Fundamental principles

- Following fundamental principles MUST be considered before studying hydraulics:

- PASCAL'S LAW: Pressure exerted on a confined fluid is transmitted undiminished in all direction and acts with equal force on equal areas & at right angles to them.
- Hydraulics is a means of power transmission.
- Work is force acting through a distance.
- WORK = FORCE x DISTANCE. W = F x D = Energy used.
- A pump does not pump pressure, its purpose is to create flow. Pumps used to transmit power are usually positive displacement types.

Fundamental principles

- Following fundamental principles **MUST** be considered before studying hydraulics:

- Pressure is caused by resistance to flow. A pressure gauge indicates the work load at any given moment.
- Fluids take the path of least resistance.
- There must be pressure drop (pressure difference) across an orifice or restriction to cause flow through it. Conversely, if there is no flow there will be no pressure difference.

Fundamental principles

- Following fundamental principles **MUST** be considered before studying hydraulics:

- Flow velocity through a pipe varies through a pipe varies inversely as the square of the inside diameter. Reducing the diameter by half increases the velocity by four times.
- Friction losses (pressure drop) in a pipe are directly proportional to velocity.

Hydraulic principles

- **Principle one**

- **Movement depends on Flow**
- For anything to move in a hydraulic machine, the actuators must be supplied with fluid flow. Nothing moves without flow.
- This cylinder is retracted. It can extend only if there is flow into port A. If there is no flow into port A, the piston will not move.

Fundamental principles

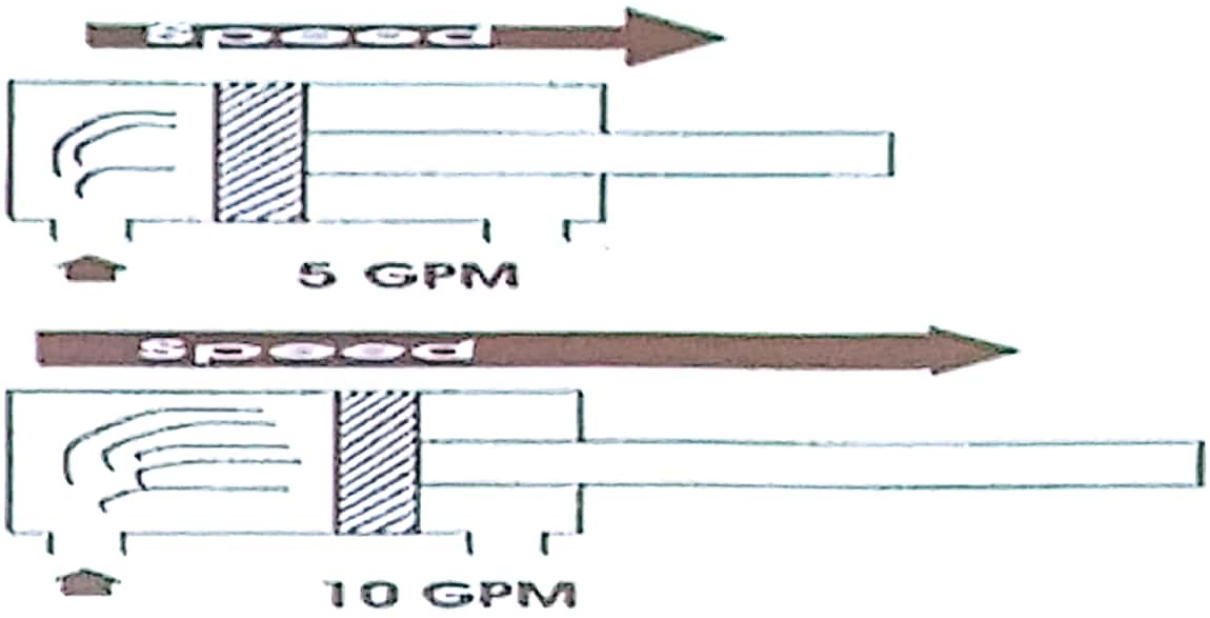
- **Principle two**

- **Rate of Flow Determines Speed**
- Actuator speed depends upon rate of flow. The faster fluid fills the cylinder, the faster the piston will move. The faster fluid fills the expanding spaces in a hydraulic motor, the faster the shaft will turn.
- What are the possible causes of slow actuator speed? Anything which reduces flow rate in or out of the cylinder. For example:

Fundamental principles

➢ Principle two

Example



Fundamental principles

➢ Principle three

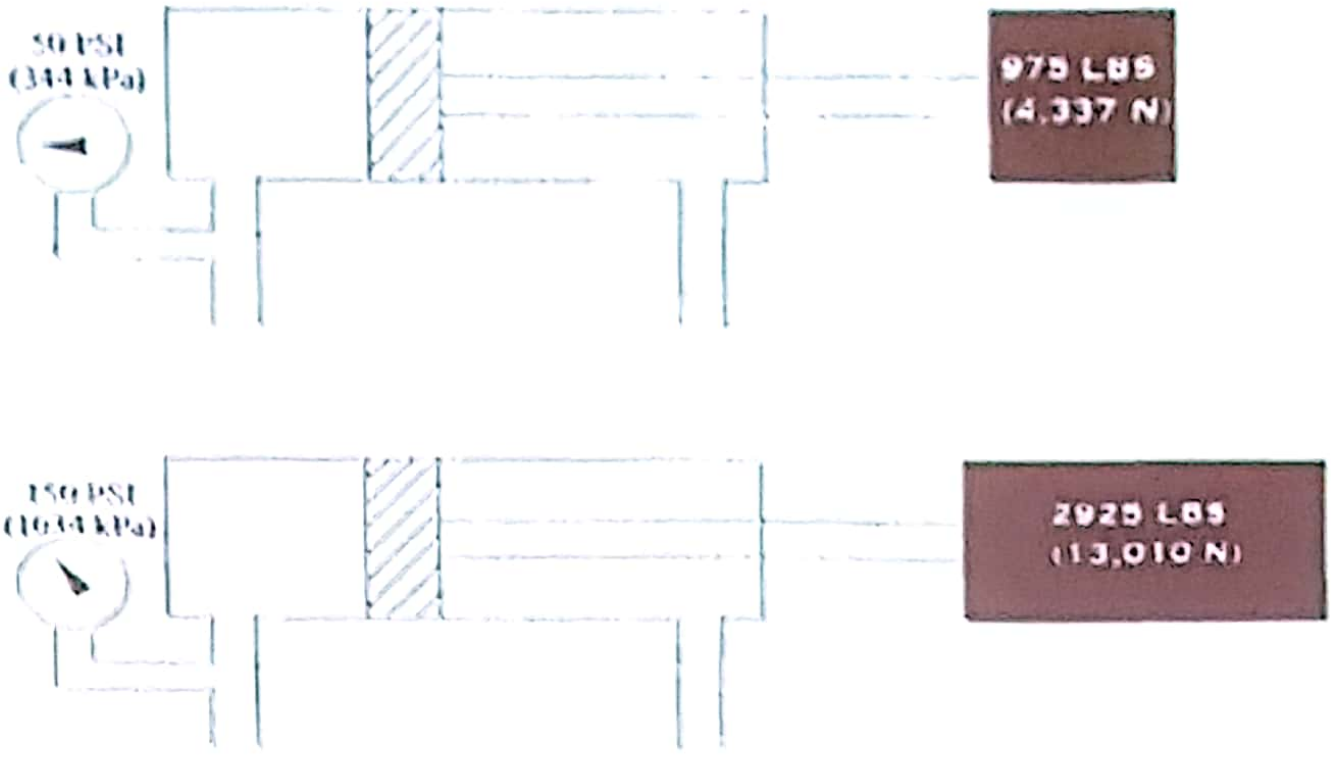
➢ Load Determines Pressure

➢ The pressure developed in an actuator depends on the load. That is, pressure will rise until the force exerts on the piston in a cylinder can move the load. The greater the load, the higher the pressure will rise.

Fundamental principles

➢ Principle three

➢ Load Determines Pressure



Units

➢ US or English Units

➢ English units of measurement, principal system of weights and measures used in a few nations, the only major industrial one being the United States. It actually consists of two related systems—the U.S. Customary System of units, used in the United States and dependencies, and the British Imperial System. The names of the units and the relationships between them are generally the same in both systems, but the sizes of the units differ, sometimes considerably.

Units

➢ US or English Units

- 1 kgf=9.81 N (practical 1kgf=10N)
- 1 $litre$= 0.2642 $gallon\,(US)$
- 1 bar=100 kPa= 14.5 psi
- 1 $kwatt\,(kw)$= 1.34 Hp
- 1 $horse\ power\,(Hp)$ = 0.7457 kw

Definitions

Energy

Energy may be defined as the ability to do work.

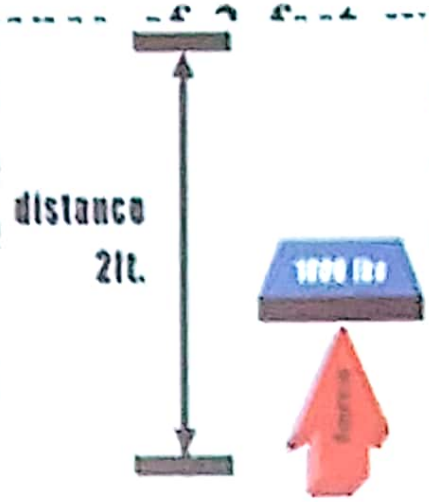
As we begin our study of basic hydraulics we must first recognize that fluid power is another method of transferring energy. This energy transfer is from a prime mover, or input power source, to an actuator or output device. This means of energy transfer, although not always the most efficient, where properly applied may provide optimum work control.

Definitions

➢ Work

➢ **Work** is defined as force through distance.

➢ If we move 1000pounds a dist---- -f ? f--t ---
have accomplished work. V
amount of work in foot-pounds
we have moved 1000 pounds
accomplished 2000 foot pounds



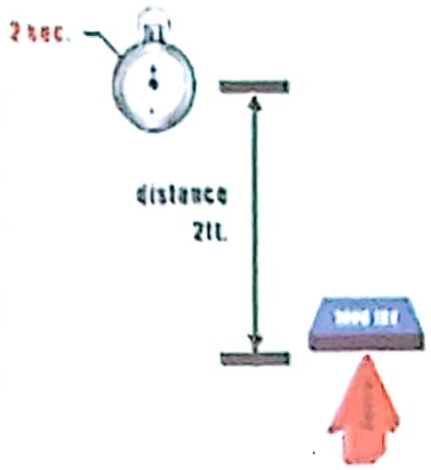
➢ Work (in • lbs) = force (lbs) x di

Definitions

Power

Power may be defined as the rate of doing work, or work over time and seconds.

If we lift 1000 pounds 2 feet i
accomplished 1000 units of p
2 divided by 2 seconds. T
meaning for measuring powe
this to horsepower which is
energy



Definitions

Torque

- Torque is twisting force, is simply the product of the force and the effective radius
  - $T = F \times d$.
- we are producing 10 foot-pounds of torque when we apply 10 pounds of force to a 1 foot-long wrench. This same theory applies to hydraulic motors. Hydraulic motors are actuators that are rated in specific torque values at a given pressure. The twisting force, or torque, is the generated work. A motor's rotations per minute (rpm) at a given torque specifies our energy usage or horsepower requirement.

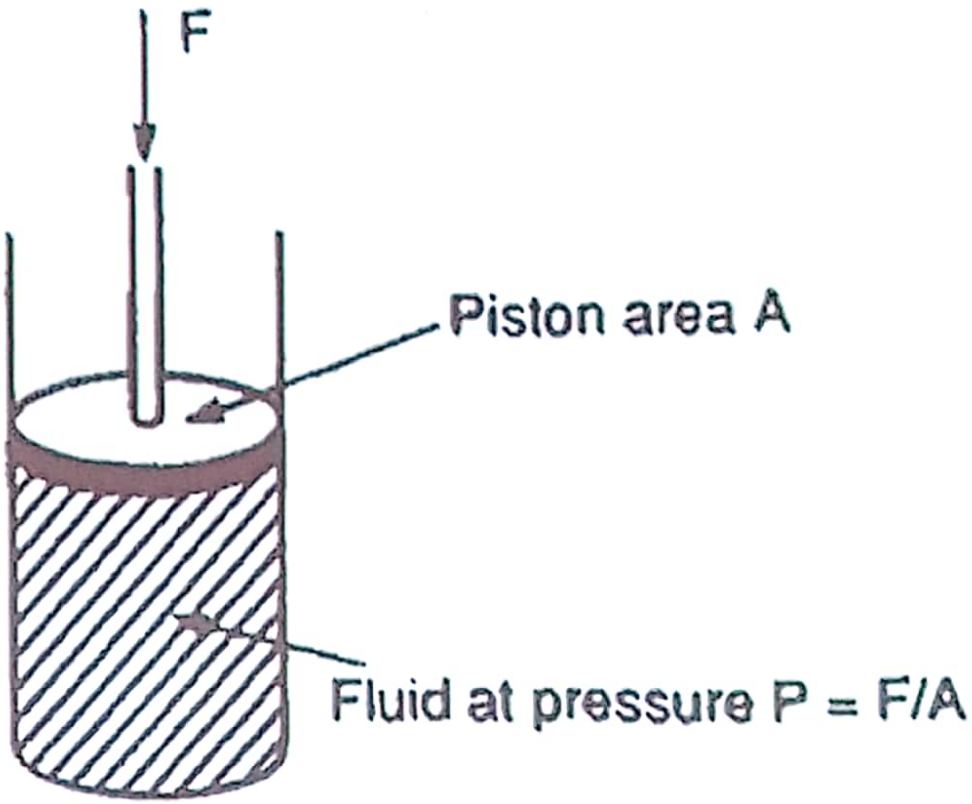
Definitions

Pressure

- Pressure occurs in a fluid when it is subjected to a force.
- In Figure a force F is applied to an enclosed fluid via a piston of area A.
- This results in a pressure P in the fluid.
- Obviously increasing the force increases the pressure in direct proportion.
- Less obviously, though, decreasing piston area also increases pressure.
- Pressure in the fluid can therefore be defined as the force acting per unit area, or: $p = F/A$

Definitions

Pressure



Definitions

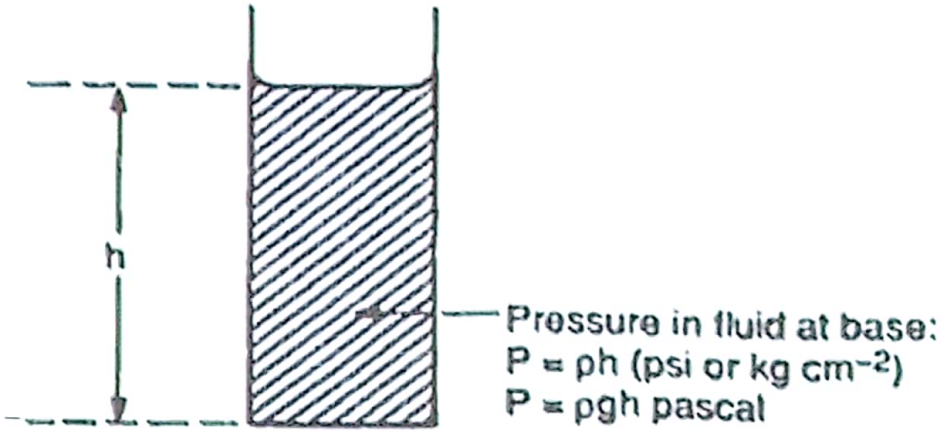
➢ Pressure

- In metric systems, F is usually given in kgf and A in square centimetres to give pressure in kilogram/force per square centimetre ($kgfcm{-}2$).
- The SI system defines pressure as the force in newtons per square meter ($Nm{-}2$).
- The SI unit of pressure is the pascal (with $1\ Pa = 1\ Nm{-}2$).
- One pascal is a very low pressure for practical use, however, so the kilopascal ($1\ kPa{=}103pa$) or the megapascal ($1\ MPa = 106\ Pa$) are more commonly used.

Definitions

Pressure

- Pressure can also arise in a fluid from the weight of a fluid. This is usually known as the head pressure and depends on the height of fluid. In Figure the pressure at the bottom of the fluid is directly proportional to height h.



Definitions

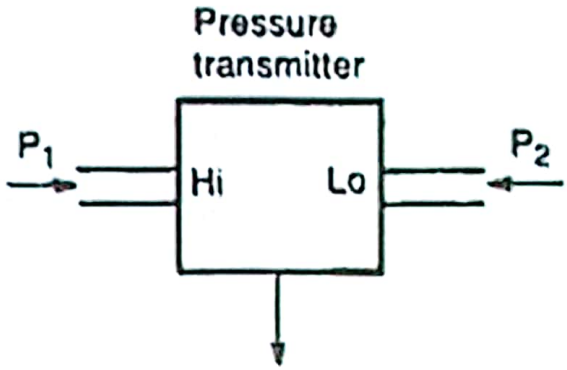
➢ Pressure

- There are three distinct ways in which pressure is measured, shown in Figure .
- Almost all pressure transducers or transmitters measure the pressure difference between two input ports. This is known as differential pressure, and the pressure transmitter in Figure a indicates a pressure of $P1-P2$.

Definitions

Pressure

- There are three distinct ways in which pressure is measured, shown in Figure .
- Almost all pressure transducers or transmitters measure th tween two input port differential pressure, ar in Figure a indicates a

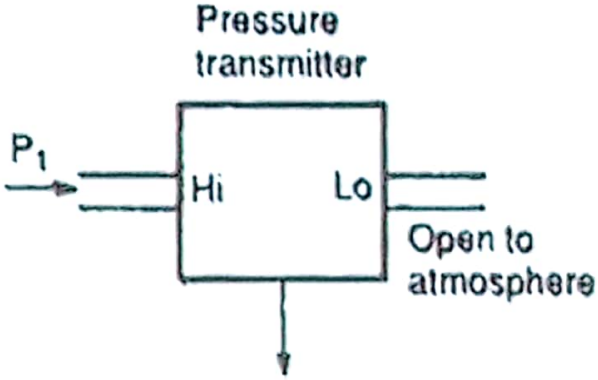


(a) Differential pressure

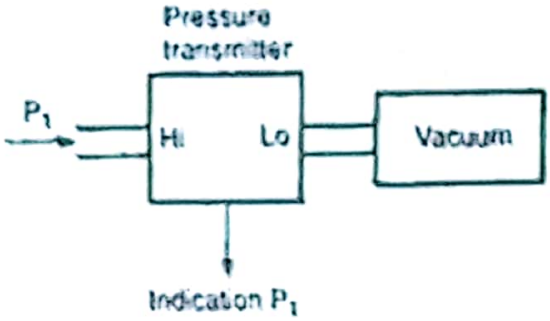
Definitions

Pressure

- In Figure b the low pressure input port is open to atmosphere, so the pressure transmitter indicates pressure above atmospheric pressure. This is known as gauge pressure, and is usually denoted by a g suffix (*e.g.psig*).
- Figure c shows the pressure transmitter measuring pressure with respect to a vacuum. This is known as absolute pressure and is of importance when the compression of gases is considered.



(b) Gauge pressure



(c) Absolute pressure

...ure. This is and is usually denoted

- Figure c shows the pressure transmitter measuring pressure with respect to a vacuum. This is known as absolute pressure and is of importance when the compression of gases is considered.

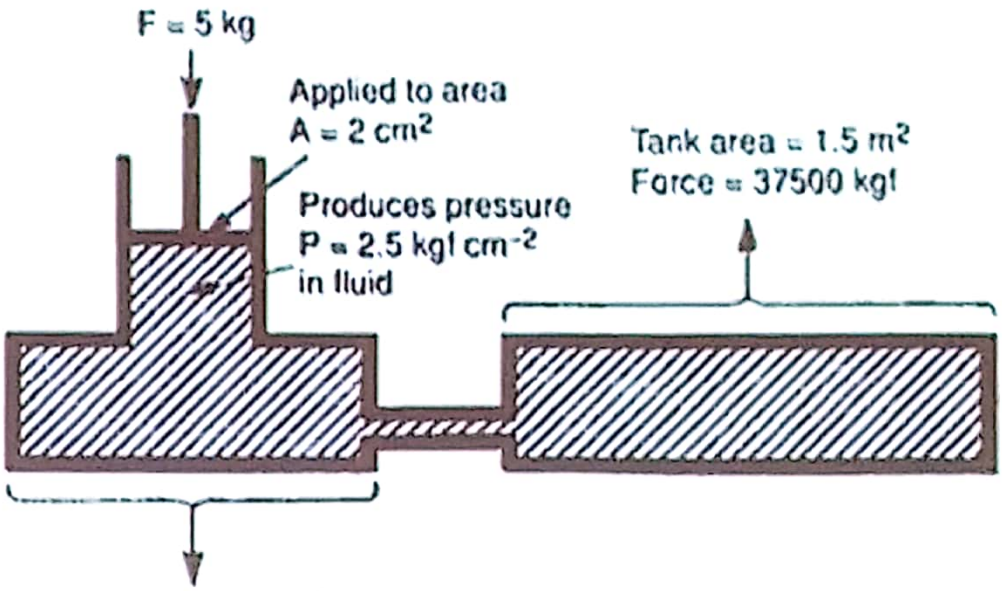
Pascal Law

Pascal's law

- Pressure in an enclosed fluid can be considered uniform throughout a practical system. There may be small differences arising from head pressures at different heights, but these will generally be negligible compared with the system operating pressure.

Pascal Law

Pascal's law

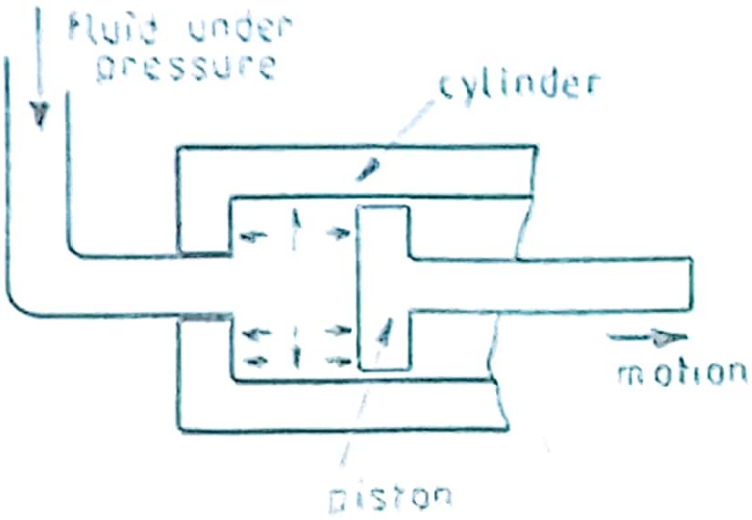


(a) Forces and pressure in closed tanks

Experiment – 2: Pressure and Force

Introduction

- By far the commonest way of converting hydraulic into mechanical effort is to apply hydraulic pressure to a piston in a cylinder.



Experiment – 2: Pressure and Force

➢ Preliminary procedure

1. Connect the outlet of the hydraulic power supply to the 'supply' connection on the servo unit, and connect the return connection to the transparent return hose of the hydraulic reservoir.
2. Plug the rectangular control unit plug into the servo unit socket.
3. Plug the multi-pin plug of the electronic power unit into the control unit socket.
4. Plug the electronic power unit into the electricity supply.
5. Plug the hydraulic power supply unit into the electricity supply. DO NOT start the pump until told.
6. Ensure that the setting of the Orifice Calibrator is fully open.

Experiment – 2: Pressure and Force

➢ Preliminary procedure