PHYSICS 331 Advanced Classical Mechanics
Problem Set 2

Task 1
A 2-kg and an 8-kg mass collide elastically, compressing a spring bumper on one of them; the bumper returns to its original length as the masses separate. Assume that the collision takes place along a single line and that you can cause the collision to occur in different ways, each having the same initial energy:

Case A: The 8-kg mass has 16 J of kinetic energy and hits the stationary 2-kg mass.

Case B: The 2-kg mass has 16 J of kinetic energy and hits the stationary 8-kg mass.

(a) Which way of causing the collision to occur will result in the greater compression of the spring? Arrive at your choice *without* actually solving for the compression of the spring.

(b) Keeping the condition of a total kinetic energy of 16 J, how should this energy be divided between the two masses to obtain the greatest possible compression of the spring?

Task 2
A particle of mass m and initial velocity u collides *elastically* with a particle of mass M initially at rest. As a result of the collision the particle of mass m is deflected through 90° and its speed is reduced to $\frac{u}{\sqrt{3}}$. The particle of mass M recoils with speed v at an angle θ to the original direction of m. (All speeds and angles are those observed in the laboratory system.)

(a) Find M in terms of m, and v in terms of u. Find also the angle θ.

(b) At what angles are the particles deflected in the centre-of-mass system?

Task 3
Thornton and Marion: Chapter 2, Problems 9, 17.

Task 4
Thornton and Marion: Chapter 2, Problems 12, 13.

Task 5

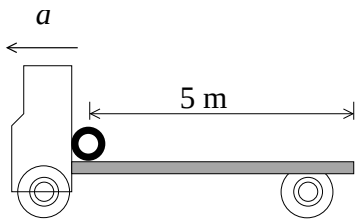
A section of steel pipe of large diameter and relatively thin wall is mounted as shown on a flat-bed truck. The driver of the truck, not realising that the pipe has not been lashed in place, starts up the truck with a constant acceleration of 0.5 g. As a result, the pipe rolls backward (relative to the truck bed) without slipping, and falls to the ground. The length of the truck bed is 5 m.

(a) With what horizontal velocity does the pipe strike the ground?

(b) What is its angular velocity at this instant?

(c) How far does it skid before beginning to roll without slipping, if the coefficient of friction between the pipe and ground is 0.3?

(d) What is its linear velocity when its motion changes to rolling without slipping?



Possibly Helpful

For T & M 2-9: When you obtain an answer for the case with air resistance [part (b)], perform an expansion of your answer to compare your result directly with that for the case of $k = 0$. Appendix D (on p. 610) has the relation that you can use to do the expansion, and you should find that the first term in the expansion agrees perfectly with your result for $k = 0$ from part (a). Now think about the modification due to the next term in the expansion. Does it make sense qualitatively?

For T & M 2-13: Check out Appendix E for "useful integrals." The quantities in the problem are selected so that you'll end up with integrals that look almost exactly like some of those in Appendix E.

Other Things

Don't forget that you have a journal assignment as well. The assigned reading is sections 2.5–2.7 of our text, *Thornton and Marion*.