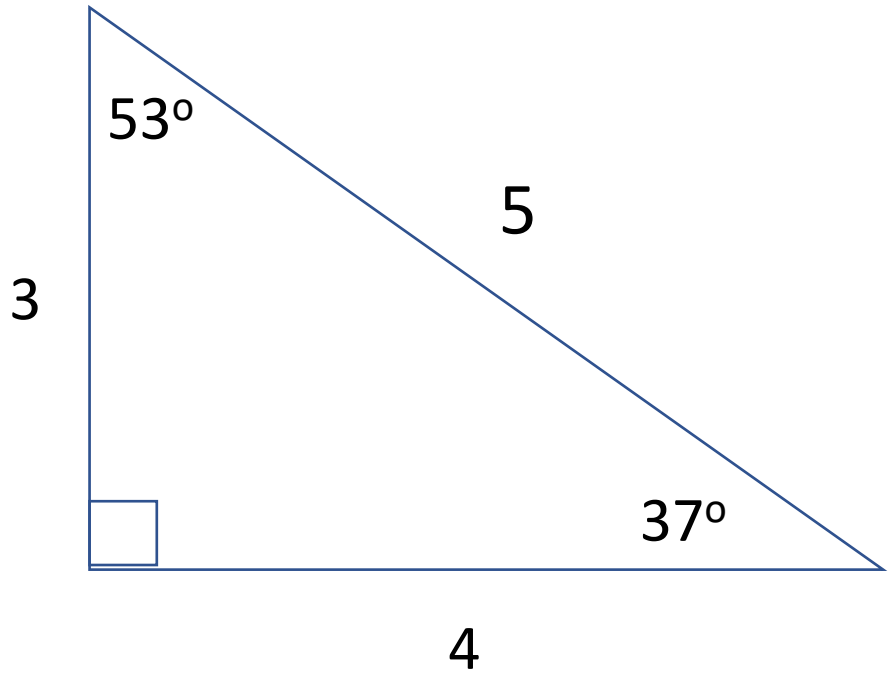
Two Special Triangles to Memorize!





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Questions:

1) Will a vector at 45° to the horizontal be larger or smaller than its horizontal and vertical components? Larger because the hypotenuse of the triangle is the longest side. By how much? By $\sqrt{2}$.
2) Calculate the resultant of the pair of velocities 100 km/h north and 75 km/h south. 25 km/h north. Calculate the resultant if both of the velocities are directed north. 175 km/h north
3) Calculate the magnitude of the resultant of a pair of 100 km/h velocity vectors that are at right angles to each other. $100\sqrt{2}\ km/h$
4) What are the horizontal and vertical components of a 10-unit vector that is oriented 53° above the horizontal? (Turn the 3-4-5 triangle into a 6-8-10 triangle. Angles are the same). Horizontal component is 6 units; vertical component is 8 units.

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Questions:

5) What is the maximum possible resultant of two vectors with magnitudes of 4 and 5 units? 9 units What is the minimum possible resultant? 1 unit

6) If you swim in a direction directly across a river and you end up downstream due to the flow of water, do you move faster than you would if the water didn't flow? Yes. The hypotenuse of that triangle is the longest side.

7) Rain falling vertically will make vertical streaks on a car's side window. However, if the car is moving, the streaks are slanted. If the streaks from a vertically falling rain make 45^{o} streaks, how fast is the car moving compared with the speed of the falling rain? Same speed.