9/04/19 Assignment Set 2 - Read Unit 1 Ch. 3 thru Ch.5 *Due Wednesday 9/11/19* Name_____________

Basic IBM† Physics

1. Many are surprised by a little "explosion" that occurs when a *90gm* superball is dropped with a *10gm* pen on top.
(a) Under ideal† conditions the pen is fired upward with a speed that is ______ †† times the speed with which the two hit the floor and rises ______†† times the height from which they were dropped. Verify with $\mathbf{V_1}$ vs $\mathbf{V_2}$ plot.
(They usually don't notice that the ball rises only ______†† times that drop height.)

† *"Ideal" means negligible internal friction and air drag and valid Independent Bang Model (IBM).*

†† *Use geometry or algebra to give factors to 2-figure precision.*

(b) Under less ideal conditions an evil student might spoil the professor's demo toy by putting a drop of *Sticky-Stuff*© between the ball and pen. Assuming that drop wastes as much energy as possible (but still separates), derive the final speed and height factors that may result.

V_{BALL}=______$\cdot v_{INIT}$ V_{PEN}=______$\cdot v_{INIT}$ h_{BALL}=______$\cdot h_{INIT}$ h_{PEN}=______$\cdot h_{INIT}$

Essay: What about IBM?

2. Discuss what is it that seems to make the IBM† work so well. (A question we take up in later Chapters.)

Random Banging Around

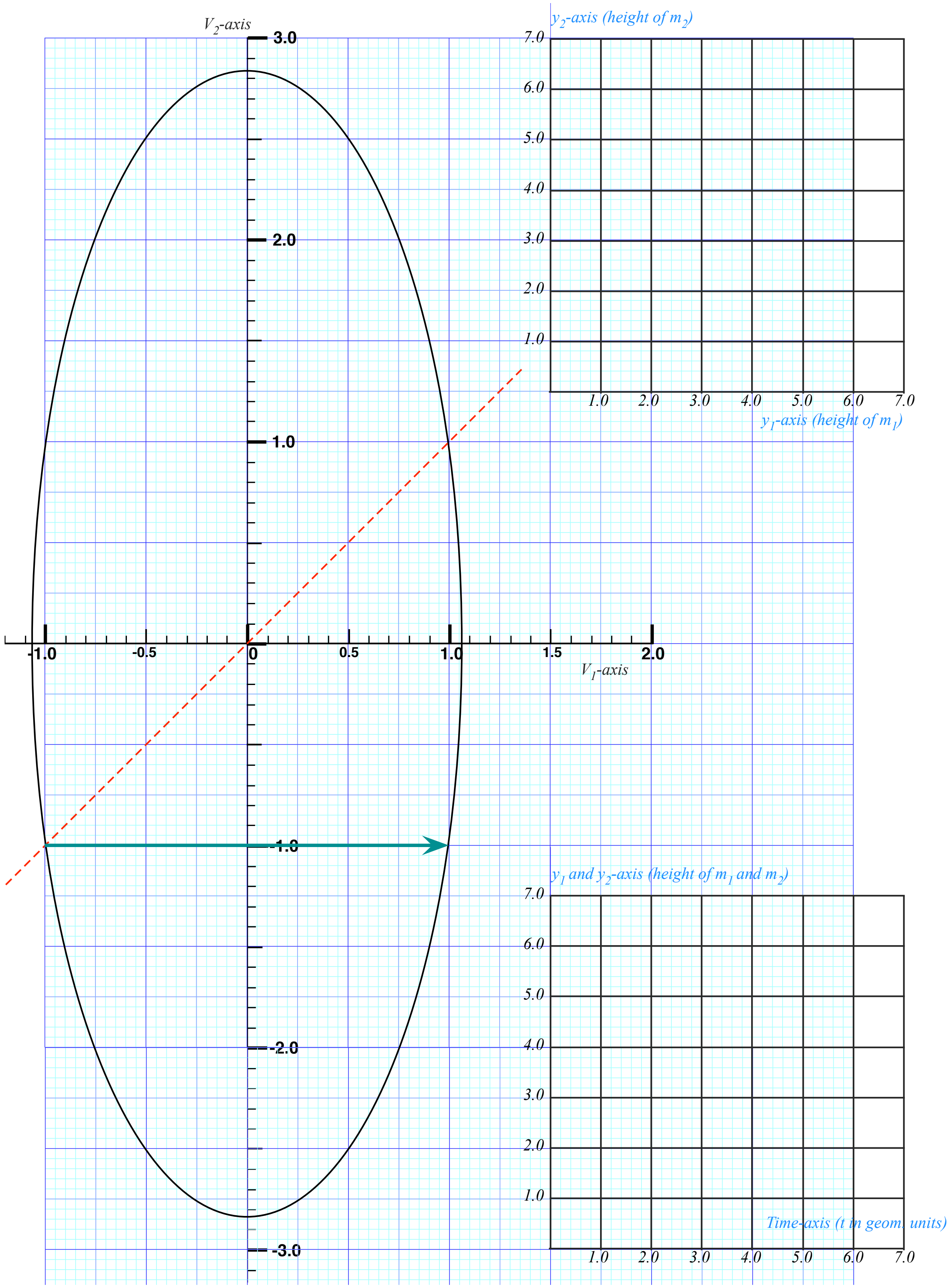
3. These same people might not be so surprised by what goes on in a low-temperature high-vacuum atomic vapor chamber that has a mixture of Hydrogen (atomic weight 1.0) and Beryllium (atomic weight 9.0). On the average the H atoms have a speed that is _______ times that of the Be atoms. If the chamber is opened to a large enclosing ultra-high vacuum chamber, then H atoms could rise _____ times as high as the Be atoms, on the average. Compare to answers in 1 and discuss briefly. (Discussion after text Fig. 5.2(d-e) is important here.)

Finding "Gameover" point (Construction we started in class 9/04)

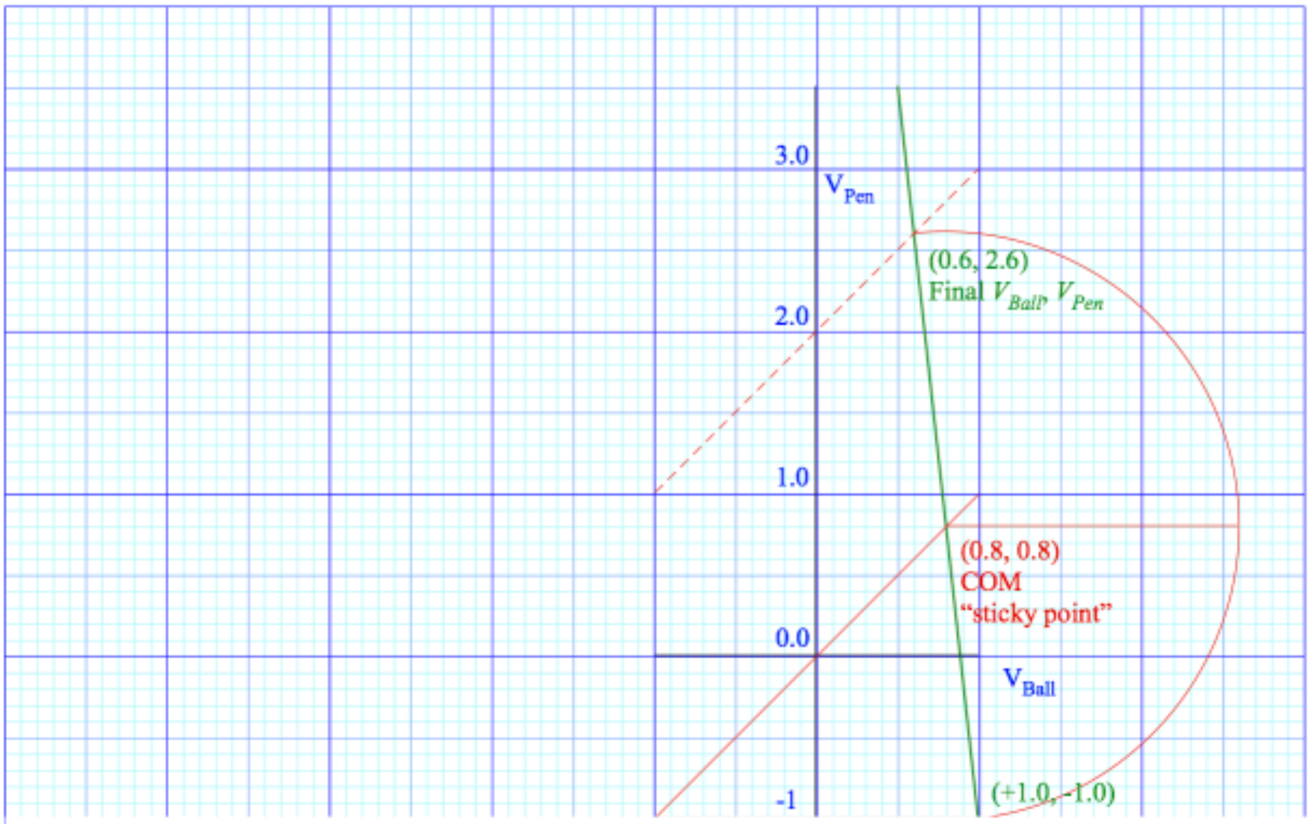
4. We began a complete space-time, velocity-velocity, and space vs. space plot construction for the pen-ball system with pen-mass $M_{pen} = 10gm = M_2$ and ball-mass $M_{ball} = 70gm = M_1$. We assumed initial positions $(y_1 = 1, y_2 = 3)$ and velocity $(v_1 = -1, v_2 = -1)$ headed toward floor. (See p. 9 to 18 in Lecture 3. Extra graph paper is on p.11.)
The objective is to plot the velocity-velocity, and space vs. space graphs assuming the ball has only a single floor bounce after which the floor is removed so both objects can fall through. (The ceiling at y=7 remains in tact.) Of particular interest is the final "gameover" bounce after which the two objects can never collide again.

The objective is to locate their last collision point and the final velocity. (As usual no gravity is present.)

You may use the BounceIt program to estimate the results but only a old fashioned construction gets full credit!


V_2-axis
3.0
2.0
1.0
-1.0
-2.0
-3.0
-1.0
-0.5
0
0.5
1.0
1.5
2.0
V_1-axis
y_2-axis (height of m_2)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
y_1-axis (height of m_1)
y_1 and y_2-axis (height of m_1 and m_2)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Time-axis (t in geom. units)
1.0
2.0
3.0
4.0
5.0
6.0
7.0

Solutions to Set 2 exercises 1 to 3



(a) Under ideal† conditions the pen is fired upward with a speed that is 2.6=13/5 †† times the speed with which the two hit the floor and rises 2.6^2=6.76=169/25†† times the height from which they were dropped.
(They usually don't notice that the ball rises only 0.6^2=0.36=9/25†† times that drop height.) (See 1st graph)

† *"Ideal" means negligible internal friction and air drag and valid Independent Bang Model (IBM).*

†† *Use geometry or algebra to give factors to 2-figure precision.*

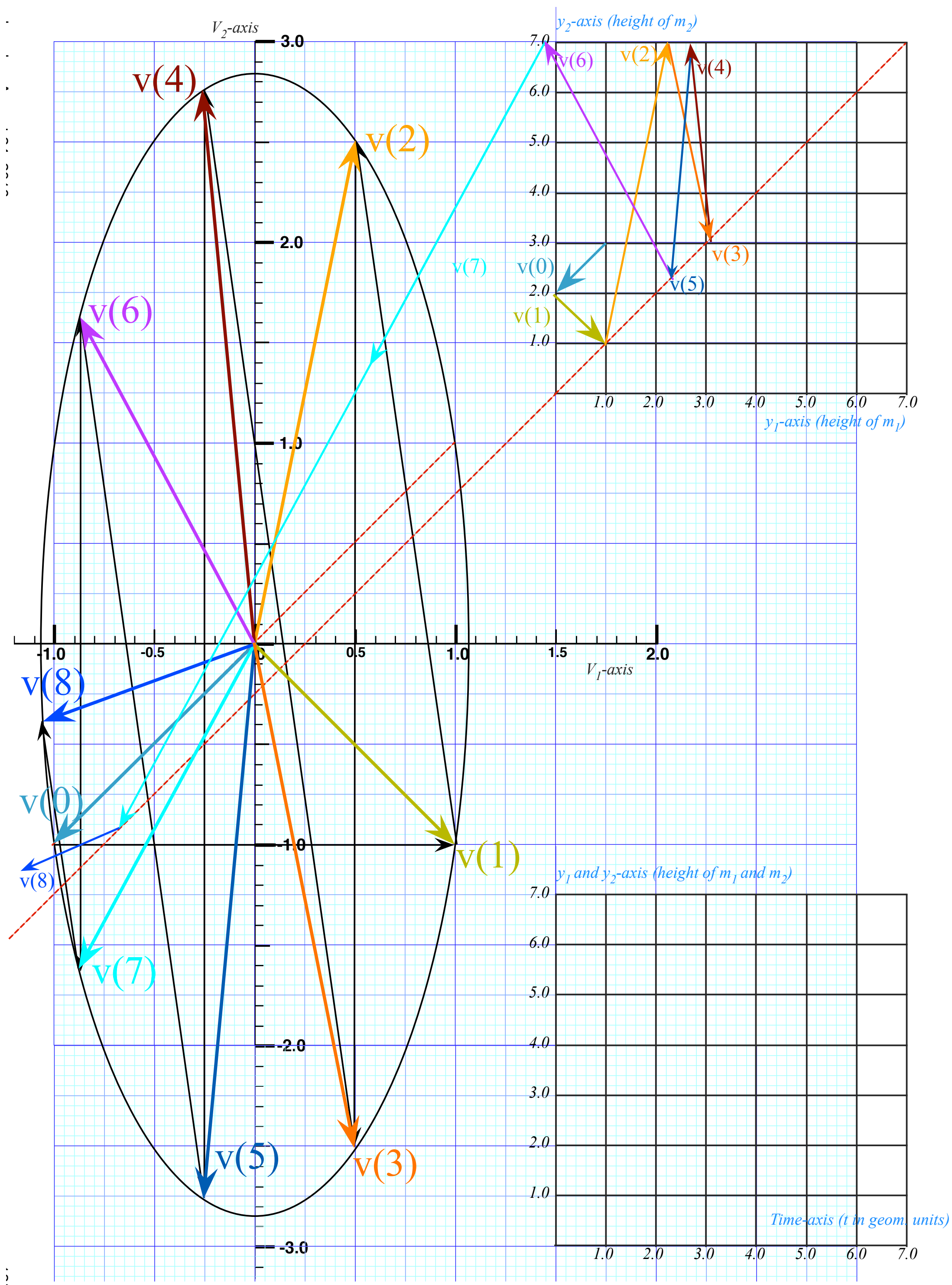
(b) Under less ideal conditions an evil student might spoil the professor's demo toy by putting a drop of *Super-Glop-Glue*© between the ball and pen. Assuming that drop wastes as much energy as possible, derive the final speed and height factors that may result. (See 1st graph at sticking point.)

$V_{BALL}=0.8=4/5\cdot v_{INIT}$ $V_{PEN}=0.8=4/5\cdot v_{INIT}$ $h_{BALL}=0.8^2=0.64\cdot h_{INIT}$ $h_{PEN}=0.8^2=0.64\cdot h_{INIT}$

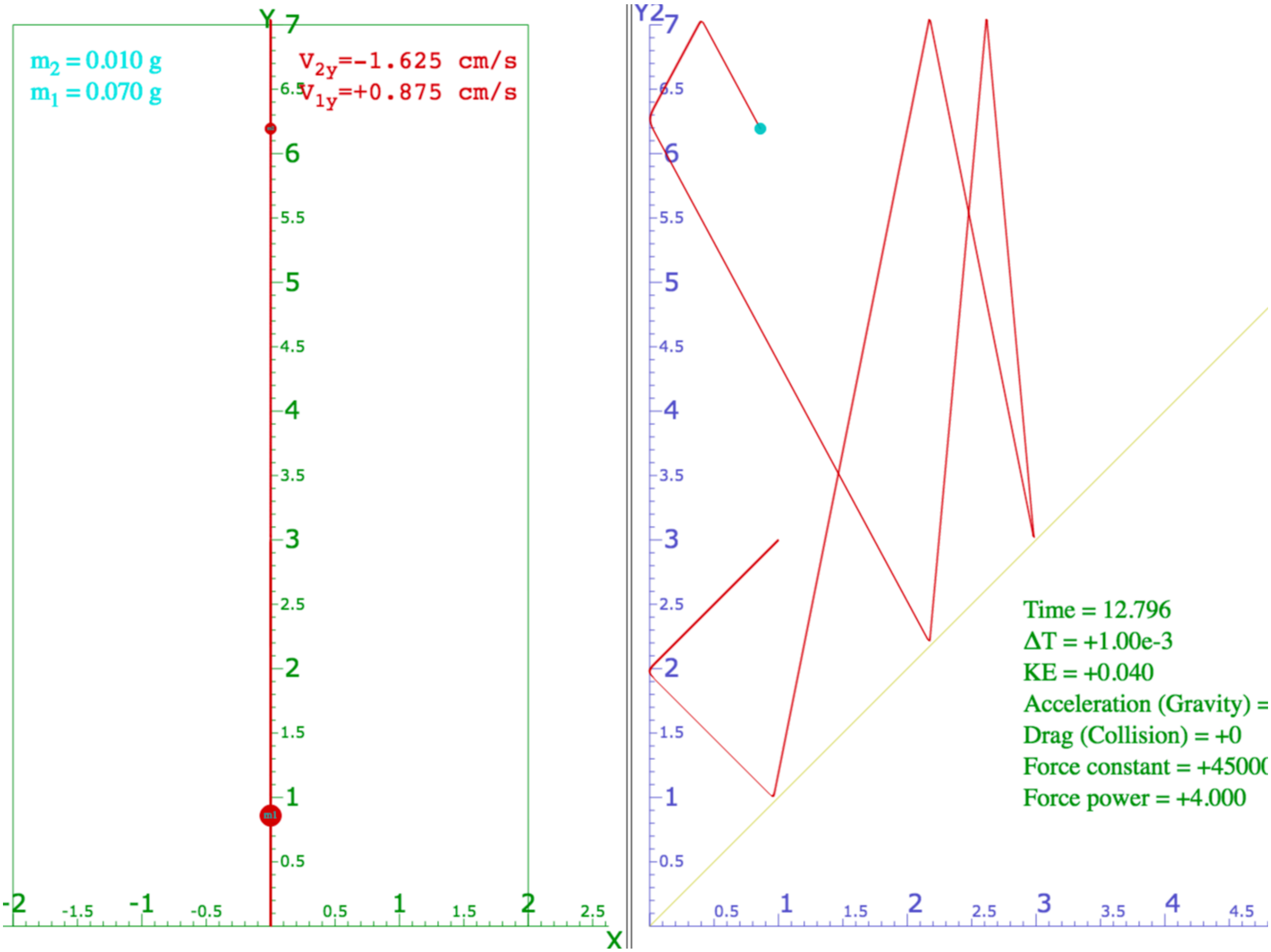
2. Discuss what is it that seems to make the IBM† valid.
Nonlinear force law provides a "gap" between balls and approximately independent collisions.

3. These same people might not be as surprised by what goes on in a low-temperature high-vacuum atomic vapor chamber that has a mixture of Hydrogen (atomic weight 1.0) and Beryllium (atomic weight 9.0). On the average the H atoms have a speed that is __3___ times that of the Be atoms. If the chamber is opened to a large enclosing ultra-high-vacuum chamber, then H atoms could rise __9__ times as high as the Be atoms, on the average. Compare to answers in 1 and discuss briefly.
Statistical (*rms*) speed ratio of $\sqrt{(M_{Be}/m_H)}=\sqrt{9}=3$ can be compared to momentary ratio $V_{Pen}/V_{INIT}=2.6$ or a more appropriate ratio $V_{Pen}/V_{Ball}=2.6/0.6=4.33$ for penball $M_{Ball}/m_{Pen}=9$ system. Both V_{Pen}/V_{Ball} and V_{Be}/V_H vary from 0 to ∞ and, given time, both equilibrate to the *rms* value of 3:1 that is the square root of their mass ratio.

Solutions to Set 2 exercise 4. Very last collision gives **V** -vector **V(8)**. M_2 will never catch M_1 again. "Gameover" point is at inter section of **V(7)** and 45° COM collision line.(See V(8) vector reflecting off 45° at lower left.



BouncrIt simulation (with tiny superballs) shown below



Not shown is the ball M1 passing thru floor when m2 is at y2= 6.25. That is about 0.5 below the construction on the preceding page. So the game-over collision should be about that much further to the left.