1) Estimate the tension in your Achilles tendon and the force your lower leg bone puts on your foot when you balance motionless on a stair step as shown in the figure below. Do not assume the force the lower leg bone puts on the foot equals your weight because the tendon is connected above at the knee and pulls down on the lower leg bone. You can approximate the situation by rising up slightly on the balls of your feet. Also assume that all other muscles and tendons are relaxed.

a) Draw a free-body-diagram of the foot. (Do this right on the figure.)

b) Measure any distances and angles you need right on the diagram. (It is drawn about 1/3 life size.)

c) Come to a group consensus about the magnitude(s) of any forces you know about and state how you know them.

The rest is up to your group. You may need to apply the equilibrium condition for force and torque more than once with different rotation axes to solve this problem completely.

\[ N_{S,F} + T_{T,F} = N_{L,F}, \quad N_{S,F} = \text{the person's weight, } mg \] (Consider a FBD of the person) est: \( m = 80\text{kg}, \) and \( g = 10\text{N/kg} \)

Axis at ankle: \( 13.0(80)(10) = 6.0T \) So \( T_{T,F} = 1730\text{N} \) then \( N_{L,F} = 1730 + 800 = 2530\text{N} \)

Axis at stair: \( 13.0(T_{T,F} + 800) = 19(T_{T,F}) \) So \( T_{T,F} = 1730 \) again
2) A modified Atwood's machine: Two masses, 10 kg and 20 kg, are attached to a massless rope which passes over a solid brass cylindrical pulley of mass 20 kg and radius 0.50 m \((I_{CM} = \frac{1}{2} mr^2)\). This rope does not slip when the pulley turns. In addition there is a man pulling down on a rope attached to the 10 kg block with a 50 N force. Assume \(g=10 \text{ m/s}^2\)

a. The system starts from rest, does the pulley turn clockwise or counter clockwise

b. After a short while the masses have displaced one meter. How much work has the man done? Is the sign positive or negative?

c. What is the speed of the 20 kg mass?

d. What is the tension in the portion of the rope attached to the 20 kg block? Is it the same as that on the 10 kg side?

a. Clockwise (notice that gravity effects a 200 N force on the 20 kg mass while only a 100 N force on the 10 kg. There are 150 N acting down on the left hang side while 200 N on the right side. The net result is a clockwise acceleration.

b. Work is negative because the displacement is opposite the man’s force.

In one-dimension, \(W_{man}=Fd = -50 \text{ J} \); \(W_{20 \text{ kg}} = 200 \text{ J} \); \(W_{10 \text{ kg}} = -100 \text{ J} \);

c. Energy is conserved: \(\Delta KE = \frac{1}{2} Mv^2 + \frac{1}{2} mv^2 + \frac{1}{2} I \omega^2 = 200 \text{ J} – 100 \text{ J} – 50 \text{ J}\)

and \(I= \frac{1}{2} m_{pulley} r^2\) and \(v = \omega r\)

So \(\Delta KE = \frac{1}{2} (M+ m + \frac{1}{2} m_{pulley}) v^2 = 20 \text{ kg} v^2 = 50 \text{ J} \) or \(|v| = 1.6 \text{ m/s}\)

d. Need the acceleration to obtain tensions.

\[ \sum F_y = M a_M = T_{20} - Mg \]

\[ -(m+M+ \frac{1}{2} m_{pulley}) a = (Mg - mg - F) \]

\[ \sum F_y = M a_m = T_{10} - mg - F \]

\[ a = - \frac{50 \text{ N}}{(40 \text{ kg})} = - 1.25 \text{ m/s}^2 \]

Let \(a = a_M = - a_m\)

\[ \sum \tau = I \alpha = -T_{20} r + T_{10} r \quad \text{and here} \quad \alpha = a/r \quad \text{so} \quad m_{pulley} a = T_{10} - T_{20} \]