

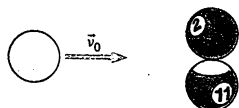
PHYS425: Homework #1

Due: Beginning of class, Monday 01/12/2015

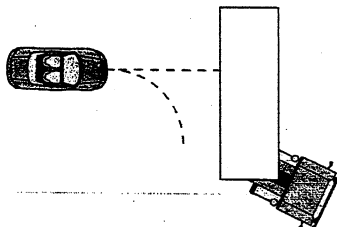
Name: _____

For all of the following problems. Identify the physics concepts involved (for example: conservation of energy, or Newton's second law), and give a brief outline of a solution. Do NOT solve the problems, only list the steps you would take. Please work on your own paper, and staple to this page to turn in.

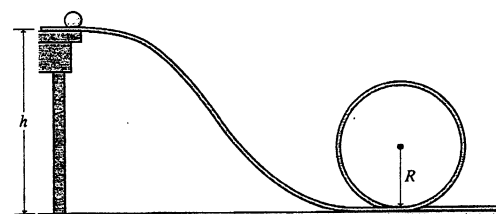
1. Two identical billiard balls are initially at rest when they're struck symmetrically by a third identical ball moving with velocity $\vec{v}_0 = v_0 \hat{i}$ (Fig. 9.26). Find the velocities of all three balls after this elastic collision.



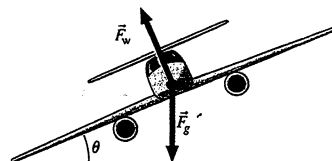
2. Two unfortunate climbers, roped together, are sliding freely down an icy mountainside. The upper climber (mass 75 kg) is on a slope at 12° to the horizontal, but the lower climber (mass 63 kg) has gone over the edge to a steeper slope at 38° . (a) Assuming frictionless ice and a massless rope, what's the acceleration of the pair? (b) The upper climber manages to stop the slide with an ice ax. After the climbers have come to a complete stop, what force must the ax exert against the ice?
3. You try to move a heavy trunk, pushing down and forward at an angle of 50° below the horizontal. Show that, no matter how hard you push, it's impossible to budge the trunk if the coefficient of static friction exceeds 0.84.
4. You're an automotive engineer designing the "crumple zone" of a new car—the region that compresses as the car comes to a stop in a head-on collision. If the maximum allowable force on a passenger in a 70-km/h collision is 20 times the passenger's weight, what do you specify for the amount of compression in the crumple zone?
5. A typical bumblebee has mass 0.25 mg. It beats its wings 100 times per second, and the wings undergo an average displacement of about 1.5 mm. When the bee is hovering over a flower, the average force between wings and air must support the bee's weight. Estimate the average power the bee expends in hovering.
6. Driving in thick fog on a horizontal road, you spot a tractor-trailer truck jackknifed across the road. To avert a collision, you could brake to a stop or swerve in a circular arc, as suggested in Fig. 5.35. Which option offers the greater margin of safety? Assume that there is the same coefficient of static friction in both cases, and that you maintain constant speed if you swerve.



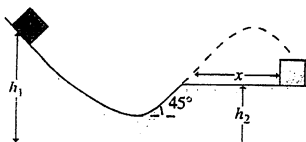
7. In a medical X-ray tube, electrons are accelerated to a velocity of 10^8 m/s and then slammed into a tungsten target. As they stop, the electrons' rapid acceleration produces X rays. If the time for an electron to stop is on the order of 10^{-9} s, approximately how far does it move while stopping?
8. Children sled down a 41-m-long hill inclined at 25° . At the bottom, the slope levels out. If the coefficient of friction is 0.12, how far do the children slide on the level ground?
9. Global Positioning System (GPS) satellites circle Earth at altitudes of approximately 20,000 km, where the gravitational acceleration has 5.8% of its surface value. To the nearest hour, what's the orbital period of the GPS satellites?
10. You're a production engineer in a cookie factory, where mounds of dough drop vertically onto a conveyor belt at the rate of one 12-g mound every 2 seconds. You're asked to design a mechanism that will keep the conveyor belt moving at a constant 50 cm/s. What average force must the mechanism exert on the belt?
11. A solid marble starts from rest and rolls without slipping on the loop-the-loop track in Fig. 10.30. Find the minimum starting height from which the marble will remain on the track through the loop. Assume the marble's radius is small compared with R .



12. You're working in quality control for a model rocket manufacturer, testing a class-D rocket whose specifications call for an impulse between 10 and 20 N·s. The rocket's burn time is $\Delta t = 2.8$ s, and its thrust during that time is $F(t) = at(t - \Delta t)$, where $a = -4.6$ N/s². Does the rocket meet its specs?
13. When a plane turns, it banks as shown in Fig. 5.33 to give the wings' lifting force a horizontal component that turns the plane. If a plane is flying level at 950 km/h and the banking angle is not to exceed 40° , what's the minimum curvature radius for the turn?

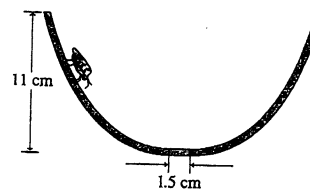


14. A block slides down a frictionless incline that terminates in a 45° ramp, as shown in Fig. 7.23. Find an expression for the horizontal range x shown in the figure as a function of the heights h_1 and h_2 .



15. You're an expert witness in a medical malpractice lawsuit. A hospital patient's leg slipped off a stretcher and his heel hit the floor. The defense attorney for the hospital claims the leg, with mass 8 kg, hit the floor with a force equal to the weight of the leg—about 80 N—and any damage was due to a prior injury. You argue that the leg and heel dropped freely for 0.7 m, then hit the floor and stopped in 2 cm. What do you tell the jury about the force on the heel?
16. In a chase scene, a movie stuntman runs horizontally off the flat roof of one building and lands on another roof 1.9 m lower. If the gap between the buildings is 4.5 m wide, how fast must he run to cross the gap?

17. A bug slides back and forth in a bowl 11 cm deep, starting from rest at the top, as shown in Fig. 7.21. The bowl is frictionless except for a 1.5-cm-wide sticky patch on its flat bottom, where the coefficient of friction is 0.61. How many times does the bug cross the sticky region?



18. The Barringer meteor crater in Arizona is 180 m deep and 1.2 km in diameter. Fragments of the meteor lie just below the bottom of the crater. If these fragments negatively accelerated at a constant rate of $4 \times 10^5 \text{ m/s}^2$ as they plowed through Earth, what was the meteor's speed at impact?
19. Your friend does five reps with a barbell, on each rep lifting 45 kg 0.50 m. She claims the work done is enough to "burn off" a chocolate bar with energy content 230 kcal (see Problem 31). Is that true? If not, how many lifts would it take?