

Impulse

$$J = F\Delta t$$

Unit: Ns

Is a _____

Both _____ and _____ play role in how responds to _____

Linear Momentum

$$p = mv$$

Unit: kg m/s

Is a _____

Is important when talking about _____

Impulse-Momentum Theorem

$$F\Delta t = mv_f - mv_0$$

_____ = change in _____

Find change in momentum

- Use _____ and _____ of contact to find average _____ of contact

A baseball ($m = 0.14 \text{ kg}$) with initial velocity of -40 m/s (90 mph) is hit. It leaves the bat with a velocity of 60 m/s after 0.001 s . What is the impulse and average net force applied to the ball by the bat?

A raindrop ($m = 0.001 \text{ kg}$) hits a roof of a car at -15 m/s . After it hits, it spatters so the effective final velocity is 0 . The time of impact is 0.01 s . What is the average force?

What if it is ice so that it bounces off at 10 m/s ?

Practice Work

- Two identical automobiles have the same speed, one traveling east and one traveling west. Do these cars have the same momentum? Explain.
- Two objects have the same momentum. Do the velocities of these objects necessarily have (a) the same directions and (b) the same magnitudes? Give your reasoning in each case.
- You have a choice. You may get hit head-on either by an adult moving slowly on a bicycle or by a child that is moving twice as fast on a bicycle. The mass of the child and bicycle is one-half that of the adult and bicycle. Considering only the issues of mass and velocity, which collision do you prefer? Or doesn't it matter? Account for your answer.
- When you're driving a golf ball, a good "follow-through" helps to increase the distance of the drive. A good follow-through means that the club head is kept in contact with the ball as long as possible. Using the impulse-momentum theorem, explain why this technique allows you to hit the ball farther.
- Explain in terms of impulse how padding reduces forces in a collision. State this in terms of a real example, such as the advantages of a carpeted vs. tile floor for a day care center.
- (a) Calculate the momentum of a 2000-kg elephant charging a hunter at a speed of 7.50 m/s. (b) Compare the elephant's momentum with the momentum of a 0.0400-kg tranquilizer dart fired at a speed of 600 m/s. (c) What is the momentum of the 90.0-kg hunter running at 7.40 m/s after missing the elephant? (OpenStax 8.1) **$1.50 \times 10^4 \text{ kg m/s}$, 24.0 kg m/s , $6.66 \times 10^2 \text{ kg m/s}$**
- (a) What is the mass of a large ship that has a momentum of $1.60 \times 10^9 \text{ kg} \cdot \text{m/s}$, when the ship is moving at a speed of 48.0 km/h? (b) Compare the ship's momentum to the momentum of a 1100-kg artillery shell fired at a speed of 1200 m/s. (OpenStax 8.2) **$1.20 \times 10^8 \text{ kg}$, $1.32 \times 10^6 \text{ kg m/s}$**
- A bullet is accelerated down the barrel of a gun by hot gases produced in the combustion of gun powder. What is the average force exerted on a 0.0300-kg bullet to accelerate it to a speed of 600 m/s in a time of 2.00 ms (milliseconds)? (OpenStax 8.7) **$9.00 \times 10^3 \text{ N}$**
- A car moving at 10 m/s crashes into a tree and stops in 0.26 s. Calculate the force the seat belt exerts on a passenger in the car to bring him to a halt. The mass of the passenger is 70 kg. (OpenStax 8.8) **2690 N**
- Suppose a child drives a bumper car head on into the side rail, which exerts a force of 4000 N on the car for 0.200 s. (a) What impulse is imparted by this force? (b) Find the final velocity of the bumper car if its initial velocity was 2.80 m/s and the car plus driver have a mass of 200 kg. You may neglect friction between the car and floor. (OpenStax 8.11) **-800 kg m/s , -1.20 m/s**
- One hazard of space travel is debris left by previous missions. There are several thousand objects orbiting Earth that are large enough to be detected by radar, but there are far greater numbers of very small objects, such as flakes of paint. Calculate the force exerted by a 0.100-mg chip of paint that strikes a spacecraft window at a relative speed of $4.00 \times 10^3 \text{ m/s}$, given the collision lasts $6.00 \times 10^{-8} \text{ s}$. (OpenStax 8.12) **$6.67 \times 10^3 \text{ N}$**
- A 75.0-kg person is riding in a car moving at 20.0 m/s when the car runs into a bridge abutment. (a) Calculate the average force on the person if he is stopped by a padded dashboard that compresses an average of 1.00 cm. (b) Calculate the average force on the person if he is stopped by an air bag that compresses an average of 15.0 cm. (OpenStax 8.13) **$-1.50 \times 10^6 \text{ N}$, $-1.00 \times 10^5 \text{ N}$**
- A volleyball is spiked so that its incoming velocity of +4.0 m/s is changed to an outgoing velocity of -21 m/s. The mass of the volleyball is 0.35 kg. What impulse does the player apply to the ball? (Cutnell 7.1) **-8.8 kg m/s**
- A baseball ($m = 149 \text{ g}$) approaches a bat horizontally at a speed of 40.2 m/s (90 mph) and is hit straight back at a speed of 45.6 m/s (102 mph). If the ball is in contact with the bat for a time of 1.10 ms, what is the average force exerted on the ball by the bat? Neglect the weight of the ball, since it is so much less than the force of the bat. Choose the direction of the incoming ball as the positive direction. (Cutnell 7.4) **-11600 N**