Physics 172 – Recitation 03

Spring 2012

You will find more information about the new topics covered by today's problems throughout chapter 2 of the text.

Problem 1. Two astronauts decide to pass some time during a long stay aboard the ISS (International Space Station) by making a video entitled *Toys in Space*. They record the behavior of toy-like systems as they rotate, vibrate and move through the station.

One "toy" whose motion they record consists of a pair of metal spheres whose centers are connected by a weak spring. The spring's relaxed length is $l_0 = 10\text{ cm}$. Its stiffness is $k = 20\text{ N/m}$, and its mass is very small compared to the masses of the spheres, $m_1 = 0.1\text{ kg}$ and $m_2 = 0.2\text{ kg}$. Assume that the spheres are small compared to the distance between their centers.

The astronauts record one motion of this toy that begins with the sphere centers at initial locations $\vec{r}_1 = <2.10, 0.02, 1.30>\text{ m}$ and $\vec{r}_2 = <2.05, -0.02, 1.34>\text{ m}$ with initial velocities $\vec{v}_1 = <-0.07, 0.05, 0.12>\text{ m/s}$ and $\vec{v}_2 = <-0.08, 0.04, 0.13>\text{ m/s}$ in a coordinate system whose origin is near the center of the ISS lab space.

a) What is the magnitude of the initial force exerted by the spring on sphere 1?

b) What is the direction of that force? Hint: a dimensionless unit vector will be useful when answering this question.

c) Estimate the momentum of sphere 1 a millisecond after the toy is released. Explain clearly how you used fundamental principles and definitions to build any equations that you used to obtain your answer.

d) Estimate the momentum of sphere 2 at that same time. Explain clearly how you used fundamental principles and definitions to build any equations that you used to obtain your answer.

e) What is the initial value of the toy's total momentum, that is, what is the initial momentum of the system consisting of spheres 1 and 2 and the spring?

f) What is the value of the toy's total momentum 1 millisecond later? Did you need your answers to parts c) and d) to answer this question? Are your answers to parts c) and d) consistent with Newton's 3rd law?

Save your answers to c) and d). You will need them later.

[Checkpoint 1]

g) Estimate where spheres 1 and 2 will be a millisecond after the toy was released. Do you expect your estimates to be perfectly accurate? Explain why or why not. Hint: Are the forces acting on the spheres constant during the one millisecond time interval of interest?

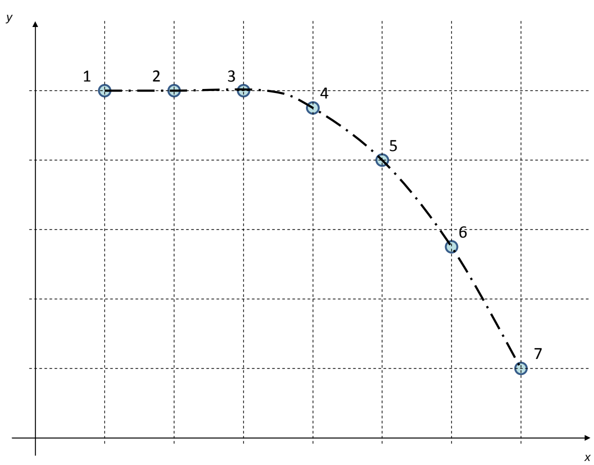
h) If you knew the forces acting on the spheres one millisecond after the toy was released, could you determine their velocities and positions two milliseconds after it was released? If not, explain why not. If so, describe the sequence of steps you would use to determine them given the components of the forces acting on each sphere.

i) Since you have estimated the positions and velocities of the spheres one millisecond after the toy was released, can you estimate the forces acting on them at that time? If not, explain why not. If so, describe the sequence of steps you would use to determine the components of the force acting on each sphere (you do not have to calculate the components).

j) After reading through chapter 2 of the text, your roommate says "That means that if I know the initial position and velocity of any object and can determine the net force that acts on it at any later time, I can make a good estimate of where it will be and how it will be moving at any later time. Wow!" Explain why you agree or disagree with them.

[Checkpoint 2]

Problem 2. The figure below was used last week to display the motion of a child's low-friction toy car moving across and flying off the edge of a balcony. It shows the car's position at a sequence of equally spaced times separated by 0.226 seconds. The car runs of the balcony's edge at t_3. The gridlines shown are 1 meter apart.



Consider a different situation in which a child is running with the toy car across a pedestrian bridge over a creek. The child is pretending that it is a "flying space car" and he/she is holding it out over the bridge's handrail while running at constant speed.

In a coordinate system with the *x* axis running across the creek's surface parallel to the bridge, the position of the child's car at times t_1, t_2 and t_3 are the same as the ones in the figure above. If the child drops the car at t_3, where do you think it will hit the water? Explain why you think your estimate is reasonable.

[Checkpoint 3]