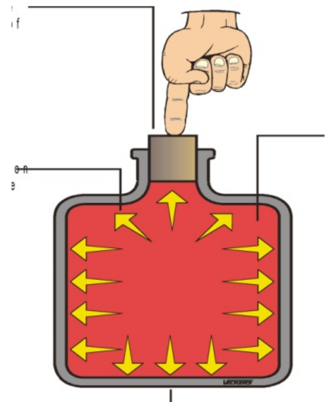
Fluid Power Fundamentals for FP Challenges

2018 03 26

The information on these pages should be covered with the students as they work through the Challenge. The post-test will give you a good indication of what they learn.

PASCAL'S LAW



Pressure applied to a confined liquid is transmitted undiminished in all directions, and acts with equal force on all equal areas, and at right angles to those areas.

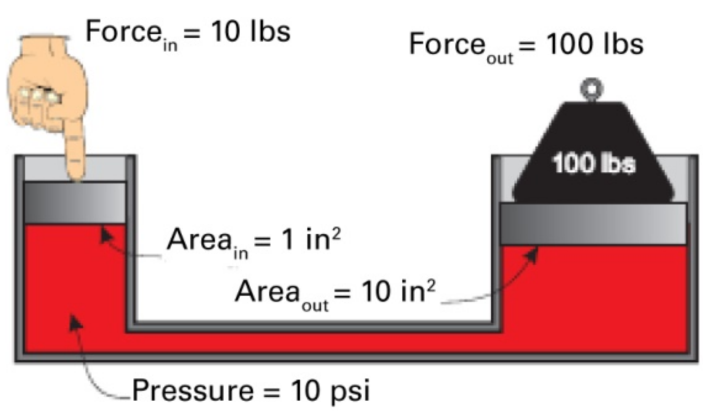
Because liquid is essentially incompressible, and forces are transmitted undiminished throughout the liquid, act equally on equal areas of the bottle, and the area of the body of the bottle is much greater than the neck, the body will break with a relatively light force on the stopper.

The bottom of the bottle has a total area of 20 in² as shown above, and the force applied by the liquid is 10 pounds per in². Therefore, the combined force over the entire bottom area is the sum of 10 pounds acting on each of the 20 inch² areas. Because there are 20 areas, each of which are one square inch, and 10 pounds on each, the combined force at the bottom of the bottle is 200 pounds (lbs).

This relationship is represented by the following formula:
Force = Pressure × Area
200 lbs = 10 lbs / in² X 20 in²

Pascal demonstrated the practical use of his laws with illustrations such as that shown below. This diagram shows how, by applying the same principle described above, a small input force applied against a small area can result in a large force by increasing the output area.

What is the *mechanical advantage* of this system?



List a few **examples of mechanical vehicles and devices** that move in our world

- Cars
- Airplanes
- Dump truck bed
- Automatic doors
- Conveyor belts

What is the **primary power source** for these vehicles and devices?

• Cars	internal combustion engines or electric motors
• Airplanes	turbine or internal combustion engines
• Dump truck bed	hydraulic cylinder
• Automatic doors	electric motors or pneumatic cylinders
• Conveyor belts	electric motors or hydraulic cylinders

How is **fluid power used for secondary systems** on some of the above?

• Cars:	hydraulic brakes
• Airplanes:	hydraulics to retract and extend the undercarriage (wheels); and to actuate the flaps, rudder and other control surfaces.

ADVANTAGES OF FLUID POWER

High horsepower-to-weight ratio. You could probably hold a 5-hp hydraulic motor in the palm of your hand, but a 5-hp electric motor might weight 40 lb or more

Safety in hazardous environments because they are inherently spark-free and can tolerate high temperatures. Typical application: stirring flammable liquids like paint.

Can operate in very dirty environments. Electric motors will overheat if they get covered in dirt and grease. This is not a problem for fluid power systems because coolers remote from the hydraulic motor or cylinder doing the work in the dirty environment can be added to the source of the pressurized liquid or gas.

High torque at low speed — unlike electric motors, pneumatic and hydraulic motors can produce high torque while operating at low rotational speeds. Some fluid power motors can even maintain torque at zero speed without overheating

Pressurized fluids can be transmitted over long distances and through complex machine configurations with only a small loss in power

Multi-functional control — a single hydraulic pump or air compressor can provide power to many cylinders, motors, or other actuators

Motion can be reversed almost instantly

TWO TYPES OF FLUID POWER

Hydraulic fluid power systems transfer energy through **liquids**, typically mineral oil but also sometimes water.

Pneumatic fluid power systems transfer energy through **gases**. Air is by far the most common gas used.

Example of hydraulic systems:

- Mining conveyor (taking ore from the mine to the processing mill)
- Back hoes and other heavy-duty construction equipment

Example of pneumatic systems:

- Paint stirring (because pneumatic motors are explosion proof)
- Production of plastic components e.g. LEGO pieces

Resistance to movement

1. **Viscosity**

   A fluid's resistance to flow. The higher the resistance, the higher the viscosity and the more power is required to get the fluid to flow.

2. **Density of fluid**

   The degree of consistency of a substance measured by the quantity mass per unit volume.

   The density of water is set at 1000 kg/m^3 or $1g/cm^3$ or $62lb/ft^3$.

   The density of cooking oil is less than water, around $56lb/ft^3$ or $0.9g/cm^3$. The density of diesel fuel is $52lb/ft^3$ or $0.84g/cm^3$.

   There is no relationship between viscosity, the thickness or thinness of a fluid, and density which refers to the space between the fluid's particles. However, both are affected by temperature.

3. **Inertia**

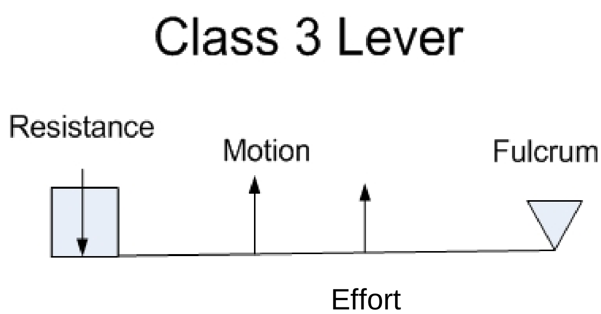
   A system's resistance to initial movement

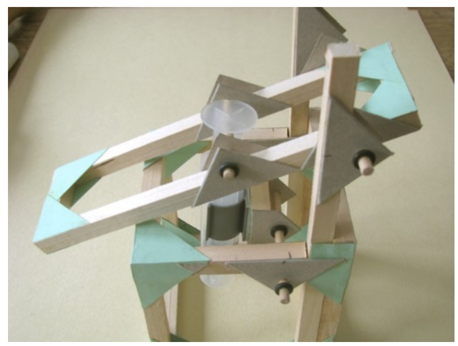
   For example, in the model lifter completed pre-Challenge day: the initial "stickiness" experienced as the plunger first moves indicates that the system is overcoming inertia.

Efficiency of movement

The placement of levers and the proficiency of linkages are important factors in making efficient use of the advantages of fluid power. Unnecessary use of force to operate a levered mechanism is a waste of fluid power and energy; hence the objective in the design of levered systems is to maximise mechanical advantage.

For example – a class 3 levered system has effort in the middle: the resistance or load is on one side of the effort and the fulcrum is located on the other side, for example, a pair of tweezers or a platform lifter





In the Lifter model the effort is applied by a pneumatic cylinder between the fulcrum (the dowel connected to the uprights) and the resistance or load at the end of the arm. If the effort were applied closer to the fulcrum more effort or pneumatic force would be required to lift the same load.