Appendix C

Workload Calculations

Hooke's Law

$F = kx$

Potential Energy Stored in a Spring

$U = \frac{1}{2}kx^2$

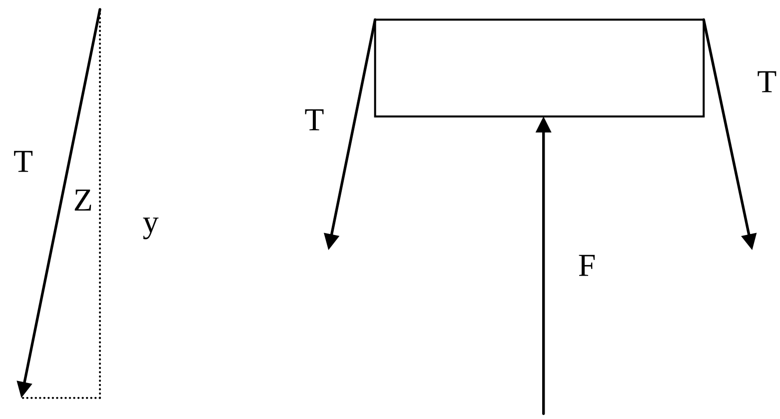

Figure 10: The right triangle on the left is a zoomed in model of the free body diagram of our pedal on the right. The force F is from the patient's foot, and the two tensile forces, T, are from the exercise tubing.

Based on our Model

$F = \frac{2T}{cosZ}$

$T = ky$

$F = \frac{2ky}{cosZ}$

$U = \int F$

$U = \int \frac{2ky}{cosZ} dy$

$U = \frac{ky^2}{cosZ}$

The angle Z changes slightly during the motion of our device. As the foot pedal is pushed away from the user, the angle decreases. However, because Z is always fairly small (around 5°), cos(Z) will be approximately 1 and can be ignored for ease of calculation (small angle approximation theorem).

$U = ky^2$

From our tensile testing, the k value for the red 20 pound resistance tubing is 1.4234 pounds force per inch, or **17.08** lbf / ft. The displacement of the pedal for a patient with a height of 6' is 8.5 inches (.71 ft), the y value. This value was acquired by the following calculations:

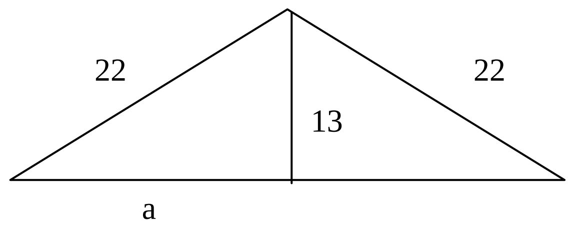

Figure 11: The isosceles triangle is a schematic of a patient's legs while in the bore. The hip to knee length is approximately the same length of the knee to ankle (22 inches on a 6' patient). The height of the bore where the legs will be positioned is 13 inches.

Pythagorean Theorem

$$a^2 + b^2 = c^2$$

$$a^2 + 13^2 = 22^2$$

$$\text{a} = 17.75 \text{ in}$$

The total length of the leg is 44 inches, and 2a = 35.5 in

$$44 - 35.5 = 8.5\ inches = y = \mathbf{.71\ \mathit{ft}}$$

Continuing the workload calculation:

$$U = \left(17.08 \frac{lbf}{ft}\right)(.71\ ft)^2 = 8.57\ ft \cdot lbf$$

At a cadence of 120 individual leg presses a minute

$$P = 8.57\ ft \cdot lbf\ \times 120 \frac{cycles}{minute} = 1028.3\ \frac{ft \cdot lbf}{minute} = \mathbf{23.2\ \mathit{Watts}}$$

Using the maximum resistance available for our device (10 lb tube, 15 lb tube, and 20 lb tube with respective k values .72, 1.07, 1.42), the following wattage can be acquired:

$$k = 0.72 + 1.07 + 1.42 = 3.21 \frac{lbf}{in} = 38.52 \frac{lbf}{ft}$$

The k values can be added because the resistance tubes are used in parallel

$$U = \left(38.52 \frac{lbf}{ft}\right)(.71\ ft)^2 = 19.42\ ft \cdot lbf$$

At a cadence of 120 individual leg presses a minute

$$P = 19.42\ ft \cdot lbf\ \times 120 \frac{cycles}{minute} = 1028.3\ \frac{ft \cdot lbf}{minute} = \mathbf{52.6\ \mathit{Watts}}$$