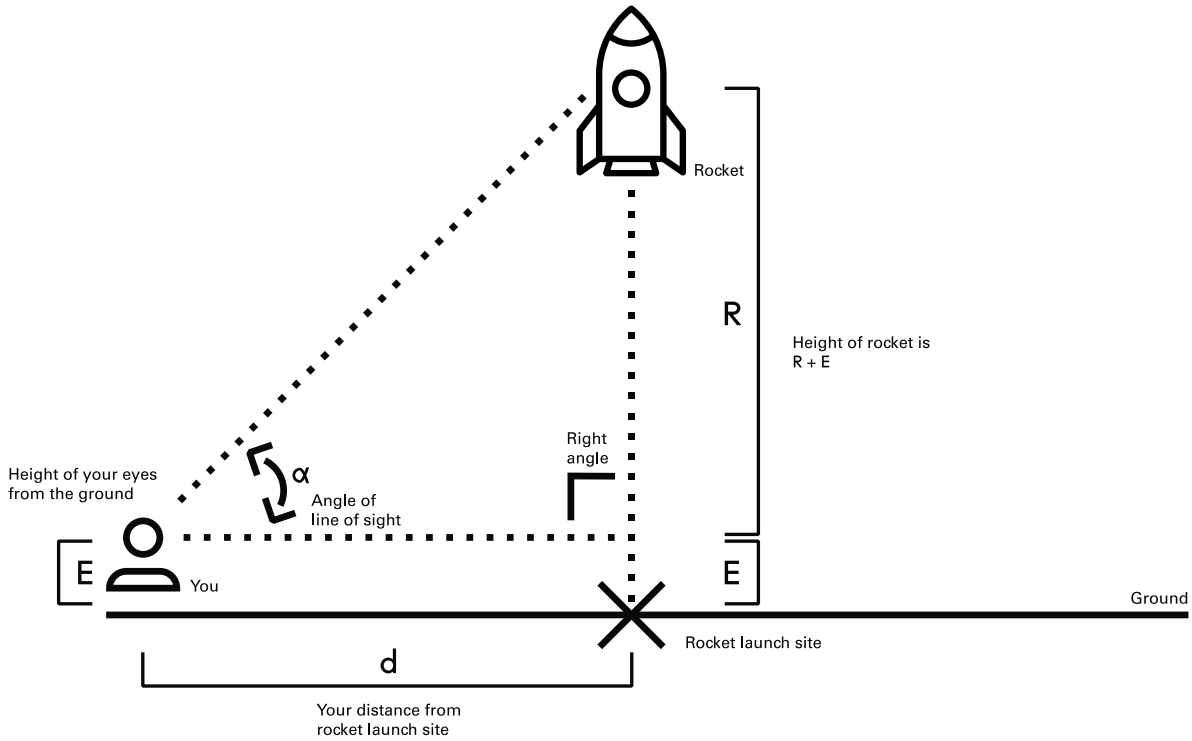
# The height of the rocket

**Suppose you launch a rocket straight into the air. How can you tell from the ground how high the rocket went? Trigonometry comes to the rescue!**

You can use simple trigonometry to tell how high a rocket went, if you know your distance *d* from the launch area and the angle $\alpha$ that your line of sight to the rocket makes with the ground. You can measure that "angle of inclination" using a protractor or by constructing a simple *clinometer*, as shown in the Basic Clinometer From Classroom Materials Instructable by dmuldoonlla.

If you want to be really precise you can even take into account how tall you are, by considering the height *E* of your eyes from the ground. The figure below illustrates the quantities *d*, $\alpha$, and *E*, as well as a length *R* that we will compute using trigonometry. If you don't know trigonometry yet, you can just think of the function "tan" as a button on your calculator, and still use this method.




Looking just at the right triangle formed by the dotted lines in the illustration above, the side opposite from angle $\alpha$ has length *R*, and the side adjacent to $\alpha$ has length *d*. Since the tangent of an acute angle in a right triangle is the ratio of the length of the opposite side to the length of the adjacent side, we have:

$$\tan \alpha = R / d.$$

The length $R$ is what will help us determine the height of the rocket, so the next step is to solve for $R$:

$$R = d \tan \alpha.$$

Now given any experimental values for $\alpha$ and $d$, you can use a calculator to solve for the value of $R$. Looking back at the illustration above, we see that the height of the rocket is the sum of this length $R$ and the height $E$ of your eyes from the ground. Therefore, to compute the height of the rocket just add $E$ to the expression we already found for $R$:

$$\text{Height of rocket} = E + d \tan \alpha.$$

So, just measure $E$, $d$, and $\alpha$ and plug them into the formula above to find out how high your rocket went. For example, suppose that you are standing 30 feet away from the launch area, the rocket travels directly upwards, and your eyes are 5 feet from the ground. If you measure the angle of inclination to the top of the rocket at its height point and find it to be 47 degrees, then the maximum height your rocket reached can be computed as follows:

$$\text{Height of rocket} = 5 + 30 (\tan 47^\circ) \approx 37 \text{ feet}.$$

Remember, even if you don't know trigonometry yet, you can use this formula and a calculator with a button labeled "tan" to calculate the height of your rocket. Just make sure your calculator is in "degree mode" before applying the formula.

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Attribution information:
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