Physics 151
Practice Exam 1
Fall 2012

ACTUAL SOLUTIONS ARE AT BACK. NOT ENOUGH ROOM HERE

(1.) A car is traveling at $35.0\,m/s$ when the driver hits the brakes causing a constant deceleration of $2.50\,m/s^2$. How far does the car go while stopping?

(a) $14\,m$	(b) $5.6\,m$	(c) $245\,m$	(d) $490\,m$

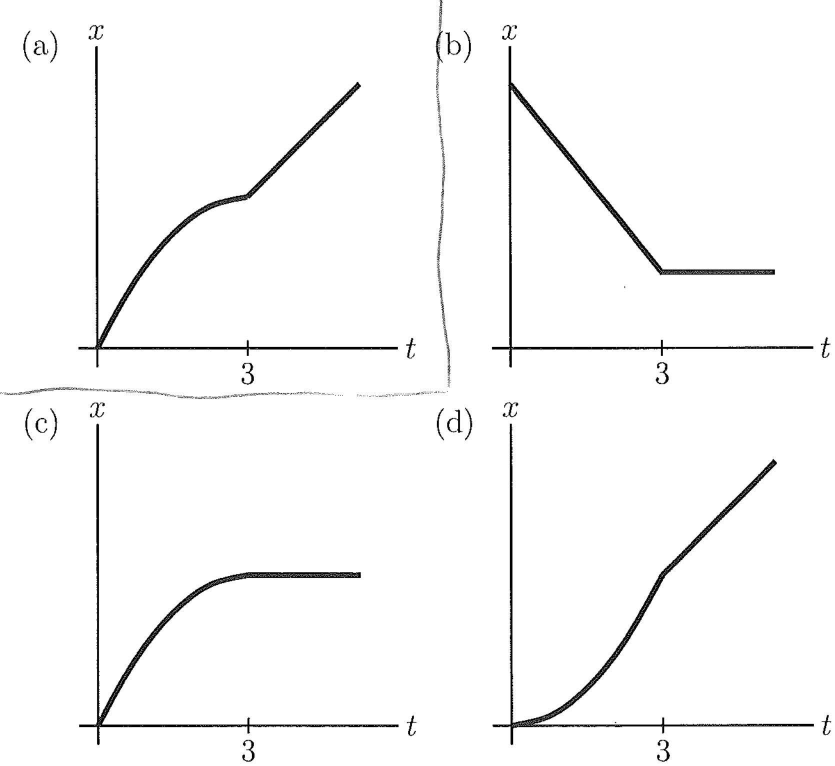
(2.) Your physics instructor starts at Regener Hall and runs to the Physics department with average speed $4.0\,m/s$. He then turns around (and being hungry) runs to the Pita Pit for lunch. Due to the hill on Yale, his average speed on his return trip is $2.5\,m/s$. If we assume, for simplicity, that the physics department is $1.2\,km$ due North of Regener Hall and the Pita Pit is $0.75\,km$ due South of Regener Hall, what is the magnitude of the average *velocity* for the entire trip?

(a) $0.69\,m/s$	(b) $1.3\,m/s$	(c) $2.9\,m/s$	(d) $6.9 \times 10^{-4}\,m/s$

(3.) Your physics instructor finds himself on the moon! where the acceleration due to gravity is roughly one-third of that on earth. If he throws a ball upwards at $10\,m/s$ and the ball is released $1.6\,m$ above the ground, what is the maximum height above the ground of the ball?

(a) $15.3\,m$	(b) $16.9\,m$	(c) $25.1\,m$	(d) $6.7\,m$

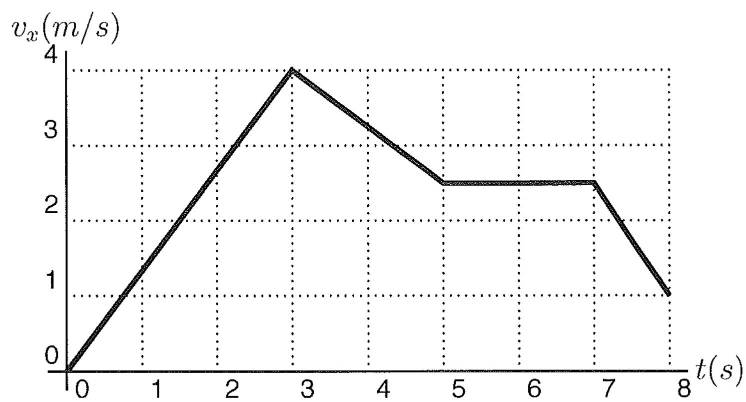
(4.) Your physics instructor is driving his 1973, orange-colored Gremlin on Lomas Boulevard when he notices that there is an upcoming red stoplight. Hitting the brakes, he has a constant deceleration for $3\,s$. At that point, the light turns green, so he hits the gas again and from that point onwards maintains a constant velocity. Which of the following plots, correctly corresponds to his position versus time graph?



(5.) A turtle and a rabbit are having a race. The rabbit runs the race with an average speed of $15\,km/h$ while the turtle's average speed is $6.5\,km/h$. If the turtle finishes the race $25\,min$ after the rabbit, what distance was the race?

(a) $287\,km$	(b) $6.25\,km$	(c) $4.8\,km$	(d) $3.5\,km$

(6.) From the intersection of Yale and Central, your instructor's 1973, orange-colored Gremlin starts from rest and has the velocity versus time graph shown below. What was the car's acceleration at $t = 4\,s$?



(a) $-0.8125\,m/s^2$	(b) $1.3\,m/s^2$	(c) $-0.75\,m/s^2$	(d) $0.125\,m/s^2$

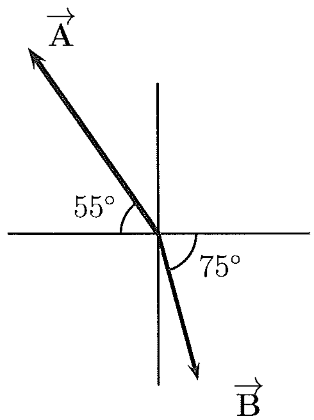
(7.) Your physics instructor takes a flight in a hot-air balloon which rises with constant $5.00\,m/s$ speed. $12.0\,s$ after takeoff, a sandbag falls off the balloon. If the missing sandbag causes the balloon to begin accelerating at $2.00\,m/s^2$, how high (above the ground) is the balloon when the sandbag hits the ground? Ignore air resistance in your calculations.

(a) $96.6\,m$	(b) $264\,m$	(c) $89.8\,m$	(d) $65.1\,m$

(8.) What is the range of a projectile that is launched from ground level with a speed of $25\,m/s$ and at a $29°$ angle? Ignore air resistance.

(a) $123\,m$	(b) $112\,m$	(c) $54\,m$	(d) $25\,m$

(9.) What is the magnitude of the vector sum $\vec{\mathbf{A}} + \vec{\mathbf{B}}$ for the vectors shown below?



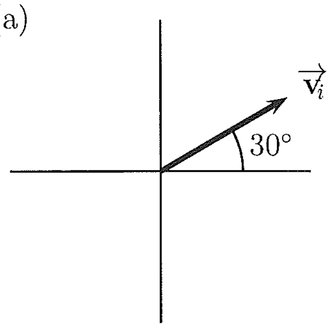
$A = 3.0\,m$

$B = 2.0\,m$

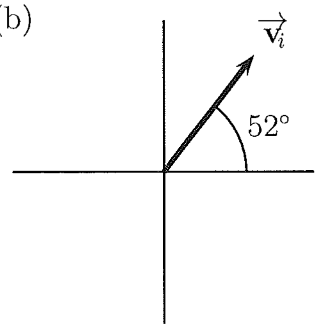
(a) $4.9\,m$	(b) $5\,m$	(c) $-0.68\,m$	(d) $1.3\,m$

(10.) A grasshopper launches itself from the top of a table that is 1.1 m high. Its time of flight is 0.85 s and its range is 1.9 m. Assuming air resistance was negligible, at what angle did the grasshopper launch itself?

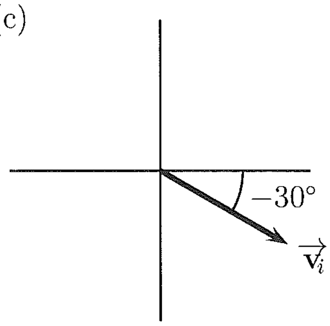
(a)



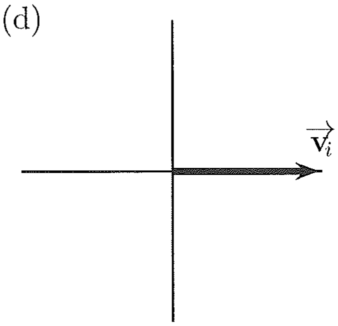
(b)



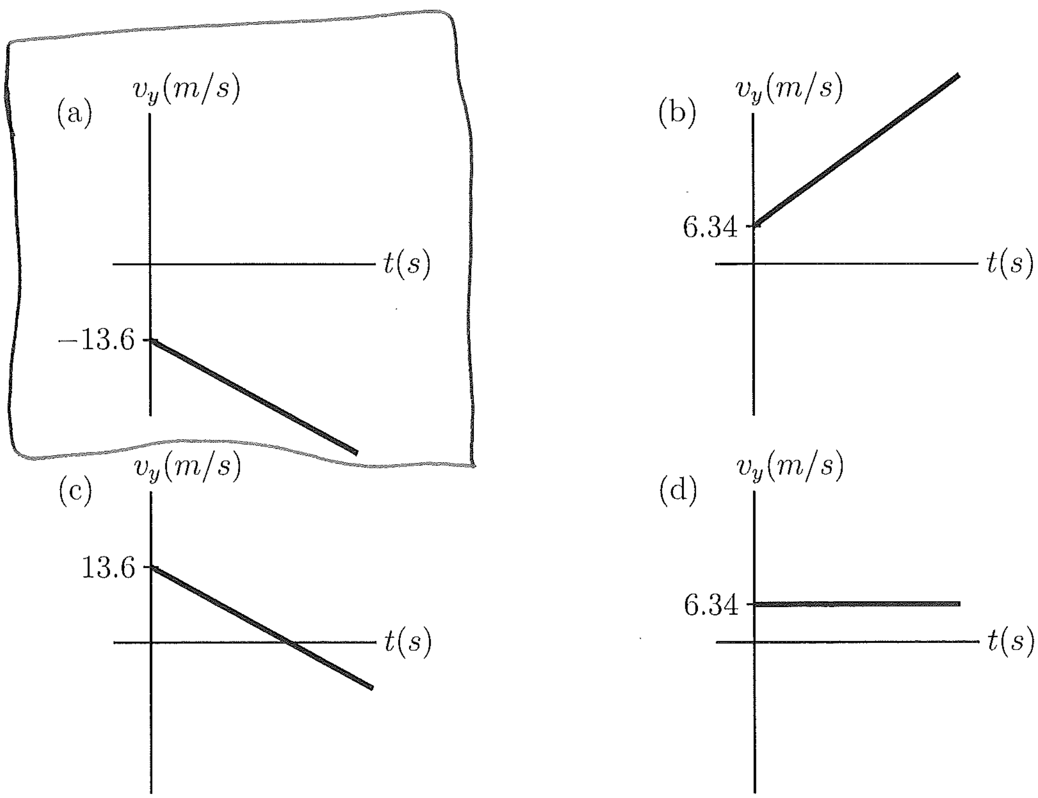
(c)



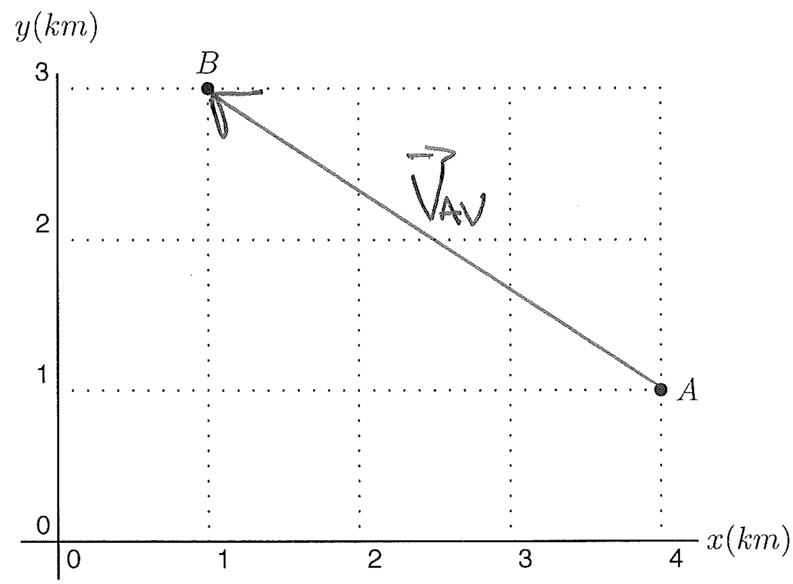
(d)



(11.) One day finds your physics instructor hiking the La Luz trail up to Sandia Peak. At one point in his hike, very near the top of the mountain, his boot dislodges a large rock. If the rock is kicked out at 15.0 m/s and at an angle of $-65.0°$, which of the following is the correct v_y vs. t graph, if we ignore air resistance?



(12.) One day while shopping for physics supplies at Walmart, your instructor tries to park his 1973, orange-colored Gremlin. He enters the parking lot at the point labeled A on the graph below and then parks at the point B. If driving from point A to B takes $2.5\,min$, what is the magnitude and direction of the average *velocity* for the motion from A to B? All angles are given as standard angles.

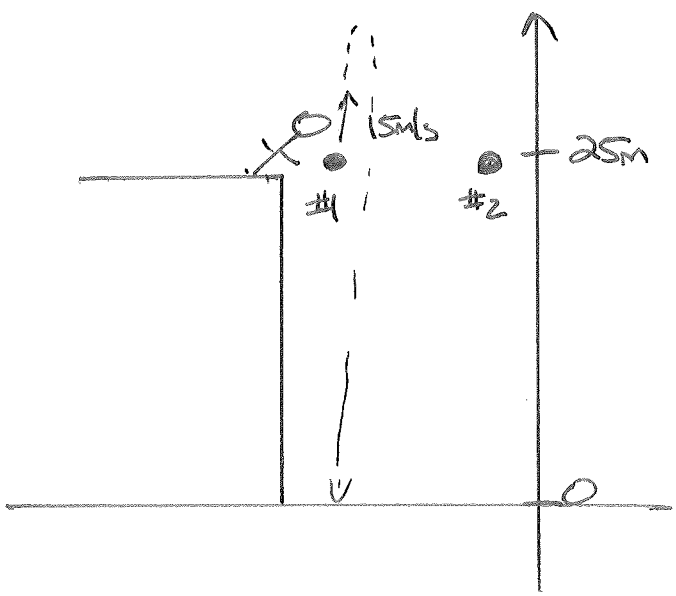


(a) $1.6\,km/min$ at $14°$	(b) $1.3\,km/min$ at $71.6°$
(c) $1.4\,km/min$ at $146.3°$	(d) $3.6\,km$ at $146.3°$

(13.) One day, in the name of science, your instructor goes to the middle of Kansas with a gun and an egg. He fires the gun horizontally with speed $125\,m/s$ at the same instant he drops the egg, both from a height of $1.8\,m$. Ignoring air resistance and assuming Kansas is so flat and empty that the bullet hits nothing on the way down, which of the two objects hits the ground first?

(a) The egg	(b) The bullet
(c) They hit at the same time	(d) There is not enough information to determine

(14.) At the top of a building 25 m high, your instructor throws an egg upwards at 15 m/s. 1.5 s later, he throws another egg. If both eggs hit the ground at exactly the same time, did your instructor throw the second egg upwards or downwards? You must do a numerical calculation to receive full points.



$(V_y)_{i2}$ tells us whether #2 went up OR DOWN.

Positive $(V_y)_{i2} \Rightarrow$ UP

Negative $(V_y)_{i2} \Rightarrow$ DOWN

KNOWN: #1 $(V_y)_{i1} = 15\,m/s$, $y_i = 25\,m$, $y_f = 0$, $a_y = -9.8\,m/s^2$

UNKNOWN: Δt_1, $(V_f)_1$

$y_f = y_i + (V_y)_i \Delta t - \frac{1}{2} g \Delta t^2$ CAN FIND $\Delta t_1 \Rightarrow 0 = 25\,m + (15\,m/s)\Delta t_1 - 4.9\,m/s^2 \Delta t_1^2$

$\Rightarrow +4.9\,m/s^2\, \Delta t_1^2 - (15\,m/s)\, \Delta t_1 - 25\,m = 0$

$$\Rightarrow \Delta t_1 = \frac{+15\,m/s \pm \sqrt{(15\,m/s)^2 - 4(4.9\,m/s^2)(-25\,m)}}{2(4.9\,m/s^2)} = \frac{15\,m/s \pm \sqrt{715\,m^2/s^2}}{9.8\,m/s^2}$$

$\Delta t_1 = 4.26\,s$ OR $\cancel{-1.198\,s}$

#2 gets 1.5s less time to REACH Bottom!

$\Rightarrow \Delta t_2 = 4.26s - 1.5s = 2.76s$

<u>KNOWN FOR #2</u>: $\Delta t_2 = 2.76s$, $y_i = 25m$, $y_f = 0$

$a_y = -9.8 m/s^2$

<u>UNKNOWN</u>: $(V_y)_i$, $(V_y)_f$

$$y_f = y_i + (V_y)_i \Delta t + \frac{1}{2} a_y \Delta t^2$$

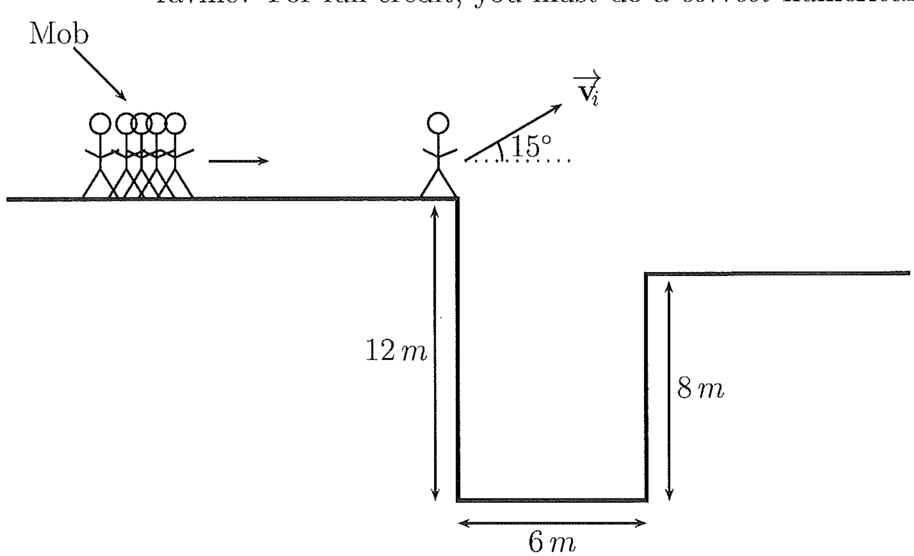
$$\Rightarrow 0 = 25m + (V_y)_i (2.76s) + \frac{1}{2}(-9.8 m/s^2)(2.76s)^2$$

$$\Rightarrow 0 = 25m + (V_y)_i (2.76s) - 37.3m$$

$$\Rightarrow 0 = (V_y)_i (2.76s) - 12.3m$$

$$\Rightarrow (V_y)_i = \frac{+12.3m}{2.76s} = 4.466 m/s$$ ← positive, so he threw #2 upwards

(15.) One day finds your instructor fleeing from a mob of angry physics students. As is usually the case in situations like this, he eventually finds himself caught at the edge of a 12-m high ravine. 6.0 m away is the other side of the ravine which is only 8.0 m high. (As schematically shown below.) In desperation, your instructor launches himself with speed 6.5 m/s and angle 15°. Does he make it to the other side of the ravine? For full credit, you must do a *correct* numerical calculation.



Assume $X_f = 6M$
Find y_f. If
y_f less than 8m
Doesn't make it.

$$\underline{\text{Known}}: X_i = 0,\ X_f = 6m,\ y_i = 12m,\ \vec{V}_i = 6.5m/s \text{ at } 15^\circ$$

$$\Rightarrow (V_x)_i = 6.5m/s \cos 15^\circ = 6.28m/s$$

$$(V_y)_i = 6.5m/s \sin 15^\circ = 1.68m/s$$

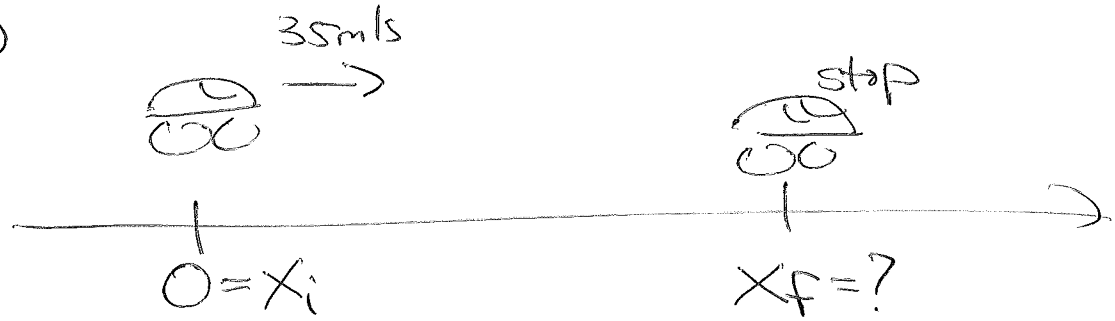
$$\underline{\text{Unknown}}: \Delta t,\ y_F$$

$$X_f = X_i + (V_x)_i \Delta t \Rightarrow 6m = 0 + 6.28m/s\,\Delta t \Rightarrow \Delta t = \frac{6m}{6.28m/s} = 0.955s$$

$$y_F = y_i + (V_y)_i \Delta t - \tfrac{1}{2}g\Delta t^2 = 12m + (1.68m/s)(0.955s) - 4.9m/s^2(0.955s)^2 = 9.13m$$

Makes it!

1)



KNOWN: $X_i = 0$, $(V_x)_i = 35\,m/s$, $(V_x)_f = 0$

$a_x = -2.5\,m/s^2$

UNKNOWN: Δt, X_f

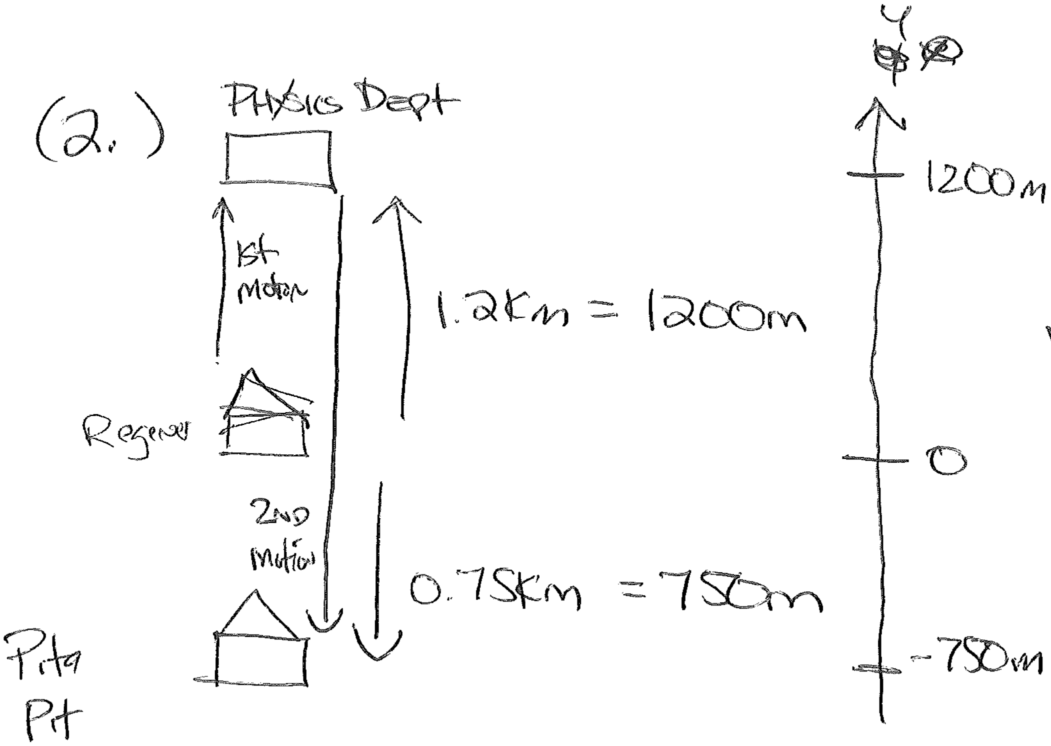
SINCE WE DON'T CARE About Δt:

$$(V_x)_f^2 = (V_x)_i^2 + 2a_x(X_f - X_i)$$

$$\Rightarrow 0^2 = (35\,m/s)^2 + 2(-2.5\,m/s^2)(X_f - 0)$$

$$\Rightarrow X_f = \frac{(35\,m/s)^2}{5\,m/s^2} = 245\,m$$

(2.)



FOR ENTIRE TRIP

$$V_{AV} = \frac{\Delta y_{TOTAL}}{\Delta t_{TOTAL}}$$

KNOWN: 1^{st} MOTION: $V_1 = 4 m/s$, $y_{i,1} = 0$, $y_{F,1} = 1200m$

2^{ND} MOTION: $V_2 = -2.5 m/s$ $y_{2,i} = 1200m$, $y_{2,F} = -750m$

TOTAL MOTION: $y_{T,i} = 0$, $y_{T,f} = -750m$

$$\Delta y_{TOTAL} = -750m - 0 = -750m$$

$\Delta t_{total} = \Delta t_1 + \Delta t_2$ where $V_1 = \frac{\Delta y_1}{\Delta t_1}$ AND $V_2 = \frac{\Delta y_2}{\Delta t_2}$

$$\Delta t_1 = \frac{\Delta y_1}{V_1} = \frac{(y_{F,1} - y_{i,1})}{V_1} = \frac{(1200m)}{4 m/s} = 300s$$

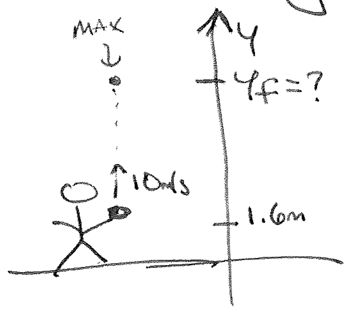
$$\Delta t_2 = \frac{\Delta y_2}{V_2} = \frac{(y_{F,2} - y_{i,2})}{V_2} = \frac{(-750m - 1200m)}{-2.5 m/s} = \frac{-1950m}{-2.5 m/s} = 780s$$

So $\Delta t_{TOTAL} = 300s + 780s = 1080s$

$$V_{AV,TOTAL} = \frac{-750m}{1080s} = -0.694 m/s$$

So magnitude $0.69 m/s$

3.) ON MOON $g = \frac{1}{3}(9.8 m/s^2) = 3.267 m/s^2$



KNOWN: $(V_y)_i = 10 m/s$, $(V_y)_F = 0$ at max height

$y_i = 1.6m$ $\quad a_y = -3.267 m/s^2$

UNKNOWN: Δt, y_F

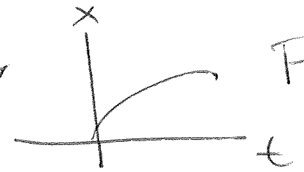
Again, since we don't care about Δt

$$(V_y)_f^2 = (V_y)_i^2 + 2a_y(y_f - y_i)$$

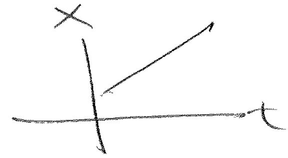
$$\Rightarrow 0 = (10 m/s)^2 + 2(-3.267 m/s^2)(y_f - 1.6m)$$

$$\Rightarrow y_f = 1.6m + \frac{(10 m/s)^2}{2(3.267 m/s^2)} = 1.6m + 15.3m = 16.9m$$

4.) MOTION OF TWO PIECES: DECELERATION (Constant)

$\Rightarrow$ 

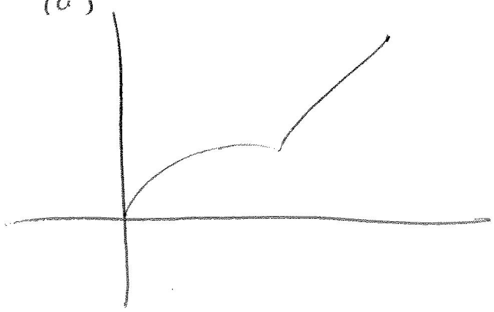
PARABOLA

THEN UNIFORM MOTION $\Rightarrow$ 

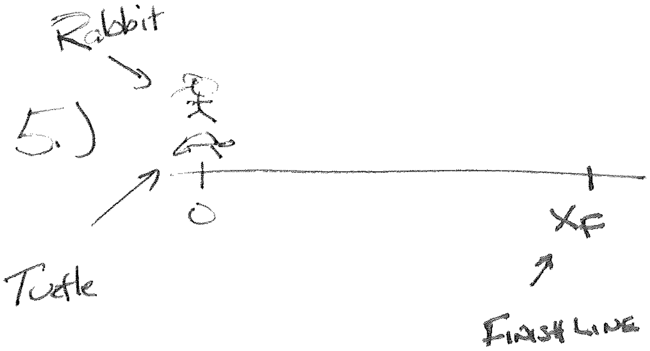
STRAIGHT LINE

so together:

(a)



5.)



KNOWN: Rabbit: $V_R = 15 km/h$

Turtle: $V_T = 6.5 km/h$

UNKNOWN: Rabbit: Δt_R, X_F

Turtle: Δt_T, X_F

BUT WE KNOW THAT X_F IS SAME FOR BOTH AND TURTLE FINISHES 25 MIN AFTER $\Rightarrow \Delta t_T = \Delta t_R + 25 min$. To keep units consistent: $25 min \times \frac{1h}{60 min}$

$= 0.4167 h$

$$V_{AV} = \frac{\Delta x}{\Delta t} \Rightarrow V_R = \frac{X_F - 0}{\Delta t_R}, \quad V_T = \frac{X_F - 0}{\Delta t_T} = \frac{X_F}{\Delta t_R + 0.4167h}$$

$$X_F = V_R \Delta t_R \qquad X_F = V_T(\Delta t_R + 0.4167h)$$

$\therefore \quad X_f = V_R \Delta t_R = (15\,km/h)\Delta t_R$

$X_f = V_T(\Delta t_R - 0.4167h) = 6.5\,km/h\,(\Delta t_R + 0.4167h)$

$= 6.5\,km/h\,\Delta t_R + 2.7083\,km$

So $(15\,km/h)\Delta t_R = (6.5\,km/h)\Delta t + 2.7083\,km$

$\Rightarrow (15\,km/h - 6.5\,km/h)\Delta t_R = 2.7083\,km \Rightarrow (8.5\,km/h)\Delta t_R = 2.7083\,km$

$\Rightarrow \Delta t_R = \dfrac{2.7083\,km}{8.5\,km/h} = 0.3186h$

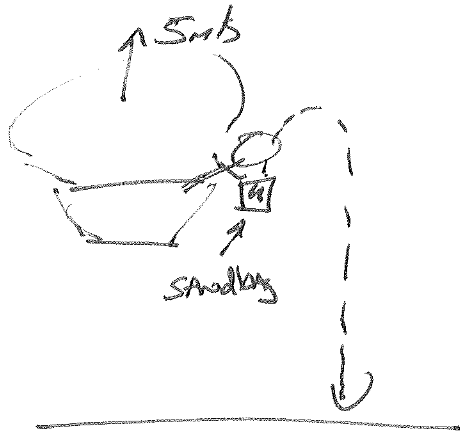
$X_f = (15\,km/h)(0.3186h) = 4.779\,km = 4.8\,km$

(e) Given V_x vs t $\Rightarrow$ Acceleration is <u>slope</u>

at $t=4s$ we can use $t_i = 3s$, $V_i = 4m/s$ $t_f = 5s$, $V_f = 2.5m/s$

Since acceleration is SAME constant for all times between 3s and 5s (since V_x vs. t is straight line)

$$a_x = \frac{V_f - V_i}{t_f - t_i} = \frac{2.5m/s - 4m/s}{5s - 3s} = \frac{-1.5m/s}{2s} = -0.75m/s^2$$



SANDBAG RISES BEFORE FALLING BACK DOWN BECAUSE ITS $(V_y)_i = 5\,m/s$ SINCE IT WAS ON BALLOON.

KNOWN: ACTUALLY THERE ARE 3 MOTIONS

BALLOON RISES WITH CONSTANT SPEED = #1

SANDBAG FALLS WITH $a_y = -9.8\,m/s^2$ = #2

BALLOON ACCELERATES UP AT $2\,m/s^2$ = #3

KNOWN FOR #1: $y_i = 0$, $(V_y)_i = (V_y)_{F1} = 5\,m/s$, $a_y = 0$, $\Delta t_1 = 12\,s$

UNKNOWN FOR #1: $y_{F,1}$

UNIFORM MOTION $\Rightarrow y_{F,1} = y_i + (V_y)_i \Delta t \Rightarrow y_F = 0 + (5\,m/s)(12\,s) = 60\,m$

THE FINAL $y_{F,1}$ BECOMES INITIAL FOR #2 AND #3, $(V_y)_{F1}$ ALSO INITIAL FOR #2, #3

KNOWN FOR #2: $y_{i,2} = 60\,m$, $(V_y)_{i,2} = 5\,m/s$, $a_y = -9.8\,m/s^2$; $y_F = 0$

UNKNOWN: Δt_2, $(V_y)_{F2}$

$$y_F = y_i + (V_y)_i \Delta t + \tfrac{1}{2} a_y \Delta t^2 \Rightarrow 0 = 60\,m + (5\,m/s)\Delta t_2 + \tfrac{1}{2}(-9.8\,m/s^2)\Delta t_2^2$$

$$\Rightarrow 0 = 60\,m + (5\,m/s)\Delta t_2 - 4.9\,m/s^2\,\Delta t_2^2 \Rightarrow +4.9\,m/s^2\,\Delta t_2^2 - (5\,m/s)\Delta t_2 - 60\,m = 0$$

QUADRATIC EQN: $$\Delta t_2 = \frac{+5\,m/s \pm \sqrt{(5\,m/s)^2 - 4(4.9\,m/s^2)(-60\,m)}}{2(4.9\,m/s^2)} = \frac{5\,m/s \pm \sqrt{1201\,m^2/s^2}}{9.8\,m/s^2}$$

$\Delta t_2 = 4.046s$ or $\cancel{-3.026s}$

Finally, we know $\Delta t_3 = \Delta t_2$ since we want how high balloon is when sandbag hits ground

Known for #3: $y_{i,3} = 60m$, $(V_y)_{i3} = 5m/s$, $a_y = 2m/s^2$, $\Delta t_3 = \Delta t_2 = 4.046s$

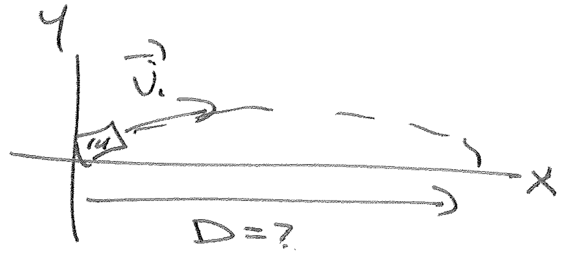
Unknown: $(V_y)_{f,3}$ $y_{f,3}$

$$y_f = y_i + (V_y)_i \Delta t + \frac{1}{2} a_y \Delta t^2$$

$$\Rightarrow y_{f,3} = 60m + (5m/s)(4.046s) + \frac{1}{2}(2m/s^2)(4.046s)^2$$

$$\Rightarrow y_{f,3} = 96.6m$$

8) What is Range?



Known:

$x_i = 0$, $y_i = 0$, $y_f = 0$

$\vec{V}_i = 25m/s$ at $29°$

$\Rightarrow (V_x)_i = 25m/s \cos 29° = 21.865m/s$

$(V_y)_i = 25m/s \sin 29° = 12.12m/s$

Unknown: Δt, $x_f = D = ?$

To Find X_f, we first need to find Δt

$y_f = y_i + (V_y)_i \Delta t - \frac{1}{2} g \Delta t^2$ will work

$0 = 0 + (12.12\,m/s)\,\Delta t - \frac{1}{2}(9.8\,m/s^2)\,\Delta t^2$

$\Rightarrow 0 = \Delta t\,[12.12\,m/s - 4.9\,m/s^2\,\Delta t]$

$\Rightarrow \Delta t = 0$ OR $12.12\,m/s - 4.9\,m/s^2\,\Delta t = 0 \Rightarrow \Delta t = \frac{12.12\,m/s}{4.9\,m/s^2}$

$= 2.47\,s$

$X_f = X_i + (V_x)_i \Delta t \Rightarrow X_f = 0 + (21.865\,m/s)(2.47\,s)$

$\Rightarrow X_f = 54\,m$

9) Standard Angle for $\vec{A}$: $180° - 55° = 125°$

Standard Angle for $\vec{B}$: $-75°$

$\Rightarrow A_x = 3\,m \cos 125° = -1.72\,m$, $A_y = 2.46\,m$

$B_x = 2\,m \cos(-75°) = 0.518\,m$, $B_y = 2\,m \sin(-75°) = -1.93$

$R_x = A_x + B_x = -1.72\,m + 0.518\,m = -1.202\,m$

$R_y = A_y + B_y = 2.46\,m - 1.93\,m = 0.53\,m$

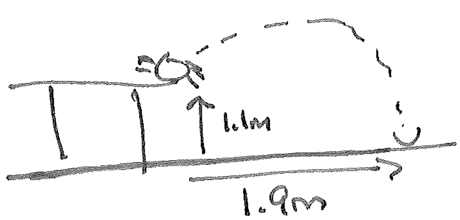
$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{(1.202m)^2 + (0.53m)^2} = 1.31366m$$
$$= 1.3m$$

SINCE I'M at it: R_x Neg, R_y pos. $\Rightarrow \vec{R}$ IN 2ND QUAD.

So Calculator WRONG by 180°

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) + 180° = \tan^{-1}\left(\frac{.53}{-1.202}\right) + 180° = -23.8° + 180°$$
$$= 156.2°$$

10)



KNOWN: $X_i = 0$, $X_F = 1.9m$

$Y_i = 1.1m$, $Y_F = 0$

$\Delta t = 0.85s$

UNKNOWN: $(V_x)_i$, $(V_y)_i$, $(V_x)_F$, $(V_y)_F$

$$X_F = X_i + (V_x)_i \Delta t \Rightarrow 1.9m = 0 + (V_x)_i (0.85s) \Rightarrow (V_x)_i = 2.235 m/s$$

$$Y_F = Y_i + (V_y)_i \Delta t - \tfrac{1}{2} g \Delta t^2 \Rightarrow 0 = 1.1m + (V_y)_i (0.85s) - \tfrac{1}{2}(9.8 m/s^2)(0.85s)^2$$

$$\Rightarrow 0 = 1.1m + (V_y)_i (0.85s) - 3.54m \Rightarrow 0 = (V_y)_i (0.85s) - 2.44m$$

$$\Rightarrow (V_y)_i = \frac{2.44m}{0.85s} = 2.87 m/s$$

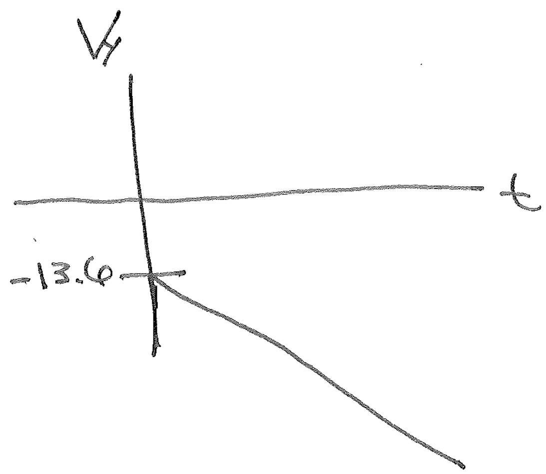
I can't Help
& Myself!

$$V_i = \sqrt{(V_x)_i^2 + (V_y)_i^2} = \sqrt{(2.235\text{m/s})^2 + (2.87\text{m/s})^2} = 3.64\text{m/s}$$

$$\theta = \tan^{-1}\left(\frac{(V_y)_i}{(V_x)_i}\right) = \tan^{-1}\left(\frac{2.87}{2.235}\right) = 52^\circ$$

11.) $(V_y)_f = (V_y)_i - g\Delta t \Rightarrow$ LINE WITH Negative slope. $(V_y)_i = V_i \sin\theta = 15\text{m/s} \sin(-65^\circ) = -13.6\text{m/s}$

$\Rightarrow$



12.) SEE picture ON original but $\vec{V}_{AV}$ points FROM A to B

$\vec{V}_{AV} = \frac{\Delta\vec{r}}{\Delta t}$ $\Delta\vec{r}$ has Components $\Delta X = (1\text{Km} - 4\text{Km}) = -3\text{Km}$

$\Delta y = (3\text{Km} - 1\text{Km}) = 2\text{Km}$

$$\Delta r = \sqrt{\Delta X^2 + \Delta Y^2} = \sqrt{(3\text{Km})^2 + (2\text{Km})^2} = \sqrt{13\text{Km}^2} = 3.6\text{Km}$$

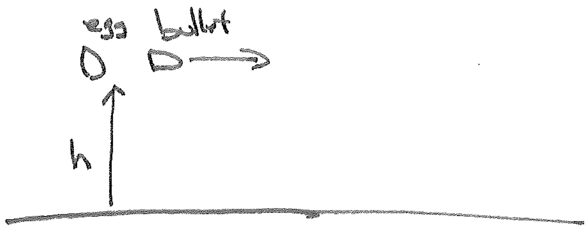
$$V_{AV} = \frac{\Delta r}{\Delta t} = \frac{3.6\text{Km}}{2.5\text{MIN}} = 1.442\text{Km/MIN} = 1.4\text{Km/MIN}$$

SINCE $\vec{V}_{AV}$ AT SAME Angle AS $\Delta\vec{r}$, WE CAN FIND its Standard Angle.

Δx Neg., Δy positive $\Rightarrow$ 2ND QUAD. $\Rightarrow$ Calculator wrong by $180°$ $\Rightarrow \theta = \tan^{-1}\left(\frac{\Delta y}{\Delta x}\right) + 180° = \tan^{-1}\left(\frac{2}{-3}\right) + 180°$

$\Rightarrow \theta = -33.69° + 180° = 146.3°$

13.)



$y_f = y_i + (V_y)_i \Delta t - \frac{1}{2} g \Delta t^2$

Since bullet FIRED Horizontally, its $(V_y)_i = 0$

egg dropped FROM Rest, so its $(V_y)_i = 0$

$\Rightarrow 0 = h - \frac{1}{2} g \Delta t^2$ FOR Both

$\Rightarrow \Delta t$ SAME FOR BOTH