

LINEAR MOMENTUM – 2

7.2, 7.3, 7.4

CONSERVATION OF LINEAR MOMENTUM

- THE TOTAL MOMENTUM OF AN **ISOLATED** SYSTEM OF BODIES REMAINS CONSTANT.
 - Isolated** – the only forces present are those between the objects of the system
 - $\sum F_{ext} = 0$ due to Newton's 3rd Law
- Momentum **WON'T** be conserved **IF** external forces are present who vector sum is **NOT** equal to zero.
 - A falling rock does not conserve **p** since **Fg** is acting on the rock and changing its **p**.
 - HOWEVER**, if we include the Earth in the system, **p_{total}** of the Earth-Rock system is conserved.
 - What does this mean about the velocity of the earth?

CONSERVATION OF LINEAR MOMENTUM

- This is very useful for explosions and rockets.
 - Rockets are a controlled form of explosion.
 - Before Launch: $p_{total} = 0 = p_{fuel} + p_{rocket}$
 - As the fuel burns the negative **p** of the expelled gas is balanced by the positive **p** gained by the rocket.
 - Rockets can operate in a vacuum (like space) they don't need the earth or air to push against.
 - It's like using the recoil of a gun to propel the gun.

COLLISION AND IMPULSE

- When a collision occurs between 2 objects that are not overly rigid, both objects are deformed—
 - all objects are deformed at the atomic level since an atom is mostly empty space

COLLISION AND IMPULSE

- Both particles are deformed in a collision.
 - At the moment of impact, **F** jumps from ZERO to a very large value in a very short time and abruptly returns to ZERO again.
 - A graph of the **F** an object exerts on another object during a collision as a function of time, is something like that shown by the red curve in fig. 7-9.
 - Δt is very small
 - applies to EACH of the objects in a collision

$$F\Delta t = \text{Impulse} = \Delta p$$

FIGURE 7-9 Force as a function of time during a typical collision.

COLLISION AND IMPULSE

- The TOTAL Δp is the **impulse** in a collision
 - Impulse is of help mainly when dealing with forces that act over a short time: hitting a baseball with a bat...stuff like that.
 - The **F** is often **NOT** constant but varies like the graph in figure 7-10.

FIGURE 7-10 The average force \bar{F} acting over an interval of time Δt gives the same impulse ($\bar{F}\Delta t$) as the actual force.

COLLISION AND IMPULSE

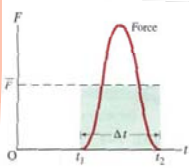
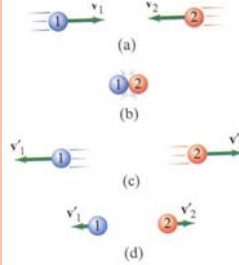


FIGURE 7-10 The average force \bar{F} acting over an interval of time Δt gives the same impulse ($\bar{F}\Delta t$) as the actual force.

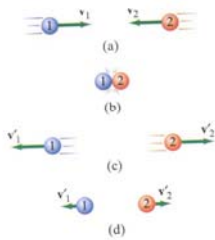
- It is sufficient to approximate such a varying F by using \bar{F} of a time Δt , like the dashed line in the graph.
- \bar{F} is chosen so that the shaded area ($\bar{F} \times \Delta t$) = area under the *actual curve* F vs. t which represents the impulse.
- NOTE:** the same impulse and same change in momentum Δp , can be given to an object by a smaller force, \bar{F} , if applied over a greater time, as long as $\bar{F} \Delta t$ remains the same.

CONSERVATION OF ENERGY AND MOMENTUM



- If a collision occurs between two hard objects with no heat or sound produced in the collision, then KE is also conserved.
- Of course, for the brief moment during which the 2 objects are in contact, some [or all] of the E is stored in the form of elastic PE.

CONSERVATION OF ENERGY AND MOMENTUM



- Such a collision, with conservation of KE, is defined as an **elastic collision**
 - Recall the kinetic theory of matter and its postulates?

$$\frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 = \frac{1}{2} m_1 v_1'^2 + \frac{1}{2} m_2 v_2'^2$$