MINNESOTA 4-H STEM PROGRAM

Fluid Power and the 4-H Engineering Design Challenge Level 2

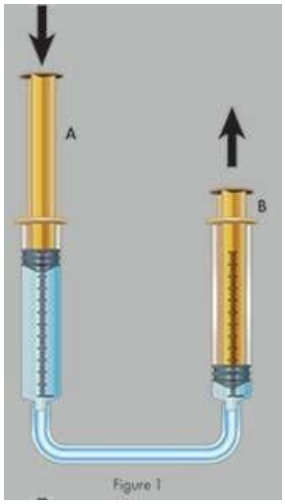
The 4-H Engineering Design Level 2 challenge is exciting because it allows participants to use more than one type of engineering design. For the Level 2 Engineering Design Challenge, at least one step will involve fluid power. This information explains the aspects of fluid power.

WHAT IS FLUID POWER?

Fluid power is the use of fluids (like gas or liquid) to move something in order to accomplish a task. Hydraulics (i.e. liquid power, like oil) are used on agricultural and construction equipment. For example, farm implements are raised and lowered with hydraulic cylinders. Pneumatics (i.e. gas power, like air) are used in manufacturing plants. For example, products are packaged with the use of pneumatic powered equipment. Participating in this design challenge will prepare you for a future in engineering—offering you the opportunity to learn about an exciting technology that is used in so many different engineering positions.

HOW MIGHT FLUID POWER BE USED IN BUILDING THE 4-H ENGINEER DESIGN CHALLENGE LEVEL 2?

To visualize a basic hydraulic system, think about the two identical syringes connected together with tubing and filled with water (see Figure1). Syringe A represents a pump (as the device that converts mechanical force to fluid power), and Syringe B represents an actuator (as the device that converts fluid power into mechanical force) in this case the cylinder. Pushing the plunger of Syringe A pressurizes the liquid inside. This fluid pressure acts equally in all directions (Pascal's Law), and causes the water to flow out the bottom, into the tube, and into Syringe B.[1]



SOURCE: National Fluid Power Association https://www.nfpa.com/home/AboutNFPA/What-is-Fluid-Power.htm

For the Engineering Design Challenge, at least one step of the machine will use a set of the syringes filled with water representing hydraulics. Another step of the machine will use a set of syringes consisting of air representing pneumatics. Teams are encouraged to use more than two sets of syringes. Check out the Help-Techniques for ideas.

[1]What is Fluid Power? (2017). National Fluid Power Association. Milwaukee, WI

WHY USE FLUID POWER OVER OTHER POWER SOURCES?

Fluid power systems easily produce linear motion using hydraulic or pneumatic cylinders, whereas electrical and mechanical methods usually must use a mechanical device to convert rotational motion to linear.

Fluid power systems generally can transmit equivalent power within a much smaller space than mechanical or electrical drives can, especially when extremely high force or torque is required.

Fluid power systems also offer simple and effective control of direction, speed, force, and torque using simple control valves. Fluid power systems often do not require electrical power, which eliminates the risk of electrical shock, sparks, fire, and explosion.[2]

PASCAL'S LAW

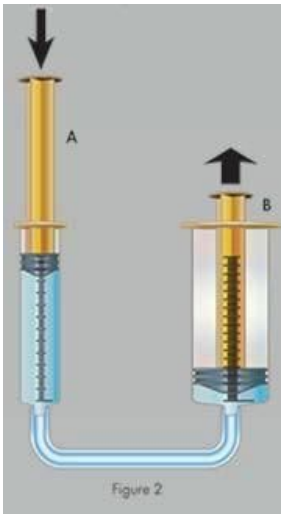
Pascal's law states that when there is an increase in pressure at any point in a confined fluid, there is an equal increase at every other point in the container.

Let's discuss Pascal's Law and the mathematics of fluid power.

Fluid pressure acts equally in all directions (Pascal's Law), and causes the water to flow out the bottom, into the tube, and into Syringe B. If you placed a 5 lb. object on top of the plunger of Syringe B, you would need to push on Syringe A's plunger with at least 5 lbs. of force to move the weight upward. If the object weighed 10 lbs., you would have to push with at least 10 lbs. of force to move the weight upward.

If the area of the plunger (which is a piston) of Syringe A is 1 sq. in., and you push with 5 lbs. of force, the fluid pressure will be 5 lbs./sq. in. (psi). Because fluid pressure acts equally in all directions, if the object on Syringe B (which, again has an area of 1 sq. in.) weighs 10 lbs., fluid pressure would have to exceed 10 psi before the object would move upward. If we double the diameter of Syringe B (see Figure 2), the area of the plunger becomes four times what it was.
This means a 10 lb. weight would be supported on 4 sq. in. of fluid.

Therefore, fluid pressure would only have to exceed 2.5 psi (10 lbs. ÷ 4 sq. in. = 2.5 psi) to move the 10 lb. object upward. So moving the 10 lb. object would only require 2.5 lbs. of force on the plunger of
Syringe A, but the plunger on Syringe B would only move upward ¼ as far as when both plungers were the same size. This is the essence of fluid power.
Varying the sizes of plungers and syringes allows multiplying the applied force.[3]



SOURCE: National Fluid Power Association https://www.nfpa.com/home/AboutNFPA/What-is-Fluid-Power.htm

[2,3] What is Fluid Power? (2017). National Fluid Power Association. Milwaukee, WI

Teams are encouraged to do their own research to learn more about the mathematics of fluid power.

HOW WILL THE FLUID POWER CYLINDERS BE BUILT INTO THE MACHINE DESIGN?

The Level 2 Engineering Design Challenge consists of a series of chain-reaction steps that will lead to an end result or accomplishing a designated task. Teams will use their creativity to construct a machine using repurposed items. The fluid power plungers and cylinders will be one or more steps in the machine construction. The cylinders (syringes) will be secured to the machine. One of the cylinders will serve as the pump, the other attached cylinder will serve as the actuator that caused the next chain reaction step. Keep in mind, the plunger on the pump cylinder needs to be acted up by a step in the machine design, (i.e. a weight that is triggered or released applies pressure to the extended cylinder plunger which results in the movement of the actuator plunger on the second cylinder. At no time during the run of the machine can the cylinder pump or the actuator be triggered or manually operated by a team member. This would be considered a “human intervention” and points would be deducted according to the judges score sheet.

WHERE DO TEAMS OBTAIN THE SYRINGES AND TUBING?

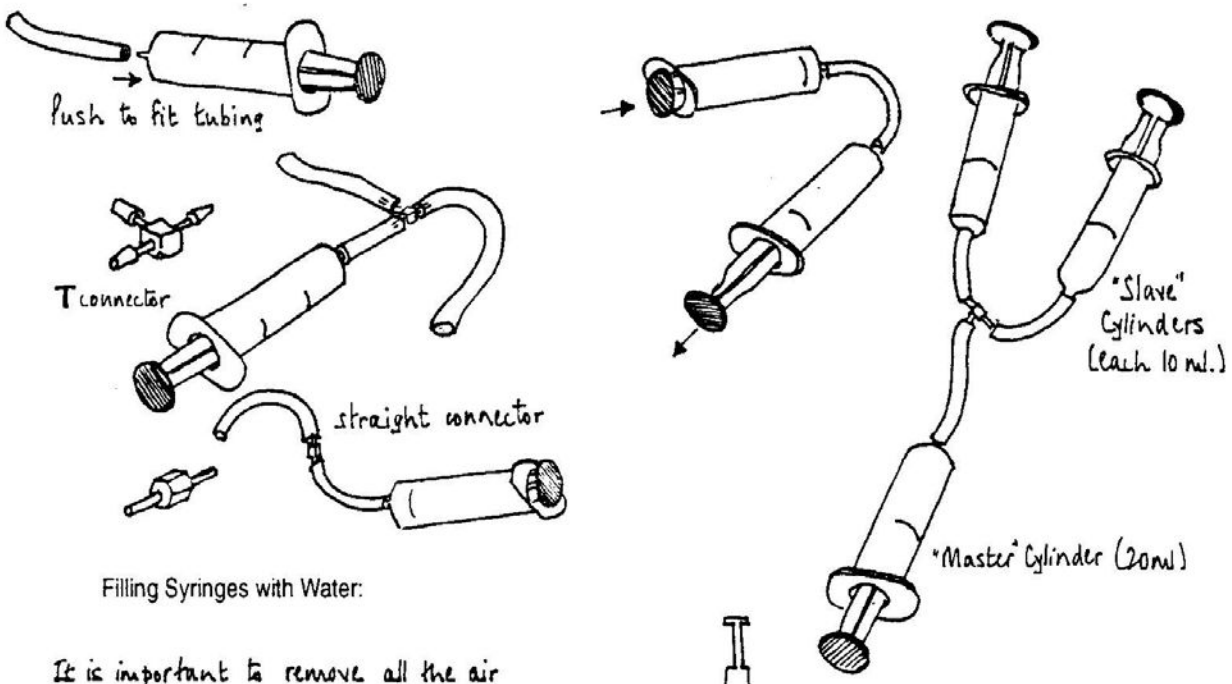
Teams are responsible for purchasing their own syringes, syringe holders, tubing and supplies to construct their 4-H Engineering Design Challenge machine. Teams can secure the supplies from farm/fleet stores and large chain/box stores. Certain hardware stores also sell syringes and tubing. Teams can also place an order with the following suppliers:

1. Mechanical Kits Limited STEM Learning, Science, Technology, Engineering & Math.

   The website is https://www.fluidpowerkits.com/product-category/replacement/. The phone number is 1-877-430-4549. The email address is support@mechanical-kits.com.

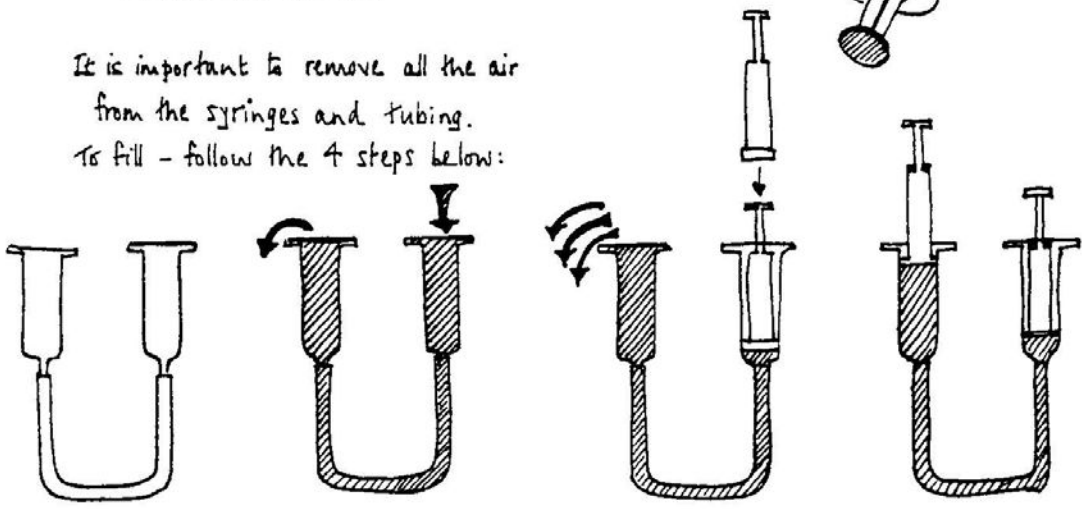
2. PITSCO EDUCATION P.0. Box 1708 Pittsburg, KS 66762-1708 Order: 800-835-0686;
   Email Order:
   orders@pitsco.com Order
   online: Pitsco.com
   Online Support: Pitsco.com/help

Connecting Syringes:



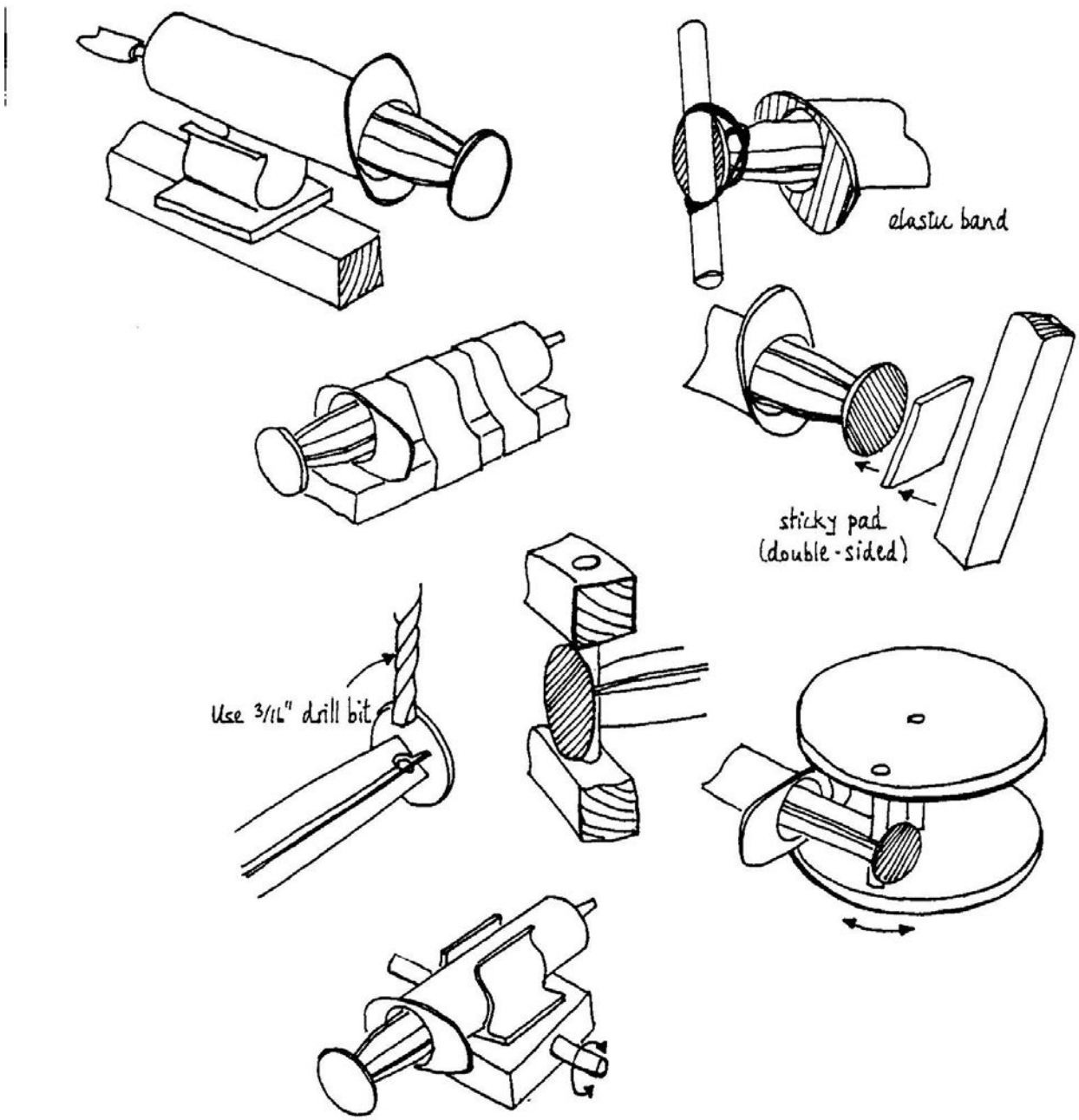
Filling Syringes with Water:

It is important to remove all the air from the syringes and tubing.
To fill - follow the 4 steps below:

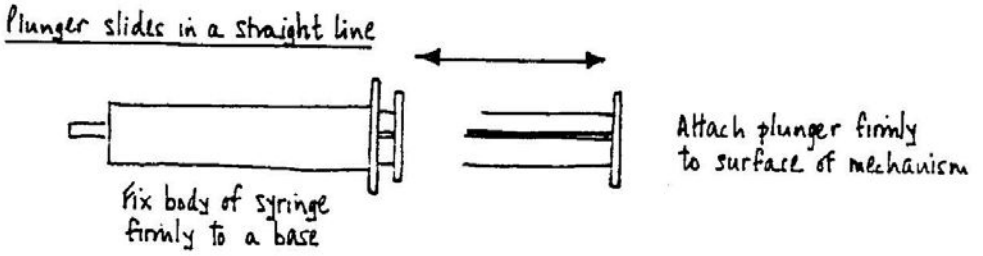


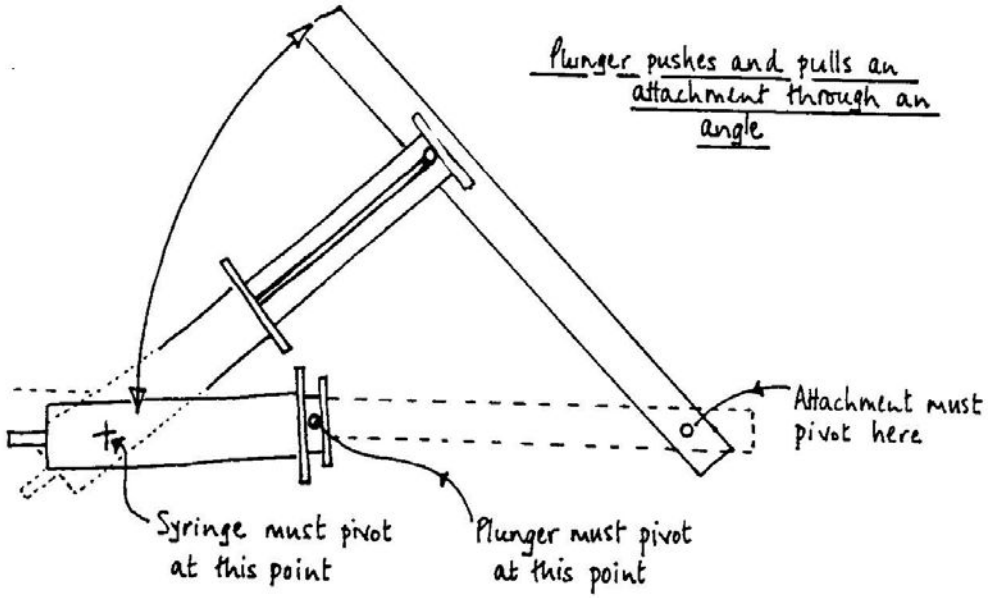
1. remove plungers
2. fill with water until overflow
3. push plunger into one syringe until it is fully inserted
4. carefully insert the other plunger

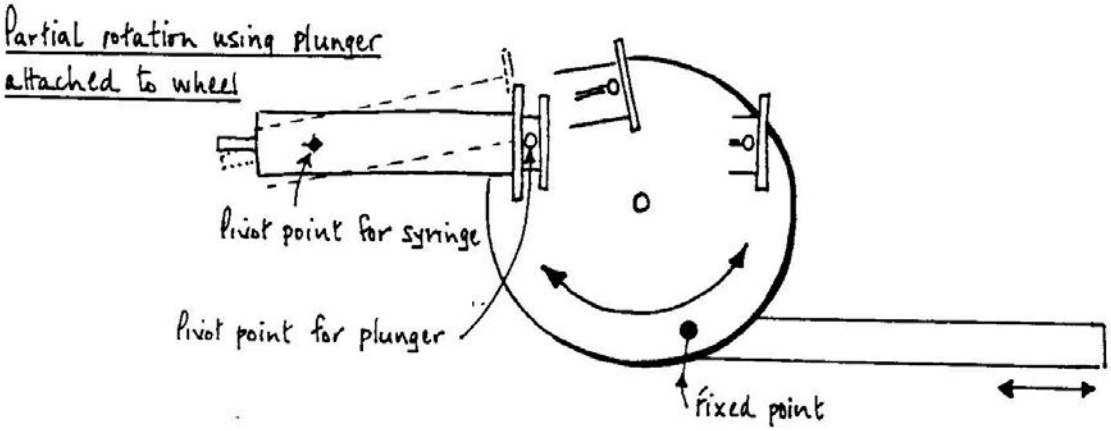
Fixing Materials to Syringes:



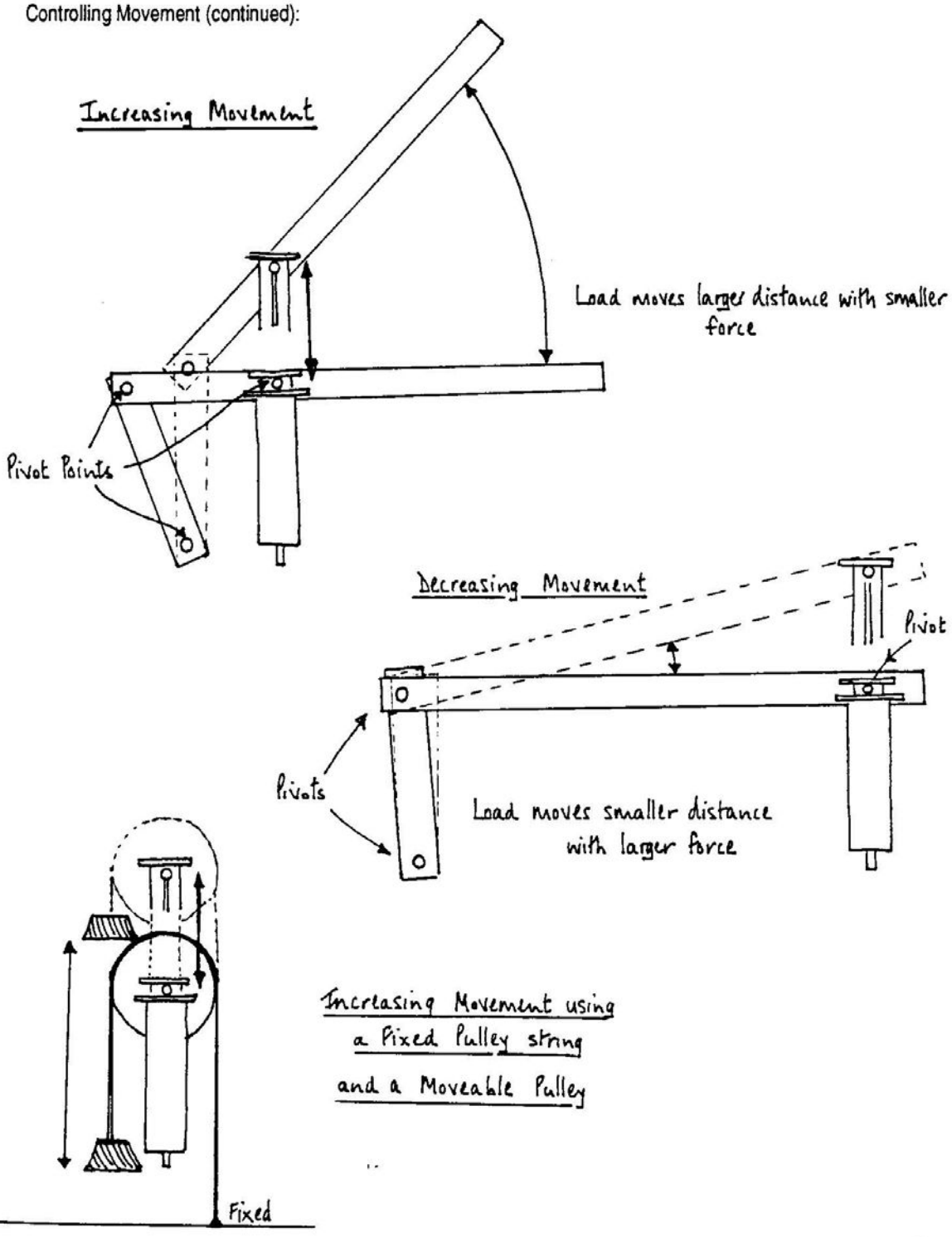
Controlling Movement:







Controlling Movement (continued):



LEARN MORE ABOUT FLUID POWER

National Fluid Power Association (NFPA)
Milwaukee, WI https://www.nfpa.com/home.htm

National Fluid Power Association – You Tube
www.youtube.com/user/NatFluidPower Assn

ACKNOWLEDGMENTS:

The information used in this document was obtained from:

What is Fluid Power? (2017). National Fluid Power Association. Milwaukee, WI
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