Gears
Educational Systems, LLC

Work and Energy in Pneumatic Systems

Using Pneumatic Systems to Perform Work and Power Mechanisms

The Concept of Work and Energy

Work and energy are equivalent expressions. Work is a term used by engineers to describe how energy is used or stored. Work and energy can be described mathematically as the product of force and distance.

Work = Force x Distance = Energy

There are several common units used to describe work and energy. These units are the combination of the units used to describe force and distance. These units are:

Foot Pounds = Distance (Feet) x Force (Pounds)
Inch Pounds = Distance (Inches) x Force (Pounds)

Or

Newton Meters = Force (Newtons) x Distance (Meters)

Example of Work

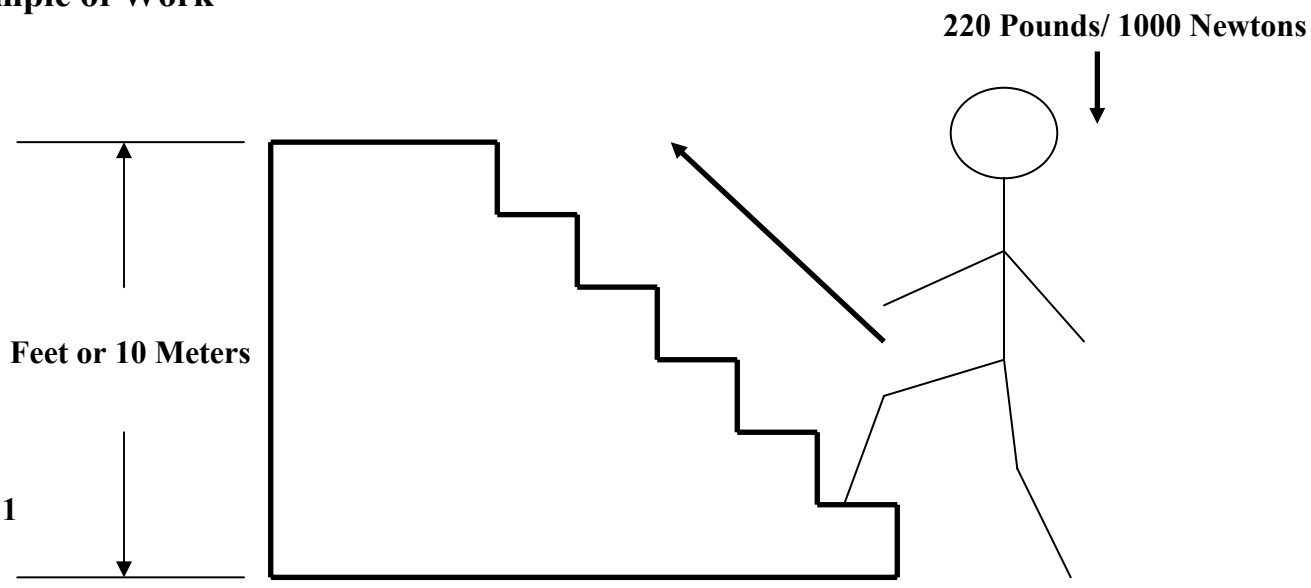

Figure 1

A 220 pound man exerts a force of approximately 1000 Newtons downward. If that man climbs upward 3 flights of stairs, he elevates himself *(vertically)* 33 feet or approximately 10 meters. The expression on the following page describes the work produced;

Work = Force x Distance
Work = 220 pounds x 33 ft. = 7260 ft. pounds or
Work = 1000 Newtons x 33 meters = 33,000 Newton Meters

Work and Energy in Pneumatic Cylinders

Integrating knowledge and skills

Work Done by a Pneumatic Cylinder

Work is the product of force and distance. Pneumatic cylinders apply forces over distance equal to the piston stroke. It is a simple matter to calculate the average work done by a pneumatic cylinder each time it cycles through a stroke. The following example (Fig,2) explains how to make this calculation for the pneumatic cylinder pictured below. *Note: 1 MPa = 1 x 10^6 Newton/m^2*

Cylinder Bore = 0.625" or 0.016 meter
Stroke = 1" or 0.0254 meter
Pressure = 100psi or .689 MPa

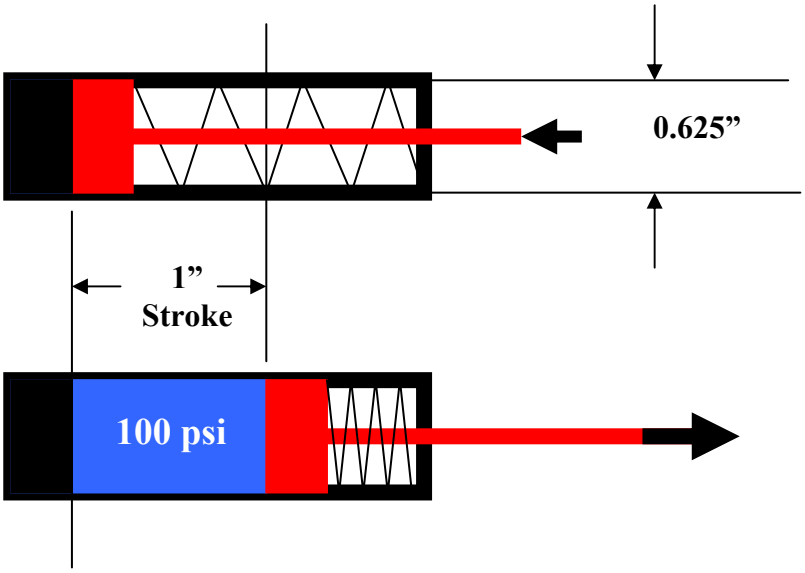

Figure 2

Procedure:

1.) Calculate the piston area

$\text{Area}_{\text{piston}} = \pi * r^2 = 0.307\ \text{in}^2$ or 0.0002m^2

2.) Calculate the force on the piston

$\text{Force}_{\text{piston}} = \text{Area}_{\text{piston}} * \text{Pressure}$

Force = 30.7 lbs f or 136.56 Newtons

3.) Calculate the cylinder work or energy output

Work = Force x Stroke
Work = 30.7 inch pounds or 3.468 Newton meters

Sample Problems

Directions: Using the procedure and formulas listed above calculate the work output for the cylinders described in the table below. *Hint: This exercise can be completed faster and with less effort if you take the time to create a spreadsheet solution to these problems.*

Cylinder SMC Part Number	**Bore inch/metric**	**Stroke Inch/metric**	**Pressure Psi/MPa**	**Work Output Pounds f and Nm**
NC Q8B 200-200S	**2"**	**2"**	**75psi**	
C J5F16SR-45	**16mm**	**45mm**	**1MPa**	
C M2 B40F-150	**40mm**	**150mm**	**0.75MPa**	
C S1B 300-1000JN	**300mm**	**1000mm**	**1.5 MPa**	
NC A1B400-1200	**4"**	**12"**	**250psi**	
NC J2F10-300	**0.375"**	**3"**	**50psi**	

Work and Energy in Pneumatic Systems
Using the Pneumatic Test Module

The energy used to perform work in a pneumatic system is stored as pressurized air. The work done pumping and compressing the air creates pressure in the reservoir. The pressurized air in the reservoir is similar to a compressed spring. The pneumatic system you built for this lesson will be used to evaluate the work and energy capacities of a pneumatic system. *Note: If you have not yet built this pneumatic test module then click on the image below to open the instruction manual.*

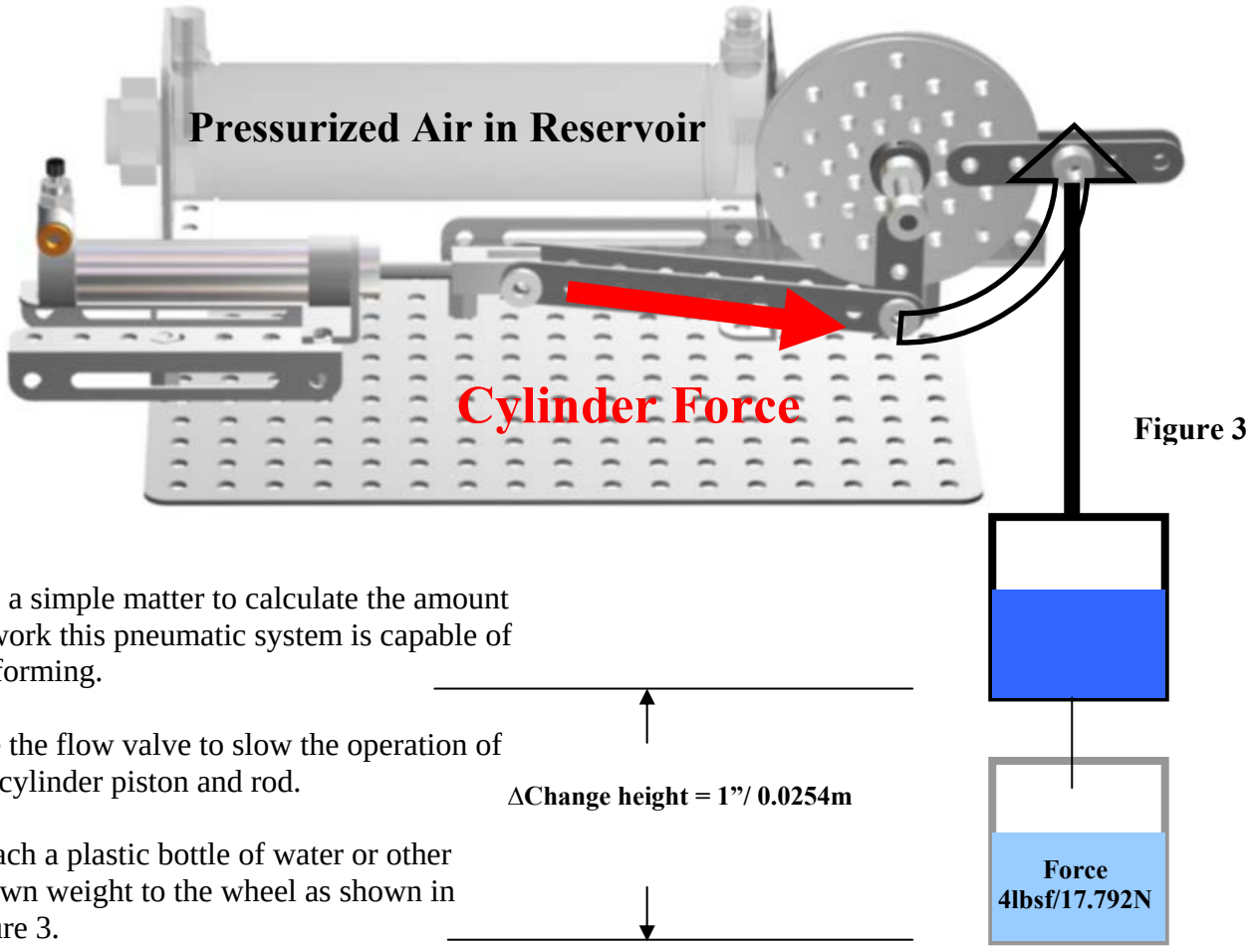

Figure 3

It is a simple matter to calculate the amount of work this pneumatic system is capable of performing.

Use the flow valve to slow the operation of the cylinder piston and rod.

Attach a plastic bottle of water or other known weight to the wheel as shown in figure 3.

Operate the mechanism and measure the change in distance of the water pail or weight.

Work and Energy are Equivalent Terms
Work and energy are the product of force x distance in any system
SI Units = 1 Newton x 1 meter =1 Newton meter = 1 joule
Imperial Units = 1 foot x 1pound-f = 1 ft-lb = 12 in-lb

Work Calculation (Imperial)

$$\text{Work} = \text{Force} * \text{Distance} = 4\,\text{lbsf} * 1" = 4"\text{-lbs}$$

Work Calculation (SI)

$$\text{Work} = \text{Force} * \text{Distance} = 17.79\text{N} * 0.0254\text{m} = 0.452\text{Nm} = 0.452\text{Joules}$$