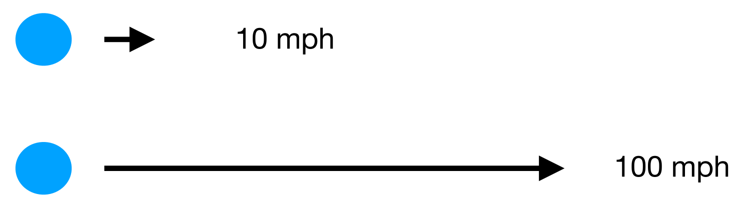
Momentum = p = m x v

Momentum is a measure of how hard it is to stop the object.
More momentum = harder to stop

A- Consider two objects of the same mass, e.g. two baseballs. One of them is coming at you at 10 mph, and the other at 100 mph. which one has the greater momentum (harder to stop)?

Baseball 1 (m, 10 mph), P1 = m x 10

Baseball 2 (m, 100 mph), P2 = m x 100,



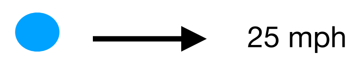
Compare P1 and P2. Which one is bigger? Baseball 2 is harder to stop.

Momentum = p = m x v

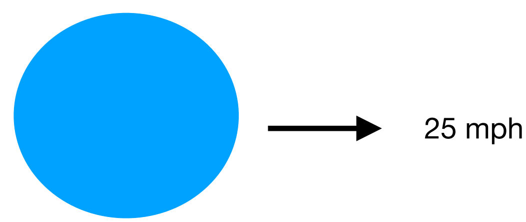
Momentum is a measure of how hard it is to stop the object.

B- Now consider two objects of different mass with the same velocity, e.g. a Ping-Pong ball and a cannon ball, both coming at you at 25 mph. Which one has the greater momentum (harder to stop)?

Ping-Pong ball (m, 25 mph), P1



Cannon ball (M, 25 mph) P2,



Compare P1 and P2. Which one is bigger? Cannon ball is harder to stop, so it has bigger momentum.

Why there are no seatbelts in the bus?

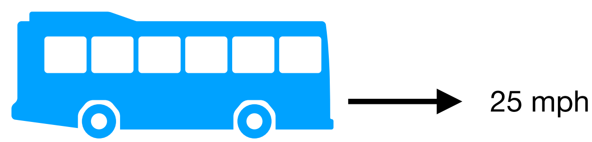
Momentum = p = m x v

Momentum is a measure of how hard it is to stop the object.

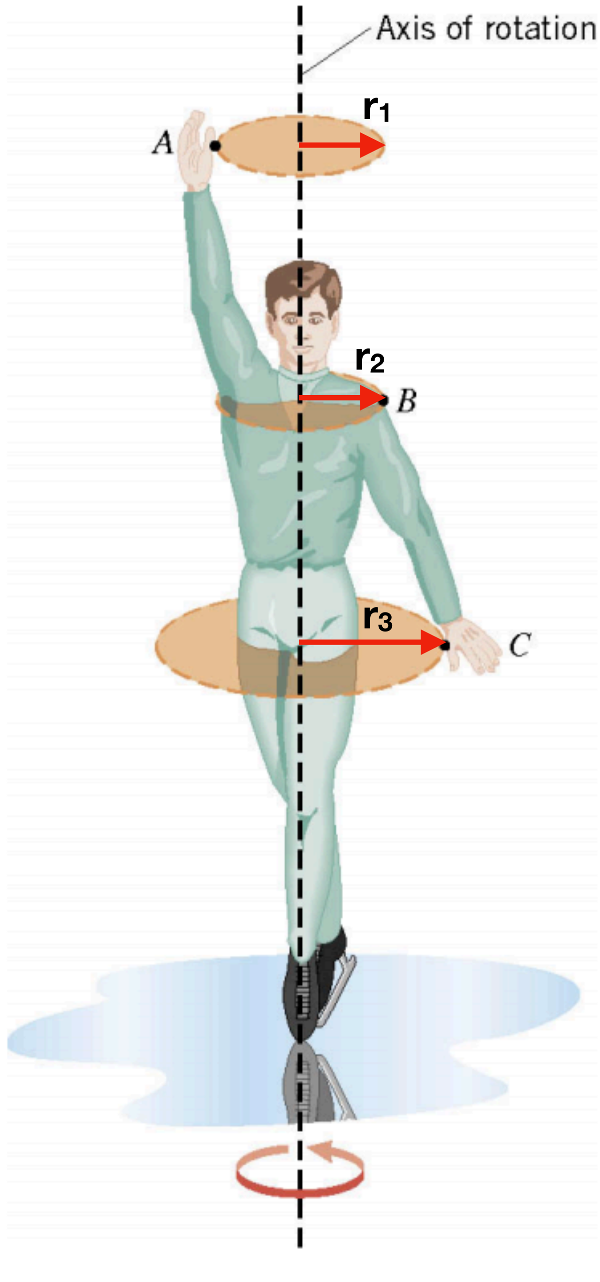
More momentum = harder to stop

Car (m, 25 mph), P1

Bus (M, 25 mph) P2,



Compare P1 and P2. Which one is bigger? The bus is harder to stop, so it has bigger momentum.


Axis of rotation
r1
A
r2
B
r3
C

Friction?

Ice Skater Scratch Spin

Relationship:

The closer her arms and legs to her body, the faster she spins.

Angular momentum:

Because she is spinning/circling :

Isolated system:

No external force is acting on the skater. She is an isolated system.

Conservation of Momentum:

No outside force is acting on her. Her angular momentum is **conserved. The angular momentum (L) stays the same** from beginning to end.

Angular Momentum = mass x velocity x radius

$$L = m \times v \times r$$

What to do to make *L* big?

$$L = m \times v \times r$$

To have a large angular momentum. You need to have a big r , v and m.

a) Beginning:

She extended her arms and legs to have a large r and consequently a large L.

Beginning: Assume that the skater has a mass of 50 kg (m = 50 kg) and she was able to rotate 2 rounds per second (V = 2 RPS) when her arms were open (r = 1 m). Calculate her angular momentum at the beginning.

Angular Momentum = mass x velocity x radius

L = m x V x **r**

= 50 x 2 x **1**= 100 kg.RPS.m

The momentum (100) will stay the same until the end.

b) During: Conservation of momentum:

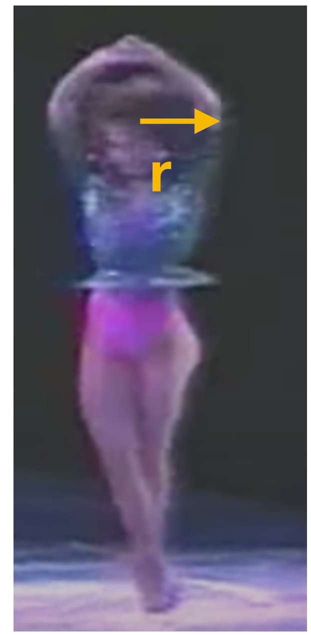
L (100)

1
r = 1 m
V = 2 rps

L (100)

2
r = 0.5 m
V = 4 rps

L (100)



3
r = 0.25 m
V = 8 rps

(1) L = 100, r = **1** m, V = **2** RPS

(2) L = 100, r = **0.5** m, Calculate V.

$$L = m \times v \times r$$

$$100 = 50 \times V \times \mathbf{0.5} = 25 \times V$$

$$\frac{100}{25} = \frac{25}{25} \times V$$

V = **4** RPS

Her speed doubled when she folded her hands.

(3) $L = 100$, $r =$ **0.25** m, $m = 50$ kg, $V = ?$

$$L = m \times V \times \mathbf{r}$$

$$100 = 50 \times V \times \mathbf{0.25}$$

$$100 = 12.5 \times V$$

$$\frac{100}{12.5} = \frac{12.5}{12.5} \times V$$

V = **8** RPS

Her speed doubled when she folded her hands over her head.

Conservation of momentum and summary:

Her momentum stay 100 until the end.
Her mass will not change

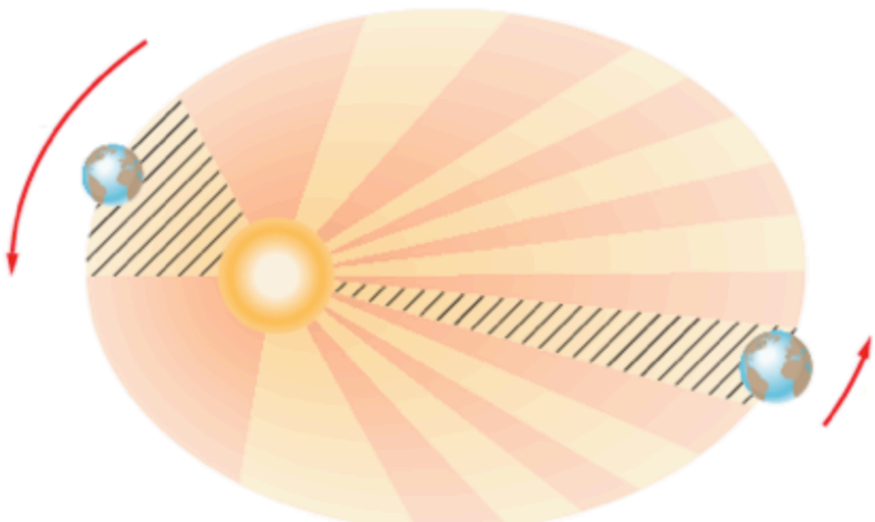
If r decreases, then V must increase.

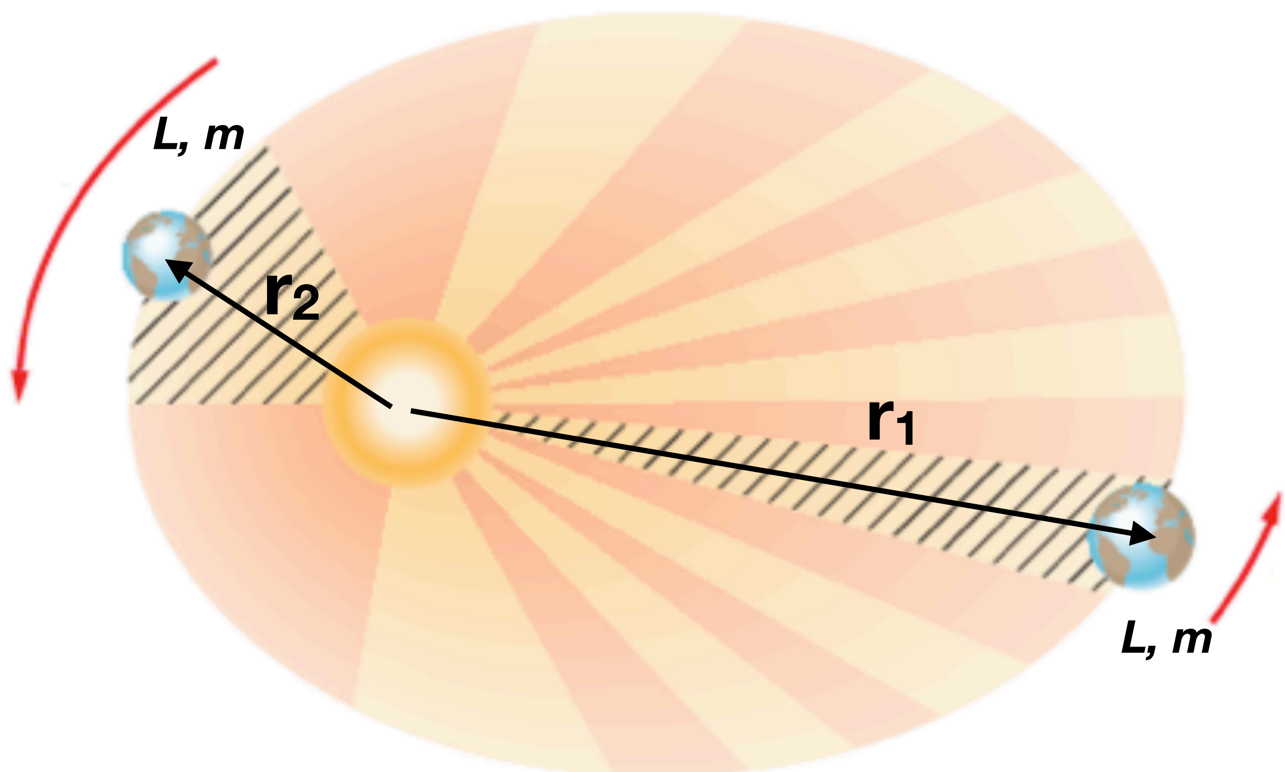
L = mass x V (↑) x r (↓)

The closer her arms and legs to her body (r ↓
, the faster she spins (V ↑

The Earth moves faster when it is closer to the sun. Why?

Use conservation of angular momentum to explain, similar to the ice skater.




L, m
r2
r1
L, m

Conservation of momentum and summary:

1. Earth is spinning = Angular momentum (L)
2. Isolated system = Conservation of momentum = Momentum stays the same
3. Earth mass is the same.

If r decreases, then V must increase.

$$L = \text{mass} \times V(\uparrow) \times r(\downarrow)$$

Earth moves faster when it is closer to the sun because r is smaller.