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CDI Revision Notes

Term 1 (2017 – 2018)

Grade 12 Advanced

Unit 2 – Mechanical Systems

STUDENT INSTRUCTIONS –

- Student must attempt **all** questions.
- For this examination, you must have:
 - (a) An ink pen – blue.
 - (b) A pencil.
 - (c) A ruler.
 - (d) A calculator (if required).
- Electronic devices are not allowed.

Examination Specifications

| Domain | Marks | Time |
|---|-------------------|---|
| Section 1 - 5 Multiple Choice Questions | 5 Marks | 3 - 4 minutes |
| Section 2 - 5 True or False Statements | 5 Marks | 3 - 4 minutes |
| Section 3 - 2 Short answer Questions | 10 Marks (2 x 5) | 8 - 10 minutes |
| 2 Diagram Questions | 20 Marks (2 x 10) | 10 – 12 minutes |
| 1 Matching Task | 10 Marks | 3 – 5 minutes |
| | Total – 50 Marks | Total – 35 minutes (5 minutes reading) |



SECTION 1 - MECHANICAL SYSTEMS

| Word | Meaning | Image |
|------------------|--|---|
| Fluid | A substance , either a gas or liquid, which flows and conforms to the shape of it container. |  |
| Hydraulic system | A fluid power system, which transmits force through an incompressible fluid. |  |
| Pneumatic system | A fluid power system, which transmits force through a compressible fluid. |  |
| Hydraulic seal | A relatively soft, non metallic ring, captured in a groove or fixed in a combination of rings, formed to block or separate fluid in reciprocating motion applications. |  |



APPLICATIONS OF PNEUMATIC SYSTEMS

AIR COMPRESSORS



AIR BRAKES



DENTAL DRILLS



APPLICATIONS OF HYDRAULIC SYSTEMS

CAR LIFTS



CRANES



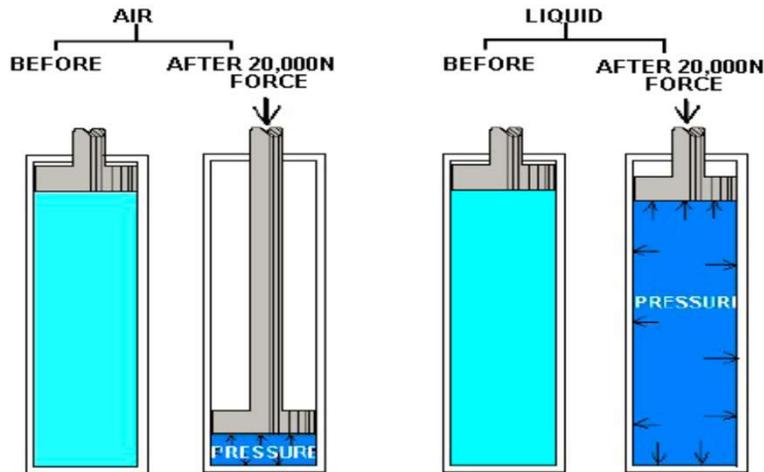
HEDGE CUTTERS





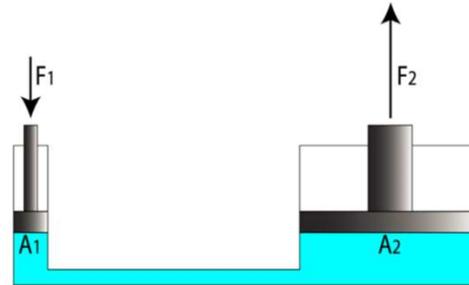
COMPRESSIBILITY OF FLUID

- All liquids have a high resistance to compression.
- The example shows two cylinders of equal volume, each fitted with pistons.
- One containing liquid and the other one containing air.
- A force of 20,000 N (Newton's) is applied to both pistons.
- The decrease in volume of the air is very large compared to that of the liquid.



PASCAL'S LAW

- Pressure in an enclosed container is transmitted equally and undiminished to all parts of the container and acts at right angles to the enclosing walls.
- Force applied at one point is transmitted to another point using fluid that can't be compressed.



$$P_1 = \frac{F_1}{A_1}$$

P_1 = pressure by left piston on the fluid
 F_1 = applied force to the left piston
 A_1 = the area of the left piston

$$P_2 = \frac{F_2}{A_2}$$

P_2 = pressure at the right piston
 F_2 = applied force to the right piston by the fluid
 A_2 = the area of the right piston

$$P_1 = P_2 \rightarrow \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

The unit of pressure is Pascal (Pa).
The unit of force is Newton (N).
The unit of area is square meter (m²).

To find F_2 , F_2 is increased by the ratio of the areas A_2 over A_1 .



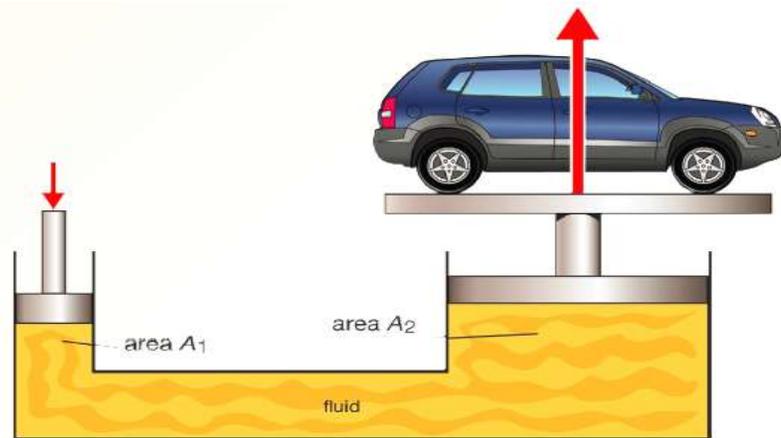
QR CODE FOR
PRINCIPLE OF
HYDRAULIC LIFT

$$F_2 = \left[\frac{A_2}{A_1} \right] F_1$$



Problem:

A hydraulic system is used to lift a 2000-kg vehicle in an auto garage, as shown in the figure given below. If the vehicle sits on a piston of area 1m^2 , and a force is applied to a piston of area 0.05m^2 , what is the minimum force that must be applied to lift the vehicle?



Solution:

$$A_1 = 0.05 \text{ m}^2; A_2 = 1 \text{ m}^2; W = 2000 \text{ kg}; g = 9.8 \text{ m/s}^2$$

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_1 = \frac{F_2}{A_2} \times A_1$$

$$F_1 = \frac{2000 \times 9.8}{1} \times 0.05$$

$$F_1 = 100 \times 9.8 = 980 \text{ N}$$

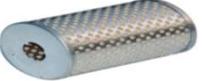
SECTION 2 - BASIC HYDRAULIC SYSTEM

United Arab Emirates
Ministry of Education



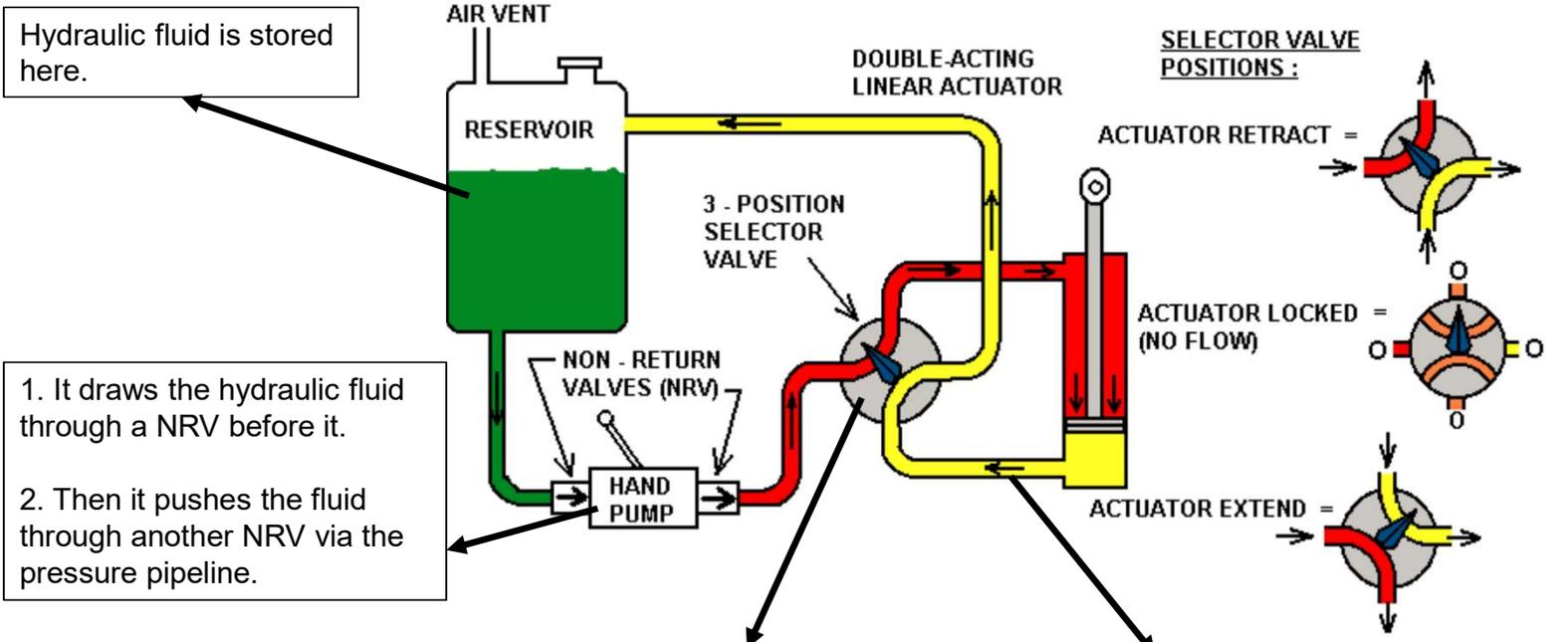
الإمارات العربية المتحدة
وزارة التربية والتعليم

| Word | Meaning | Image |
|-----------------|---|---|
| Hydraulic Pump | A mechanical device that converts mechanical power into hydraulic energy, to generate hydraulic pressure. |  |
| Actuator | A component that converts a type of energy to mechanical energy to move a movable part in the system. |  |
| Linear actuator | An actuator that creates motion in a straight line. |  |
| Reservoir | A container for holding the fluid required to supply the system, including a reserve to cover any losses from minor leakages and evaporation. |  |

| Word | Meaning | Image |
|-----------------------|---|---|
| Non – return valve | A one – way valve that normally allows fluid (liquid or gas) to flow through it in one direction only, also called “check valve”. |  |
| Selector Valve | A directional control device that ensures the movement of the hydraulic fluid flow in the proper direction. |  |
| Pressure relief valve | A safety device designed to protect a pressurized system during an overpressure event. |  |
| Hydraulic filter | A device that removes contaminants from the hydraulic fluids. |  |



SIMPLE HYDRAULIC SYSTEM

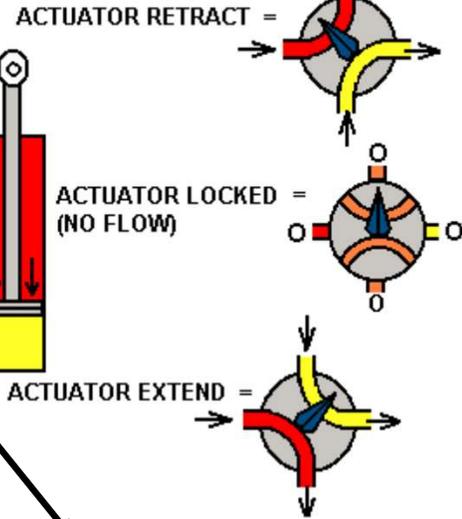


Hydraulic fluid is stored here.

1. It draws the hydraulic fluid through a NRV before it.
2. Then it pushes the fluid through another NRV via the pressure pipeline.

- The fluid is then pushed to the selector valve and depending on its position.
1. the fluid is directed through a port to one side of a double acting linear actuator piston - OR
 2. the fluid will be locked in an actuator and there is no movement of the piston.

SELECTOR VALVE POSITIONS :

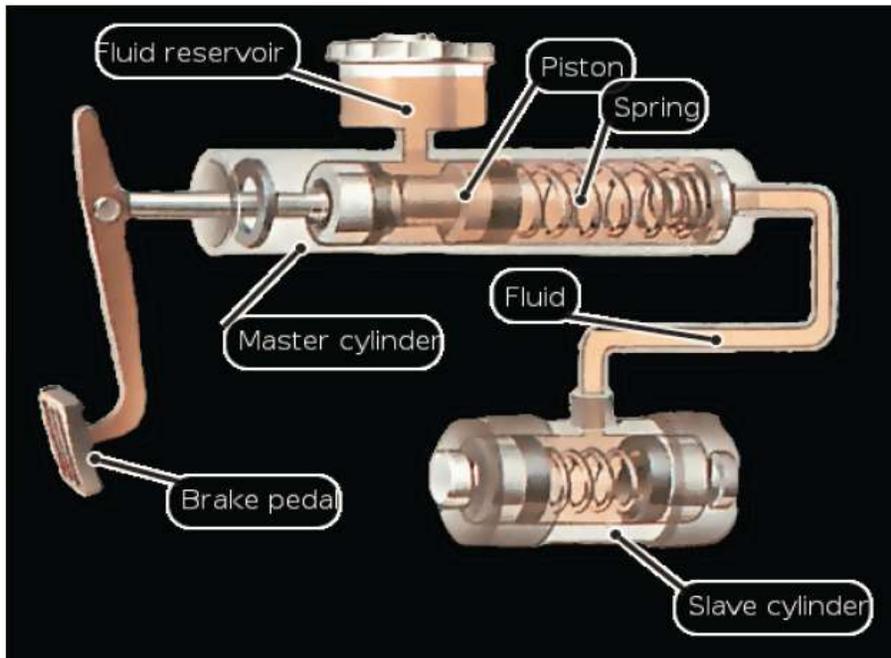


- Non – pressurized fluid in green
- Pressurized fluid in red
- Return fluid in yellow

Fluid from the non pressure side of the actuator piston is directed back to the reservoir by another port in the selector valve via the return pipeline.



CAR BRAKE SYSTEM



1. The driver presses the brake pedal.
2. A spring is actuated.
3. The piston forces the fluid through a series of brake lines to a slave cylinder.

1. Fluid – Hydraulic brake fluid
2. Slave Cylinder – located at each wheel which applies force to the brake pads creating friction between the rotation drum or disc and slowing wheel rotation.



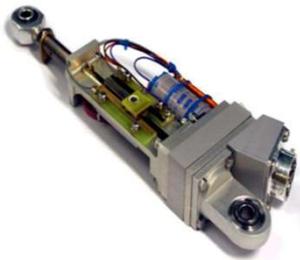
Slave cylinders are mounted to the back – plate on a drum brake system



A slave cylinder is incorporated into the brake caliper on a disc brake system



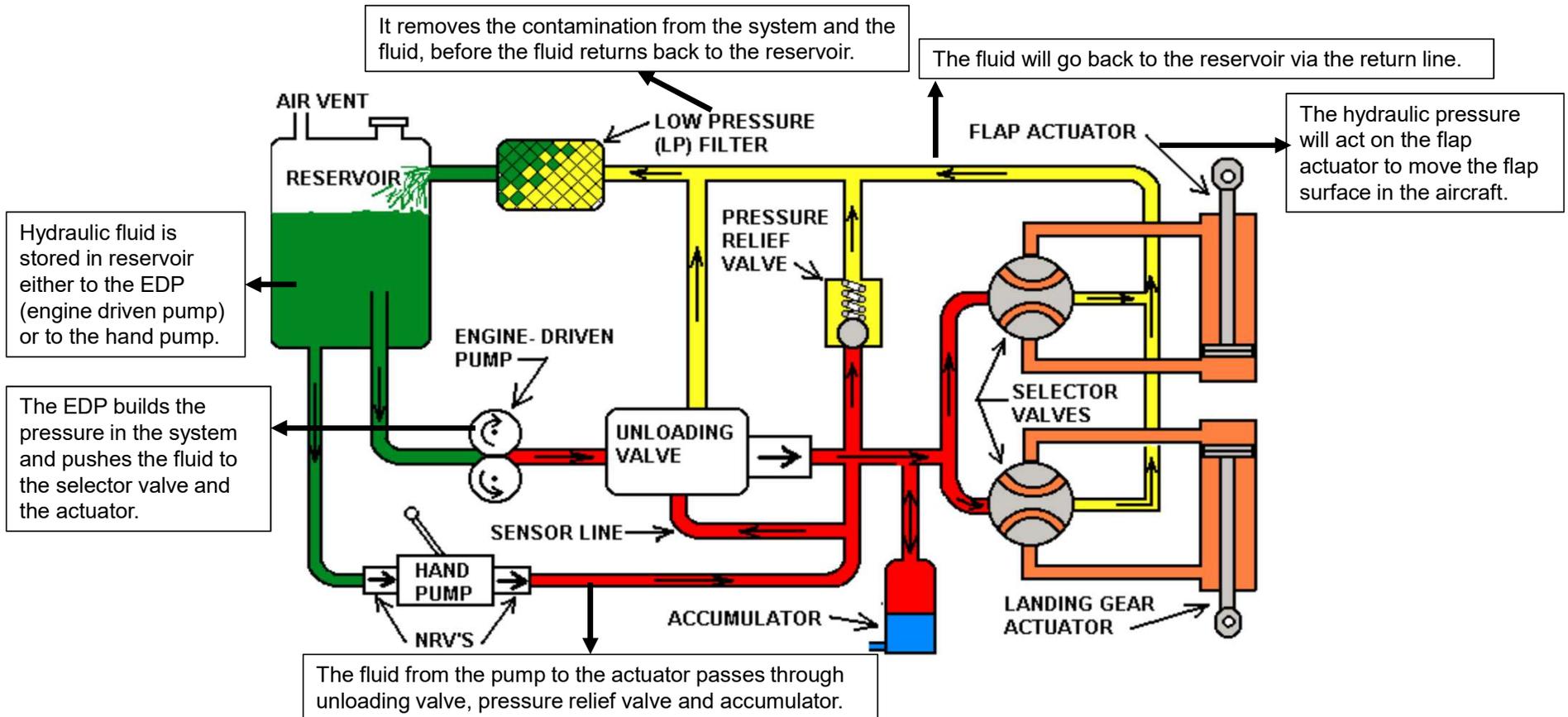
SECTION 3 - ADVANCE HYDRAULIC SYSTEM

| Word | Meaning | Image |
|------------------------------|--|---|
| Flap actuator | It is used to move the flap (aerofoil attached to the back of the wing) in the aircraft. |  |
| Low – pressure return filter | A filter located in the return line, just before the fluid enters the reservoir. |  |

| Word | Meaning | Image |
|--------------------|--|---|
| Engine driven pump | A pump is driven by the engine gearbox to give the hydraulic system a certain amount of pressure and flow. |  |
| Accumulator | A component which stores energy in the form of hydraulic pressure. |  |
| Unloading valve | A valve that relieves the pressure off the pump by delivering the fluid back to the reservoir. |  |



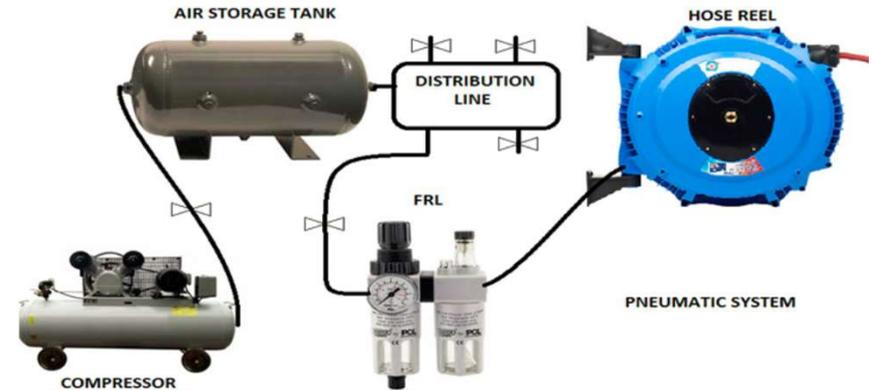
LIGHT AIRCRAFT HYDRAULIC SYSTEM





SECTION 4 - PNEUMATIC SYSTEMS

| Word | Meaning |
|------------------|--|
| Pneumatic | Containing or operated by air or gas under pressure. |
| Pneumatic system | A fluid power system which transmits force through compressible air. |
| Compressed air | Air that is at a higher pressure than atmospheric pressure. |
| Vacuum | A space entirely devoid of matter. |
| Valve | A device for controlling the passage of liquid or gas (air) through a pipe, duct, etc. |
| Innovation | A uniquely new idea, device or method. |



| Component | Function |
|----------------|---|
| Receiver tank | It stores the air that comes to the compressor. |
| Compressor | It increases the pressure of the air. |
| Air filters | Used to remove the contaminants from the air. |
| Control Valves | These are used to regulate, control and monitor pressure and control flow direction. |
| Air actuator | It is a component of a machine that is responsible for moving or controlling a mechanism and operated by pneumatic power. |
| Air cooler | It reduces the temperature of the compressed air during the compression process. |



INNOVATION AND THE FUTURE OF PNEUMATICS

Pneumatic Transport - Hyperloop

How does the Hyperloop work?

1. There's a tube (tunnel) from point A to point B.
2. The air from the tube has been removed; i.e., low air pressure is present inside the tube.
3. Then there are some pods inside that tube.
4. These pods will levitate and move forward tackling friction and reducing drag (as the air has already been removed).
5. For some air left in that tube, compressor fans installed in the front of the pods will suck in the air and push them via air bearings.
6. Anything can be put inside the pods, depending upon its dimensions and capacity.
7. These pods will move from point A to point B, moving the things (or people) in them. Imagine this. You have a tube with low air pressure in it. Now you are shooting pods inside it at high speeds

