ADVANCED PHYSICS CLUB

JANUARY 12, 2020

Today's meeting

Today we discussed energy and momentum conservation in application to collision problems. The momentum conservation can be used when the impulse of an external force acting on the system is negligible. The energy conservation is used when there is no loss of mechanical energy into other forms of energy (usually thermal). The collisions without any loss of mechanical energy are referred to as "completely elastic" or simply "elastic". The loss of mechanical energy is maximal in collisions when colliding objects get stuck during the collision. The easiest way to show this is to consider the collision in the center-of-mass frame. The latter type of collision is referred to as "completely inelastic".

We derived the velocities after 1d elastic collision of two masses using "difference of squares" trick. Namely, we found that the conservation of energy can be rewritten using the conservation of momentum as $v_1 + v_1' = v_2 + v_2'$. This equation is obvious in the center-of-mass frame where masses just bounce back with the same velocities. Then we derived:

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2} v_1 + \frac{2m_2}{m_1 + m_2} v_2 \,,$$
$$v_2' = \frac{2m_1}{m_1 + m_2} v_1 - \frac{m_1 - m_2}{m_1 + m_2} v_2 \,.$$

It is useful to notice that if $m_1 = m_2$ then masses just exchange their velocities during the collision $v_1' = v_2$ and $v_2' = v_1$. Also, in many problems one particle is initially at rest $v_2 = 0$. In this case we obtain simpler formulas

$$v_1' = \frac{m_1 - m_2}{m_1 + m_2} v_1 \,,$$
$$v_2' = \frac{2m_1}{m_1 + m_2} v_1 \,.$$

We solved the problems 6, 7, 8 of $F = ma$ 2015
`https://aapt.org/physicsteam/2015/upload/exam1-2015-1-8.pdf`

Homework problems

1. Solve problems 9, 10, 23 of $F = ma$ 2015
   `https://aapt.org/physicsteam/2015/upload/exam1-2015-1-8.pdf`

2. Solve the problem 13 of $F = ma$ 2016
   `https://www.aapt.org/physicsteam/2016/upload/exam1-2016-3-1-2.pdf`

3. Solve problems 7,8 from $F = ma$ exam 2017.
   `https://www.aapt.org/physicsteam/2018/upload/2017-Fma-exam.pdf`

4. Solve problems 20, 21, 22 from $F = ma$ exam 2017.
   `https://www.aapt.org/physicsteam/2018/upload/2017-Fma-exam.pdf`

5. The moving ball collides non-centrally and elastically with the ball of the same mass. What is the angle between velocities of the balls after the collision?

6. The balls of masses m_1 and m_2 move inside the stationary circular tube with initial velocities v_1 and v_2. What are velocities of the balls after 2019, 2020 collisions? The collisions are elastic, the tube is smooth.

IMPORTANT

The next club meeting is on January 19, 2020. We will consider collision problems and start talking about mechanical oscillations. We will use $F = ma$ problems as examples.