NORTHERN ILLINOIS UNIVERSITY

PHYSICS DEPARTMENT

Physics 210 – Mechanics & Heat   Spring 2021

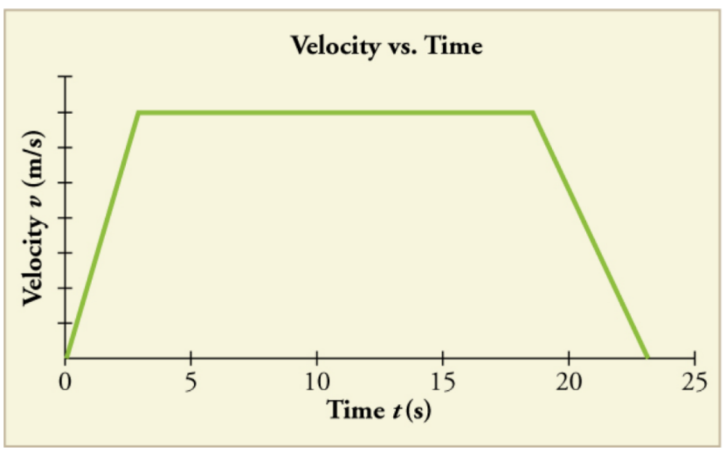
Problem Set #3

Problem Set Due: Thurs., Jan. 28, 2021
Read OpenStax: Chapter 3, Lecture Notes #2

Show explicitly all your work for full credit.

1. A swan on a lake gets airborne by flapping its wings and running on top of the water.
   (a) If the swan must reach a velocity of 6 m/s to take off and it accelerates from rest at an average rate of 0.35 m/s^2, how far will it travel before becoming airborne?
   (b) How long does this take?

2. A rescue helicopter is hovering over a person whose boat has sunk. One of the rescuers throws a life preserver straight down to the victim with an initial velocity of 1.40 m/s and observes that it takes 1.8 s to reach the water.
   (a) List the knowns in this problem.
   (b) How high above the water was the preserver released? (Ignore air resistance).



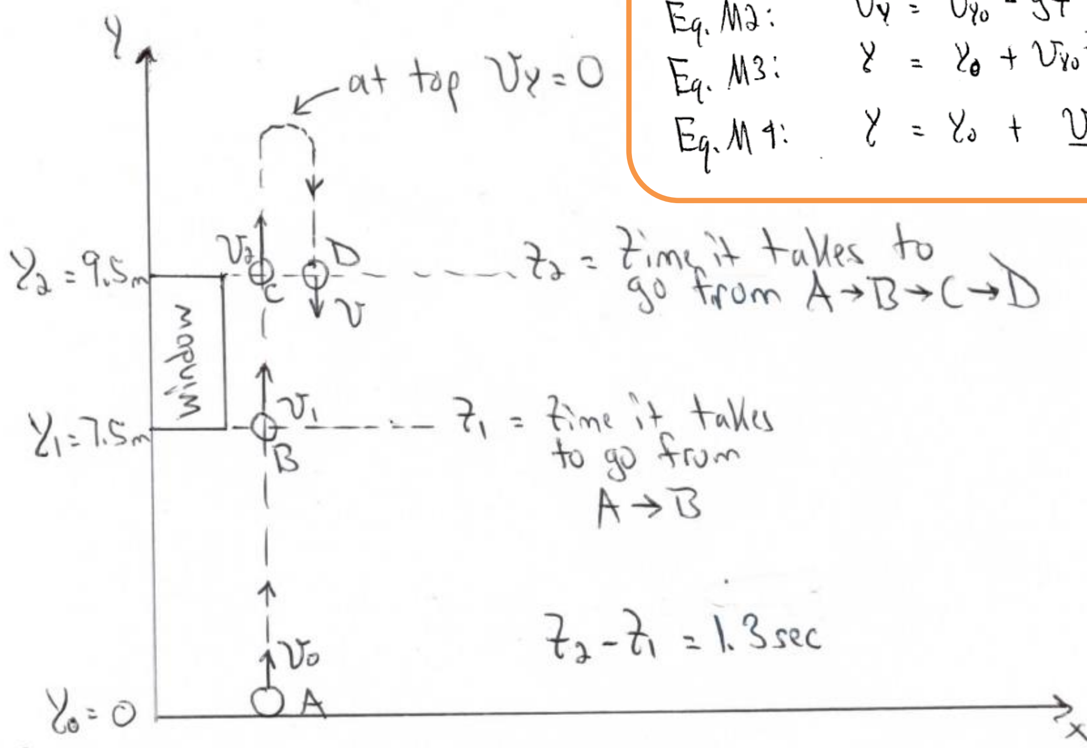
3. Consider the velocity vs. time graph of a person in an elevator shown above. Suppose the elevator is initially at rest. It then accelerates for 3 seconds, maintains that velocity for 15 seconds, then decelerates for 5 seconds until it stops. The acceleration for the entire trip is not constant so we cannot use the equations of motion for the entire trip (we could, however, use them in the three individual sections where acceleration is a constant). Sketch graphs of (a) position vs. time and (b) acceleration vs. time for this trip.

Eq. M1: $a_y = -g$ = constant

Eq. M2: $v_y = v_{y0} - gt$

Eq. M3: $y = y_0 + v_{y0}t - \frac{1}{2}gt^2$

Eq. M4: $y = y_0 + \frac{v_y^2 - v_{y0}^2}{2(-g)}$



4. A ball is thrown straight up from ground level. It passes a 2-m-high window. The bottom of the window is 7.5 m off the ground. The time that elapses from when the ball passes the bottom of the window on the way up, to when it passes the top of the window on the way back down is 1.3 s.

The Expert TA method (a nice way to solve the problem):

(a) Find the velocity of the ball v_1 (at the bottom of the window) given the information in the problem. (*7.90846 m/sec –hint use* ***Eq.M3***)

(b) Now find the initial velocity of the ball v_0. (*14.4756 m/sec –hint use* ***Eq. M4***)

The Brute Force method done in Class (no thinking involved):

(c) At time t_1 and position y_1, **Eq.M3** gives: $y_1 = y_0 + v_0 t_1 - \frac{1}{2}gt_1^2$

which when you plug in all known values gives: $7.5 = v_0 t - 4.9t^2$

since $y_0 = 0$ and $y_1 = 7.5$ (I am purposely leaving off units for now).

At time t_2 and position y_2, **Eq.M3** gives: $y_2 = y_0 + v_0 t_2 - \frac{1}{2} g t_2^2$

which when you plug in all known values gives: $9.5 = v_0 t_2 - 4.9 t_2^2$

since $y_0 = 0$ and $y_2 = 9.5$. The problem states that $t_2 - t_1 = 1.3$.

These 3 equations gives: $\begin{Bmatrix} t_2 - t_1 = 1.3 \\ 7.5 = v_0 t_1 - 4.9 t_1^2 \\ 9.5 = v_0 t_2 - 4.9 t_2^2 \end{Bmatrix}$

There are now a simultaneous set of 3 equations and 3 unknowns (t_1, t_2, v_0).

Solve for v_0 and show that you get the same solution as in Part (b).

5. Expert TA: **c4.1.1** — *conceptual problem—explain*
6. Expert TA: **2.4.8** — show calculation and figure
7. Expert TA: **c4.3.5** — *conceptual problem—explain*
8. Expert TA: **4.3.1** — show calculation and figure
9. Expert TA: **4.3.6** — show calculation and figure