In Class Activity Plan
Week Three: Become Quantitative with Constant Acceleration

20 min **Becoming Quantitative (Page one) (Word, Pdf)**
PURPOSE: The first page gets students to agree on one specific model which is then generalized in the second page
Video Examples: (Discussion1, Discussion2)
Logistic Notes:
- This works best if you print this as two separate pages and hand out the pages one at a time and do a whiteboard discussion about each page
    - The first page should be the one without numbers, and the second page should be the one with numbers
- Watch out for d = vt, they will try to use this (and it doesn't apply in the constant acceleration model), enforce class norms of only using things we've established as rules

Page 1 Goals:
- Create quantitatively accurate position versus time and acceleration versus time graphs
- Focus on finding slope and area and writing them correctly on the relevant graphs
- Note that they will have to make an assumption about the initial position of the object

10 min **Whiteboard – Becoming Quantitative (Page One)**
PURPOSE: Share specific model
- Put the complete model on your whiteboard

20 min **Board Meeting**
PURPOSE: Students share solutions to problem, articulate process of modeling specific situation
- Make sure the models are internally consistent
- What can you find?
    - p-t graph, a-t graph, motion map
    - writing down assumptions you make
    - values for displacement (total and for each second), acceleration
- Compare and contrast different people's models (particularly those who make different initial position assumptions)

20 min **Becoming Quantitative (Page Two) (Word, Pdf)**
PURPOSE: This problem is identical to the first side, but with the numbers replaced by variables, so students can model the situation but get equations for constant a.

Video Examples: (Why you get confused)

Page 2 Goals:

- Again, create quantitatively accurate position versus time and acceleration versus time graphs, but this time they will be using variables
- During the process they will find 2 equations:
  - $d = v_0 t + \frac{1}{2} t\left(v_f - v_0\right)$
  - $a = \frac{v_f - v_0}{t_f - 0}$
  - *Seed:* In the displacement equation we can replace Δv with aΔt and get $d = v_0 t + \frac{1}{2} at^2$

10 min **Whiteboard – Becoming Quantitative (Page Two)**

PURPOSE: Share model

- Put the complete model on your whiteboard

30 min **Board Meeting**

PURPOSE: To develop a set of equations for use with the constant acceleration model

Video Examples: (Group1, Group2)

- The area under the curve give $d = v_o t + \frac{1}{2} t(v_f - v_o)$
- The slope gives $a = \frac{v_f - v_0}{t_f - 0}$
- Will probably have to explicitly show the algebraic steps between the first displacement equation and $d = v_0 t + \frac{1}{2} at^2$
- Initial position assumption – the *d* in the equation represents displacement, not the position because we can't tell anything about the initial position
- Make these equations part of the rules for the constant acceleration model

30 min **Specific models using constant a (Word, Pdf)**

PURPOSE: Practice using equations in modeling of variety of situations.

Video Examples: (Whiteboards, We like them, Discussion)

Presumably you have 10 groups, so you would have 2 groups complete each problem (no group does all 5).

Goal:

- To use the equations developed, graphs, and motion maps, to create quantitatively accurate specific models of the situation
- To help guide towards the need for a basic model for constant acceleration instead of several specific models

10 min **Whiteboard – Specific models using constant a**

PURPOSE: Share specific model

- Give each group one of the 5 situations to model
- This is an opportunity, and you should point it out, that groups are presenting problems that most students have not done, so it's important that they pay attention, check for mistakes, and make sense of each problem.

45 min **Board Meeting**

PURPOSE: Build consensus about characteristics of basic constant acceleration model

Video Examples: (Group1, Group2, Group3)

Note: If you read about a general model in a paper, a basic model is the same concept

- Let each group discuss their model for the specific case
- Ask what is common about all of their specific models
  - Develop a basic constant acceleration model which consists of the following:
    - Curved p-t graphs, constant slope v-t graphs, horizontal line a-t graph
    - Relations between graphs
      - Slope of v-t graph is acceleration
      - Integral of v-t graph is change in position
      - Slope of p-t is instantaneous velocity
      - Integral of a-t is change in velocity
    - Motion maps: changing arrows, the way that they change indicates the acceleration
    - Equations: $v = v_o + at$ & $d = v_ot + ½ at^2$
  - Point out that the specific models are only useful in a very particular case, but the basic model applies to all the constant acceleration cases, so we want to look for a basic model
- What goes into a good model?
  - Representations
    - P-t graphs, v-t , a-t graphs,
    - Motion maps
    - Mathematical (equation) representation
  - Assumptions
  - Interpretations
    - Working out the math – for example, 'What is the value of the acceleration for the car?'

30 min **Five Situations using constant v (Word, Pdf)**
PURPOSE: Practice using equations in modeling of variety of situations.
Give each problem to 2 groups
Goal:

- To see the constant v is a different basic model than constant a
- Develop rules for a constant v basic model

10 min **Whiteboard - Five Situations using constant v**
PURPOSE: Practice using equations in modeling of variety of situations.

- Give each group a different situation to whiteboard

SEED:

- *Get a group to draw an a-t graph to see the acceleration is 0, but constant*

20 min **Board Meeting**
PURPOSE: Build consensus about characteristics of basic constant velocity model
Note: This discussion is pretty straight forward because they have just had a similar discussion regarding the constant acceleration basic model

- What is common about the specific models?
    - Graphs: linear p-t graphs, horizontal v-t graphs
    - Relation between graphs:
        - Slope of p-t graph is velocity
        - Area under v-t graph gives change in position
        - Slope of v-t graph is always 0, which is the value of the acceleration
    - Motion Maps: constant spacing between points, length of arrow stays the same
    - Equation: $v = \Delta p/\Delta t$
- What about constant position? (boring)
- Point out that basic constant v model is just a special case of the basic constant a model when a=0

60 min **Practice with One Dimensional Motion (Word, Pdf)**
PURPOSE: Practice adapting basic constant a model to a variety of situations.
Logistic Notes:

- *The antelope problem is super complicated with equations, but easy with graphs.*
- *If you don't finish this worksheet in class, assign 1 or 2 problems for homework*

Assign for homework as a bridge to next activity (not for collection, just for thought): ***"How do these models change with two dimensional motion?"***