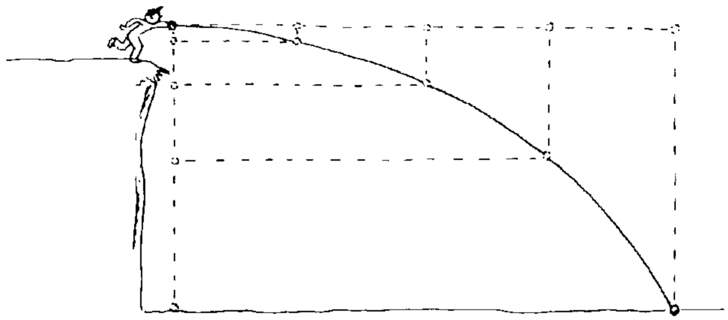
Rock Off a Cliff



Throw a rock horizontally off a cliff and its path is a smooth parabola all the way down to the bottom. Gravity causes the rock to fall from the straight line it would otherwise go if it weren't for gravity. Worksheet 5-1 gives you practice how to plot the position of the rock with and without gravity.

Now we are going to analyze what happens if the rock is tossed upwards at angle off the cliff. If it weren't for gravity, the rock would travel in a straight line when released—forever. However, in our world there is gravity (thank goodness!) and it causes things to fall downwards at the rate of $\frac{1}{2} gt^2$, where g is the acceleration of gravity and t is the time in seconds. If we use $g = 10$ m/s^2, then this formula reduces to the even simpler $5t^2$.

On a piece of graph paper, plot the paths of a rock tossed off a cliff tossed off a cliff at 35 degrees—one *without* gravity and the other *with* gravity. Use the scale 1 cm = 5m. Assume the rock is tossed one inch per second off a cliff 7 inches high (on your graph paper). Use the "tangent method" to construct the 35-degree angle. The straight-line graph represents the path the rock would take if there were no gravity. Label it "Path of the rock without gravity". Label the rock's position with and without gravity in successive seconds as "t = 0" where the rock is tossed, "t =1" at one inch, "t = 2" at two inches, etc., all the way to the edge of the paper. Then plot where the rock would be because it falls due to gravity according to $d = 5t^2$. Carefully sketch the parabolic path of the rock until it hits the water below. Ignore the affects of air friction.

Using your graph of the rock's trajectory, answer the following:

1. How *long* to the nearest tenth of a second does it take the rock to hit the water? Show your work on your graph by drawing a dashed line.

t = ______s

2. What is the range of the rock (how far horizontally does the rock hit the water from the cliff)? Show your work (by drawing a dashed line) on your graph.

R = ______m

3. What is the initial horizontal component of the rock's velocity as it leaves the cliff? Show your work on your graph by constructing a slope triangle (rise/run).

v_x = ______m/s

4. What is the initial vertical component of the rock's velocity as it leaves the cliff? Show your work on your graph (conversions to m/s).

v_y = _______m/s

5. What is the horizontal component of the rock's velocity just before it hits the water?

v_x = _______ m/s

6. Make a sketch of the velocity vector of the rock hitting water at the bottom of the cliff. Label the velocity vector "v", the vertical component "v_x", and the horizontal component "v_y".

7. What is the vertical component of the rock's velocity just before it hits the water? Remember, $v_y = v_i - gt$.

v_y = _______ m/s

8. What is the magnitude of the velocity of the rock just before it hits the water? Remember, since the components form a right triangle, you can use the Pythagorean Theorem to calculate the magnitude of the velocity. Show your calculations.

v = _______m/s

9. What angle relative to the water does the rock hit the water? It's not a sin to use tangent! Hint: $\tan\theta = v_x/v_y$

θ = ________degrees

Going Further—Analyze and Discuss

10. Do you think the angle for maximum range (horizontal distance from the cliff) is greater than, less than, or equal to 45 degrees? Explain you reasoning.