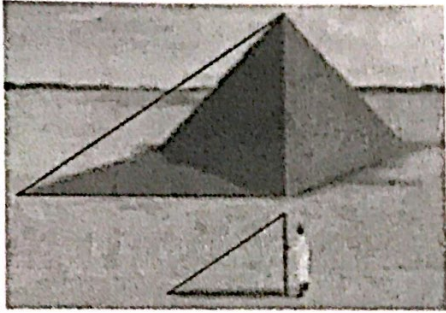


Indirect Measurement

indirect measurement allows you to use properties of similar polygons to find distances or lengths that are difficult to measure directly.

Shadow Reckoning



Shadow reckoning is a type of indirect measurement using heights compared to shadow lengths to set up a proportion to solve for a height that is not directly measurable.

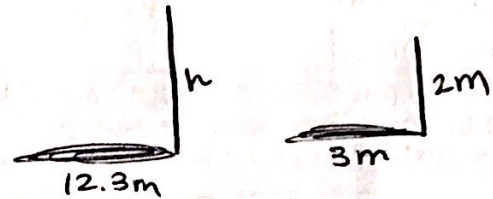
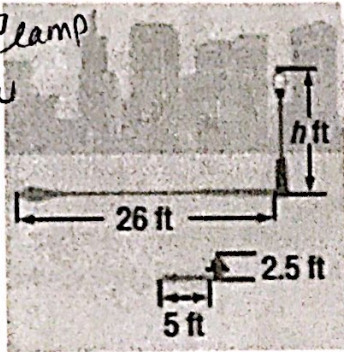
Thales used shadow reckoning to relate his shadow to the pyramid shadow. He measured his height and the length of his shadow then compared it with the length of the shadow cast by the pyramid.

$$\frac{\text{Thales' shadow}}{\text{pyramid's shadow}} = \frac{\text{Thales' height}}{\text{pyramid height}}$$

A fire hydrant 2.5 foot high casts a 5 foot shadow. How tall is a street light that casts a 26 foot shadow at the same time? Let h represent the height of the street light.

At the same time a 2-meter street sign casts a 3-meter shadow, a telephone pole casts a 12.3-meter shadow. How tall is the telephone pole?

$$\frac{\text{height}_{\text{lamp}}}{\text{height}_{\text{fire}} = \frac{\text{shadow}_{\text{lamp}}}{\text{shadow}_{\text{fire}}}$$



$$\frac{h}{2.5} = \frac{26}{5}$$

$$5(26) = 5h$$

$$130 = 5h$$

$$h = 26$$

$$\frac{h}{2} = \frac{12.3}{3}$$

$$2(12.3) = 3h$$

$$24.6 = 3h$$

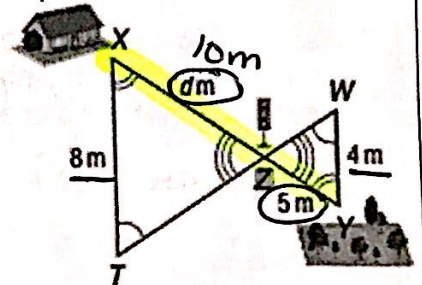
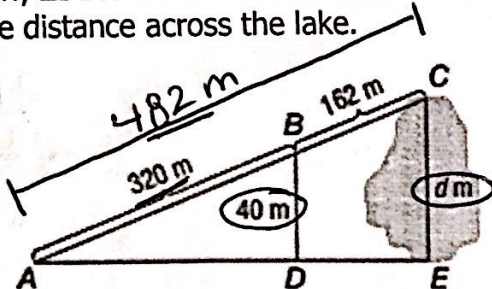
$$8.2 = h$$

$$8.2 \text{ m}$$

You can also use similar triangles that do not involve shadows to find missing measurements.

In the figure below, $\triangle DBA$ is similar to $\triangle ECA$. Ramon wants to know the distance across the lake.

Find the distance from the park to the house.



$$\frac{BD}{CE} = \frac{BA}{CA}$$

$$\frac{40}{d} = \frac{320}{482}$$

$$40(482) = 320d$$

$$19280 = 320d$$

$$60.25 = d$$

$$60.25 \text{ m}$$

$$\frac{4}{8} = \frac{5}{d}$$

$$4d = 8(5)$$

$$4d = 40$$

$$d = 10 \text{ m}$$

House - Park
10 + 5
 15 m

Law of Reflection:

"The angle at which the light reflects off the mirror is the same as the angle at which it hits the mirror."



Anatole is visiting Paris, and wants to know the height of the Eiffel Tower. Since he is unable to speak French, he decides to measure it in three steps.

1. He measures out a point 500 meters from the base of the tower, and places a small mirror flat on the ground.
2. He stands behind the mirror in such a spot that standing upright he sees the top of the tower reflected in the mirror.
3. He measures both the distance from the spot where he stands to the mirror (2.75 meters) and the height of his eyes from the ground (1.8 meters).

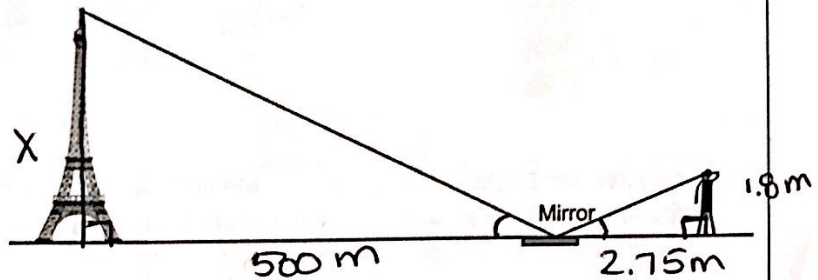
$$\frac{2.75}{500} = \frac{1.8}{x}$$

$$500(1.8) = 2.75x$$

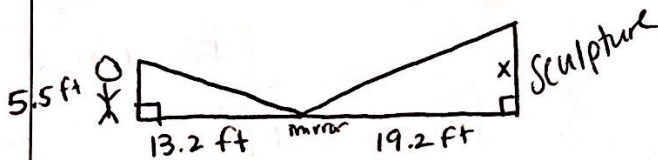
$$900 = 2.75x$$

$$327.27 = x$$

$$\boxed{327.27 \text{ m}}$$



Micah is visiting a museum. He wants to know the height of one of the sculptures. He places a small mirror on the ground between himself and the sculpture, and then backs up until he can see the top of the sculpture in the mirror. Micah is standing 13.2 ft. from the mirror and is 5.5 ft. tall to his eyes. If the sculpture is 19.2 ft. from the mirror, what is the height of the sculpture? (draw a diagram)



$$\frac{13.2}{19.2} = \frac{5.5}{x}$$

$$19.2(5.5) = 13.2x$$

$$105.6 = 13.2x$$

$$8 = x$$

$$\boxed{8 \text{ ft}}$$

The sun causes a flagpole to cast a shadow that measures 85 ft. from the base of the pole. At the same time of the day, a 6.5 ft tall basketball player casts a shadow that measures 9.75 ft.

- a. What is the scale factor relating the height of the ball player to his shadow's length? Express your answer as a fraction in lowest term.

$$\frac{6.5}{9.75} \rightarrow \frac{2}{3}$$

- b. Determine the height of the flagpole. Express your answer to the nearest tenth of a foot.

$$\frac{x}{85} = \frac{6.5}{9.75}$$

$$9.75x = 6.5(85)$$

$$9.75x = 552.5$$

$$x = \boxed{56.67 \text{ ft}}$$

- c. The basketball player's little sister is 3.5 ft. tall. At the same time of the day, determine her shadow's length to the nearest tenth of a foot.

$$\frac{6.5}{3.5} = \frac{9.75}{x}$$

$$6.5x = 3.5(9.75)$$

$$6.5x = 34.125$$

$$x = \boxed{5.25 \text{ ft}}$$

