Slowing Momentum

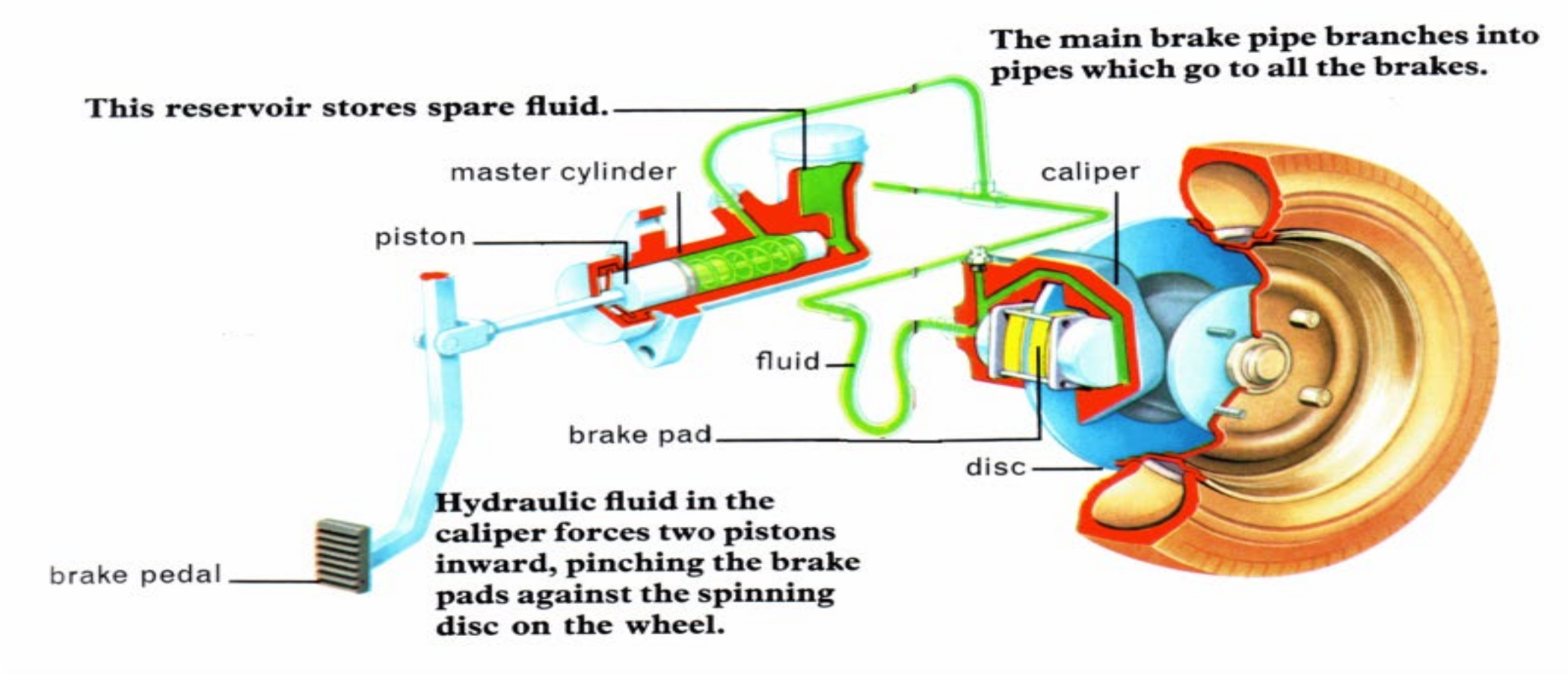
Braking:
- counteracts momentum
- apply a force that stops vehicles by decreasing their momentum

Brakes use **friction**.
Friction: the force that two objects have on each other when they press against each other.

Brakes use friction in two ways:
1. The brake pedal causes the brake pads to press against the inside of the brake drums on the vehicle's wheels.

2. Friction between the tires and the surface of the road also reduces momentum.

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: combination of the size of the force and the time over which the force acts

- ***impulse = change momentum***

(bigger impulses change the momentum more)

Δp = "delta" means "change in"

eg) when a car slows down, the seat belt applies a restraining force to counteract the momentum and make it zero

$\Delta p = F \times t$

Impulse = Force x Time

where impulse = measured in kgm/s
force = measured in kgm/s² or N
time = measured in seconds

Math Connect #1 (pg. 275)

A football player collides with another player. The force of the collision is 1000 kgm/s². The collision lasts 1 second. What is the impulse?

$\Delta p = ?$

$F = 1000 \frac{kgm}{s^2}$

$t = 1s$

$\Delta p = F \times t$

$= 1000 \frac{kgm}{s^2} \cdot 1s$

$= 1000 \frac{kgm}{s}$

Math Connect #2 (pg. 275)

What would be the impulse created by the same force of tackle (1000 kgm/s²), but this time lasting for 2 seconds?

$\Delta p = ?$

$F = 1000 \frac{kgm}{s^2}$

$t = 2s$

$\Delta p = F \times t$

$= 1000 \frac{kgm}{s^2} \cdot 2s$

$= 2000 \, kgm/s$

Math Connect #3 (pg. 275)

A baseball player feels a frictional force of 400 N as she slides into home. What is the impulse if the slide lasts 0.5 seconds?

$\Delta p = ?$

$F = 400\,N$

$t = 0.5\,s$

$\Delta p = F \times t$

$= 400\,N \times 0.5\,s$

$= 200\,Ns$

Math Connect #4 (pg. 275)

What would the impulse be if the same slide lasted 2 seconds?

$\Delta p = ?$

$F = 400\,N$

$t = 2\,s$

$\Delta p = 400\,N \times 2\,s$

$= 800\,Ns$

Collisions

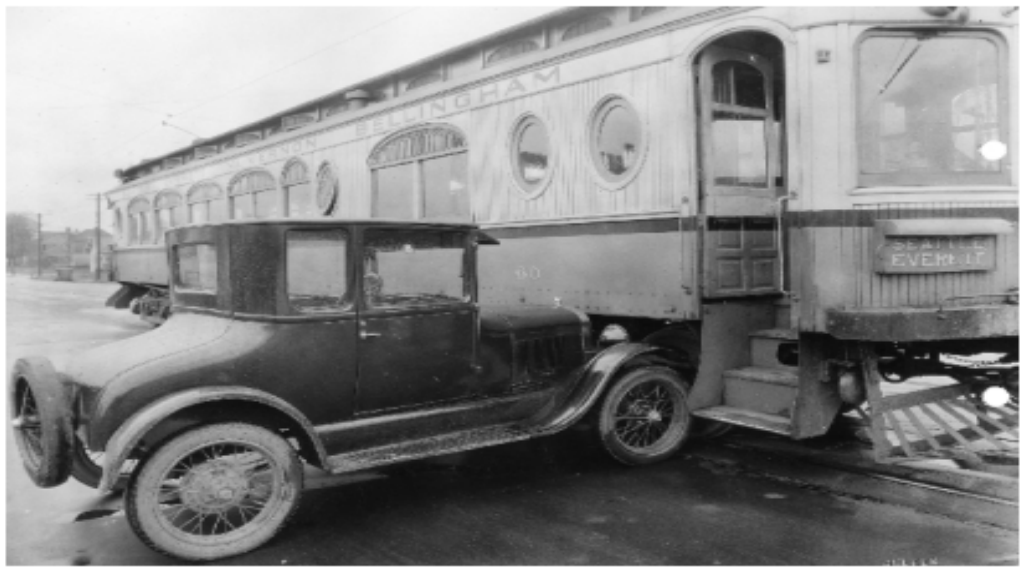
During a collision, the same thing happens as if a car came to a NORMAL stop --- momentum changes to ZERO.

The difference: The time it takes to come to a STOP.

ex) Regular driving: going from 60 km/h to 0 km/h may take 10 sec.
Collision: going from 60 km/h to 0 km/h may take 1 sec.

The force needed to make this change is LARGER because it has to happen in less time.
(ie. impulse is the same so force has to increase)

The Force is the difference between safety, injury, and death.



Force = Mass x Change in Velocity / Time

$$F = \frac{m \cdot \Delta V}{t}$$

Math Connect #1 (pg. 278)

1a. During a race, a 1200 kg car slowed down to 100 km/h (28 m/s) just before it hit a brick wall. It stopped in 1 s. What force was involved?
NOTE: This is Car B in Figure 15.7 (on page 277).

$m = 1200\ kg$

$v_i = 100\ km/h = 28\ m/s$

$v_f = 0\ km/h = 0\ m/s$

$t = 1\ s$

$$F = \frac{m\Delta V}{t} = \frac{1200\ kg\,(0\ m/s - 28\ m/s)}{1\ s}$$

$$= -33\,600\ N$$

b. How much larger is this force than the force in the sample problem?

$F_{sample} = -1344\ N$

$$F - F_{sample} = \overbrace{25\ s}$$

$$= -33\,600\ N - (-1344\ N)$$

$$= -32\,256\ N$$

Math Connect #2 (pg. 278)

2. A sport utility vehicle with a mass of 2000 kg is travelling at 100 km/h. The driver brakes to avoid a small animal in the road. The velocity changes from 28 m/s (100 km/h) to 8 m/s (30 km/h) in only 2 seconds. What force does the vehicle experience?

$m = 2000\,kg$

$V_f = 8\,m/s$

$V_i = 28\,m/s$

$t = 2\,s$

$F = ?$

$$F = \frac{m\Delta v}{t}$$

$$= \frac{2000kg\,(8\,m/s - 28\,m/s)}{2s}$$

$$= -20\,000\,N$$

Sec 15.2

CYU (p276) #1-5

Sec 15.3

CYU (p280) #1-3

Math Connect #3 (pg. 278)

3a. A 1500 kg car collides with a roadside barrier, and the car's velocity changes from 28 m/s (100 km/h) to 0 m/s in 0.5 seconds. What force does the vehicle experience?

$m = 1500\text{kg}$

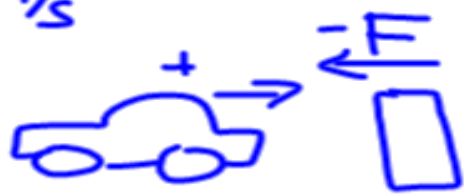
$\Delta V = 0\text{ m/s} - 28\text{ m/s}$

$= -28\text{ m/s}$

$t = 0.5\text{ s}$

$$F = \frac{m\Delta V}{t} = \frac{1500\text{kg}(-28\text{ m/s})}{0.5\text{ s}}$$

$= -84\,000\text{ N}$



b. How many times larger is this force than the force in question 2?

$F_{Q\#2} = -20000\text{N}$

$$\frac{F_{3a}}{F_2} = \frac{-84000\text{N}}{-20\,000\text{N}} = 4.2$$

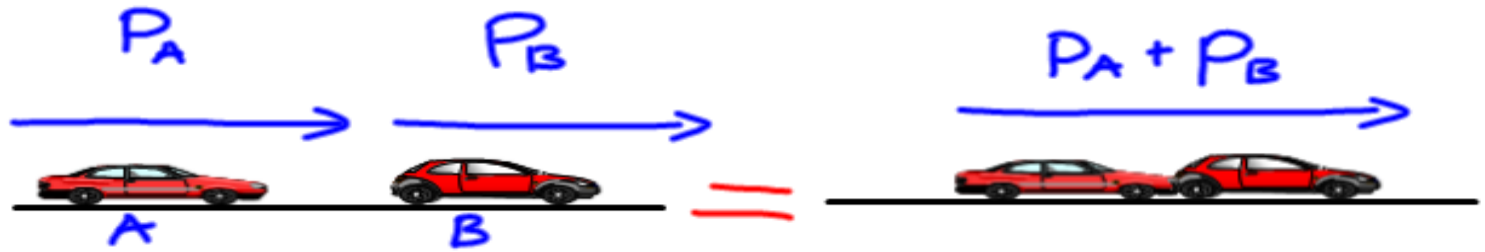
To Do: Do Check Your Understanding (pg. 280) #1 - 3

Law of Conservation of Momentum

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

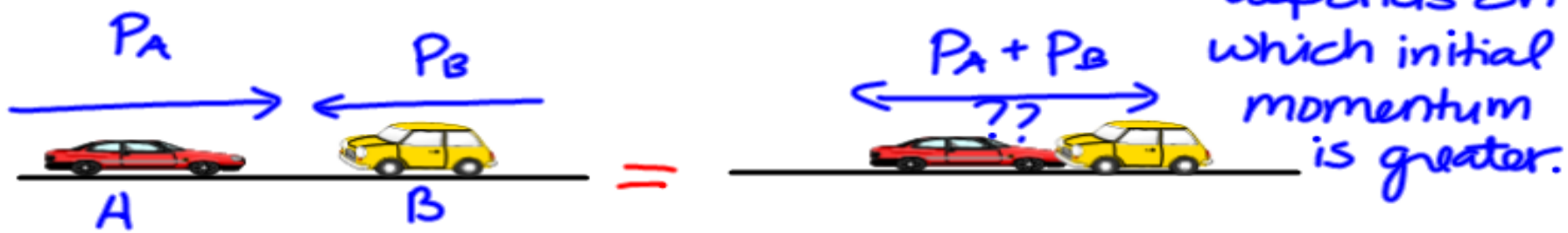
ex) Rear-end collision

Before Collision After Collision



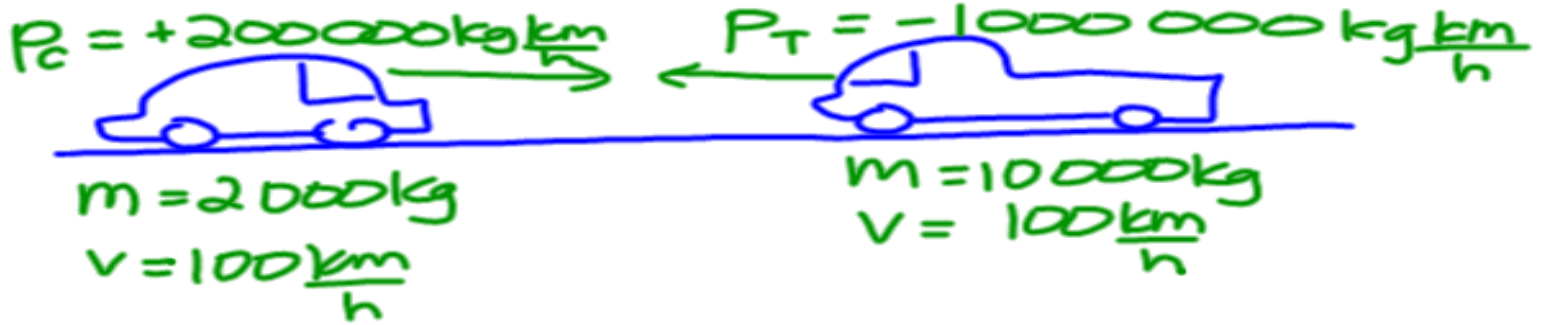
ex) Head-on collision

Before Collision After Collision



Math Connect #1 (pg. 283)

A transport truck with a mass of 10 000 kg and a car with a mass of 2000 kg are travelling at the same velocity (100 km/h) but in opposite directions. The truck is travelling to the left, and has a momentum of - 1 000 000 kg(km/h). The car is moving to the right, and has a momentum of +200 000 kg(km/h). What is the total momentum after the collision? In which direction will these vehicles move if they collide?



$$P_{after} = P_C + P_T$$

$$= +200\,000 \text{ kg}\frac{\text{km}}{\text{h}} + -1000\,000 \text{ kg}\frac{\text{km}}{\text{h}}$$

$$= -800\,000 \text{ kg km/h}$$

Left

To Do: Do Check Your Understanding (pg. 283) #1 - 2

To Do:

Do Check Your Understanding (pg. 276) #1 - 5
Do Check Your Understanding (pg. 280) #1 - 3
Do Check Your Understanding (pg. 283) #1 - 2

Do Chapter 15 Review (pgs. 284 - 285) #1 - 7 & 9 - 12