This print-out should have 15 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

Reflection 2 Rev-A
001 (part 1 of 9) 10.0 points

Firstly, we might want to know the times at which certain events occur, such as when the cart gets to the end of the track. One way to find this is by editing the condition of the while loop. Currently the condition is set to $t < 10s$, but loop conditions are rather flexible. Change the loop condition so that it ends as soon as the cart gets to the end of the track. You can refer to the x, y, and z components of the cart's position using $cart.pos.x$, $cart.pos.y$, and $cart.pos.z$, respectively. Note that the left and right ends of the track are located at the positions x=-1 and x=1, respectively.

With an initial speed of 5 m/s, how many seconds does it take the cart to reach the end of the track? (We will use this same initial speed throughout the assignment.)

1. 0.7s

2. 1.5s

3. 1.7s

4. 2.0s

5. 0.3s

6. 0.1s

7. 0.6s

8. 1.0s

9. 0.8s

10. 0.4s **correct**

Explanation:

---

002 (part 2 of 9) 10.0 points

Let us investigate the effect of a 10 N net force, $\vec{F} = \langle 10, 0, 0 \rangle$. What could this force represent, physically?

1. Friction due to sliding on the track

2. A fan attached to the cart, blowing steadily **correct**

3. Air resistance on the cart

4. A spring affixed to the left end of the track and the cart

5. A kick given to the cart just as it begins to move

6. Gravity pulling down (-y direction) on the cart

7. The normal force of the track on the cart

Explanation:

---

003 (part 3 of 9) 10.0 points

Change your code to use the above force. At what time (in seconds) will cart reach the end of the track?

1. 0.07s

2. 0.22s

3. 0.56s

4. 0.62s

5. 0.31s **correct**

6. 1.0s

7. 0.24s

8. 0.36s

9. 0.81s

10. 0.13s

Explanation:

---

004 (part 4 of 9) 10.0 points

Now try a 10 N force in the opposite direction, $\vec{F} = \langle -10, 0, 0\rangle$. Which of the following is a complete description of the cart's behavior over time?

1. The cart first moves to the left with an increasing speed, turns around, then moves to the right with a decreasing speed

2. The cart moves to the right with an increasing speed

3. The cart moves to the left with a decreasing speed

4. The cart first moves to the right with a decreasing speed, turns around, then moves to the left with an increasing speed **correct**

5. The cart moves to the left with a constant speed

6. The cart first moves to the left with a decreasing speed, turns around, then moves to the right with an increasing speed

7. The cart first moves to the right with an increasing speed, turns around, then moves to the left with an increasing speed

8. The cart moves to the right with a decreasing speed

9. The cart moves to the right with a constant speed

10. The cart moves to the left with an increasing speed

Explanation:

---

005 (part 5 of 9) 10.0 points

How long (in seconds) does the cart take to return to its original position? (Hint: You will need to edit the condition of your while loop again.)

1. 0.31s

2. 0.36s

3. 1.0s **correct**

4. 0.56s

5. 0.07s

6. 0.24s

7. 0.22s

8. 0.62s

9. 0.81s

10. 0.13s

Explanation:

---

006 (part 6 of 9) 10.0 points

Which force causes the cart to barely touch the end of track, turn around, and then return to the starting point?

1. $\vec{F} = \langle 14, 0, 0\rangle$

2. $\vec{F} = \langle -6, 0, 0\rangle$ **correct**

3. $\vec{F} = \langle 2, 0, 0\rangle$

4. $\vec{F} = \langle -2, 0, 0\rangle$

5. $\vec{F} = \langle -8, 0, 0\rangle$

6. $\vec{F} = \langle -12, 0, 0\rangle$

7. $\vec{F} = \langle -14, 0, 0\rangle$

8. $\vec{F} = \langle 6, 0, 0\rangle$

9. $\vec{F} = \langle 10, 0, 0\rangle$

10. $\vec{F} = \langle 8, 0, 0\rangle$

Explanation:

---

007 (part 7 of 9) 10.0 points

Now let us make the cart airborne. We need to change two things in the code to achieve this.

First, go to the *OBJECTS AND INITIAL VALUES* section of your code and change the initial angle at which the projectile is fired to 45 degrees. Next, change your net force to represent gravity. The mass of the cart, *cart.m*, and the gravitational acceleration, g, are already defined in the program.

How long (in seconds) is the cart airborne– that is, before it hits the ground? (It's ok if this occurs beyond the length of track.)

1. 0.72s **correct**

2. 0.79s

3. 0.49s

4. 0.63s

5. 0.12s

6. 0.88s

7. 0.35s

8. 0.56s

9. 0.33s

10. 0.41s

Explanation:

---

008 (part 8 of 9) 10.0 points

Notice where the cart lands when the angle is approximately 26 degrees. At what other angle (in degrees) will this occur? [This is because analytically, the range is proportional to $\sin(2\theta)$, which is symmetric about the value $\theta = 45$ degrees.]

1. 34

2. 51

3. 64 **correct**

4. 23

5. 82

6. 59

7. 68

8. 44

9. 73

10. 16

Explanation:

---

009 (part 9 of 9) 10.0 points

Fire the cart straight up in the air. Once you have made the change required to do this, add a line at the bottom of your program to output the final momentum:

$$print\ \ cart.p$$

Which of the following is true for this case? (Remember that iterative calculations are by nature approximate. Choose the answer that you think best represents reality.)

1. $|\vec{p_f}| > |\vec{p_i}|$

2. $|\vec{p_f}| < |\vec{p_i}|$

3. $|\vec{p_f}| = |\vec{p_i}|$ **correct**

Explanation:

Reflection 2 Rev-B

010 (part 1 of 6) 10.0 points

Do you think this relation would hold at a nonzero angle?

1. Yes **correct**

2. No

Explanation:

---

011 (part 2 of 6) 10.0 points

Let's try a somewhat less predictable trajectory. This time, we will use both the fan and gravitational forces. Let us do this by writing three lines for the forces:

$$Ffan = vector(-10, 0, 0)$$

$Fgrav =$ [what you already had before]

$$Fnet = Fgrav + Ffan$$

Change your launch angle back to 45 degrees. Which of the following is observed?

1. The cart begins by moving in the +x and +y directions, then moves in the -x and +y directions at the time of impact

2. The cart begins by moving in the +x and +y directions, then moves in the +x and +y directions at the time of impact

3. The cart begins by moving in the +x and +y directions, then moves in the +x and -y directions at the time of impact

4. The cart begins by moving in the +x and +y directions, then moves in the -x and -y directions at the time of impact **correct**

5. The cart continues to move in the +x direction with constant velocity

6. The cart continues to move in the +y direction with constant velocity

7. The cart's speed is constant, but its direction changes

Explanation:

---

012 (part 3 of 6) 10.0 points

At what angle (approximately) must the cart be launched so that $p_{fx} = 0$?

1. 59

2. 53

3. 16

4. 73

5. 33

6. 82

7. 26 **correct**

8. 11

9. 18

10. 66

Explanation:

---

013 (part 4 of 6) 10.0 points

Do you think there is any other angle between 0 and 90 degrees at which $p_{fx} = 0$? (Hint: How does the angle affect flight time? How does flight time affect p_{fx}?)

1. No **correct**

2. Yes

Explanation:

---

014 (part 5 of 6) 10.0 points

All of the above questions can also be worked out analytically because constant forces produce relatively simple motion. However, it is easy to modify our program to produce trajectories that cannot be solved for analytically, which is one of the main reasons we are interested in iterative computer modeling. One very common day-to-day example of a non-constant force is air resistance, since it depends on the velocity at which an object is moving. In the ideal case, air resistance is proportional to v^2 and is directed opposite to the direction of motion. Let us assume for the time being that the constant of proportionality is 1. Thus, $\vec{F}_{air}$ is given by

$$\vec{F}_{air} = -|\vec{v}^2|\hat{v} = -|\vec{v}|\vec{v}$$

In VPython, this statement reads

$$Fair = -mag(cart.p/cart.m) * cart.p/cart.m$$

Set your $Fnet$ equal to the sum of $Fgrav$ and $Fair$ (no fan force), then reset your launch angle to 45 degrees. Which of the following pairs of statements is true?

Is the resulting trajectory spatially symmetric like the parabola due to gravity alone?
Ia. Yes
Ib. No

IIa. $|\vec{p_f}| > |\vec{p_i}|$
IIb. $|\vec{p_f}| < |\vec{p_i}|$
IIc. $|\vec{p_f}| = |\vec{p_i}|$

1. Ib, IIa

2. Ia, IIb

3. Ib, IIb **correct**

4. Ia, IIc

5. Ib, IIc

6. Ia, IIa

Explanation:

---

015 (part 6 of 6) 10.0 points

We will now use our model to answer a subtle question. In introductory physics, it is often taught that if one bullet is shot horizontally from a gun and another bullet is dropped from the same height at the same instant, the two bullets will hit the ground at the same time. This is certainly true in the absence of air resistance, since the motion in the y direction is completely independent of the motion in the x direction. However, is this statement still true in the presence of air resistance?

We can easily use our model to find out. In the *OBJECTS AND INITIAL VALUES* section of your code, edit the cart's position so that it starts at a height of 1 m. Its position should be $pos = vector(-1, 1, 0)$. Now set your initial velocity to 5 m/s at 0 degrees. Run the program and record the time taken to hit the ground. Finally, set your initial velocity to 0 m/s at 0 degrees and again record the time taken to hit the ground. What are the two times in seconds?

[If you have time, you may want to remove F_{air} from the model to verify that the dropped and shot times are the same without air resistance; they will be. The explanation for the result you have deduced is that the motion in the x and y directions are *coupled*. In other words, they depend on one another. Therefore, the horizontal speed of the bullet affects the vertical air resistance force, leading to different times for the shot versus dropped bullets.]

1. $t_{shot} = 0.73s, t_{dropped} = 0.73s$

2. $t_{shot} = 0.78s, t_{dropped} = 0.94s$

3. $t_{shot} = 0.57s, t_{dropped} = 0.53s$ **correct**

4. $t_{shot} = 0.51s, t_{dropped} = 0.55s$

5. $t_{shot} = 0.42s, t_{dropped} = 0.42s$

6. $t_{shot} = 0.28s, t_{dropped} = 0.11s$

7. $t_{shot} = 0.77s, t_{dropped} = 0.15s$

8. $t_{shot} = 0.87s, t_{dropped} = 0.87s$

9. $t_{shot} = 0.02s, t_{dropped} = 0.47s$

10. $t_{shot} = 0.02s, t_{dropped} = 0.35s$

Explanation: