

Assignment 2

AI1110: Probability and Random Variables

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Question 7) A 13 m long ladder is leaning against a wall, touching the wall at a certain height from the ground level. The bottom of the ladder is pulled away from the wall, along the ground at the rate of 2 m/s. How fast is the height of the ladder decreasing when the foot of the ladder is 5 m away from the wall?

Solution. The various parameters involved in this question are listed in Table

TABLE I
VARIABLES USED

Parameter	Variable	value
length of the rod	s	13 m
height from ground level to tip of rod	h	??
distance from the wall to foot of rod	x	??

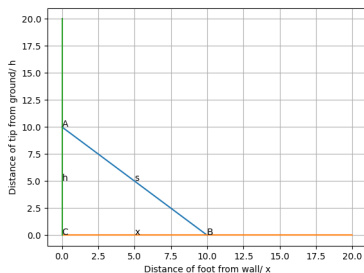


Fig. 1. Figure depicting the ladder: $AB=s, BC=x, AC=h$

Baudhāyana Sulba Sūtra: States that, if given a rectangle of side lengths a, b and diagonal length c the sum of the area of squares made by the side lengths of rectangle equals the area of square made

by the length of the diagonal of the rectangle.

$$\implies a^2 + b^2 = c^2 \quad (1)$$

In Figure-1, we can draw lines parallel to the ground and wall passing through the tip and foot of ladder respectively to get an imaginary rectangle with side lengths h, x and diagonal length s

From Baudhāyana Sulba Sūtra, we get :

$$h^2 + x^2 = s^2 \quad (2)$$

in this equation s is always constant, \therefore length of rod never changes

Now differentiating the equation on both sides with respect to time gives us

$$\frac{d(h^2 + x^2)}{dt} = \frac{d(s^2)}{dt} \quad (3)$$

$$\implies 2h \frac{dh}{dt} + 2x \frac{dx}{dt} = 0 \quad (4)$$

$$\implies h \frac{dh}{dt} = -x \frac{dx}{dt} \quad (5)$$

Given, at some time $t=t_0$, $\frac{dx}{dt}=2$ m/s and $x=5$ m

From Baudhāyana Sulba Sūtra, at time t_0

$$5^2 + h^2 = 13^2 \quad (6)$$

$$\therefore h = 12 \text{ m}$$

Now from equation (4) substituting $h, x, \frac{dx}{dt}$, we get

$$\frac{dh}{dt} = -\frac{5}{6} \text{ m/s} \quad (7)$$

The negative sign indicates that h is decreasing, \therefore the height of the ladder is decreasing at a rate of $\frac{5}{6}$ m/s