PhyzExamples: Impulse & Momentum

Physical Quantities • Symbols • Units • Brief Definitions

Momentum • p • kg·m/s, N·s • "Quantity of motion," "Inertia in motion." A measure of how hard it is to stop a body. The product of a body's mass and speed.
Impulse • Δp • N·s, kg·m/s • Change in momentum. (**Not** the *rate* of change in momentum, just the *change* in momentum.)
Force • F • N • The rate of change in momentum.

Equations

$p = mv$ • momentum = mass · speed (or velocity)
$\Delta p = m\Delta v$ • impulse = mass · change in speed
$F = \Delta p / \Delta t$ • force = impulse / time interval [Newton's second law, original form]
$F\Delta t = m\Delta v$ • force · time interval = mass · change in velocity (or speed)
$p' = p$ • momentum after an event = momentum before event [conservation of momentum]
$m_1v_1' + m_2v_2' = m_1v_1 + m_2v_2$ • conservation of momentum applied to two bodies in one dimension.

Smooth Operations Examples

1. What is the momentum of a 4 kg object moving with a velocity of 7 m/s?

1. m = 4 kg v = 7 m/s p = ?
p = mv
p = 4 kg · 7m/s
p = 28 kg·m/s

2. What is the speed of a 9 kg object whose momentum is 54 kg·m/s?

2. m = 9 kg p = 54 kg·m/s v = ?
p = mv
v = p/m
v = 54 kg·m/s / 9 kg
v = 6 m/s

3. How much force causes a 500 kg car to accelerate from rest to a speed of 25 m/s in 10 s?

3. m = 500 kg Δv = 25m/s Δt = 10 s F = ?
FΔt = mΔv
F = mΔv/Δt
F = (500 kg · 25 m/s) / 10 s
F = 1250 N

4. A rocket is propelled forward by a 10 N force as exhaust gas is expelled out the back at 100 m/s. What is the mass flow rate of the exhaust?

4. Δv = 100 m/s F = 10 N m/Δt = ?
FΔt = mΔv => m/Δt = F/Δv
m/Δt = 10 N / 100 m/s
m/Δt = 0.1 kg/s

5. If a 100-kg passenger got into the car in Problem 3 above, how much time would the vehicle need to get from 0 to 32 m/s?
5. m = 600 kg Δv = 32 m/s F = 1250 N

Δt = ?
FΔt = mΔv
Δt = mΔv/F
Δt = (600 kg · 32 m/s) / 1250 s
t = 15 s

6. An air-powered rocket whose mass is 0.10 kg accelerated from rest by a force of 47 N. If the propelling force acts for 0.062 s, what is the rocket's launch speed?

6. m = 0.10 kg Δv = ? m/s
F = 47 N Δt = 0.062s
FΔt = mΔv
Δv = FΔt / m
Δv = 47 N · 0.062 s / 0.1 kg
Δv = 29 m/s