3A/3B BIOMECHANICS 2nd Ed.

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PE STUDIES
Revision Seminars

CONTENTS	SLIDE

CONTENTS	SLIDE

NEWTON'S 2ND LAW OF MOTION

http://commons.wikimedia.org/wiki/File:Mens_100m_finals_British_Champs_and_Olympic_Trials.jpg

Q. Assuming that both sprinters are exerting the same amount of force against the starting blocks, discuss why one might accelerate at a faster rate off the blocks. Relate your answer specifically to Newton's Second Law.

NEWTON'S 2ND LAW OF MOTION

http://commons.wikimedia.org/wiki/File:Mens_100m_finals_British_Champs_and_Olympic_Trials.jpg

A. Newtons 2nd law of motion states that the rate of change of acceleration to a body is proportional to the force applied to it and inversely proportional to the mass. Therefore, if both sprinters apply the same amount of force to the blocks, the one with the smaller mass will accelerate at the greater rate.

MOMENTUM

- **CONSERVATION OF LINEAR MOMENTUM**
  - Principle states the total momentum of two objects before and after impact are equal
  - This occurs in situations where a perfectly elastic collision takes place i.e. one where no energy is lost to sound and heat
    - The momentum of one object is transferred on contact to the other object, resulting in no change in total momentum, rather a transfer of momentum

E.g. When playing snooker, once struck, the white "cue ball" will contain a certain amount of momentum. This is determined by its mass and how fast its travelling. When this ball makes contact with the black ball (pictured right) the total momentum of the two balls before and after collision will remain the same. Some of the momentum would have simply transferred from the white ball to the black ball.

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Home

NEWTON'S 3RD LAW OF MOTION

- This law directly applies to the concept of conservation of momentum.
- Newton's 3rd law explains that when collisions occur, an equal and opposite force occurs resulting in a transfer of momentum from one object to the other

E.g. When swinging a baseball bat towards a ball, both the ball and bat posses a certain amount of momentum before collision. Upon collision, the ball explodes away while the baseball bat rapidly decelerates during follow through. Total momentum between the two objects has remained the same, its just most of it has been transferred into the baseball to send it flying away.

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Home

COEFFICIENT OF RESTITUTION (COR)

- COR measures the elasticity of the collision between an object and a given surface. It measures how much energy remains in the object after a collision takes place.
- Elasticity is a measure of how much rebound exists following a collision.
- An objects COR is measured on a scale of 0→1
  - A COR of 1 represents a perfectly **elastic collision** (i.e. When a ball is dropped from a given height the ball will rebound to that same height after colliding with the ground)
  - A COR of 0 represents a perfectly **inelastic collision,** effectively stopping at the surface with which it collides (i.e. When the ball is dropped, it doesn't bounce at all)

Play dough represents a perfectly inelastic collision.
When dropped from a given height, play dough stops at the surface with which it collides.

Home

ANGULAR MOMENTUM

The quantity of angular motion possessed by a rotating body

Angular momentum = angular velocity * moment of inertia

- Remember when we are talking in a **linear sense**
  - Momentum = velocity * mass
- Angular momentum is the same, just in a **angular sense**
  - Angular velocity refers to the velocity or speed of a rotating object
  - Moment of inertia refers to the resistance of a rotating object to change its state of motion

LINEAR	ANGULAR
Mass	Moment of inertia
Velocity	Angular velocity
Linear momentum	Angular momentum

Home

ANGULAR MOMENTUM – MOMENT OF INERTIA (rotational inertia/angular inertia)

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The same concept applies to pitching in baseball;

- In the series of photos above, we see the pitcher extends his arm at the commencement of the pitch (photo 5) to ensure force can be applied to the ball over the maximum possible time and distance (increases impulse).

- To reduce the ball's moment of inertia, the pitcher bends his arm at the elbow (photo 6), bringing the mass of the ball closer to the axis of rotation (shoulder). This allows the pitcher to generate greater angular velocity at the arm which is then transferred into the ball at the point of release.

THIRD CLASS LEVER

- 3rd class levers are very effective when using striking implements (golf club, baseball bat, tennis racquet etc.)
  - By increasing the length of the resistance arm, it is possible to generate greater velocity of the striking surface, resulting in greater force being transferred onto the ball. However in striking sports, an increase in the length of the lever may result in an increased weight, affecting control.
  - This is why cricketers like Adam Gilchrist used to grip the bat at the very end of the handle – to create a longer resistance arm and therefore create increase bat velocity.
- In teaching any athlete how to kick, throw or strike a ball for distance, the same concept should be applied – maximise lever length at the point of impact by extending at the joint to maximise the speed of the impact or release point

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Maximising lever length at the point of impact ensures maximum speed at the impact or release point

http://www.flickr.com/photos/stuseeger/434121246/sizes/z/in/photostream/

BERNOULLI'S PRINCIPLE

LP = Low pressure

HP = High pressure

Throwing a discus applies the concept of Bernoulli's Principle just the same way as an airfoil on a plane.

To maximise distance, an athlete must find the appropriate angle which will create sufficient lift whilst still presenting a relatively small CSA to help minimise drag.
Too little angle (fig 1.1) and it will not have sufficient time in air
Too much angle (fig 1.3) and the discus will have too much lift.

Fig 1.1

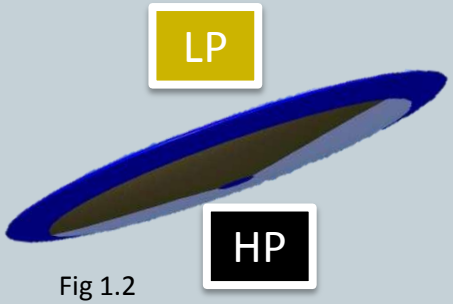


Fig 1.2

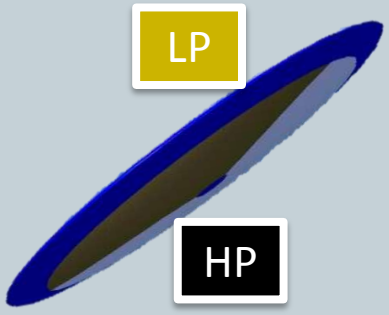
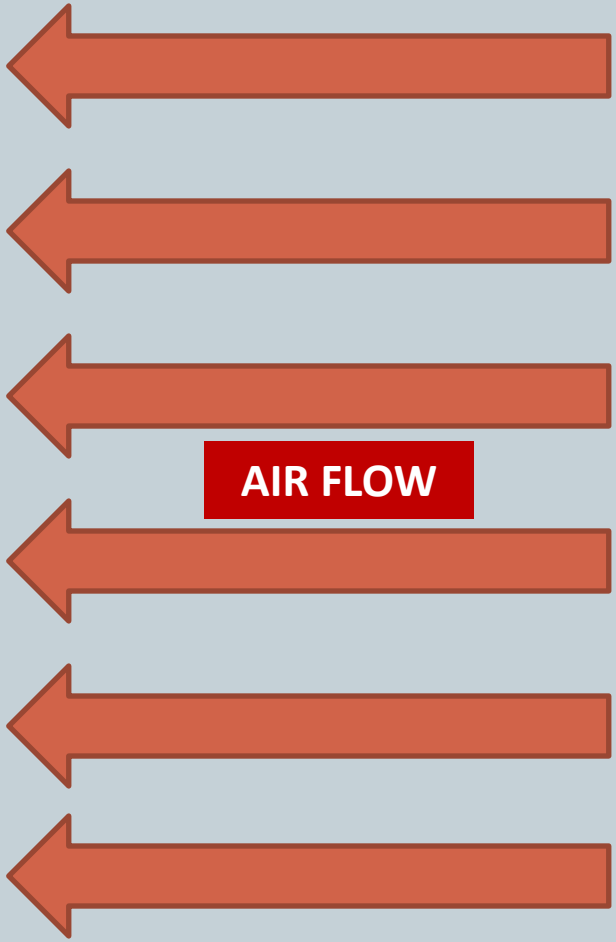


Fig 1.3



APPLICATION OF BIOMECHANICAL PRINCIPLES

- **INERTIA / MOMENT OF INERTIA**
  - Is the term used to describe the amount of resistance to a change in an objects state of motion
  - When referring to movements which involve rotation, we look at angular inertia/moment of inertia
  - The goal is to reduce the arms/bats moment of inertia at the commencement of the throw/strike by bringing the ball/bat close to the axis of rotation (the shoulder) therefore allowing the arm/bat to increase its angular velocity. This is achieved by bending at the elbow.

http://commons.wikimedia.org/wiki/File:AuntiMame_baseball_batter.svg

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