HSC COLLEGE
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YEAR 11 PHYSICS
MODULE 2

THEORY BOOKLET 3
IQ 3: MOMENTUM, ENERGY AND SIMPLE SYSTEMS

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Contents

Syllabus Covered

Enquiry Question: How is the motion of objects in a simple system dependent on the interaction between the objects?

In this section, students:

★ **conduct an investigation to describe and analyse one-dimensional (collinear) and two-dimensional interactions of objects in simple closed systems (ACSPH064)**

★ **analyse quantitatively and predict, using**

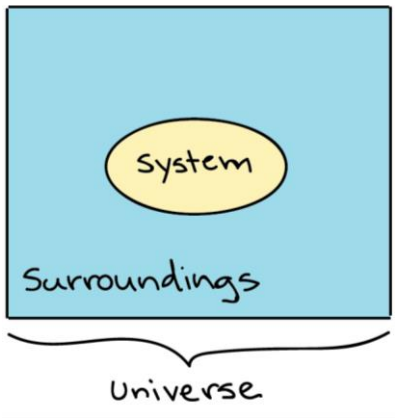
(a) conservation of kinetic energy $\sum \frac{1}{2} m v_{\text{before}}^2 = \sum \frac{1}{2} m v_{\text{after}}^2$**,**

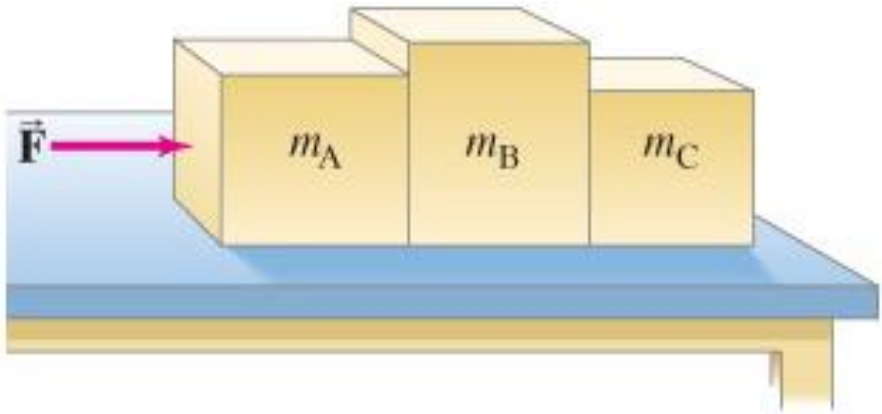
the result of interactions in elastic collisions (ACSPH066)

1.1 System

What is a System?

- **In physics, a physical system is a portion of the physical universe chosen for analysis.**
- Everything outside the system is known as the environment or the surroundings as shown in the diagram below to the left.

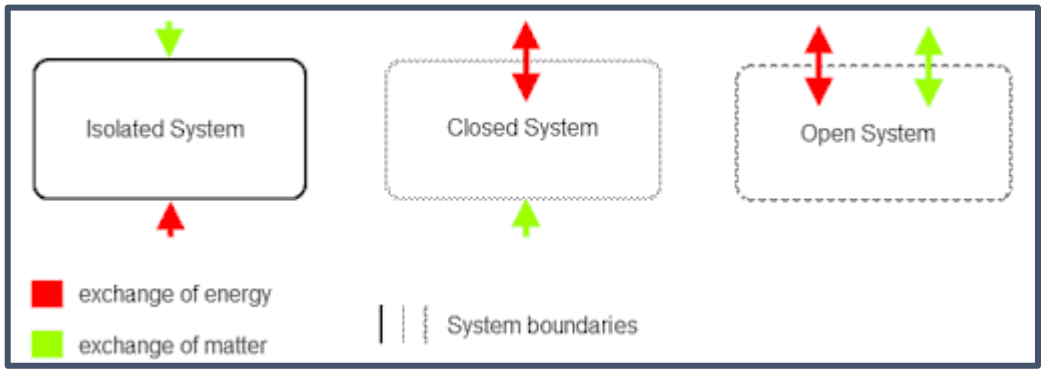




- The split between system and environment is the analyst's choice.
- For example, let's assume that we are analysing the interaction of three masses (m_A, m_B and m_C) when a force to the right is applied on m_A as shown above.
  - The system is the three masses since we are analysing the interaction of the three masses.
  - Everything else become the environment or the surroundings.
- A system may be simple, complicated complex or chaotic depending on what and how many objects are analysed.
  - In this Module, students will only look at simple systems which involve the interaction between two objects.
- **Note: one object cannot constitute a system, as no object can undergo physical interaction by itself, meaning that the minimum number of objects required for a system is two.**

Types of System

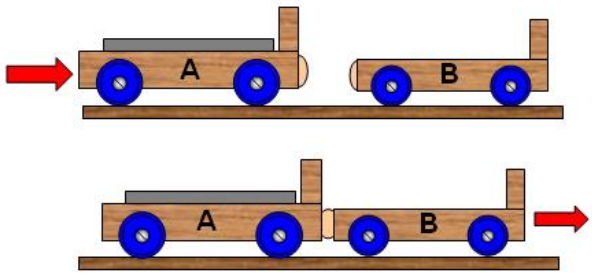
- **In physics, a system can be open, closed or isolated.**



- **Open system** is a system in which **both matter and energy** may be exchanged with the surroundings.
- **Closed system** is a system in which **energy but not matter** may be exchanged with the surroundings.
- **Isolated system** is a system in which **both matter and energy** cannot be exchanged with the surroundings.

1.2 Interactions of Objects in a Simple System

- **In physics, an interaction between two objects is described as the two objects exerting forces on one another.**
- Therefore, a one-dimensional (collinear) interaction occurs when the forces exerted are parallel in direction.
- Similarly, a two-dimensional interaction occurs when the forces exerted are on a 2D plane.

_____ **Interaction**	_____ **Interaction**
	
System:	**System:**

Collision

- **A collision is an example of a physical interaction of two or more objects through forces.**
- In collisions, all of the laws of physics hold true, including Newton's Laws of Motion, Law of Conservation of Energy, and the Law of Conservation of Momentum.
- Being able to determine which laws to apply when analysing situations in questions will determine whether you're able to solve the problem or not.

Elastic vs Inelastic Collisions

- **Collisions can either be elastic or inelastic depending on whether the total kinetic energy of a system is conserved before and after a collision.**
- If only the initial conditions (conditions before collision) of the system are given, it is impossible to determine whether the collision will be elastic or inelastic.
- However, if both the initial AND final conditions (conditions before and after collision) of the system are given, you can determine whether or not kinetic energy was conserved during the collision, and thus determine whether the collision was elastic or inelastic.

Elastic Collisions

- **An elastic collision is a collision in which internal kinetic energy is conserved.**
- In other words, the total kinetic energy of the system before the collision is equal to the total kinetic energy of the system after the collision.

$$\boxed{\Sigma E_{k_{\text{before}}} = \Sigma E_{k_{\text{after}}}}$$

- This can only be true if no kinetic energy is converted into other forms of energy such as heat, sound and energy during the collision.

Inelastic Collisions

- **An inelastic collision is a collision in which internal kinetic energy is not conserved.**
- In inelastic collisions, some or all of the kinetic energy of the system is converted into other forms of energy such as heat, sound and energy.

$$\boxed{\Sigma E_{k_{\text{before}}} \neq \Sigma E_{k_{\text{after}}}}$$

- A perfectly inelastic collision is one in which all of the kinetic energy of the system is transformed into other forms of energy, and the result is that all of the objects within the system end up stationary.