

# **Grade 12 Physics**

SPH4U

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## Chapter 3

# Unit 2: Energy and Momentum

### 3.1 Types of Collisions

#### 3.1.1 Definitions

Collisions are typically classified based on the amount of **kinetic energy** the system has after the collision, in comparison to the amount of kinetic energy the system had before the collision. In other words, **how does  $E'_k$  with  $E_k$ ?**

#### 3.1.2 Elastic Collisions

In an elastic collision, the kinetic energy of the system after the collision is **equal** to the kinetic energy of the system before the collision. In mathematics, the equation can be represented by:

$$E'_k = E_k$$

*Remark.* This does not mean the kinetic energy of the system after the collision is **equal** to the kinetic energy of the system before the collision (Unlike momentum)

#### Steps of the collision

*Remark.* This is on a horizontal frictionless surface, so we can ignore Gravitational Potential Energy

**Before the collision:** The mechanical energy is entirely in the form of kinetic energy

**First half of collision:** The interaction forces cause the object to start deform. As the object deforms, they transfer  $E_k$  to  $E_s$ .

**At the approximate midpoint of the collision:** The deformation of the object is at a maximum.  $E_s$  is the maximum and  $E_k$  is the minimum.

**During the second half of the collision:** The restoring forces are now doing *positive work* on the system, transferring elastic potential energy **back into**  $E_k$

**After the collision:** The system's mechanical energy is now entirely  $E_k$ , at this time,  $E_s = 0$ . All  $E_s$  is transferred to  $E_k$ .

#### Head-on Collision

**Before the Collision:** System's mechanical energy is entirely  $E_k$

**During the first half of the collision:** The spring get compressed.  $E_k$  is transformed into  $E_s$ .

**At the mid-point of the collision:**

- Spring is at the most compressed point.
- Distance between cars are minimumized
- $\vec{v}_A = \vec{v}_B$
- $E_k$  is minimumized
- $E_s$  is maximumized

**During the second half of the collision:**

- $\vec{v}_A < \vec{v}_B$
- Distance between the carts is increasing
- $E_s$  is being transferred back into  $E_k$

**After the collision:** The system is entirely  $E_k$  now

*Remark.* Elastic collisions **cannot occur** between visible objects in real life. At least some of the energy will be lost as thermal or sound.

### 3.1.3 Inelastic Collision

So for this collision,  $E_k'$  is less than  $E_k$

It is impossible for a system to have more kinetic energy after the collision, than it had before the collision, unless:

1. One of the object had **stored energy** before the collision, which was transferred into kinetic energy during the collision.
2. An **external** force (such as force of gravity) is doing positive work on the system, during the collision.

#### Completely inelastic collision

In this collision, the maximum amount of kinetic energy that could be "lost" is lost as a result of the collision.

After the collision, the objects involved in the collision will be **stack/attached together**

**Apple and Arrow** is an example of this question.

The following condition must be met for a Perfectly Inelastic Collision:

- $\vec{v}_A' = \vec{v}_B' = \vec{v}^*$