Dots 0, 1, and 2 on the back of this paper give the positions of a small, dense object that was thrown diagonally upward. Those positions may have been recorded by a camera with a strobe light that flashed with a steady frequency.

1. Draw an arrow from dot 0 to dot 1, using a ruler. Label it ΔD_{01}. Draw another arrow from dot 1 to dot 2, and label it ΔD_{12}. Those arrows represent changes in the object's ________.
   a. If we divide both of those vectors by the time interval between flashes, the resulting vectors should be called _____ and _____ because $\Delta D/\Delta t$ is the definition of "_____________".
   b. If we multiply each side of equation 1a by Δt we get ΔD = _____. That means we can re-label the ΔD_{01} arrow as _____ and the ΔD_{12} arrow as ______. *Please do that now.*

2. Starting at dot 2, lightly draw a pencil line parallel to the arrow labelled $V_{01}\Delta t$. *Use a ruler.* Then draw an arrow from dot 2 along that line, making it equal but opposite to $V_{01}\Delta t$. Label it clearly. *Don't forget its sign.*

3. Draw a dotted arrow from dot 1 to the tip of the $-V_{01}\Delta t$ arrow that you made in #2. This dotted arrow represents the result that you get when you subtract ______ from _____. We can simplify its name by using algebra: (_____) - (_____) = (___ - ___)$\Delta t = \Delta V \Delta t$. *Label your dotted arrow with that simplified name.*

4. The definition of "acceleration" on RS IV says a = ____/Δt. If you multiply both sides of that equation by Δt^2 you get another name for the dotted arrow: ______ = ______

5. This acceleration was caused by the force we call __________. If your dotted arrow does not point directly toward the bottom of the paper it's because the camera was tilted.
   a. Do we expect the earth's gravity to change while the object is in the air? ____
   b. In which cell of the grid would you guess that dot 3 should be located? ___ If we knew the location of dot 3 we could repeat the vector subtraction to get a new dotted arrow from dot 2.
   c. Although we *don't* know exactly where dot 3 is located, we can still draw that arrow accurately, starting at dot 2. *Label it as in #4.*

6. Write a vector equation similar to #3, but using V_{12} and V_{23}: $a\Delta t^2$ = (   ) - (   )

7. Solve that equation for the unknown vector: $V_{23}\Delta t$ = (   ) + (   )

8. Do the vector addition described in #7 by drawing and labelling a new arrow from the tip of the dotted arrow that you made in 5b. Then draw and label a new arrow to represent the result. If drawn correctly, the tail of that new arrow will be on dot __, and the tip gives us the location of dot ___, which was previously a mystery. *Now we know it is in cell ____ on the grid.*

9. Is it possible to repeat the process above many times to get a long series of dots describing the "trajectory" (path) of the thrown object? _____ Please illustrate by drawing such a series of dots on another sheet of paper, showing *roughly* what such a trajectory could look like.

10. The real trajectory would be a __________ line passing through those dots. (straight, curved, zig-zag) Please add such a line to the sketch that you made for #9.

11. At the instant when the object passes through dot 2 on the new picture, it has a velocity that is _________ to the curved path. Draw such an arrow from that dot and label it "V_2".

12. Draw and label another arrow from dot 2 on the new picture to describe the object's acceleration, which is caused by ____________. The angle between the object's velocity and its acceleration is ______________ 90 degrees. (less than , equal to, greater than)
   -Is that true for all points on the trajectory? ____

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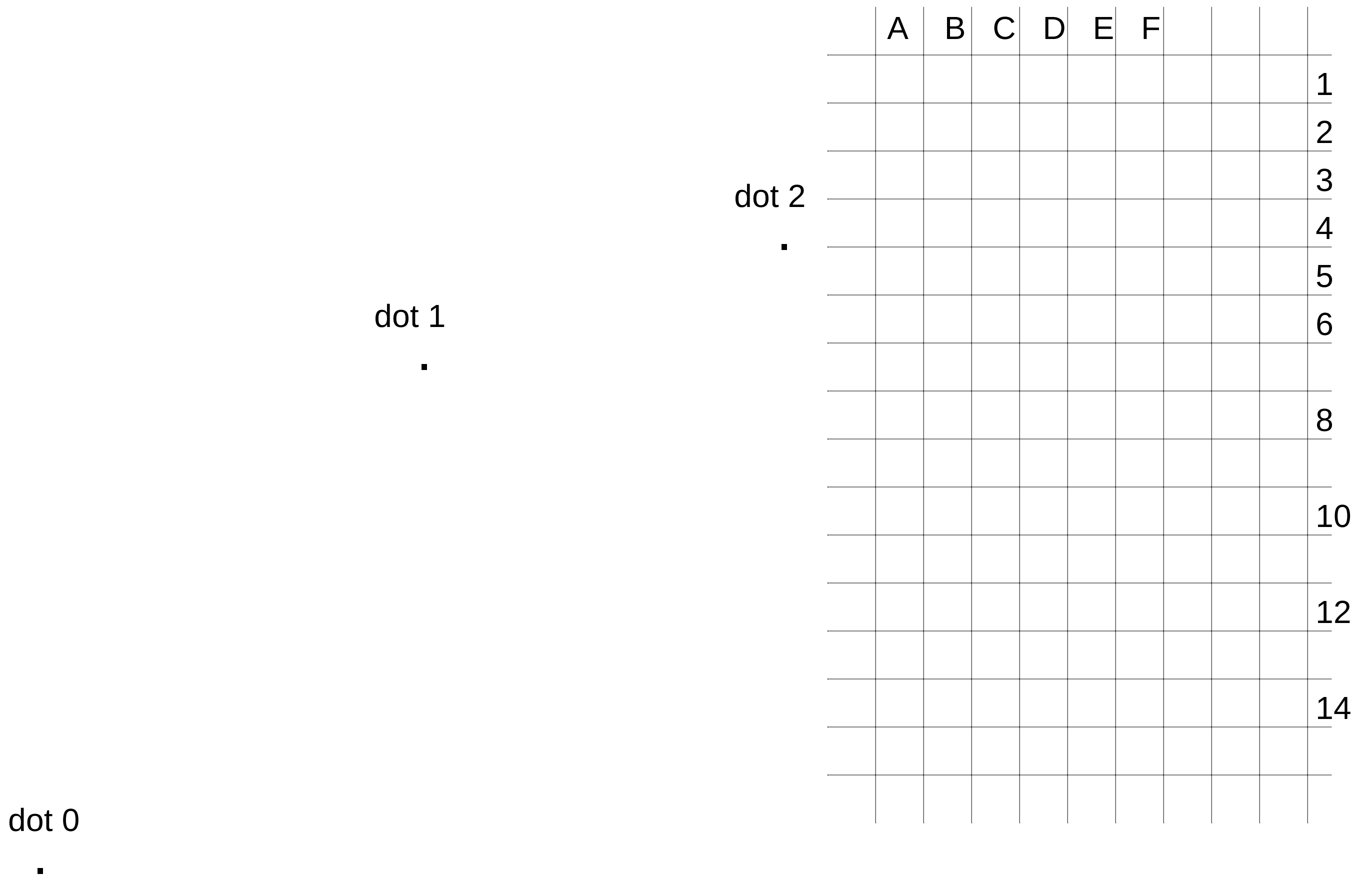

13. Draw straight vertical lines through dots 0, 1, 2, and 3.
  a. Are those lines evenly spaced and parallel to each other?
  b. We conclude that the horizontal component of the object’s velocity ______________.
     (increases, decreases, remains constant)
  c. That fact is known as the “first trajectory principle”. It is true because there ______ a horizontal force on the object. (is, isn’t)

14. Draw horizontal lines through the dots.
  a. Use them to make a graph showing how the vertical component of the the velocity changes as time goes on.
  b. Describe the pattern displayed by that graph.
  c. We shall call that the “second trajectory principle”.
     What causes the vertical velocity to change in that way? ______________