

Context matters in scale determination

How big is this church? →



Really. →



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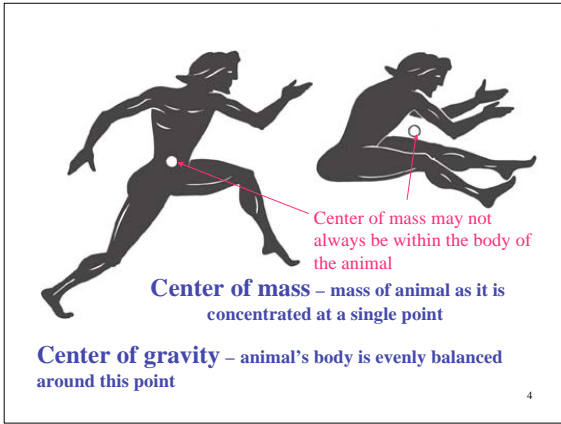
Biomechanics

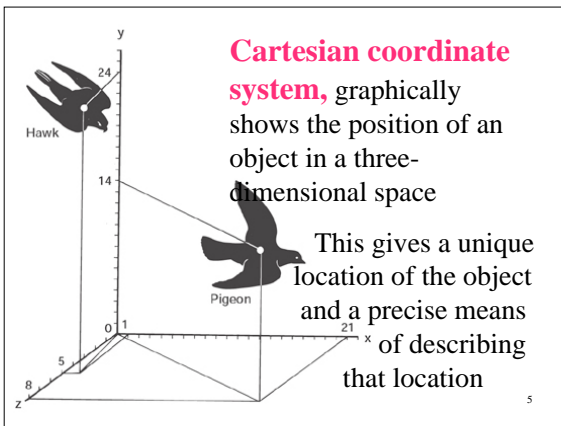
- Analysis of biological “design”
- Components include: length, time, force and mass
 - Mass is a property of matter
 - Weight is a property of force
 - When weight does not affect an object it is still difficult to move under water or in space because of mass
- Velocity – rate of change of an object’s position
- Acceleration – rate of change of the velocity
- Pressure – force divided by area

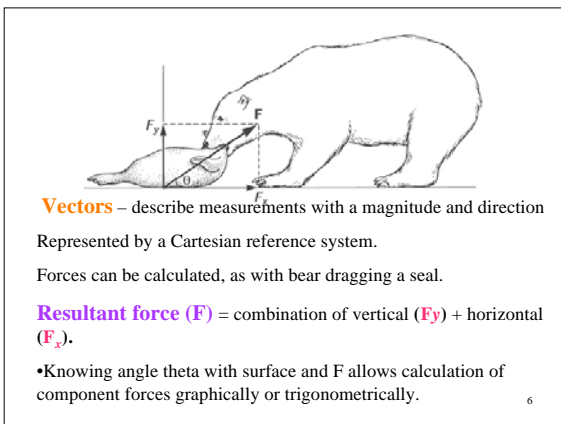
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- Power – the rate at which work is done
- Power = work/time
 - Power is not an appropriate term to use in discussing biomechanical “work” because as it is used in physics, it always indicates that work is done
 - In biological systems, effort may be exerted, but if nothing changes nothing is accomplished; therefore no work is done, so no power has been generated

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Force Laws (Isaac Newton – 1642-1727)

- **First Law of Inertia** – every body continues in a state of rest or in a uniform path of motion until acted upon by a new force
 - **Inertia** – tendency of a body to resist change in its state of motion
- **Second Law of Motion** – change in an object's motion is proportional to the force acting on it
 $F = ma$
- **Third law of action, reaction** – between two objects in contact, there is an equal and opposite reaction for each

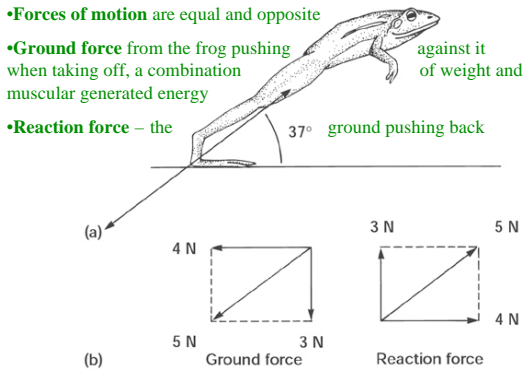
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Einstein's Theory of Relativity

Placed limits on Newtonian laws, but they work well enough until we get close to the speed of light, so will be used here.

=== We are not going to have to learn things that fast!!!! ===

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Free body diagram
 – depicts an isolated body part with forces acting on it.

In A the forces of the diver's weight and the diving board are equal, so only linear motion

In B angular motion results in unequal forces

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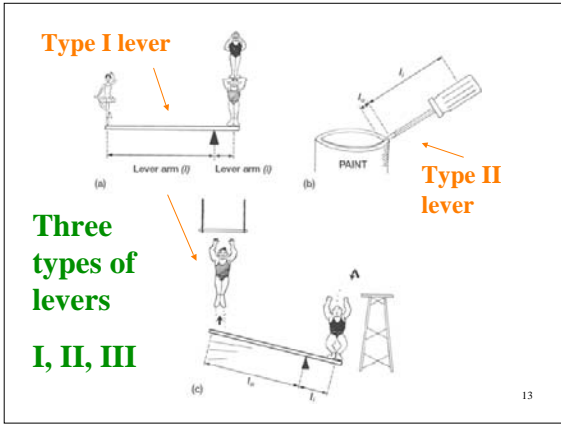
Torques and Levers

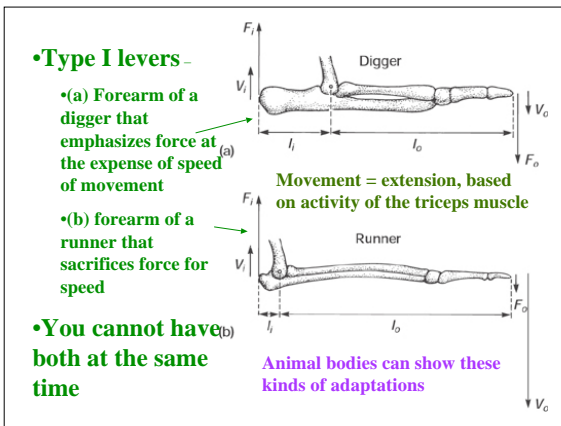
- **Lever** = a rigid bar that can be pushed or pulled to rotate about a fixed point
- **Fixed point** = fulcrum, pivot (point) or axis of rotation
- Pivot points are usually at **joints**
- Levers are moved by muscles that attach at various points along them
- The amount of force generated or required is determined by:
 - Position of load relative to pivot
 - Point of attachment of muscles

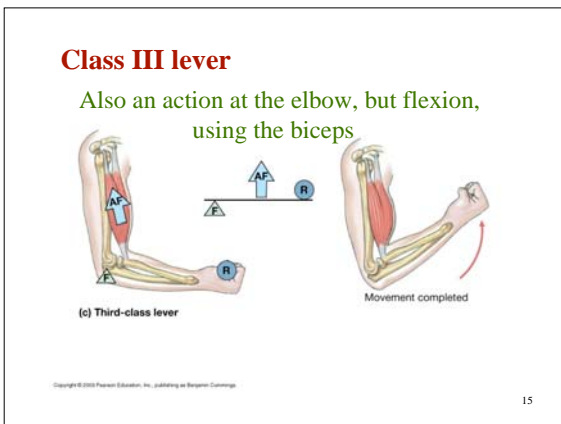
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- **Torque** – a force which acts at a distance from the fulcrum and turns the lever
- Forces generated by levers producing work are **in-torques** (= in-forces) and **out-torques** (out-forces)
- If more force is required, the “out” is shortened and the “in” is lengthened – **increases force at the expense of speed**
- If more speed is required, the “in” is shortened and the “out” is lengthened – **increases speed at the expense of force**


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High gear = speed

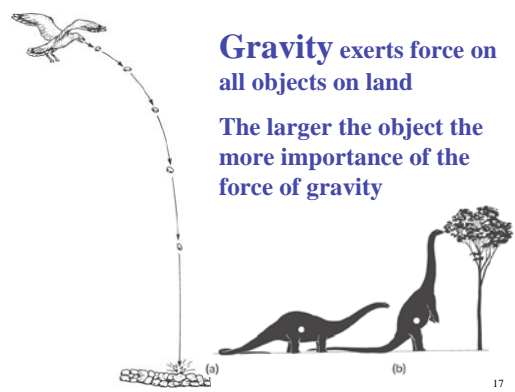


Mechanical advantage
The ratio of F_o/F_i , the output force to the input force

Speed
The ratio of the output lever to the input lever arm

Muscle gear ratios
Animals have limbs with muscles of different mechanical advantages that allow different contributions of force or speed

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Gravity exerts force on all objects on land

The larger the object the more importance of the force of gravity

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Air = compressible fluid

Water = dense, incompressible fluid

Drag = Fluid media resisting passage of object

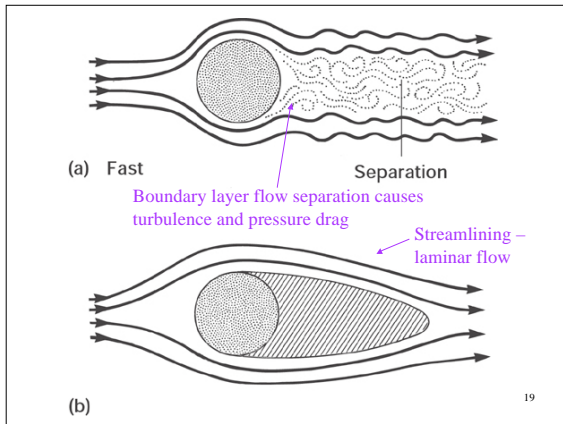
Friction (= skin drag) drag occurs from pressure on the skin of the animal as it passes through the medium

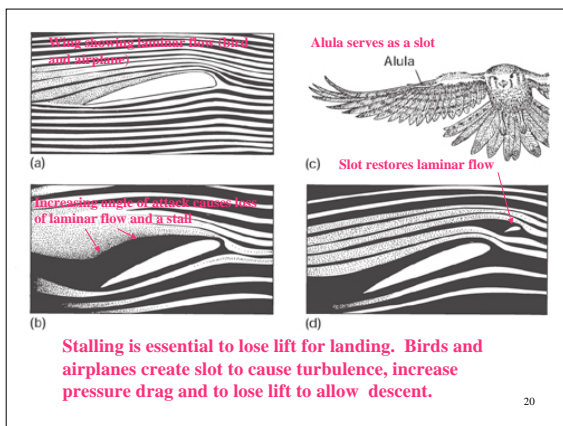
Streamlining = general layered patterns of fluid flow

Boundary layer = fluid layer that adheres to the surface

Pressure drag = boundary layer separation (= flow separation) because streamlines cannot close smoothly behind object, fluid behind object moves faster, pressure decreases

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Profile drag – combination of friction (skin drag) and pressure drag

- Related to the **shape of an object** as it forces itself through the fluid
- **Smooth** shape passes more easily
- **Tapered** shape passes more easily
- **Narrow**, or **sharp edges** pass more easily than broad or thick edges.
- This explains wing shape among different organisms and aircraft.

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