Dynamics – Momentum and Impulse - Outline

1. Compare the momentum of different moving objects.
2. Compare the momentum of the same object moving with different velocities or having different masses.
3. Relate change in momentum and impulse.
4. Describe changes in momentum in terms of force and time and calculate the force, the time, or the change in momentum.
5. Describe the interaction between two objects in terms of the change in momentum of each object.
6. Compare the total momentum of two objects before and after they interact.
7. State the law of conservation of momentum.
8. Predict the final velocities of objects after collisions, given the initial velocities.
9. Identify different types of collisions, such as elastic or inelastic.
10. Determine the changes in kinetic energy during perfectly inelastic collisions.
11. Compare conservation of momentum and conservation of kinetic energy in perfectly inelastic and elastic collisions.
12. Find the final velocity of an object in perfectly inelastic and elastic collisions.

Notes

- Momentum

  - ✓ Example:

- Change in Momentum

  - ✓ Example

- Impulse

  - ✓ Example:

- Impulse-Momentum Theorem

  - ✓ Long time of contact:

  - ✓ Stopping Time:

  - ✓ Large Force:

- Conservation of Momentum

  - ✓ Examples:

- Inelastic Collisions

- Elastic Collision

- Two Dimensional Collisions

- **Sample/Practice Problems**

A.

1. A moving car has momentum. If it moves twice as fast, its momentum is _____ as much.

2. Two cars, one twice as heavy as the other, move down a hill at the same speed. Compared to the lighter car, the momentum of the heavier car is _____ as much.

3. The recoil momentum of a gun that kicks is
   (more than) (less than) (the same as)
   the momentum of the bullet it fires.

4. If a man firmly holds a gun when fired, then the momentum of the bullet is equal to the recoil momentum of the
   (gun alone) (gun-man system) (man alone)

5. Suppose you are traveling in a bus at highway speed on a nice summer day and the momentum of an unlucky bug is suddenly changed as it splatters onto the front window.

   a. Compared to the force that acts on the bug, how much force acts on the bus?
      (more) (the same) (less)

   b. The time of impact is the same for both the bug and the bus. Compared to the impulse on the bug, this means the impulse on the bus is
      (more) (the same) (less)

   c. Although the momentum of the bus is very large compared to the momentum of the bug, the change in momentum of the bus, compared to the *change* of momentum of the bug is
      (more) (the same) (less)

   d. Which undergoes the greater acceleration?
      (bus) (both the same) (bug)

   e. Which therefore, suffers the greater damage?
      (bus) (both the same) (the bug of course!)

B.

$$Ft = m\Delta v$$

Impulse = change in Momentum

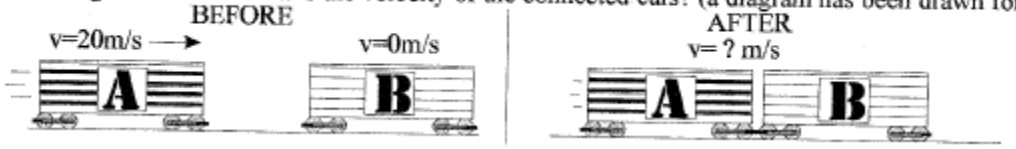
1. A force of 60N is applied to a puck for 0.8 seconds. What is the magnitude (with units) of the impulse?

2. How much force must a gun produce to get a 0.01Kg bullet up to a velocity of 300m/s if the bullet is only in the barrel of the gun for 0.001 seconds?

3. If **Action Reaction's** starship **Actsuprised** {the faster you say it the better it sounds} has a mass of 6,000Kg. How much force must the engine produce to get the starship going from rest to light speed (300,000,000m/s) in 20 seconds time?

C.

1. A Railroad car of mass 1000Kg is moving at a velocity of 20m/s to the right when it runs into **and connects** to another 1000Kg car at rest. What is the velocity of the connected cars? (a diagram has been drawn for you)



2. A Railroad car of mass 1000Kg is moving at a velocity of 20m/s to the right when it runs into **and connects** to another car of mass 3000Kg at rest. What is the velocity of the connected cars? Show a diagram.

3. A Railroad car of mass 1000Kg is moving at a velocity of 40m/s to the left when it runs into **and connects** to a 3000Kg car moving at a velocity of 10m/s left. What is the velocity of the connected cars? Show a diagram.

1. A football player of mass 100Kg running at 4m/s slams into a stationary tackling sled of mass 200Kg. What is the velocity of the sled if the football player is still attached to the sled after the collision?

D.

4. A Railroad car of mass 1000Kg is moving at a velocity of 40m/s to the right when it runs into **and connects** to a3000Kg car moving at a velocity of -30m/s. What is the velocity of the connected cars? Show a diagram.

Homework Problems:

I.

4. If a 1000Kg car is going 10m/s how long must the engine supply a force of 30N until the car reaches 24m/s?

6. If **Action Reaction** (m=100Kg) is catapulted through a brick wall and he applies a 5000N force on the wall for 0.5 seconds as he passes through it, what change in velocity must he undergo?

7. An automobile passenger with a mass of 50Kg runs into a bridge support going 24m/s. The passenger is brought to rest in 0.1 seconds, what is the force applied on the passenger?
   b) What is the force if a seat-belt is used and increases the time by 0.1s?
   c) What is the force if air bags further increase the time by another 0.2 seconds?
   d) What is the force if a *crushable* front end increases the time by another 0.2 seconds?
   e) What is the force if foam pilings are used in front of the support and increase the time by another 0.1s?

II.

2. The Starship Enterprise (m = 3,900,000,000kg) is traveling at warp 1 (300,000,000 m/s) when it accidentally slams into the Earth (m_E = 6,000,000,000,000,000,000,000,000 Kg, *assumed to be at rest*). What is the velocity of the Earth if the Enterprise sticks to it?

3. How fast would a bullet (m = 0.005Kg) need to be traveling to bring a 20,000Kg tractor trailer moving at 24m/s to rest? {assume the bullet sticks to the truck) Could this be possible if the **maximum speed** possible is 300,000,000 m/s?

4. If you (m = 50Kg) were standing on a sheet of ice (ignore friction) and you threw a 1Kg baseball at a velocity of 25m/s what would your recoil velocity be?

5. Two equally massive billiard balls undergo a collision, If ball 1 is moving with velocity V, and ball 2 is at rest before the collision, what must be true of ball 2 after the collision if ball 1 is now at rest?

III.

5. A 0.005Kg bullet is fired at 300m/s east into a 10Kg block of wood at rest. If the bullet sticks into the wood, what is the velocity of the wood bullet system? Show a diagram.

6. A 0.005Kg bullet is fired at 300m/s east into a 10Kg block of wood at rest. If the bullet passes through the wood and continues at 100m/s east, what is the velocity of the block of wood? Show a diagram.

7. A 0.005Kg rubber bullet is fired at 300m/s east at a 10Kg block of wood at rest. If the bullet bounces off the wood and continues at 100m/s west, what is the velocity of the block of wood? Show a diagram.

8. If a 200Kg cannon fires a 2Kg cannon ball at 200m/s west, what is the recoil velocity of the cannon? *{Hint: the cannon and cannon ball are initially at rest and the firing is the collision.}* Show a diagram.

5. Imagine three astronauts (all of equal mass) were outside the space shuttle enjoying a **zero g** environment. If two of them played a game of catch, using the third astronaut as the ball, what would happen as this game continued?

6. If a car (m = 1000Kg) traveling East at 24m/s collides with a truck (m = 3000Kg) traveling North at 15m/s, what is the magnitude and direction of the resulting momentum if they're stuck together?

7. Aircraft carriers are equipped with catapults that literally throw an airplane off the deck and into the air {much the same way you throw a paper airplane. Starting from rest the plane gets catapulted 40m and ends up going 50m/s. Using this information and that the mass of the plane is 5000kg and the mass of the ship is 4,000,000kg, If the ship was originally at rest, what is its velocity after launching the plane?