Week 4 Quiz

Thursday, October 22, 2020 12:31 PM

In an atmospheric science experiment, Benny launches a model rocket from rest on the Earth's surface. For the first 5.00 seconds of its flight, assuming a standard coordinate system, Benny measures the rocket's acceleration to be < 0 , 14.73 > m/s². At exactly 5.00 seconds into the flight, the thrusters on the rocket turn off.

(a) What is the largest height above the Earth's surface that the rocket reaches? (assume no air resistance)

Consider the following table of times when answering parts (b) and (c) (Note: you do ***not*** need to find values for these times)

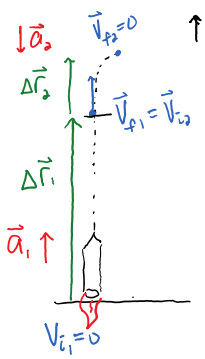
t_0	Time of launch
t_5	Time when thrusters turn off
t_{top}	Time when rocket reaches highest elevation
t_{crash}	Time when rocket lands back on Earth

(b) Over which time intervals (or between which of the above times) is the rocket accelerating? Briefly explain your reasoning in words, phrases, diagrams, etc.

(c) Over which time intervals (or between which of the above times) is the rocket slowing down? Briefly explain your reasoning in words, phrases, diagrams, etc.

(b) The rocket is accelerating **during the entire motion**. Acceleration is defined as a changing velocity and the rocket is changing its velocity the entire trip. The acceleration in the first stage is from the rocket's thrusters overcoming gravity to give it a positive 14.73 m/s². When the rocket's thrusters turns off it is only under the influence of gravity and maintains a constant -9.8 m/s² all the way until it hits the ground.

(c) The rocket is moving upward with an acceleration pointing upward while the thrusters are on. This results in it speeding up during that time interval. **After the thrusters turn off the velocity is still upward but the acceleration from gravity points downward. From the time the thrusters turn off to the time the rocket reaches its maximum height, it slowing down because the velocity points in the opposite direction of the acceleration.** From the time it is a max height all the way until it hits the ground the rocket is speeding up because the velocity points downward, in the same direction as the acceleration from gravity.



$\hat{y}$ 1-D

Stage 1	K	UK
	$a_1 = +14.73\ m/s^2$	v_{f1}
	$\Delta t_1 = 5s$	Δy_1 ?
	$v_{i1} = 0\ m/s$	

Stage 2		
	$a_2 = -9.8\ m/s^2$	Δy_2 ?
	$v_{f2} = 0\ m/s$	$v_{i2} = v_{f1}$ ← Connections
		Δt_2

eqs.

(i) $\Delta y = v_i \Delta t + \frac{1}{2} a \Delta t^2$

(ii) $v_f = v_i + a \Delta t$

(iii) $v_f^2 = v_i^2 + 2a\Delta y$

Rubric

(a) 8 points

- 1.5 pts - physical representation
- 1 pt - known and unknown variables
- 1 pt - treating it as a 2 stage problem
- 1 pt - finding delta_y_1
- 1 pt - finding V_f_1
- 0.5 pt - V_f_1 = V_i_2
- 1 pt - finding delta_y_2
- 0.5 pts - max height = delta_y_1 + delta_y_2
- 0.5 pts - final answer + units

(b) 1 point

(c) 1 point

[1] (i) $\Delta y_1 = \cancel{v_{i1}}^{0} \Delta t_1 + \frac{1}{2} a_1 \Delta t_1^2$

$\Delta y_1 = 184.125\ m$

now find $v_{f1} = v_{i2}$

(ii) $v_{f1} = \cancel{v_{i1}}^{0} + a_1 \Delta t_1$

$v_{f1} = 73.65\ m/s = v_{i2}$

[2] (iii) $\cancel{v_{f2}}^{0\,2} = v_{i2}^2 + 2a_2 \Delta y_2$

$\Delta y_2 = \frac{-v_{i2}^2}{2a_2} = -\frac{(a_1 \Delta t_1)^2}{2a_2} = 276.75\ m$

total height

$\Delta y_{tot} = \Delta y_1 + \Delta y_2$

$\Delta y_{tot} = \frac{1}{2} a_1 \Delta t_1^2 - \frac{(a_1 \Delta t_1)^2}{2a_2}$

Dimensional Analysis checks out

$\Delta y_{tot} = 461\ m$