Scheme of Evaluation and Solutions

Sub:	Mechatronics				Sub Code:	17ME753	Branch:
Date:		Duration:	90 min's	Max Marks: 50	Sem / Sec:	7^{th} B	

	Answer any 3 full questions, choosing ONE full question from each module.	MARKS
	Module 1	
1.	a. why is mechatronics important to industrial automation? Explain the applications of mechatronics. b. what are the merits and demerits of mechatronics?	10 10
	OR	
2.	a. Define transducers and sensor. List the difference between transducer and sensors. b. Explain light sensors, proximity switch and hall effect sensors.	10 10
	Module 2	
3	a. Define microprocessors and microcontrollers. With the help of sketch, explain the application of microprocessor to automobile system (car). b. What are the elements of control systems? Mention the difference between microcontroller and microprocessor.	10 10
	OR	
4.	a. Explain principle operation of Programmable Logic Controller (PLC). How PLC is different from microprocessor in control system. b. What do you mean by ladder diagram? Explain the same with the help of an example.	10 10
	Module 3	
5.	a. Draw a neat sketch of 8085 microprocessor. Explain different types of registers used in this processor.	10
	OR	
6.	a. Explain background of actuator in mechatronics systems. Explain briefly typical hydraulic actuator and pneumatic actuator.	10

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1.

a. **Definition of Mechatronics**

Mechatronics is defined as **"The synergistic integration of mechanical engineering with electronics and electrical systems with intelligent computer control in the design and manufacture of industrial products, processes, and operations”**. Mechatronics can also be termed as replacement of mechanics with electronics or enhance mechanics with electronics. For example, in modern automobiles, mechanical fuel injection systems are now replaced with electronic fuel injection systems. This replacement made the automobiles more efficient and less pollutant.

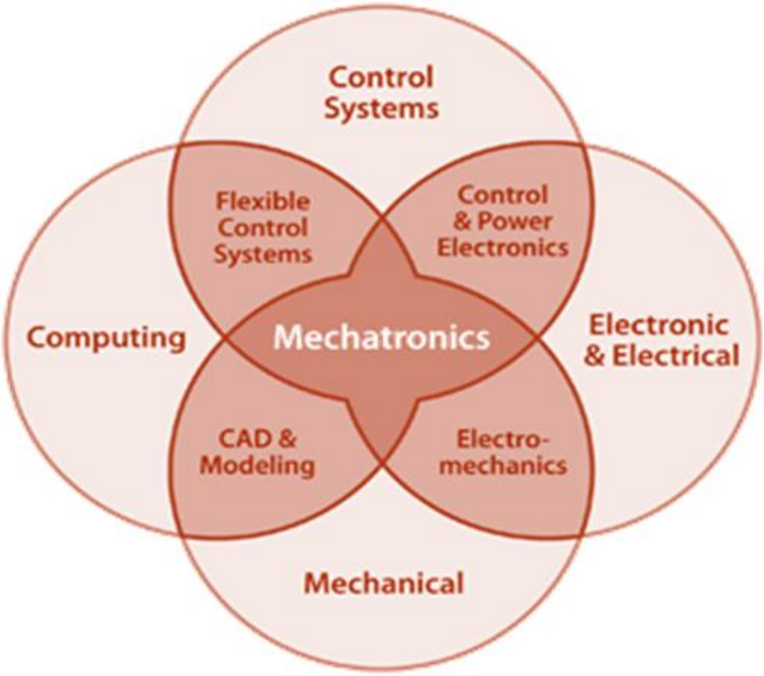


Figure 1.1 Multidisciplinary scenario of Mechatronics.

Objective of mechatronics:

The primary objective of mechatronics is to integrate mechanical systems with electrical, electronics and computer systems and to provide a multidisciplinary approach (figure 1.1) to product development and manufacturing system design.

The secondary objectives of mechatronics are:

- To improve efficiency of the system
- To reduce cost of production
- To achieve higher precision and accuracy
- For easy control of systems
- Customer satisfaction and comfort

1. **.b. Define programmable logic controllers. Briefly explain the structure of PLC**.

A *programmable logic controller* (PLC) is a special form of microprocessor- based controller that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting and arithmetic in order to control machines and processes.
PLC’s are designed to be operated by engineers with perhaps a limited knowledge of computers and computing languages. They are not designed so that only computer programmers can set up or change the programs. Thus, the designers of the PLC have pre-programmed it so that the control program can be entered using a simple, rather intuitive, form of language.

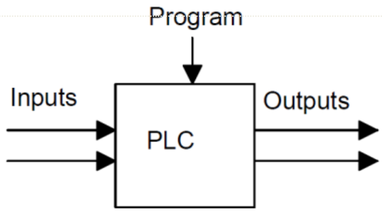


Fig. A programmable logic controller

The term *logic* is used because programming is primarily concerned with implementing logic and switching operations, e.g. if A or B occurs switch on C, if A and B occurs switch on D. Input devices, e.g. sensors such as switches, and output devices in the system being controlled, e.g. motors, valves, etc., are connected to the PLC. The operator then enters a sequence of instructions, i.e. a program, into the memory of the PLC. The controller then monitors the inputs and outputs according to this program and carries out the control rules for which it has been programmed.

Typically a PLC system has the basic functional components of processor unit, memory, power supply unit, input/output interface section, communications interface and the programming device. Figure below shows the basic arrangement.

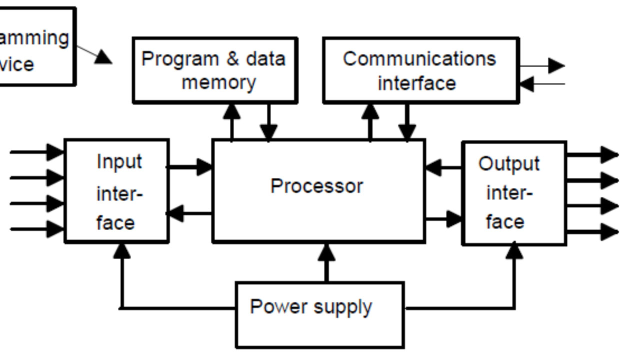


Figure *The PLC system*

1 The ***processor unit*** or *central processing unit (CPU)* is the unit containing the microprocessor and this interprets the input signals and carries out the control actions, according to the program stored in its memory, communicating the decisions as action signals to the outputs.

2 The ***power supply unit*** is needed to convert the mains a.c. voltage to the low d.c. voltage (5 V) necessary for the processor and the circuits in the input and output interface modules.

3 The ***programming device*** is used to enter the required program into the memory of the processor. The program is developed in the device and then transferred to the memory unit of the PLC.

4 The ***memory unit*** is where the program is stored that is to be used for the control actions to be exercised by the microprocessor and data stored from the input for processing and for the output for outputting.

5 The ***input and output sections*** are where the processor receives information from external devices and communicates information to external devices. The inputs might thus be from switches, The outputs might be to motor starter coils, solenoid valves, etc. Input and output devices can be classified as giving signals which are discrete, digital or analogue

2. **Briefly explain the concept of ladder diagram used in PLC programming.**

A very commonly used method of programming PLCs is based on the use of *ladder diagrams*. Writing a program is then equivalent to drawing a switching circuit. The ladder diagram consists of two vertical lines representing the power rails. Circuits are connected as horizontal lines, i.e. the rungs of the ladder, between these two verticals.

In drawing a ladder diagram, certain conventions are adopted:
1 The vertical lines of the diagram represent the power rails between which circuits are connected. The power flow is taken to be from the left-hand vertical across a rung. 2 Each rung on the ladder defines one operation in the control process. 3 A ladder diagram is read from left to right and from top to bottom, Figure 5.3 showing the scanning motion employed by the PLC. The top rung is read from left to right. Then the second rung down is read from left to right and so on. When the PLC is in its run mode, it goes through the entire ladder program to the end, the end rung of the program being clearly denoted, and then promptly resumes at the start. This procedure of going through all the rungs of the program is termed a *cycle*. The end rung might be indicated by a block with the word END or RET for return, since the program promptly returns to its beginning.

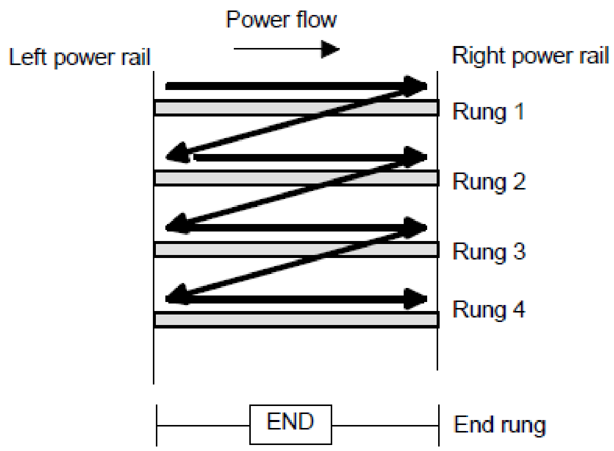
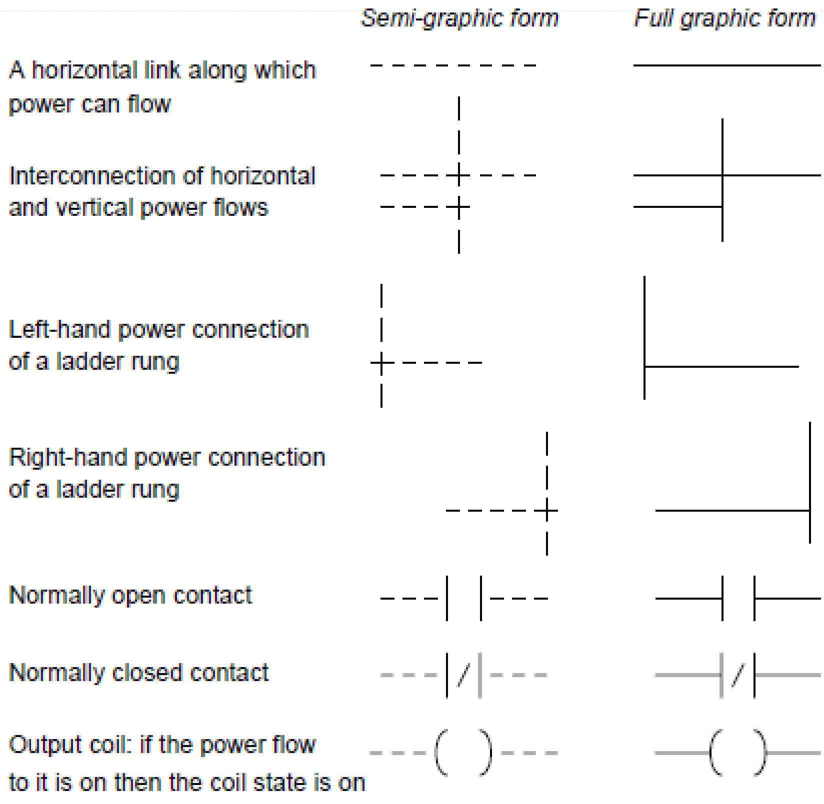


Figure 5.3 *Scanning the ladder program*

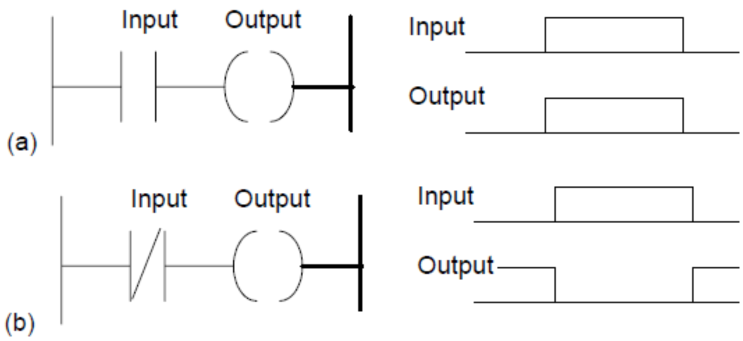
4 Each rung must start with an input or inputs and must end with at least one output. The term input is used for a control action, such as closing the contacts of a switch, used as an input to the PLC. The term output is used for a device connected to the output of a PLC, e.g. a motor.
5 Electrical devices are shown in their normal condition. Thus a switch which is normally open until some object closes it, is shown as open on the ladder diagram. A switch that is normally closed is shown closed.
6 A particular device can appear in more than one rung of a ladder. For example, we might have a relay which switches on one or more devices. The same letters and/or numbers are used to label the device in each situation.
7 The inputs and outputs are all identified by their addresses, the notation used depending on the PLC manufacturer. This is the address of the input or output in the memory of the PLC.

3. Explain the basic standard symbol used in ladder diagram for programming PLC.

Figure below shows standard IEC 1131-3 symbols that are used for input and output devices. Some slight variations occur between the symbols when used in semi-graphic form and when in full graphic. Note that inputs are represented by different symbols representing normally open or normally closed contacts. The action of the input is equivalent to opening or closing a switch. Output coils are represented by just one form of symbol.



To illustrate the drawing of the rung of a ladder diagram, consider a situation where the energising of an output device, e.g. a motor, depends on a normally open start switch being activated by being closed. The input is thus the switch and the output the motor. Figure 5.5(a) shows the ladder diagram.



4. **Briefly explain logic gates used in PLC programming explain any one logic gate.**

There are many control situations requiring actions to be initiated when a certain combination of conditions is realised. Thus, for an automatic drilling machine, there might be the condition that the drill motor is to be activated when the limit switches are activated that indicate the presence of the workpiece and the drill position as being at the surface of the workpiece. Such a situation involves the AND logic function, condition A and condition B having both to be realised for an output to occur.

AND

Figure 5.7(a) shows a situation where an output is not energised unless two, normally open, switches are both closed. Switch A and switch B have both to be closed, which thus gives an AND logic situation. We can think of this as representing a control system with two inputs A and B (Figure 5.7(b)). Only when A and B are both on is there an output. Thus if we use 1 to indicate an on signal and 0 to represent an off signal, then for there to be a 1 output we must have A and B both 1. Such an operation is said to be controlled by a *logic gate* and the relationship between the inputs to a logic gate and the outputs is tabulated in a form known as a *truth table*. Thus for the AND gate we have:
An example of an AND gate is an interlock control system for a machine tool so that it can only be operated when the safety guard is in position and the power switched on.
Figure 5.8(a) shows an AND gate system on a ladder diagram. The ladder diagram starts with | |, a normally open set of contacts labelled input A, to represent switch A and in series with it | |, another

normally open set of contacts labelled input B, to represent switch B. The line then terminates with O to represent the output. For there to be an output, both input A and input B have to occur, i.e. input A and input B contacts have to be closed (Figure 5.8(b)).
In general: *On a ladder diagram contacts in a horizontal rung, i.e. contacts in series, represent the logical AND operations.*

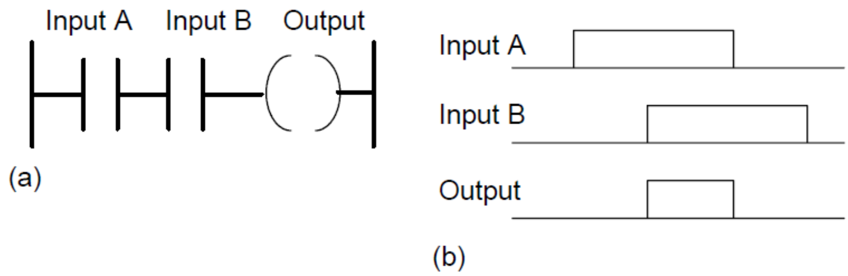


Figure 5.8 *AND gate with a ladder diagram rung*

logic gate and the outputs is tabulated in a form known as a *truth table.*
Thus for the AND gate we have:

Inputs		Output
A	B	
0	0	0
0	1	0
1	0	0
1	1	1

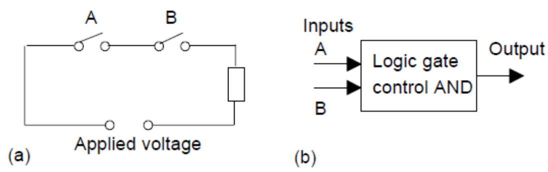


Figure 5.7 *(a) AND circuit, (b) AND logic gate*

5. Illustrate PLC ladder diagram with a simple application.

A signal lamp is required to be switched on if a pump is running and the pressure is satisfactory, or if the lamp test switch is closed. For the inputs from the pump and the pressure sensors we have an AND logic situation since both are required if there is to be an output from the lamp. We, however, have an OR logic situation with the test switch in that it is required to give an output of lamp on regardless of whether there is a signal from the AND system. The function block diagram and the ladder diagram are thus of the form shown in Figure 5.37. Note that with the ladder diagram we tell the PLC when it has reached the end of the program by the use of the END or RET instruction.

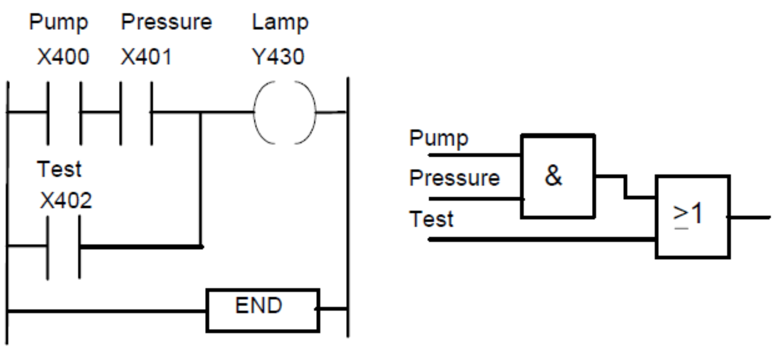


Figure 5.37 *Signal lamp task*

6. With a neat sketch explain various components of a hydraulic system.

Functions of the components shown in Fig. 1.1 are as follows:

1. A reservoir is used to hold the hydraulic oil.

2. An actuator to convert the fluid power into mechanical power to perform useful work.
3. A pump is used to force the fluid from the reservoir.
3. Valves are used to control the direction, pressure and flow rate of a fluid.
4. An electric motor is required to drive the pump.
6. Piping system carries the hydraulic oil from one place to another.
7. Filters are used to remove any foreign particles so as keep the fluid system clean and efficient.
8. Pressure regulator regulates (i.e. maintains) the required level of pressure in the hydraulic fluid.

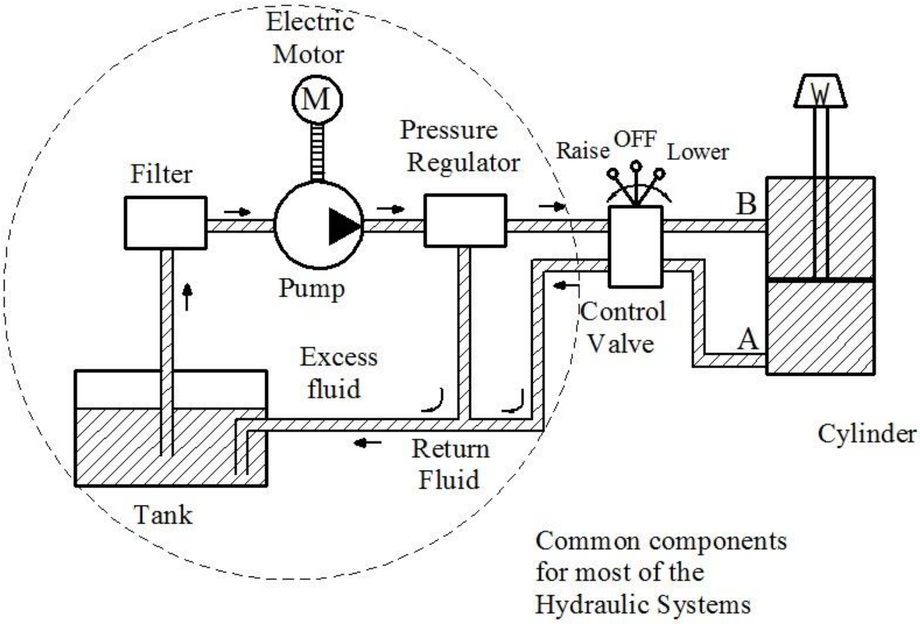


Figure 1.1 Basic components of a hydraulic System

A hydraulic linear actuator suitable for this application is the ram; shown schematically in Figure 1.1 This consists of a movable piston connected directly to the output shaft. If fluid is pumped into pipe A, the piston will move up and the shaft will extend; if fluid is pumped into pipe B, the shaft will retract.

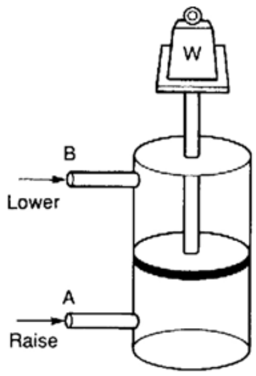


Fig 1.2 Hydraulic cylinder

The system requires a liquid fluid to operate; this is expensive and messy and, consequently, the piping must act as a closed loop, with fluid transferred from a storage tank to one side of the piston, and returned from the other side of the piston to the tank. Fluid is drawn from the tank by a pump which produces fluid flow at the required pressure.

Cylinder movement is controlled by a three-position direction control valve (DCV). To extend the cylinder, port A is connected to the pressure line and port B to the tank. To reverse the motion, port B is connected to the pressure line and port A to the tank. In its centre position the valve locks the fluid into the cylinder.

7. Discuss about the construction and types of cylinders used in hydraulic system.

Hydraulic Cylinders

The hydraulic cylinders convert the hydraulic power into mechanical power, performing rectilinear motion. Cylinders are linear actuators that can push and pull, and when mounted around a joint, can actuate rotary motion. The pressure of input oil is converted into the force acting on the piston.

The Construction of Hydraulic Cylinders

The construction of hydraulic and pneumatic linear actuators is similar. However they differ at their operating pressure ranges. Typical pressure of hydraulic cylinders is about 100 bar and of pneumatic system is around 10 bar.

It consists mainly of the piston, a piston rod, cylinder barrel, cylinder head, and cylinder cap. The piston rod is extruded through the cylinder head. The piston carries a convenient sealing assembly to insure the required internal tightness, while the cylinder head is equipped with convenient seals to resist external leakage.

There are 2 types of cylinders:

1. Single-acting
2. Double-acting

Single-acting

A single-acting cylinder can exert a force in only the extending direction as fluid from the pump enters the blank end of the cylinder hence they are named as single acting cylinders. Single acting cylinders do not retract hydraulically. The cylinder retracts due to either gravitational force or assisted by a spring.

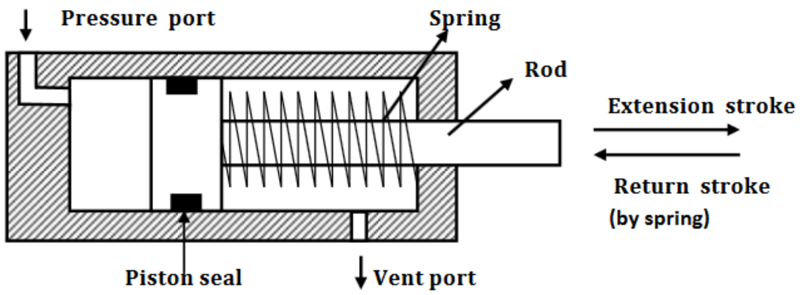


Figure 2.1Single-acting cylinders

Double acting cylinder

The main parts of a hydraulic double acting cylinder are: piston, piston rod, cylinder tube, and end caps. These are shown in Figure 2.2. The piston rod is connected to piston head and the other end extends out of the cylinder. The piston divides the cylinder into two chambers namely the rod end side and piston end side. The seals prevent the leakage of oil between these two chambers. The cylindrical tube is fitted with end caps. The pressurized oil, air enters the cylinder chamber through the ports provided. In the rod end cover plate, a wiper seal is provided to prevent the leakage of oil and entry of the contaminants into the cylinder. The combination of wiper seal, bearing and sealing ring is called as cartridge assembly. The end caps may be attached to the tube by threaded connection, welded connection or tie rod connection. The piston seal prevents metal to metal contact and wear of piston head and the tube. These seals are replaceable. End cushioning is also provided to prevent the impact with end caps.

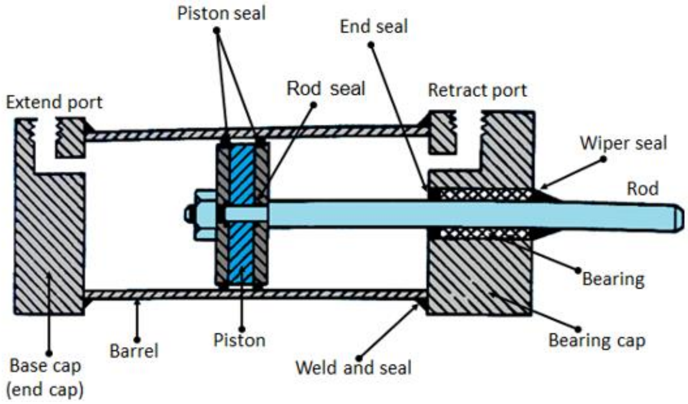


Fig. 2.2 Double acting cylinder