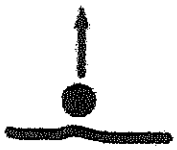
Projectile motion – Vertical

proficiency: It is expected that you can do the following

- Determine all components of velocity and acceleration in both X and Y components. (level 1)
- Determine time in the air. (level 2)
- Velocity at any time. (level 3)
- Location at any time or time at any location. (level 3)
- Full ability to solve these with both kinematics and energy is required. (level 3)

1. A ball is thrown up at 25m/s.
   a. What is velocity in X: 0 Y: +25
   b. What is the acceleration in X: 0 Y: -9.8
   c. How much time is required for this ball to hit the ground?



$V_f = V_i + at$
$0 = 25 + -9.8(t)$ $t = -25/-9.8 = 2.55\text{sec}$ ← Time to top

   d. How high will this ball be at its maximum height? ×2

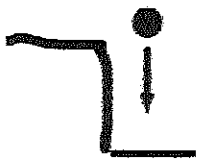
use t/2 → $Y_f = Y_i + V_i t + \frac{1}{2}at$ $63 + -12.49$ 5.10
$Y_f = 0 + 25(2.55) + \frac{1}{2}(-9.8)(2.55)^2$ → 51.2 m

   e. Student hypothesis: When the ball is 10 m off the ground, it is traveling faster on the way down because it is accelerating on the way down and slowing down on the way up? Justify/nullify this statement.

↑↓ Travel is same up as down same "a" on both trips

2. A rock is dropped off a 50m cliff.

Initial ?? →
   a. What is velocity in X: 0 Y: 0
   b. What is the acceleration in X: -9.8 Y: 0
   c. How much time is required for this rock to hit the ground?



$-50 = 0 + 0 + \frac{1}{2}(-9.8)t^2$
$t = 3.19\text{sec}$

   d. How fast is the rock going at the time of impact?

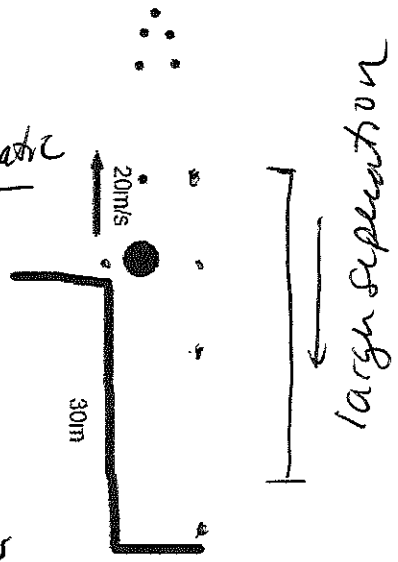
$V_f = V_i + at = 0 + -9.8(3.19) = 31.3\text{ m/s}$

   e. Student Hypothesis: At 25M the velocity of the rock is traveling exactly ½ the velocity of "d". NO, The 1st half (25m) takes more time than second half, Cause 2nd half moving faster.
   f. What is the velocity at the half way point. Use ~~energy~~ (left) kinematics (right)

Time of ½
$Y_f = Y_0 + V_i t + \frac{1}{2}at^2$
$25 = 0 + 0 + \frac{1}{2}(-9.8)(t)^2$
$t = 2.25\text{ sec}$

V@ ½ time
$V_f = V_i + at$
$= 0 + -9.8(2.25)$
$V_f = 22.05\text{ m/s}$

3. A rock is thrown up at 20m/s over a 30m cliff.
   a. The picture to the right has 6 dots showing the location of the rock at certain times. Add the rest of the dots as the rock approaches the ground.



   b. How much time is the rock in the air?

use quadratic

$y_f = y + v_i t + \frac{1}{2}at^2$

$-30 = 0 + 20t + -4.9t^2$

$t = 5.24$

   c. What is the velocity of the rock as the person sees it pass them on the way down (same location it was thrown from)?

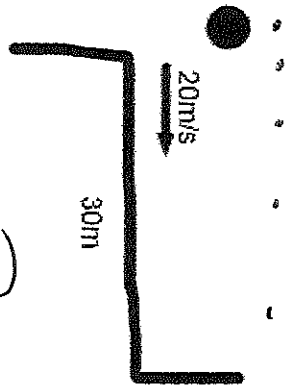
$\downarrow -20$

   d. What is the velocity of the rock as it impacts the ground?

$V_f = 20 + (-9.8)5.24 \quad V_f = -30.9\ m/s$

4. A rock is thrown down at 20m/s over a 30m cliff.
   a. Add dots showing relative location as the rock approaches the ground.
   b. How much time is the rock in the air?

   c. What is the velocity of the rock as it impacts the ground? Solve this problem with energy (left) kinematics (right)



Need time

$X_f = X_i + v_i t + 1/2 a t^2$

$-30 = 0 + -20t + -4.9t^2$

$t = 1.16\ sec$

$V_f = V_i + at$

$= -20 + (-9.8)(1.16)$

$-31.3\ m/s$