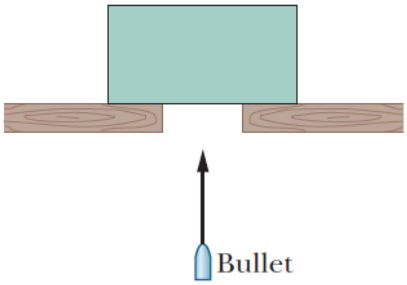
University of Huddersfield
School of Computing & Engineering

Problem Set # 8 — Linear Momentum

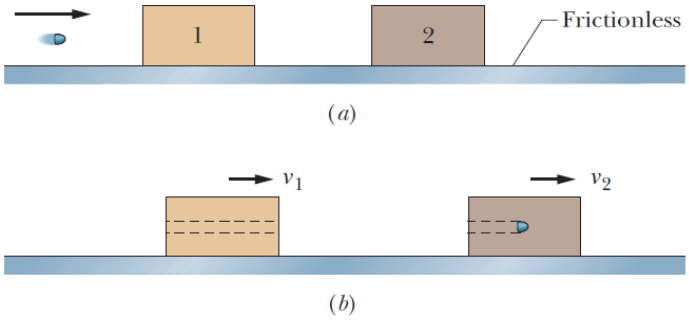
1. A 10 g bullet moving directly upwards at 1000 m/s strikes and passes through the centre of a 5 Kg block initially at rest. The bullet emerges from the block moving directly upwards at 400 m/s. Assuming that the bullet passes through the block so quickly that the block has not had time to move through any distance yet, to what maximum height does the block then rise above its initial position?



2. A 3.50 g bullet is fired horizontally at two blocks at rest on a frictionless table. The bullet passes through block 1 (mass 1.20 Kg) and embeds itself in block 2 (mass 1.80 Kg). The blocks end up with speeds $v_1 = 0.630$ m/s and $v_2 = 1.40$ m/s. Neglecting the material removed from block 1 by the bullet, find

   (a) the speed of the bullet immediately after emerging from the first block;

   (b) the original speed of the bullet.



3. Spheres A (mass 0.02 Kg), B (mass 0.03 Kg), and C (mass 0.05 Kg) are approaching the origin as they slide on a frictionless table. The initial velocities of A and B are given in the diagram shown below. All three spheres arrive at the origin at the same time and stick together.

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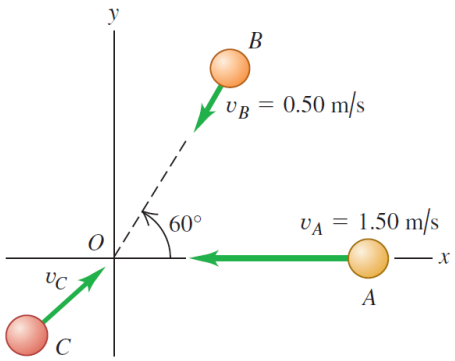


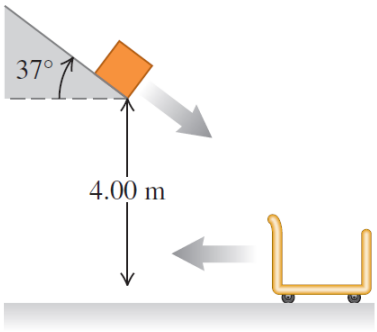
(a) What must the x- and y-components of the initial velocity of C be if all three objects are to end up moving at 0.5 m/s in the positive direction of the x-axis after the collision?

(b) If C has the velocity found in part (a), what is the change in the kinetic energy of the system of three spheres as a result of the collision?

4. In a shipping company distribution centre, an open cart of mass 50.0 Kg is rolling to the left at a speed of 5.0 m/s, as shown in the diagram included below (you can ignore friction between the cart and the floor). A 15 Kg package slides down a chute that is inclined at $37°$ from the horizontal and leaves the end of the chute with a speed of 3.0 m/s. The package lands in the cart and they roll off together. If the lower end of the chute is a vertical distance of 4.0 m above the bottom of the cart, what are

   (a) the speed of the package just before it lands in the cart?

   (b) the final speed of the cart?



5. Three perfectly elastic spheres A, B, and C have masses $3m$, $2m$ and m, respectively. They are lying in a straight line on a horizontal plane and A is projected with speed v_0 to collide directly with B, which goes on to collide directly with C. Find the speed of each sphere after the second impact. Explain why there will be no further impacts.

6. A small sphere is dropped on to a horizontal plane from a height H. If the coefficient of restitution between the sphere and the plane is e find, in terms of H and e, the height to which the particle rises after each of the first, second, and third impacts, showing that these heights are in geometric progression.

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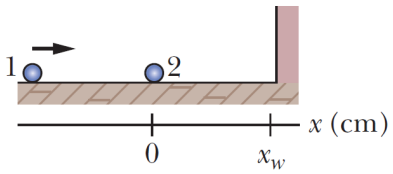
7. A small smooth ball bearing falls from rest at a height H above a smooth horizontal plane. The coefficient of restitution between the ball bearing and the plane is e $(0 < e < 1)$. Show that the total distance travelled by the ball bearing before coming to rest is

$$\left(\frac{1+e^2}{1-e^2}\right) H\,.$$

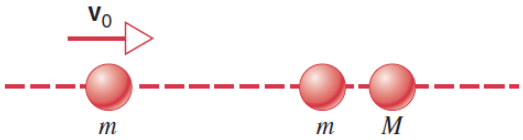
8. In relation to the previous question, show that the time taken for the bouncing to cease is

$$\left(\frac{1+e}{1-e}\right)\sqrt{\frac{2H}{g}}\,.$$

9. In the sketch below, particle 1 of mass $m_1 = 0.30$ Kg slides rightward along an x-axis on a frictionless floor with a speed of 2.0 m/s. When it reaches $x = 0$, it undergoes a one-dimensional elastic collision with a stationary particle of mass $m_2 = 0.40$ Kg. When particle 2 then reaches a wall at $x_w = 70$ cm, it bounces from the wall with no loss of speed. At what position on the x-axis does particle 2 then collide with particle 1?



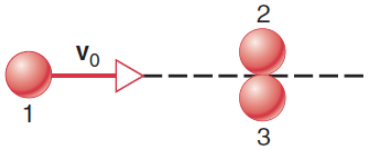
10. The two spheres on the right in the diagram included below are slightly separated and initially at rest; the left sphere is incident with speed v_0. Assuming head-on elastic collisions,



(a) if $M \leq m$, show that there are two collisions and find all final velocities;

(b) if $M > m$, show that there are three collisions and find all final velocities.

11. A ball with an initial speed of 10.0 m/s collides elastically with two identical balls whose centres are on a line perpendicular to the initial velocity and that are initially in contact with each other. The first ball is aimed directly at the contact point, and all balls are frictionless. Find the velocities of all three balls after collision.



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