CHAPTER FIFTEEN: THE PHYSICS OF COLLISIONS

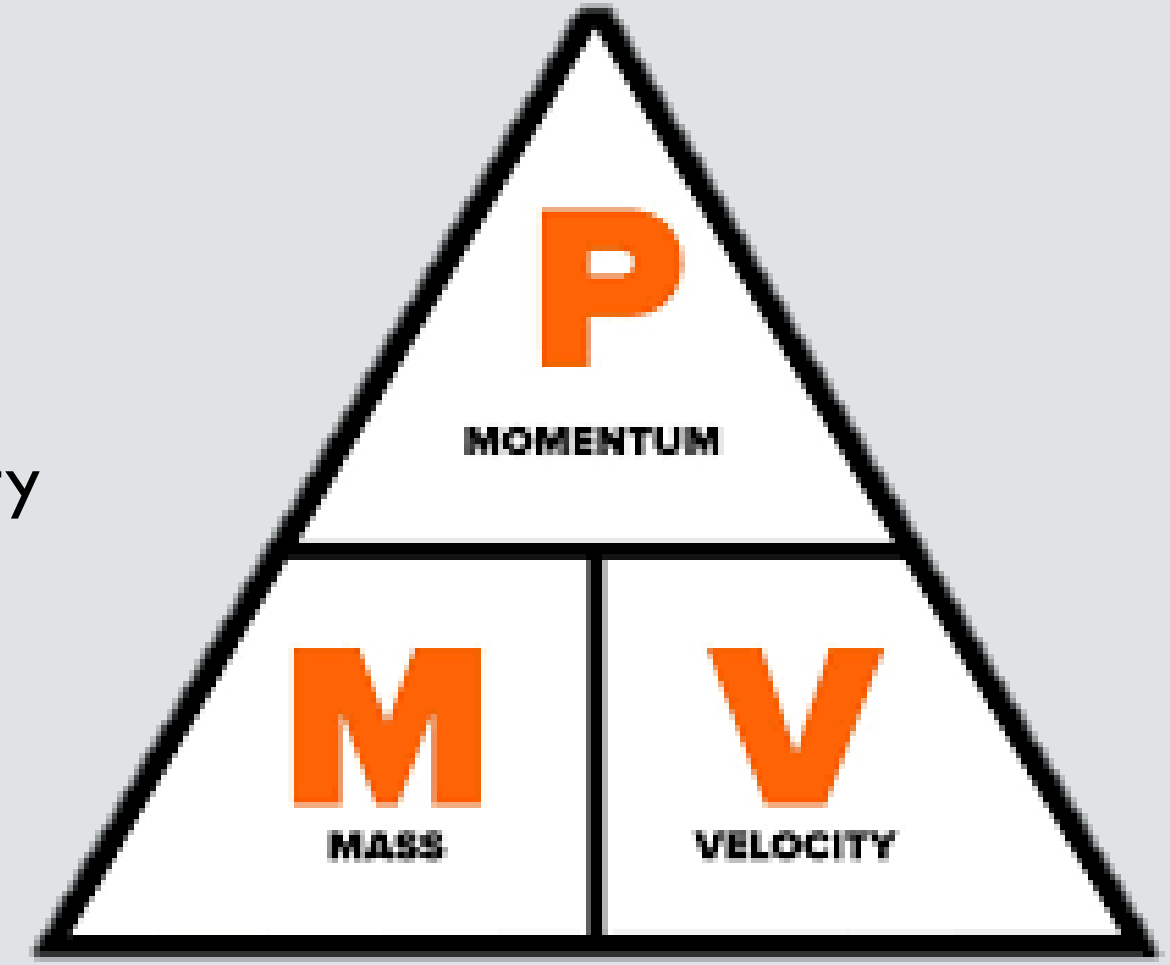
Momentum and Force

- **Momentum (p)** is the measure of an object's motion
- **Force (F)** is any push or pull on an object

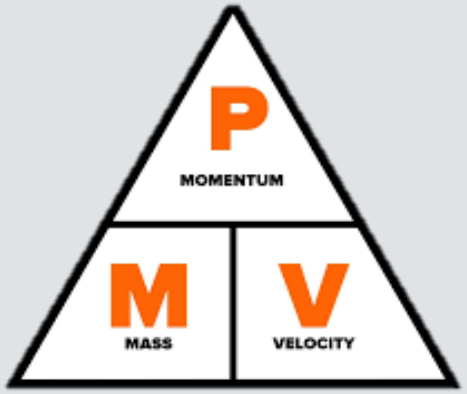
- **Newton's First Law**
  - An object in motion will stay in motion unless acted upon by an external force
  - An object at rest will stay at rest unless acted upon by an external force

Momentum

- **<u>Momentum</u>** formula:
  - Momentum equals mass times velocity
  - P = m x v
  - Measured in (kg x m)/s



Momentum Practice



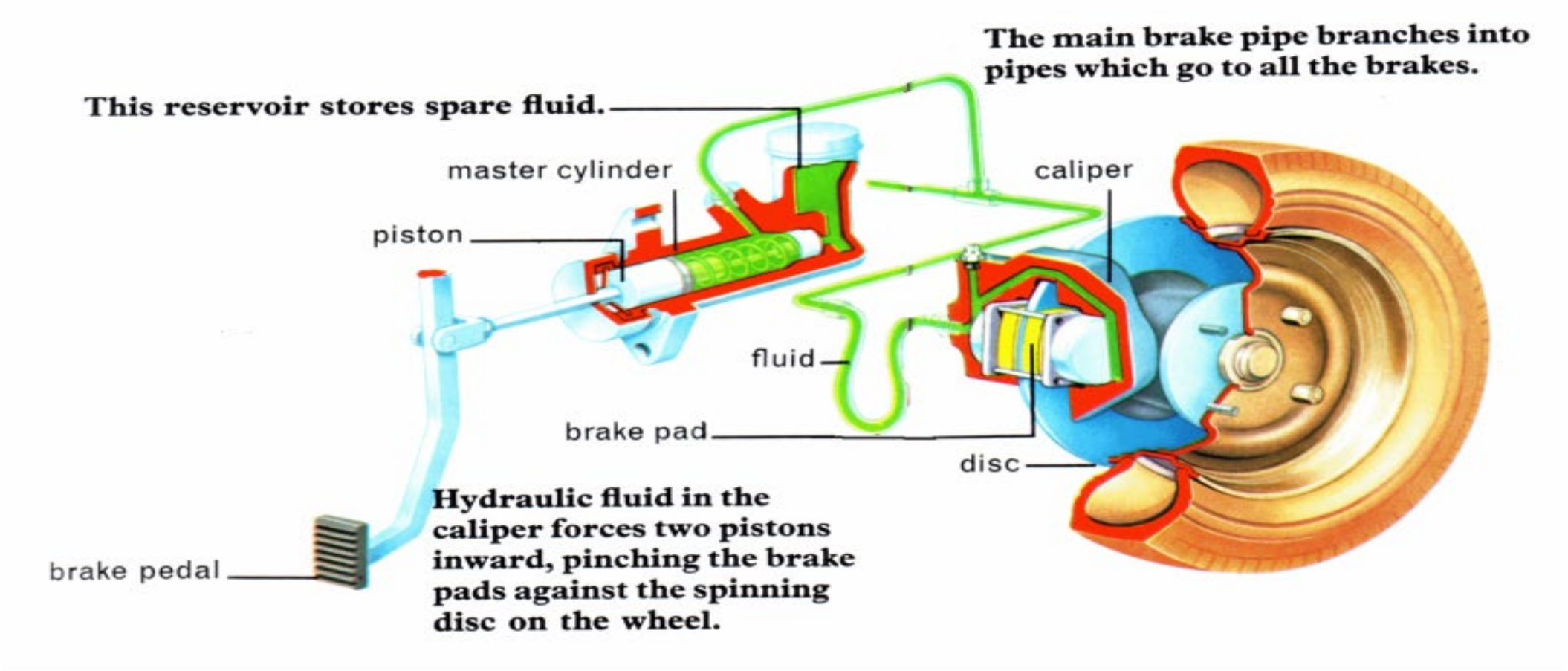
1. A 2000kg car drives down the road at 60 km/h. What is its momentum? [33 333 (kg x m)/s]

2. A 60kg human (Mr. Cuesters) jogs at 10km/h. What is his momentum? [166 (kg x m/s)]

SLOWING MOMENTUM

- Braking
  - Counteracts momentum using **friction**
  - Applies a force that stops vehicles by decreasing their momentum
- **Friction**
  - The force two objects that press against each other exert, slowing or stopping movement
- Braking uses friction in two ways
  - The brake pedal uses the brake pads to slow down the wheels using friction
  - The wheels and the road also experience friction

Braking system of a car



Brakes work best:
- in _____ conditions
- when the brakes are in _____ conditions

Worn brakes do NOT work as quickly to counteract momentum.

Slippery roads (ie. ice, water, etc) reduce the amount of friction.

Other things that are slowed by friction:
- canoes
- kayaks

(stop paddling and it will eventually stop)

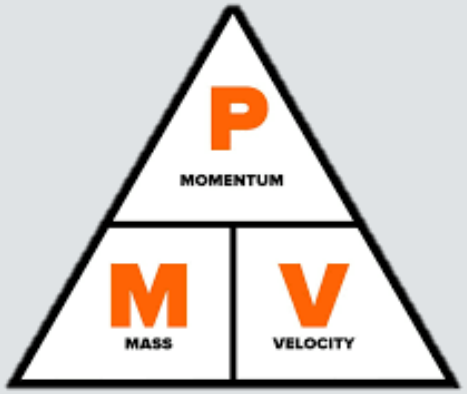
Impulse

- Impulse is a **change in momentum (Δp)**. A larger impulse means a bigger change.

- It can be calculated either from a **change in speed**, or from an **applied force over time**

$$\Delta p = F \times \Delta t = m \times \Delta v$$

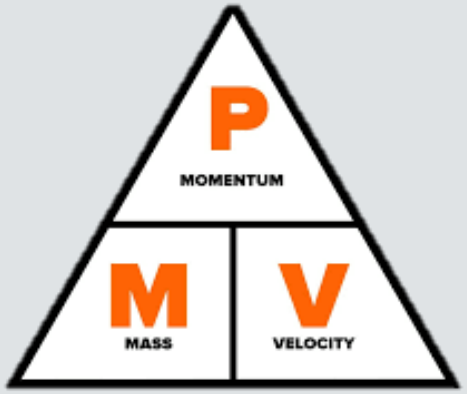
Impulse Practice



1. A football player collides with another football player. The force of the collision is 1000 N, and it lasts for 1 second. What is the impulse? [1000 (kg x m)/s)]

2. What would be the impulse if it had lasted for two seconds? [2000 (kg x m)/s

Impulse Practice

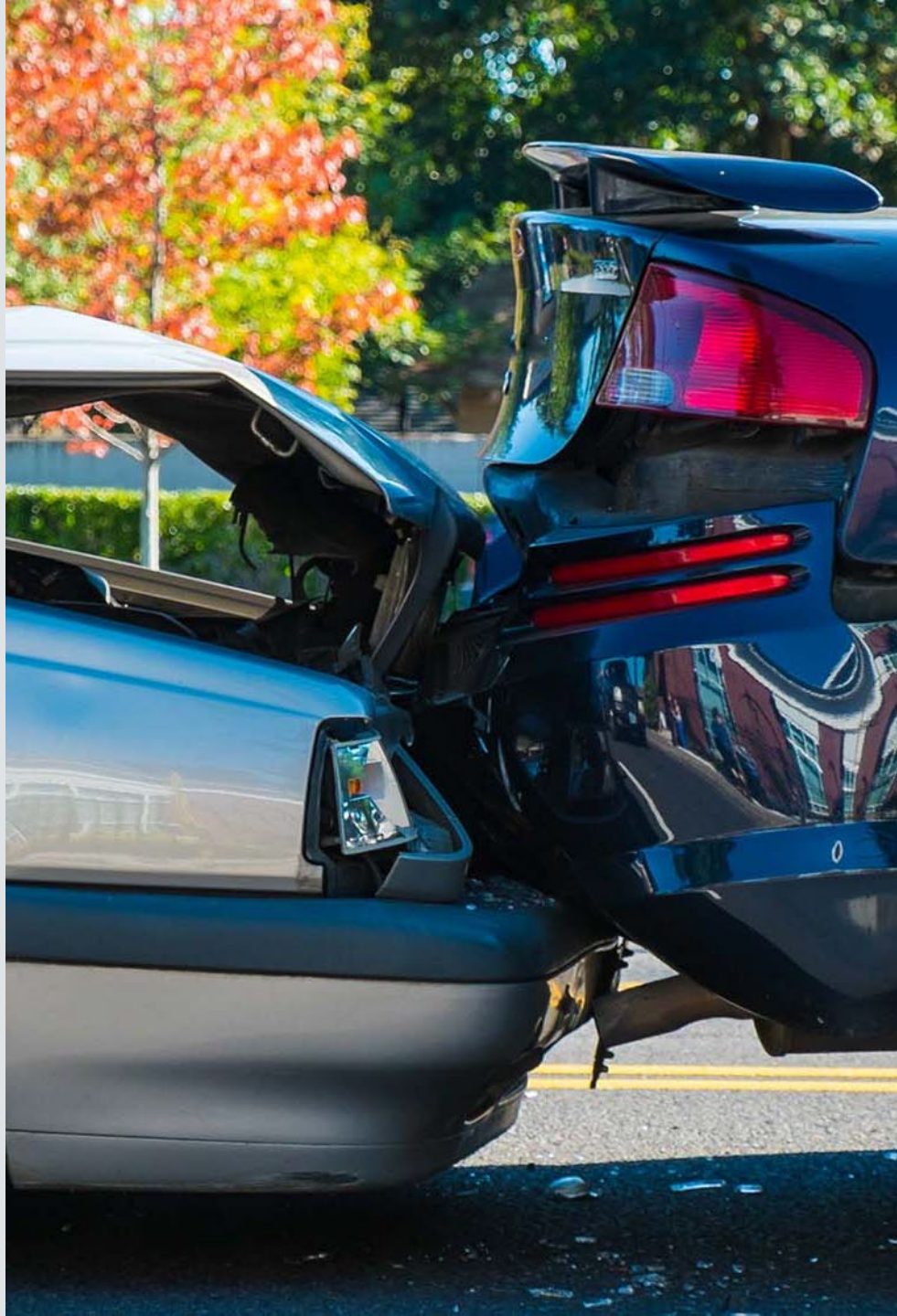


3. A bus moving 40km/h collides with Regina George, who weighs 40kg. She is accelerated to 40km/h in 0.25 seconds. What force does she experience? (1778 N)

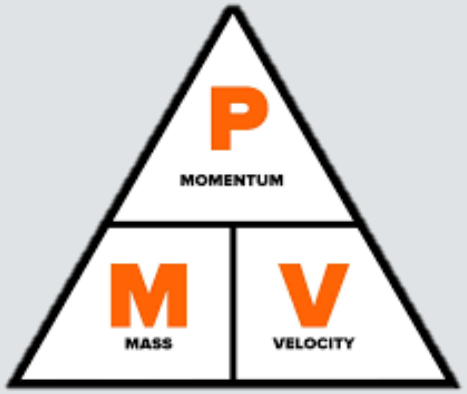
4. Mr. Cuesters (60kg) is determined to prove Taekwondo is better than Kung Fu and duels Mr. Putnam (? kg). He lands an axe kick with his full body weight at a speed of 5 m/s, decelerating in 0.5s. How much force do both men experience? (600 N)

Impulse and Collisions

- When a car comes to a stop, its **momentum** is reduced to zero
- In a collision the momentum change is the same, but in much less **time**
  - **7** seconds to stop from 60 km/h
  - In an accident, that takes **1** second
- The result is a **greater force**. Force is the difference between safety, injury, and death in car accidents.



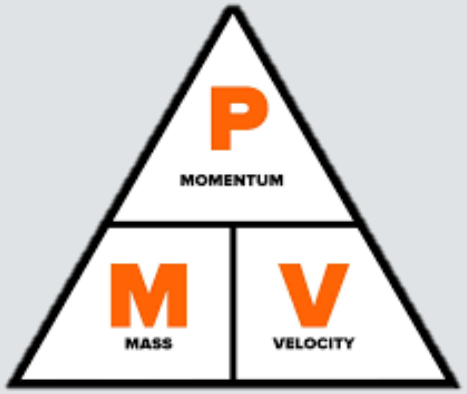
Collision Practice



1. A 1200kg car brakes from 60 km/h to 0 km/h in 10 seconds. What force does it experience? (2000 N)

2. The same 1200kg car hits a wall at 60 km/h, slowing to zero in 1 second. What force does it experience? (20 000 N)

Collision Practice

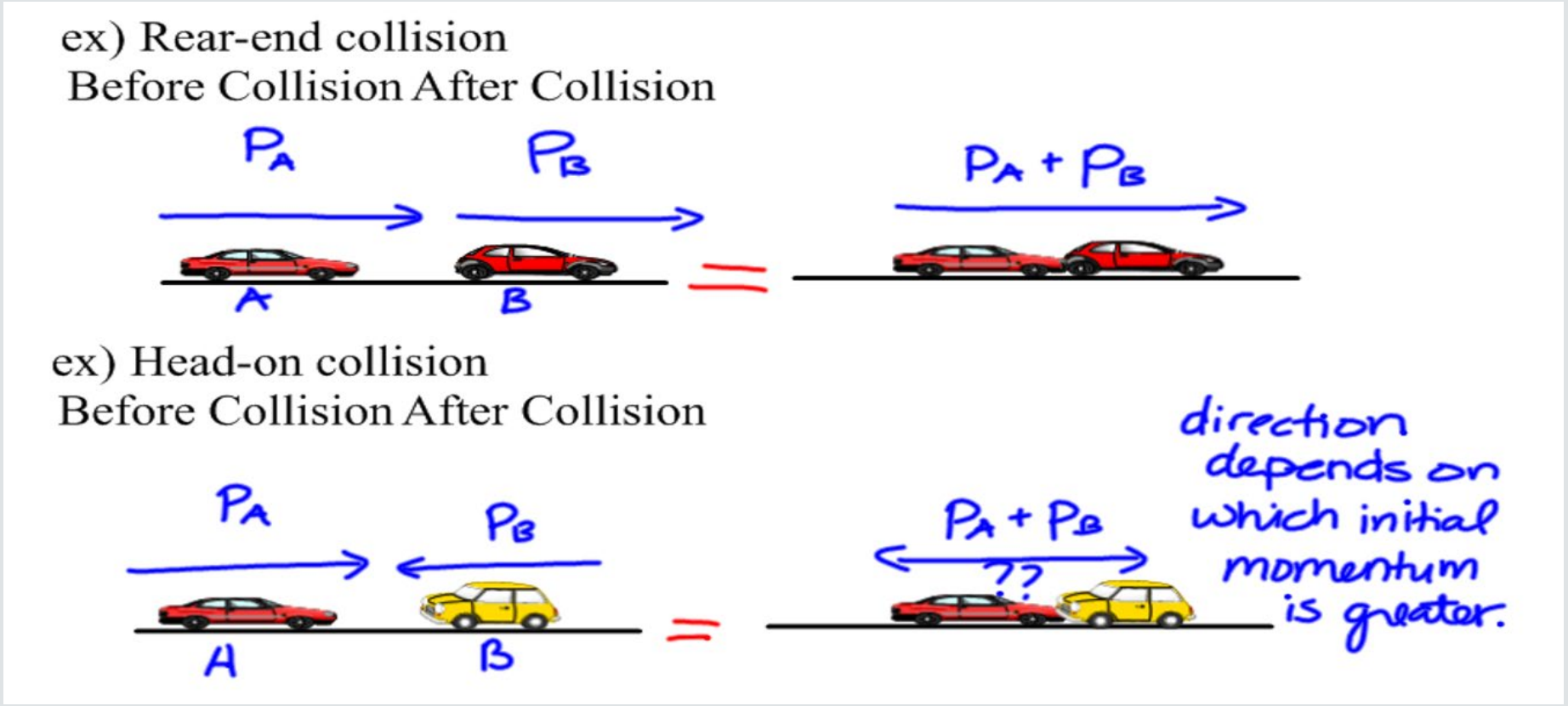


3. Mr. Cuesters (60kg) falls off a desk while lecturing, hitting the ground at 5 m/s. He stops in 0.25s. What force does he experience? (1200 N)

4. It takes around 1600 N to break a watermelon. If a 10kg watermelon is hurled at a wall and breaks, how fast was it moving? Assume it decelerated in 0.1 s. (16 m/s)

Conservation of Momentum

- The total momentum after a collision is the **same** as the total momentum before a collision
- We will (as always) disregard friction
- In car accidents, we often see this as the two vehicles locking together and moving as one



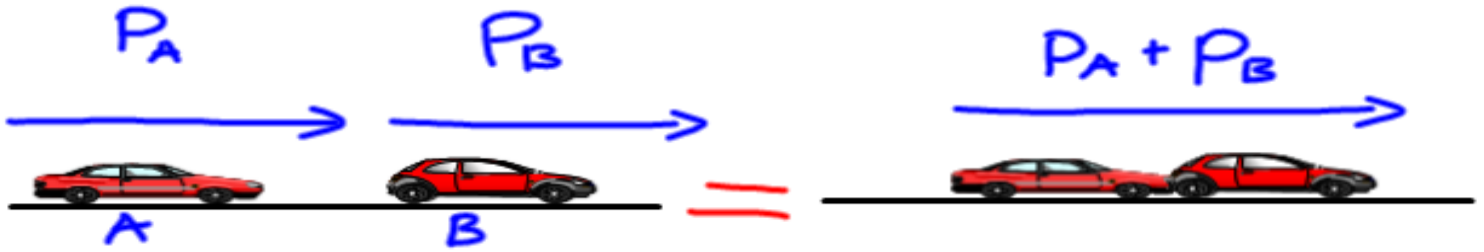
CONSERVATION OF MOMENTUM: DIAGRAM

Law of Conservation of Momentum

The total momentum of colliding objects stays the same after their collision. (momentum is NOT lost)

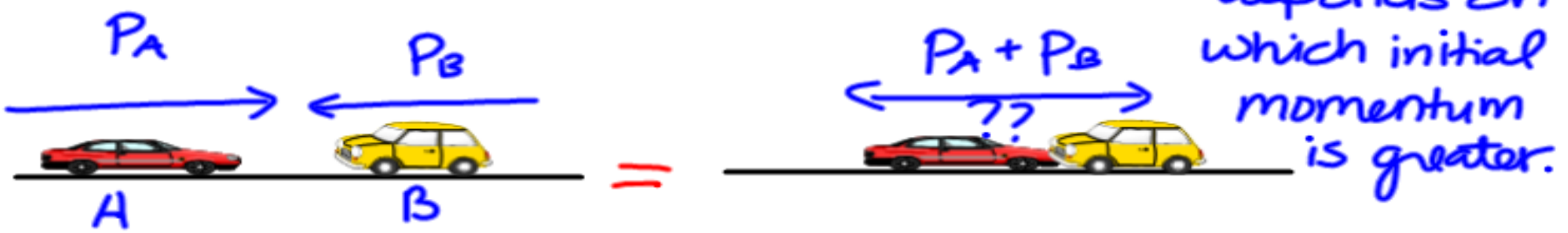
ex) Rear-end collision

Before Collision After Collision

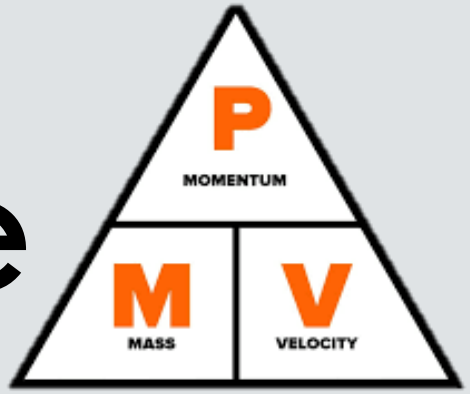


ex) Head-on collision

Before Collision After Collision



Conservation Practice



1. An eastbound transport truck weighing 10 000 kg and a westbound car weighing 2000 kg get in a head-on collision at 100 km/h. What is the momentum of each vehicle, including directions? [277 777 (kg x m)/s **East**, 55 555 (kg x m)/s **West**)

2. What is the total momentum before and after the collision? (222 221 (kg x m/s **East)**

3. Assume the vehicles lock together after the collision. What is their combined velocity? Include direction. (18.5 m/s **East**)