1. A water balloon is propelled into the air from the ground with a speed of 18 m/s. The angle of the launch is 62 degrees above the horizontal. A 3.1 m tall fence is located 20 m away from the launch point. Is the fence hit? If so, how far below the top of the fence is it hit? If not, how far above the fence does the balloon go?

$v_0 = 18\,m/s$
$\varphi = 62^0$
$h_1 = 3.1\,m$
$l_1 = 20\,m$
$\Delta h - ?$

Solution.

Let write the kinematic equations of the motion of the given water balloon. If the center of coordinate system is in its initial position, then the coordinates of the body depend on time as: $\begin{cases} x = v_0 \cos\varphi \cdot t \\ y = v_0 \sin\varphi \cdot t - \dfrac{gt^2}{2} \cdot \end{cases}$

Here, *X*-axis is directed towards the body motion and *Y*-axis is directed upward.

If $x = l_1$, then $t_1 = \dfrac{l_1}{v_0}\cos\varphi$. At this time, the Y-coordinate is $y(t_1) = v_0 \sin\varphi \cdot \dfrac{l_1}{v_0}\cos\varphi -$

$$-\frac{g}{2}\left(\frac{l_1}{v_0}\cos\varphi\right)^2 = \frac{l_1}{2}\sin 2\varphi - \frac{g}{2}\left(\frac{l_1}{v_0}\cos\varphi\right)^2 = \frac{20}{2}\cdot\sin 124^0 - \frac{9.81}{2}\cdot\left(\frac{20}{18}\cdot\cos 62^0\right)^2 = 6.96(m).$$

As $y(t_1) > h_1$, a water balloon will over the fence.

We can calculate the distance from the top of the fence at the moment t_1:

$$\Delta h = y(t_1) - h_1 = 6.96 - 3.1 = 3.86(m).$$

Answer: $3.86\,m$ over the hence.