What is biomechanics?

Biomechanics is the sport science field that applies the laws of mechanics and physics to human performance, (in order to gain a greater understanding of performance in athletic events).

"Every object persists in its state of rest or uniform motion in a straight line unless it is compelled to change that state by forces impressed on it."

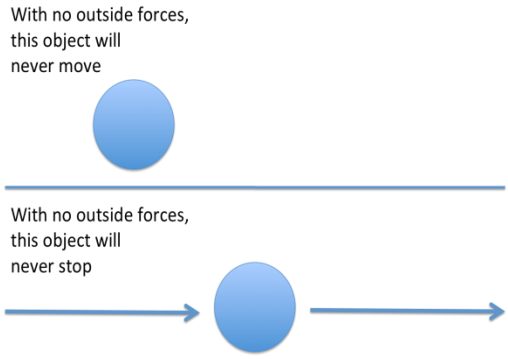
"Force is equal to the change in momentum (mV) per change in time. For a constant mass, force equals mass times acceleration." F=m a

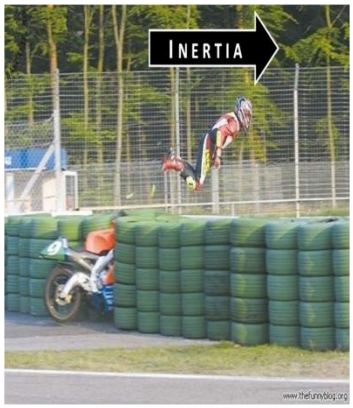
"For every action, there is an equal and opposite re-action."

Newton's first law (The law if Inertia)

An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force.

- **Inertia** is the resistance of any physical object to any change in its state of motion





Newton's Second law (F=MA)

The second law states that the acceleration of an object is dependent upon two variables - the net force acting upon the object and the mass of the object.

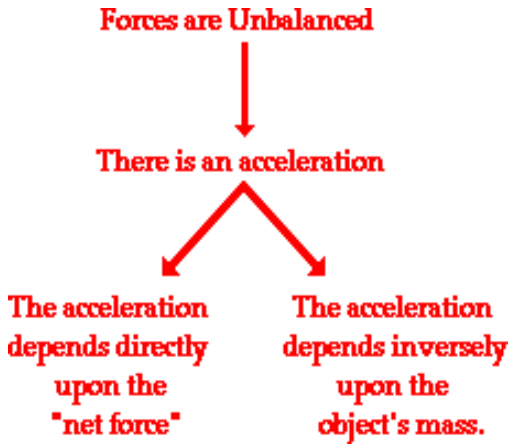
Force in newtons (N)

Mass in Kilograms (KG)

Acceleration in (m/s^2)

Force = Mass x acceleration

Acceleration = Force/Mass



Determine the accelerations that result when a 12-N net force is applied to a 3-kg shot putt and then to a 6-kg shot putt.

A 3-kg object experiences an acceleration of _____

A 6-kg object experiences an acceleration of _____

Think about the forces needed to stop your head from coming off during a crash 'whiplash'.

Newton's Third Law

For every action, there is an equal and opposite reaction.

Now Recap -

4.3.8. Explain how Newton's laws relate to sporting activities.

Activity	Explanation with example
Newtons First Law	
Newtons second law	
Newtons Third Law	Block start
	The third law states: for every action, there is an equal and opposite reaction. Athletes must push backwards and downwards with large forces on to the blocks. According to Newton's third law, the blocks will push back with the same force, but in the opposite direction ‹forwards and upwards› (reaction force) As the blocks are connected to the ground ‹which has a much larger mass than the athlete› the ground will not move backwards, but the athlete will move forwards and upwards out of the blocks.

State and explain the factors that affect projectile at take-of or release

- Newton's first law states that things that are in motion keep moving without the need for an external force.
- Therefore, once a force has been removed the object can no longer be altered
- This means that the path of the object is determined at the moment it leaves the hand/bat etc

State and explain the factors that affect projectile at take-of or release

- Gravity, air resistance and lift play a part in how far an object will go
- The most important factors are…..
    - Projection speed
    - Projection angle
    - Projection height

Throwing a ball to a friend or shooting a cannon are both examples of projectile motion. **Gravity** is a force that acts upon objects, drawing them towards the center of the Earth at 9.81 m/s^2. Horizontal motion happens when an object is acted upon by an outside force, and it will stay in motion until acted upon by another force, including hitting the ground.

- **Newton's Third Law of Motion** says that an object will stay in motion unless acted on by an outside force, so this means that there is no acceleration in the horizontal direction.
- The angle at which something is thrown or shot also affects how far it will travel, because what goes up must come down!

Problem: Find the launch angle of a projectile for the longest distance.

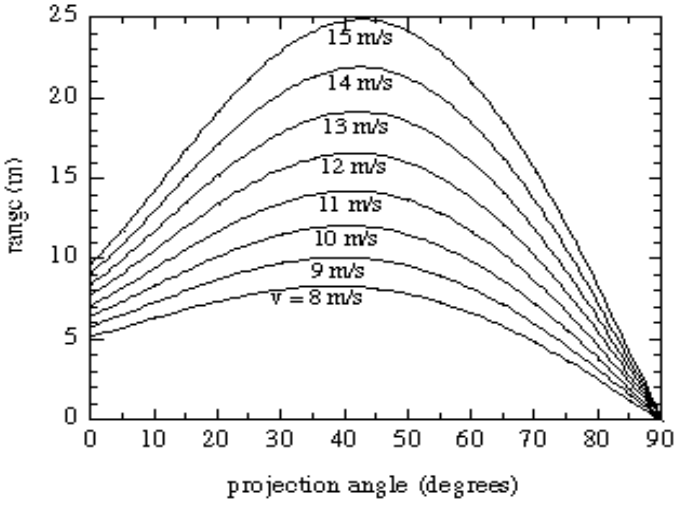
-Which angle will launch the projectile the farthest? Why? What happens if the launch angle is smaller? Greater?

- **Materials**: Marshmallow gun, Marshmallows, Tape measure, Calculator

<u>The effect of velocity on distance in throwing the shot putt</u>

As a coach, would you change your shot putters angle to 40 to improve distance???

- The structure of the human body motions production of force in the horizontal direction more than vertical i.e. should press vs bench press
- shot-putter must expend a greater effort during the delivery phase to overcome the weight of the shot, and so less effort is available to accelerate the shot (i.e. produce projection speed).

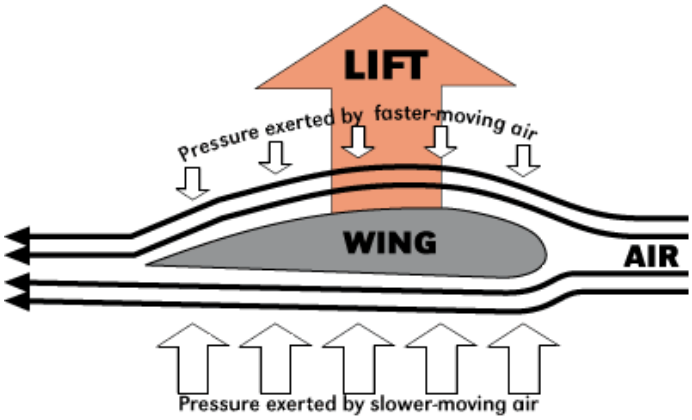


Conclusion

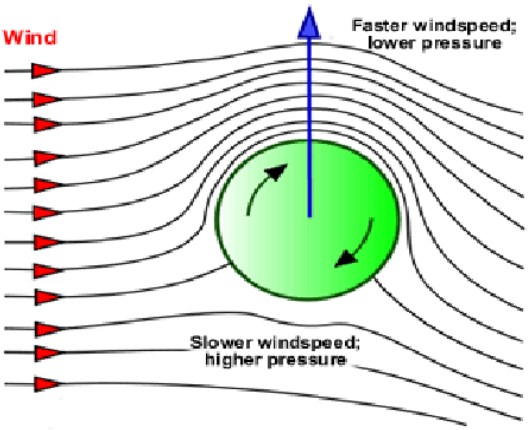
- In the throwing and jumping events, the optimum projection angle is usually considerably less than 45° because the speed an athlete can produce decreases as the projection angle is raised.
- The optimum projection angle is different for every athlete.
- Most athletes find their optimum projection angle relatively quickly through trial-and-error, and achieving a high projection speed is much more important than throwing or jumping at the optimum angle.

The Bernoulli Principle

- The Bernoulli's Principle is a physics principle that an increase in the speed of a fluid/air produces a decrease in pressure and that a decrease in the speed of a fluid/air produces an increase in pressure.
- The principle states that the total energy of a moving fluid remains constant at all times.
- Therefore fluid pressure is inversely proportional to fluid velocity.



The ***Magnus Effect*** describes the flow of air around a rotating sphere (baseball, golf ball, soccer ball).



- On one side of the sphere the velocity will be enhanced. On the opposite side the velocity will be decreased.
- According to Bernoulli's principle, this creates a pressure differential and a force perpendicular to the velocity vector of the sphere. This is the Magnus force. (curveball, etc)
- **Dimples** on a **golf ball** create a thin turbulent boundary layer of air that clings to the **ball's** surface.
- This allows the smoothly flowing air to follow the **ball's** surface a little farther around the back side of the **ball**, thereby decreasing the size of the wake.
- This reduces the Magnus force and thus the effects of the Bernoulli Principle causing the ball to fly on a straighter line.