Exercises in Introductory Physics I

Exercise Sheet 8
due to 11.12.23, 11:59 AM

Collisions

1. Two elementary particles A and B are colliding with high velocities and fuse with a release of energy. In the first experiment, A and B move in a way that their center of mass remains unchanged. The total kinetic energy before the collision is E_{tot}.

   In the second experiment, the particle B is at rest. What kinetic energy E_{A} should particle A have, so that the energy release in the second experiment will be the same as in the first experiment? (2P)

2. Given is the one-dimensional, procedural, elastic collision process provided in the figure below. The spheres B_1, B_2 and B_3 are at rest, $v_1 = v_2 = v_3 = 0$. Sphere B_0 has a speed of $v_0 = 10\,\text{m/s}$ before colliding with sphere B_1. The mass of the next neighbouring sphere is four times of the previous sphere: $4m_0 = m_1$, $4m_1 = m_2$, $4m_2 = m_3$.

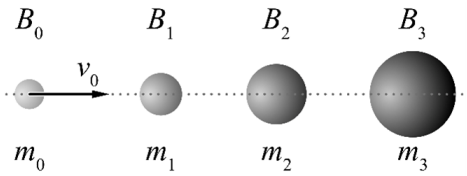

Figure 1: Colliding spheres

   a) Consider the first collision. Calculate the speed after the collision v_0' and v_1' of B_0 and B_1. (2P)

   b) What is the speed v_3' of B_3 after its collision with B_2? (1P)

3. Upon colliding elastically, two bodies with the masses m and $2m$ are moving in opposite directions with the speeds $2v$ and v, respectively.
   Find the velocity of the center-of-mass of the system before the collision. (1P)

4. A body with a mass of $m_B = 60\,g$ is attached to a massless spring with a spring constant of $k = 10\,N/m$ on a frictionless surface. At $t = 0$, a ball with an unknown mass m_A and a horizontal speed of $v_A = 50\,cm/s$ collides elastically with the body. The body then starts to oscillate with an initial speed of $v(t = 0) = 20\,cm/s$.

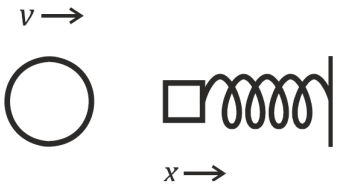

Figure 2: A sphere hitting a block no a spring

   (a) Calculate the mass of the ball m_A. (1P)

   (b) Derive an expression for the equation of motion (x(t)) of the body. (2P)
   Hint: Assume that no further collisions will occur.

5. A block of mass m and a pan of equal mass are connected by a string going over a smooth light pulley as shown in the figure below. Initially the system is at rest, when a particle of mass m_2 falls on the pan and sticks to it.

   If the particle strikes the pan with a speed v, find the speed with which the system moves just after the collision. (1P)

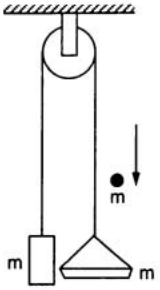

Figure 3: A block and a pan on a pulley