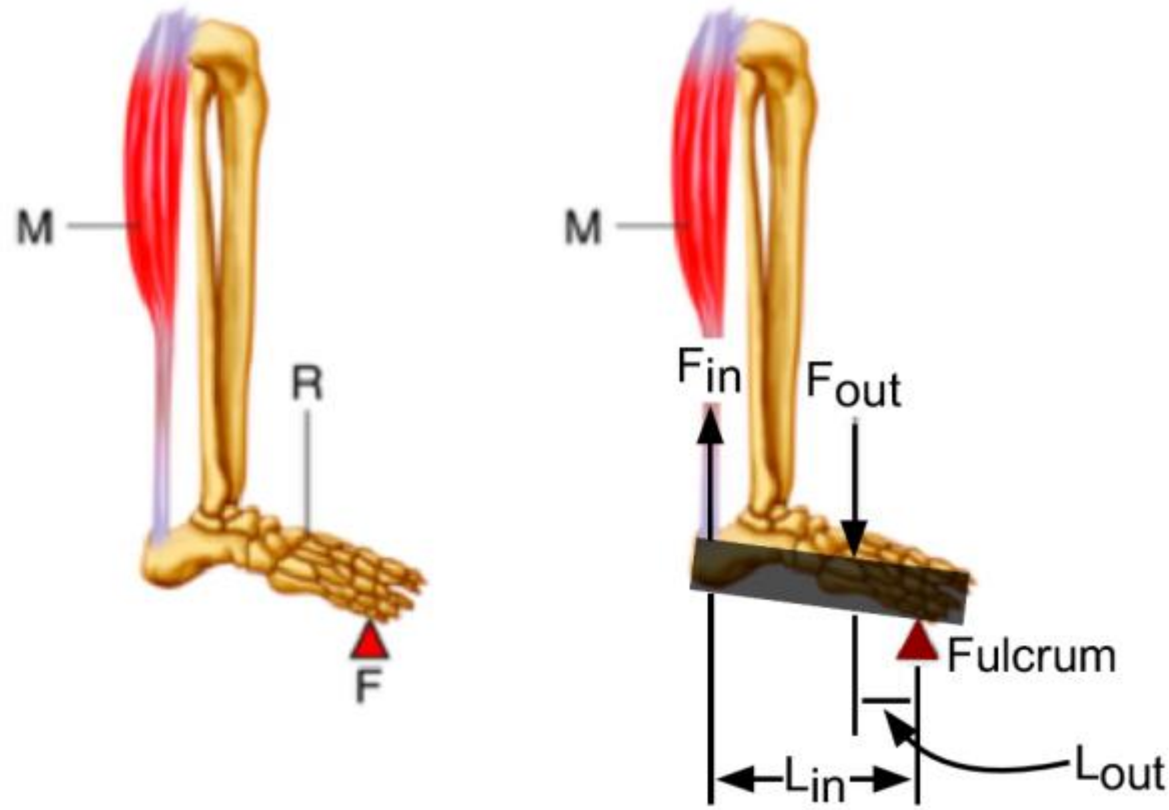
1. Tendon stress
   a. **2nd class lever**. The fulcrum is located at the ball of the foot as denoted by the figure that was provided. The force exerted by the gastrocnemius is F_{in}. The force resisting the motion—the weight of the foot—is F_{out}.



   b. Given:
      Mass of the individual = m = 70 kg
      L_{in} = 15 cm = 0.015 m
      L_{out} = 10 cm = 0.01 m
      It is important to remember that L_{in} and L_{out} correspond to the distance between the fulcrum and F_{in} and F_{out} respectively. <u>L_{in} is **NOT** the length of the muscle</u>.

      $F_{out} = F_{Resistance}$ = mg = (70 kg)*(9.8 $\frac{m}{s^2}$)
      $F_{in} = F_{Generated\ by\ muscle}$ = ?

$$F_{in}L_{in} = F_{out}L_{out}$$

$$\boxed{F_{in} = \frac{L_{out}}{L_{in}}F_{out} = \left(\frac{0.01\ m}{0.015\ m}\right)(70\ kg)\left(9.8\ \frac{m}{s^2}\right) = 457.3\ N}$$

c. Given:

d_{tendon} = 1 cm = 0.01 m

$A_{tendon} = \pi * r^2$

$$\sigma_{tendon} = \frac{F_{in}}{A_{tendon}} = \frac{457.3\ N}{\pi\left(\frac{0.01\ m}{2}\right)^2} = 5.823\ MPa$$

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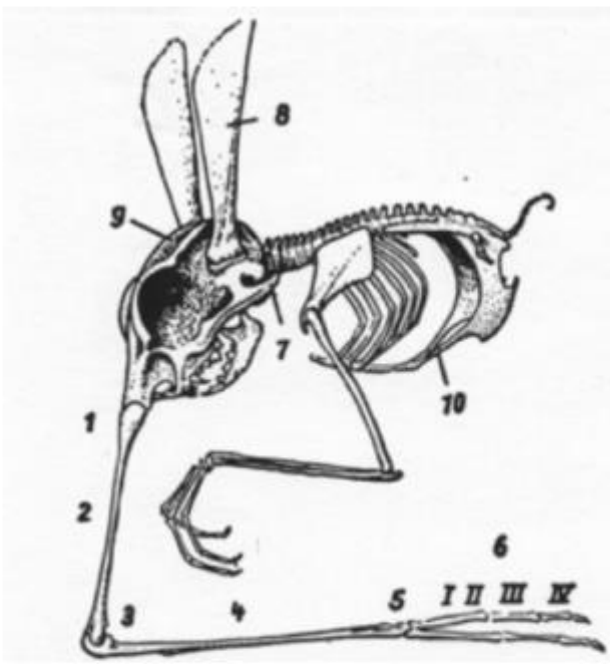
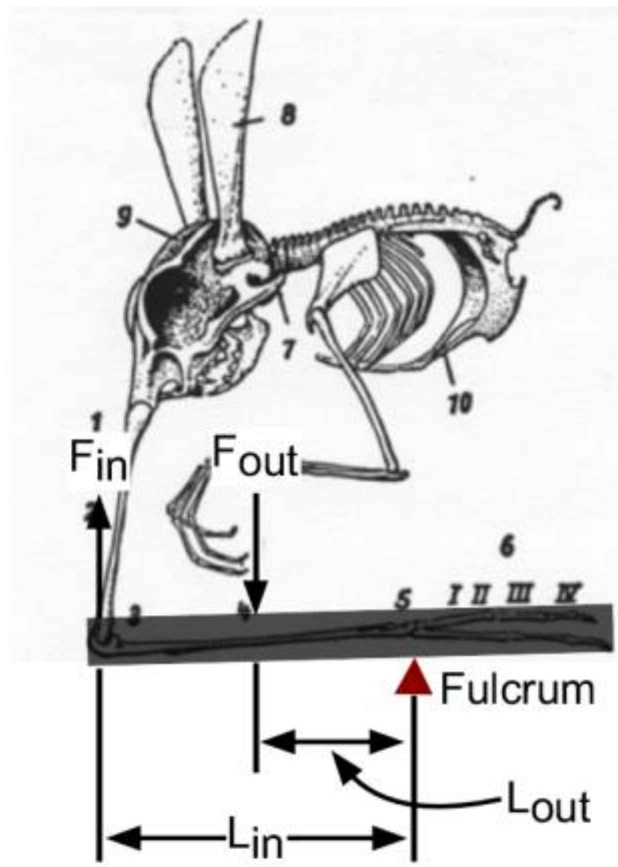
2. *Otopteryx volitans*- The Rhinogrades
   a. **2nd class lever**. Similar to the gastrocnemius problem above.





   b. Speed ratio (SR) and mechanical advantage (MA) are dimensionless numbers. Therefore, you only need the **ratio of the lengths** to compute both SR and MA.

c. What is relevant is the ratio of lengths. Note that the foot bone is 5 cm in length (when you measure it out with a ruler). This yields L_{in} to be ~5 cm, and L_{out} to be ~3.75 cm.

$$Mechanical\ advantage = MA = \frac{L_{in}}{L_{out}} = \frac{5\ cm}{3.75\ cm} = 1.33$$

$$Speed\ ratio = SR = \frac{1}{MA} = \frac{L_{out}}{L_{in}} = \frac{3.75\ cm}{5\ cm} = 0.75$$

Points were awarded as long as SR was larger (and inversely proportional) to MA.

For more information on the Rhinogrades, check this out:
http://speculativeevolution.wikia.com/wiki/The_Snouters:_Form_and_Life_of_the_Rhinogrades
They almost seem too weird to be true, right?

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3. Skater
   a.
   m = 70 kg
   R = 0.5 m
   Convert ω from rotations per minute to radians per second as follows:

$$\omega = 308 \frac{rotations}{minute}\left(\frac{1\ minute}{60\ seconds}\right)\left(\frac{2\pi\ radians}{1\ rotation}\right) = 32.25\ \frac{radians}{second}$$

$$I = \frac{1}{2} mR^2 = (0.5)(70\ kg)(0.5\ m)^2 = 8.75\ kg \cdot m^2$$

$$Kinetic\ rotational\ energy = \frac{1}{2} I\omega^2 = (0.5)(8.75\ kg\ m^2)\left(32.25\ \frac{rad}{s}\right)^2 = 4550\ Joules$$

   b. The rotational energy would **stay the same** because we assumed no energy loss, and energy is conserved.
   c. As the skater spread her arms outward, her rotational speed (ω) would **decrease**. This is because kinetic energy is conserved and the skater's action of spreading her arms increases her moment of inertia (*I*).

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4. Get creative. You MUST convert mechanical energy by manipulating some body motion into electrical energy.