IAT 3 – Nov. 2019

Sub: Mechatronics | **Code:** 15ME753

Date: 18/11/2019 | Duration: 90 mins | Max Marks: 50 | **Sem:** VII | **Branch:** MECH A&B

Note: Answer any **four** questions from Part A. Part B compulsory. Do well!

		Marks	OBE	
			CO	RBT
	PART A			
1	Explain Geneva Mechanism and Electromechanical relay with one application each.	10	CO4	L2
2	Explain brushless DC motor and Synchronus motor with an application each.	10	CO4	L1
3	What is a DCV? Explain Solenoid operated spool valve, sliding spool valve.	10	CO5	L2
4	Explain with sketch a hydraulic system with applications.	5	CO5	L2
5	With a sketch, explain valve actuation symbols for hydraulic and pneumatic systems.	10	CO5	
	PART B			
6 (C)	i) Sketch only the basic structure of PLC ii) Write a ladder logic program for the switch ON & OFF of water pump using one switch and latching function. iii) Explain the rules of ladder programming.	3+4+3	CO3	L3

CI **CCI** **HOD**

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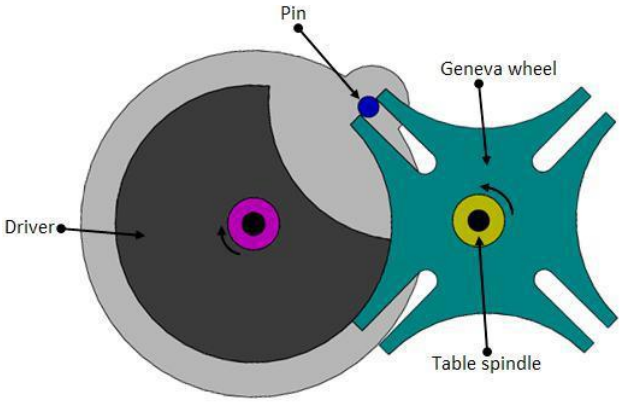
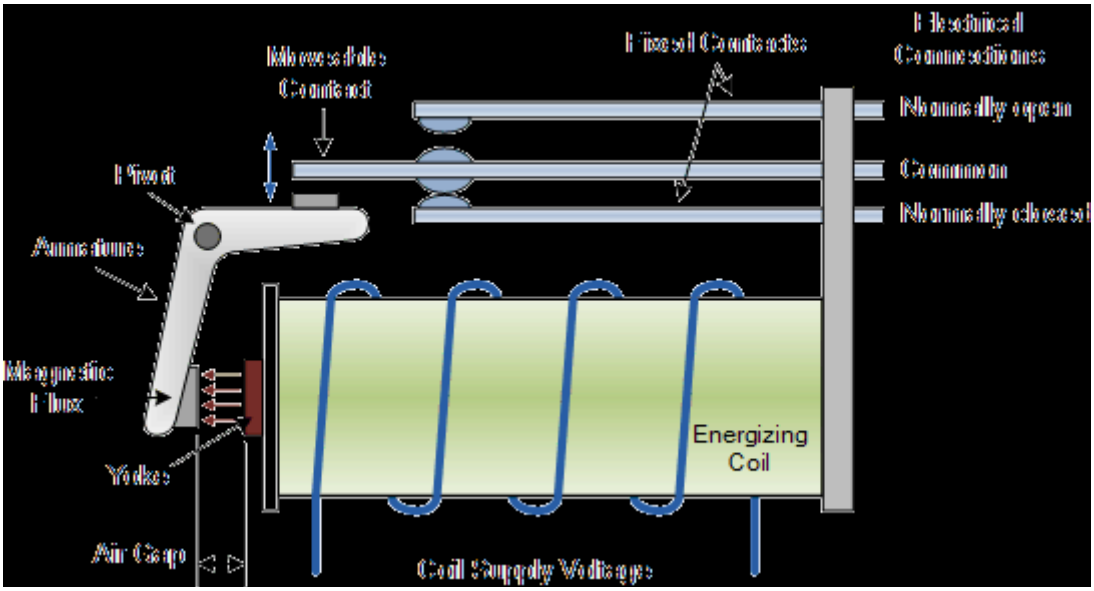
IAT 3 Solution

1)



The Geneva drive is also commonly called a Maltese cross mechanism. The Geneva mechanism translates a continuous rotation into an intermittent rotary motion. The rotating drive wheel has a pin that reaches into a slot of the driven wheel. The drive wheel also has a raised circular blocking disc that locks the driven wheel in position between steps.There are three basic types of Geneva motion mechanisms namely external, internal and spherical. The spherical Geneva mechanism is very rarely used. In the simplest form, the driven wheel has four slots and hence for each rotation of the drive wheel it advances by one step of 90°. If the driven wheel has n slots, it advances by 360°/n per full rotation of the drive wheel.In an internal Geneva drive the axis of the drive wheel of the internal drive is supported on only one side The angle by which the drive wheel has to rotate to effect one step rotation of the driven wheel is always smaller than 180° in an external Geneva drive and is always greater than 180° in an internal one. The external form is the more common, as it can be built smaller and can withstand higher mechanical stresses. Because the driven wheel always under full control of the driver, impact is a problem. It can be reduced by designing the pin in such a way that the pin picks up the driven member as slowly as possible. Both the Geneva mechanisms can be used for light and heavy duty applications. Generally, they are used in assembly machines. Intermittent linear motion from rotary motion can also be obtained using Geneva.
This type of movement is basically required in packaging, assembly operations, stamping, embossing operations in manufacturing automation.

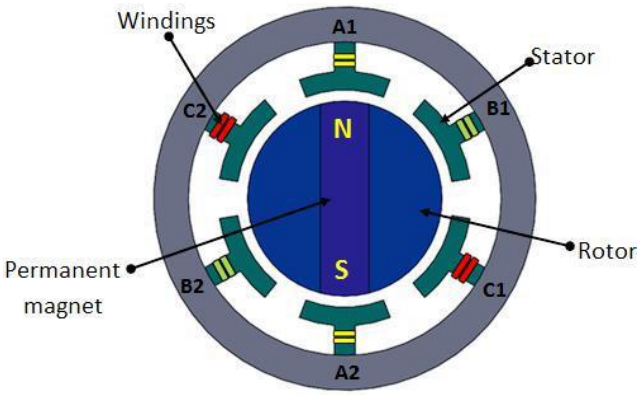
Electromechanical relay



We have two sets of electrically conductive contacts. Relays may be “Normally Open”, or “Normally Closed”. One pair of contacts are classed as **Normally Open, (NO)** or make contacts and another set which are classed as **Normally Closed, (NC)**or break contacts. In the normally open position, the contacts are closed only when the field current is “ON” and the switch contacts are pulled towards the inductive coil.
In the normally closed position, the contacts are permanently closed when the field current is n“OFF” as the switch contacts return to their normal position. These terms *Normally Open, Normally Closed* or *Make and Break Contacts* refer to the state of the electrical contacts when the relay coil is “de-energized”, i.e, no supply voltage connected to the relay coil. Contact elements may be of single or double make or break designs. An example of this arrangement is given below.
The relays contacts are electrically conductive pieces of metal which touch together completing a circuit and allow the circuit current to flow, just like a switch. When the contacts are open the resistance between the contacts is very high in the Mega-Ohms, producing an open circuit condition and no circuit current flows.

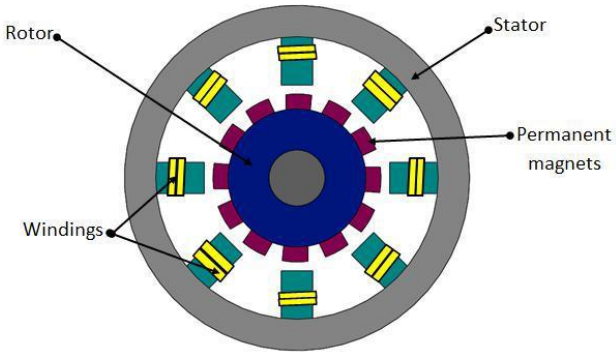
When the contacts are closed the contact resistance should be zero, a short circuit, but this is not always the case. All relay contacts have a certain amount of “contact resistance” when they are closed and this is called the “On-Resistance”, similar to FET’s. With a new relay and contacts this ON-resistance will be very small, generally less than 0.2Ωbecause the tips are new and clean, but over time the tip resistance will increase

2) Brushless DC motor



A brushless DC motor has a rotor with permanent magnets and a stator with windings.
The rotor can be of ceramic permanent magnet type. The brushes and commutator are eliminated and the windings are connected to the control electronics. The control electronics replace the commutator and brushes and energize the stator sequentially. Here the conductor is fixed and the magnet moves
The current supplied to the stator is based on the position of rotor. It is switched in sequence using transistors. The position of the rotor is sensed by Hall effect sensors. Thus a continuous rotation is obtained.
]
***Advantages of brushless DC motor*:**
• More precise due to computer control
• More efficient
• No sparking due to absence of brushes
• Less electrical noise
• No brushes to wear out
• Electromagnets are situated on the stator hence easy to cool
• Motor can operate at speeds above 10,000 rpm under loaded and unloaded conditions
• Responsiveness and quick acceleration due to low rotor inertia
***Disadvantages of brushless DC motor*:**
• Higher initial cost
• Complex due to presence of computer controller
• Brushless DC motor also requires additional system wiring in order to power the electronic commutation circuitry

Synchronous AC motor



A synchronous motor is an AC motor which runs at constant speed fixed by frequency of the system. It requires direct current (DC) for excitation and has low starting torque, and hence is suited for applications that start with a low load. It has two basic electrical parts namely stator and rotor as shown in fig. The stator consists of a group of individual wounded electro-magnets arranged in such a way that they form a hollow cylinder. The stator produces a rotating magnetic field that is proportional to the frequency supplied. The rotor is the rotating electrical component. It also consists of a group of permanent magnets arranged around a cylinder, with the poles facing toward the stator poles. The rotor is mounted on the motor shaft. The main difference between the synchronous motor and the induction motor is that the rotor of the synchronous motor travels at the same speed as the rotating magnet.

The stator is given a three phase supply and as the polarity of the stator progressively change the magnetic field rotates, the rotor will follow and rotate with the magnetic field of the stator. If a synchronous motor loses lock with the line frequency it will stall. It cannot start by itself, hence has to be started by an auxiliary motor.

3

DCV: Directional control valves are used to control the distribution of energy in a fluid power system. They provide the direction to the fluid and allow the flow in a particular direction. These valves are used to control the start, stop and change in direction of the fluid flow.

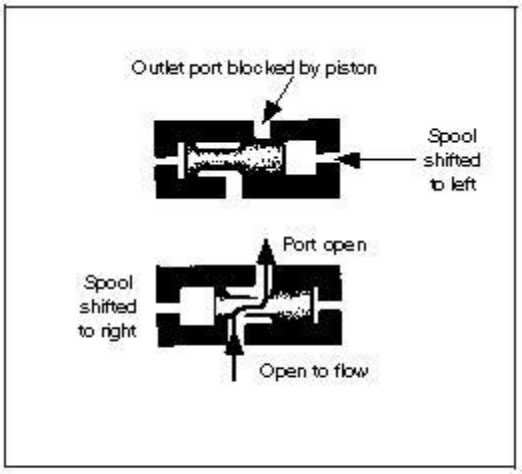
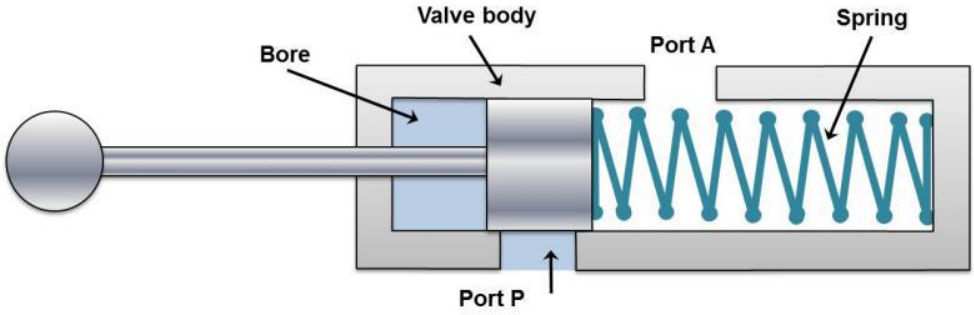


Figure 5-13. Operation of sliding-spool, directional-control valve

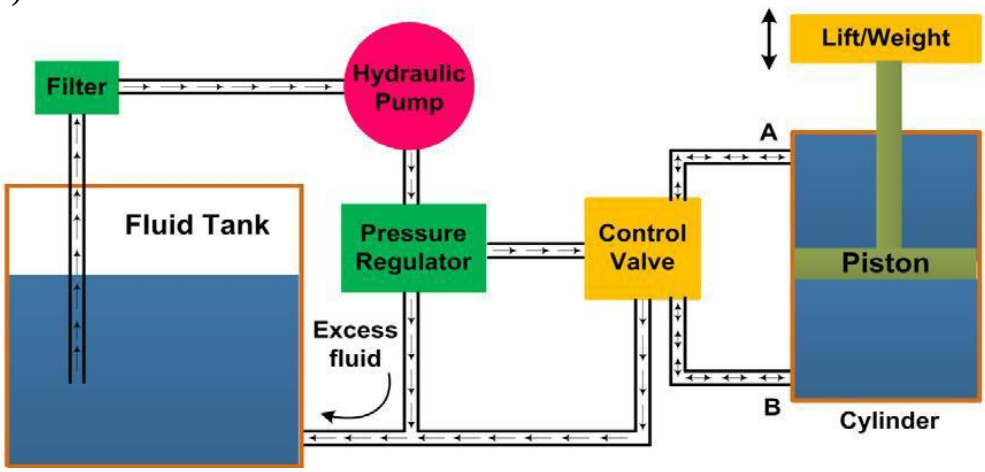
The valve element slides back and forth to block and uncover ports in the housing. Sometimes called a piston type, the sliding-spool valve has a piston of which the inner areas are equal. Pressure from the inlet ports acts equally on both inner piston areas regardless of the position of the spool. Sealing is done by a machine fit between the spool and valve body or sleeve.

Solenoid operated spool valve:



The spool valves derive their name from their appearance. It consists of a shaft sliding in a bore which has large groove around the circumference. This type of construction makes it look like a spool. The spool is sealed along the clearance between moving spool and housing (valve body). The quality of seal or the amount of leakage depends on the amount of clearance, viscosity of fluid and the level of the pressure. The grooves guide the fluid flow by interconnecting or blocking the holes (ports). The spool valves are categorized according to the number of operating positions and the way hydraulic lines interconnections. One of the simplest two way spool valve is shown in Figure 5.5.1. The standard terms are referred as Port 'P' is pressure port, Port 'T' is tank port and Port 'A' and Port 'B' are the actuator (or working) ports. The actuators can move in forward or backward direction depending on the connectivity of the pressure and tank port with the actuators port.

4)



The hydraulic systems consists a number of parts for its proper functioning. These include storage tank, filter, hydraulic pump, pressure regulator, control valve, hydraulic cylinder, piston and leak proof fluid flow pipelines. It consists of:

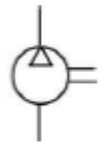
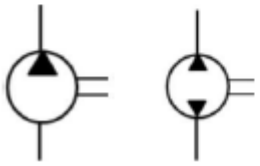
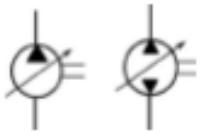
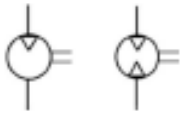
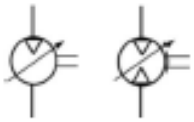
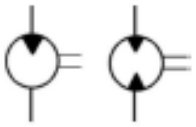
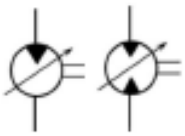
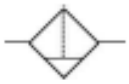
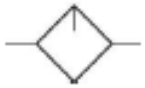
- a movable piston connected to the output shaft in an enclosed cylinder
- storage tank
- filter
- electric pump
- pressure regulator
- control valve
- leak proof closed loop piping.

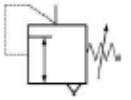
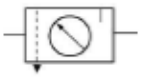
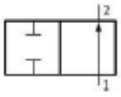
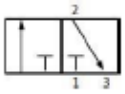
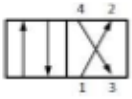
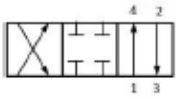
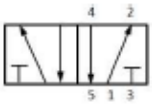
The output shaft transfers the motion or force however all other parts help to control the system. The storage/fluid tank is a reservoir for the liquid used as a transmission media. The liquid used is generally high density incompressible oil. It is filtered to remove dust or any other unwanted particles and then pumped by the hydraulic pump. The capacity of pump depends on the hydraulic system design. These pumps generally deliver constant volume in each revolution of the pump shaft. Therefore, the fluid pressure can increase indefinitely at the dead end of the piston until the system fails. The pressure regulator is used to avoid such circumstances which redirect the excess fluid back to the storage tank. The movement of piston is controlled by changing liquid flow from port A and

port B. The cylinder movement is controlled by using control valve which directs the fluid flow. The fluid pressure line is connected to the port B to raise the piston and it is connected to port A to lower down the piston. The valve can also stop the fluid flow in any of the port. The leak proof piping is also important due to safety, environmental hazards and economical aspects. Some accessories such as flow control system, travel limit control, electric motor starter and overload protection may also be used in the hydraulic systems

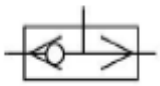
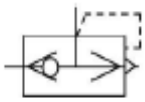
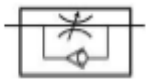
5)

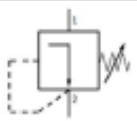
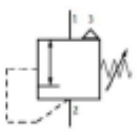
Port	Letter system	Number system
Pressure port	P	1
Working port	A	4
Working port	B	2
Exhaust port	R	5
Exhaust port	S	3
Pilot port	Z	14
Pilot port	Y	12

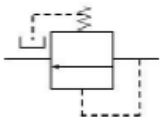
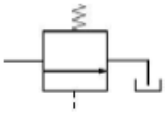
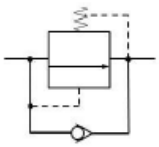
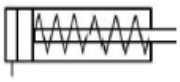
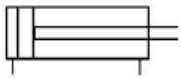
SYMBOL	DESIGNATION	EXPLANATION
Energy supply		
	Air compressor	One direction of rotation only with constant displacement volume
	Air receiver	Compressed air from the compressor is stored and diverted to the system when required
		One direction and two direction of rotation with constant displacement volume
	Hydraulic pump	One direction and two direction of rotation with variable displacement
Rotary actuators		
	Pneumatic motor	One direction and two direction of rotation with constant displacement volume
		One direction and two direction of rotation with variable displacement
	Hydraulic motor	One direction and two direction of rotation with constant displacement volume
		One direction and two direction of rotation with variable displacement
Service units		
	Air filter	This device is a combination of filter and water separator
	Dryer	For drying the air
	Lubricator	For lubrication of connected devices, small amount of oil is added to

		the air flowing through this device
	Regulator	To regulate the air pressure
	FRL unit	Combined filter, regulator and lubricator system
Direction control valves (DCVs)		
	2/2 way valve	Two closed ports in the closed neutral position and flow during actuated position
	3/2 way valve	In the first position flow takes place to the cylinder In the second position flow takes out of the cylinder to the exhaust (Single acting cylinder)
	4/2 way valve	For double acting cylinder all the ports are open
	4/3 way valve	Two open positions and one closed neutral position
	5/2 way valve	Two open positions with two exhaust ports

Direction control valve actuation methods		
	General manual actuation	Manual operation of DCV
	Push button actuation	
	Lever actuation	
	Detent lever actuation	
	Foot pedal actuation	Mechanical actuation of DCV
	Roller lever actuation	
	Idle return roller actuation	
	Spring actuation	
	Direct pneumatic actuation	Pneumatic actuation of DCV
Non return valves		
	Check valve	Allows flow in one direction and blocks flow in other direction
	Spring loaded check valve	

	Shuttle/ OR valve	When any one of the input is given the output is produced
	AND valve	Only when both the inputs are given output is produced
	Quick exhaust valve	For quick exhaust of air to cause rapid extension/ retraction of cylinder
Flow control valves		
	Flow control valve	To allow controlled flow
	Flow control valve with one way adjustment	To allow controlled flow in one direction and free flow in other

Pressure control valves		
	Pressure relieving valve	Non relieving type
		Relieving type with overload being vented out

	Pressure reducing valve	Maintains the reduced pressure at specified location in hydraulic system
	Unloading valve	Allows pump to build pressure to an adjustable pressure setting and then allow it to be discharged to tank
	Counter balance valve	Controls the movement of vertical hydraulic cylinder and prevents its descend due to external load weight
Actuators		
	Single acting cylinder	Spring loaded cylinder with retraction taking place by spring force
	Double acting cylinder	Both extension and retraction by pneumatic/hydraulic force

6)