

Hands-On-Practice 2. Linear and Angular Momentum

[PURPOSE]

The conservation laws and the conserved quantities have great importance in Physics. In previous lectures we considered three conservation laws:

1. **The conservation of Energy (E)**
2. **The conservation of Linear Momentum (P)**
3. **The conservation of Angular Momentum (L)**

In this practice, we exam concepts of linear momentum, angular momentum, collisions and the conservation of momentum.

[CONCEPTS]

Both linear and angular momentums are related with object's tendency to keep the same state of motion, **inertia**. Usually the mass of an object is the indication of the object's inertia. When an object is moving, it gains additional inertia due to motion. **Linear momentum is** inertia in linear motion and **the angular momentum is** inertia associated with rotational motions. Both the linear momentum and the angular momentum are vector quantities. The linear momentum (P) is determined by mass and velocity; $P=m \times v$. The direction of the momentum is same as that of velocity. The angular momentum (L) is defined as mass times the linear velocity times the radius from the rotational axis; $L=r \times m \times v$. The direction of the angular momentum is perpendicular to both, the radius and the linear velocity.

[Conservation of Linear Momentum]

When no net external force acts on a system, the total linear momentum of the system remains constant.

One of well known examples of the momentum conservation is a collision problem. The total momentum of the system just before the collision is same as the total momentum just after the collision when no external net force is applied.

The Collisions are generally divided to **1.Elastic Collision** and **2.Inelastic Collision**. When two objects collide and stick together, the collision is called inelastic.

[Conservation of Angular Momentum]

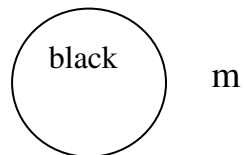
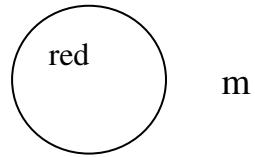
When no net external torque acts on a system, the total angular momentum of the system remains constant.

[Practice.1] Linear momentum and Head on collisions

A. Equal masses (m and m)

1. Place a black tile and a red tile in the marks provided.
2. Push the red tile to make a head on collision with the black tile.
3. Mark the locations of both tiles and draw the trajectories.

Is it an elastic collision or an inelastic collision?

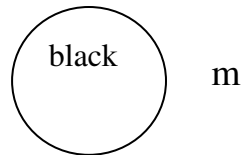
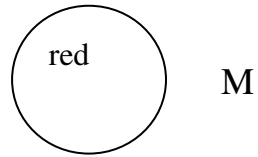


[Discussion]

[Practice.1] Linear momentum and Head on collisions

B. Unequal masses (M and m)

1. Insert a coin on top of a red tile.
2. Place a black tile (m) and a red tile (M) in the marks provided.
3. Push the red tile to make a head on collision with the black tile. (Try to apply a similar strength of force.)
3. Mark the locations of both tiles and draw the trajectories.

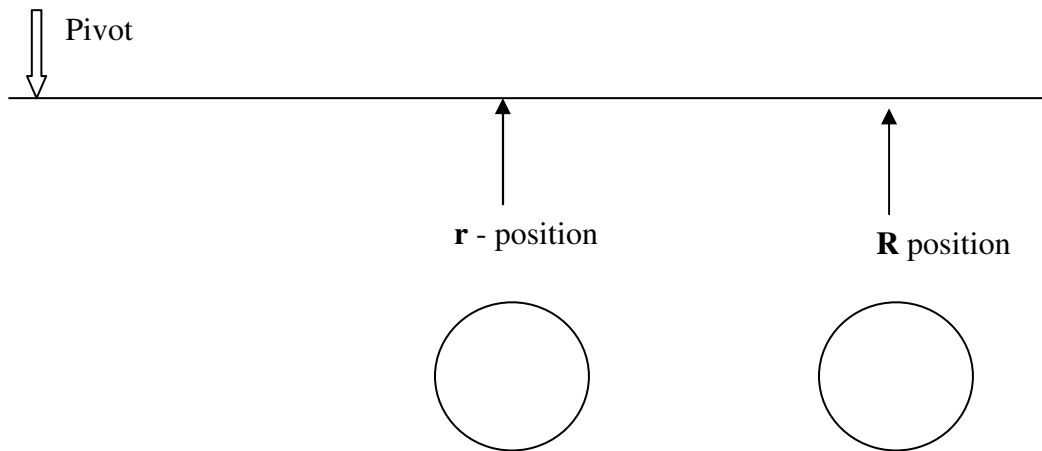


Is it an elastic collision or an inelastic collision?

[Discussion]

[Practice.2] Linear Momentum and Angular Momentum

1. Place a ruler in the mark provided and fix one end of the ruler with a sharp pen.
2. Push the red tile from the position, R and observe the rotation motion of the ruler.
Mark the trajectory.
3. Change the strength of the applied force and describe your observation.
4. Repeat it from the smaller radius position, r. Mark the trajectory. (Be consistent with the strength of the force applied.)



[Discussion]

1. Discuss your observation in the step2 in terms of the relationship between the linear momentum and the angular momentum.

2. Discuss your observation in the step3.

3. When does the ruler rotate faster, pushed from **R-position** or **r-position**?

4. Explain.

[Practice. 3] Angular Momentum Conservation

1. Connect a string to a tile using a rubber band.
2. Swing it to make it rotate.
3. While it is rotating, pull in to reduce the length of the string.
4. What happens to the angular speed?

Discuss about your observation in terms of the angular momentum conservation.