Plumbers often use a formula to determine the lengths of pipes that have to be fitted around objects. Some common terms are offset, run, and travel. The formula below is used to connect a lower horizontal pipe to a travel pipe using a 60° elbow.

\[
\frac{\text{offset}}{\text{travel}} = 0.866
\]

**Example 1.** If the offset in a particular project is 75 inches, what must the length of the travel pipe be?

**Similar Triangles:** Which triangles are similar? How do you know?

If the triangles are similar, the corresponding sides will be in the same ratio. Complete the following ratios.

\[
\frac{BC}{AB} = \frac{DE}{EF}
\]

The study of the measurement of triangles is called **Trigonometry**.
**Sine Ratio:**

- is the ratio (in fraction or decimal form) of the length of the side opposite a given angle to the length of the hypotenuse in a right triangle
- abbreviated as 'sin', but pronounced 'sine'

\[
\sin \theta = \frac{\text{length of side opposite } \angle \theta}{\text{length of hypotenuse}}
\]

In designing and construction, accuracy is important. Engineers cannot rely on approximated values because slight errors can lead to serious flaws in a design. Therefore, a calculator is used to determine the values.

**Example 2.** Use your calculator to find each of the following values. Round your answers to 4 decimal places.

- a) \( \sin 15^\circ \)
- b) \( \sin 30^\circ \)
- c) \( \sin 60^\circ \)
- d) \( \sin 80^\circ \)

What do you notice about these values?

*As the angle increases, so does the sine value.*

Use your calculator to determine the value of \( \sin 90^\circ \). What is the reason for this value?

*Sine 90° = 1 because the opposite side and the hypotenuse are the same side (they are both opposite the right angle).*
Example 3. The sine ratio can be used to help you find missing parts of a right triangle. Determine the length of PQ to the nearest tenth of a centimetre.

Example 4. A ladder 8.5 metres long makes an angle of 72° with the ground. How far up the side of a building will it reach? Draw a diagram.
Example 5. Determining the Hypotenuse.

Brad is building a ramp. The ramp must form an angle $22^\circ$ with the level ground and reach a point that is 1.5 metres above the ground. How long will the ramp be?

**Definitions**

**Direct Measurement:** uses a measuring instrument to determine the length or angle

**Indirect Measurement:** uses mathematical reasoning or a formula to determine the length or angle

**Angle of elevation:** the angle formed between the horizontal and the line of sight while looking upwards. It is sometimes referred to as the angle of inclination.

**Angle of depression:** the angle formed between the horizontal and the line of sight while looking downwards.
Example 6.

The angle of elevation of an airplane is 23° from an observer on the ground. If the airplane's altitude is 2500 m, how far away is it?

![Diagram of airplane and angle of elevation]

Example 7.

A bird sits on top of a lamppost. The angle of depression from the bird to the feet of an observer standing away from the lamppost is 35°. The distance from the bird to the observer is 25 meters. How tall is the lamppost?
7.2 Sine Ratio Assignment

1. Calculate the value of sin A to two decimal places.

   a)

   ![Diagram](image1.png)

   b)

   ![Diagram](image2.png)

2. Use your calculator to determine the value of each of the following sine ratios to four decimal places.

   a) \( \sin 10^\circ \) 

   b) \( \sin 48^\circ \) 

   c) \( \sin 62^\circ \) 

   d) \( \sin 77^\circ \) 

3. Calculate the length of the side opposite the indicated angle in the following diagrams.

   a)

   ![Diagram](image3.png)

   b)

   ![Diagram](image4.png)
4. A rafter makes an angle of $28^\circ$ with the horizontal. If the rafter is 15 feet long, what is the height at the rafter’s peak? Draw a diagram.

5. How high is a weather balloon tied to the ground if it is attached to a 15-metre string and the angle between the string and the ground is $35^\circ$?
6. Find the length of the hypotenuse in the following diagrams.

\[ a) \quad h = 7.8 \text{ mm} \]

\[ b) \quad h \quad 12.1 \text{ cm} \quad 70^\circ \]

7. How long is a guy wire that is attached 4.2 metres up a pole if it makes an angle of \(52^\circ\) with the ground?
8. George is in a hot air balloon that is 125 metres high. The angle of elevation from a house below, to the balloon, is 18°. How far is George from the house?

9. The angle of elevation of a road is 4.5°. What is the length of the section of road if it rises 16 metres?

10. The angle of depression from an airplane to a forest fire below is 62°. If the direct distance from the airplane to the fire is 3000 m, how far is the fire from a point directly below the airplane? *Hint: Don’t forget about the Pythagorean Theorem…*