

## Systems of Particles – Set 3

Name: \_\_\_\_\_

Problems Solved 1 / 7



Neo and Agent Smith are flying towards each other. They collide in mid air and grab onto each other (they stick together).

a) Assume that momentum is conserved in the Matrix and find an expression relating their initial velocities to their final velocity.

b) Let  $M_N = 70$  kg,  $V_{NI} = 50$  m/s,  $M_S = 100$  kg, and  $V_{SI} = 35$  m/s. Put these numbers into your expression and solve for their final velocity.

c) Calculate the pre-collision and post-collision kinetic energy of the system. Does this system conserve kinetic energy through the collision?

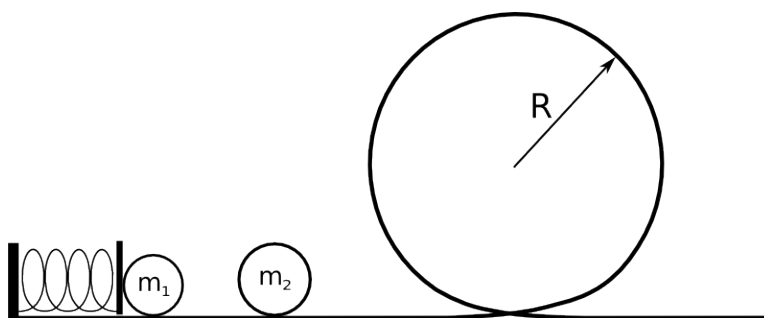
## Systems of Particles – Set 3

2

A 4000 kg railroad car collides and sticks to a chain of three other 4000 kg cars initially sitting at rest on a rough track. The four cars travel together down the rough track for 1.5 m before they stop. Assuming  $\mu_k = 0.10$ , what is the velocity of the first car at impact?

In the system below, a ball of mass  $m_1$  is placed against a spring with spring constant  $k$  that has been compressed a distance  $d$ . It is released from rest and collides with a second ball of mass  $m_2$  which then goes around the loop of radius  $R$ .

Find an expression for the minimum spring compression  $d$  in terms of  $m_1$ ,  $m_2$ ,  $k$ ,  $R$ , and  $g$  such that  $m_2$  makes it around the loop.



You are driving West along Summit Ave, lawfully doing the speed limit (50 km/hr) in your new car which (as you've read in the owners manual) has a mass of 1500 kg. Sleepy McSnoozer is driving South along Cleveland in his 1965 Ford pickup truck loaded with bags of cement. His truck (plus cement) weighs 2300 kg. Sleepy runs the red light and smashes into your car. The cars fuse together and skid to a stop.

Certain that Sleepy was speeding, you measure the skid mark and find that the length of the skid is  $L = 18$  m. You look up the rubber/asphalt coefficient of friction and find that it is  $\mu_k = 0.6$ .

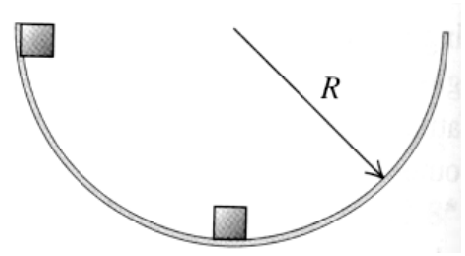
What was Sleepy's velocity? Was he speeding? The speed limit is 50 km/hr.

## Systems of Particles – Set 3

5

Two masses,  $m_1$  and  $m_2$ , are released from rest in a frictionless hemispherical bowl of radius  $R$  from the positions shown in the figure. The upper mass collides with and sticks to the lower mass and the two slide up the other side together.

Derive an expression for their final height of the combined masses.



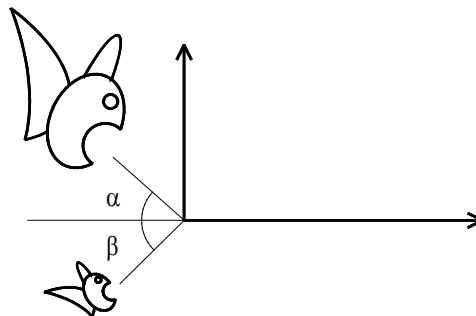
## Systems of Particles – Set 3

6

A large fish will soon make a dish of a smaller fish. What is the velocity of the large fish and his dinner immediately after he eats? Give both the magnitude and direction of the final velocity with respect to the x-axis.

$$\begin{aligned}m_{\text{large fish}} &= 4.0 \text{ kg} \\v_{0 \text{ large fish}} &= 1.0 \text{ m/s} \\ \alpha_{\text{large fish}} &= 25.0^\circ\end{aligned}$$

$$\begin{aligned}m_{\text{small fish}} &= 0.20 \text{ kg} \\v_{0 \text{ small fish}} &= 5.0 \text{ m/s} \\ \beta_{\text{small fish}} &= 50.0^\circ\end{aligned}$$



## Systems of Particles – Set 3

In many classic westerns, gunfighters fly backwards several meters after being shot, often crashing through windows or saloon doors. Assume that a typical bullet weights 2 g and that a typical cowboy weights 80 kg.

- a) If the bullet leaves the gun at 200 m/s, what is the velocity of the cowboy/bullet system after the impact?
- b) What velocity does the bullet need for the cowboy to slide 3 meters across the floor after being shot (assuming  $U_k = 0.5$ )?

