MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)
SUMMER – 2016 EXAMINATION

Subject Code : **17302** **Model Answer**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Question1. A) Attempt any Six **(12)**

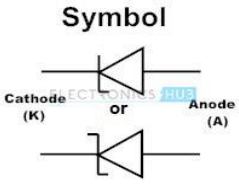
a) A rectifier is an electronic circuit that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. **(1 Mark)**

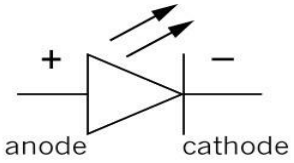
Types of rectifier:

- Half wave rectifier
- Full wave rectifier : Center tapped & Bridge rectifier

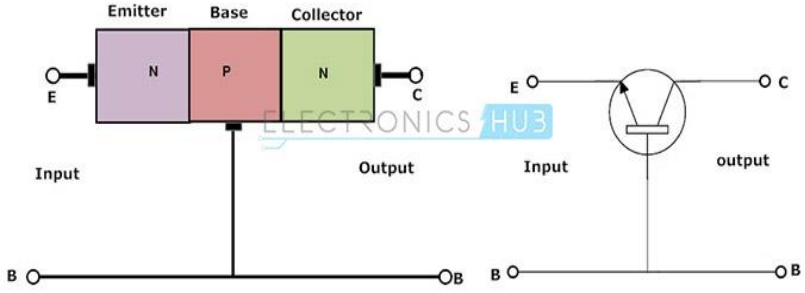
(1 Mark)

b) Symbols: **Zener Diode (1Mark)** **LED (1Mark)**



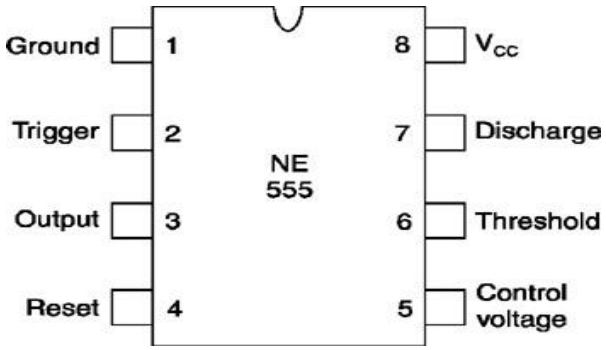


c) Input and output terminals of CB configuration **(2Marks)**



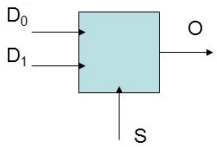
d) Pin diagram of IC 555 :

Pin diagram – **1 Mark** **Label – 1 Mark**



e) Logical symbol: 2:1 Multiplexer (1 Mark) Truth table (1 Mark)

2:1 Multiplexer



S	D_1	D_0	O
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

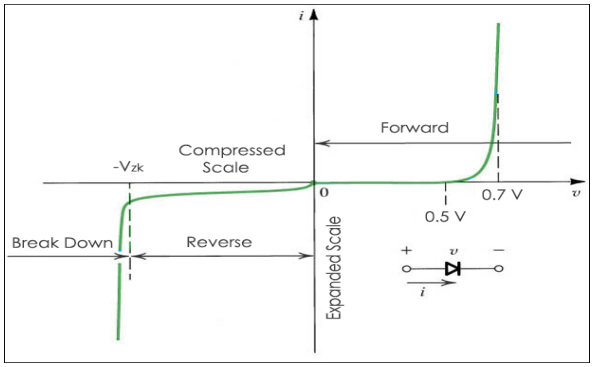
f) Types of real time mechatronics system:

i. **Hard real time system:** System must react to the input within specific amount of time(deadline) **(1 Mark)**

ii. **Soft real time system:** This system try to meet deadline, but it fails does not cause any major damage. **(1 Mark)**

Any other relevant Mechatronics systems may also considered.

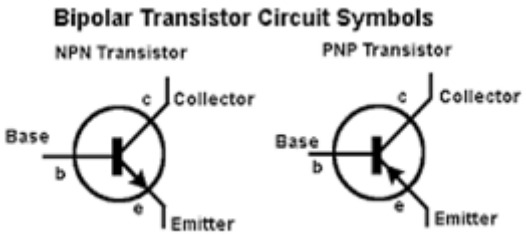
g) V-I Characteristics of P-N junction diode: (2 Marks)



h) Types of Bijunction transistor:

PNP transistor and NPN transistor (1 Mark)

Symbols with labels (1/2mark for each symbol = 1 Mark)



B) Attempt any TWO : (8 Marks)

i) Filter:

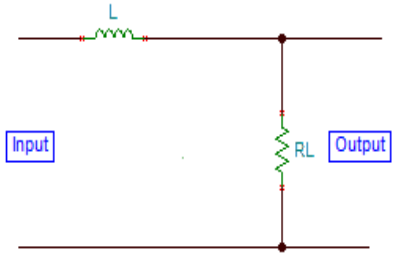
A circuit which converts the pulsating DC into pure DC is called as filter. As the name specifies it removes the ripples in the rectifier output and provides a pure DC at the output. The electronic reactive elements like capacitor and inductors are used in filter circuit to perform this operation. **(1 Mark)**

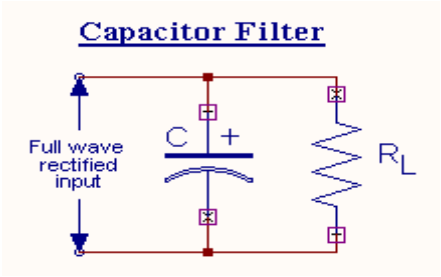
List types of Filter:

Choke input (Inductor) filter, Capacitor , LC filter and Pi (π) filter **(1 Mark)**

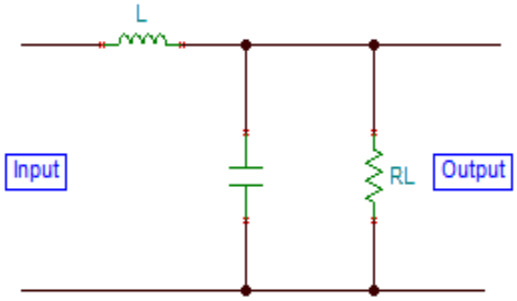
Any one circuit of the followings: **(2 Marks)**

Choke input (Inductor) Filter

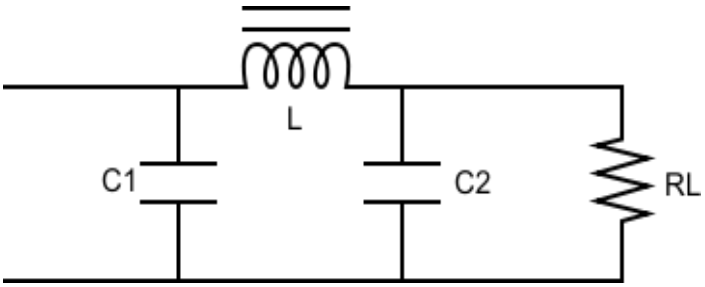




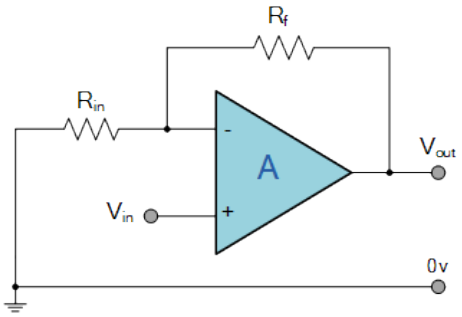
LC Filter



Pi filter



ii) Non-inverting op-amp circuit: **(2 Marks)**



Given: R_f =15 kΩ, R_i = 5kΩ

Gain is the ratio of output voltage to the input voltage and is denoted by A_V.

For Non-inverting op-amp, gain is expressed by : $A_V = 1+R_f/R_i$

Therefore; $A_v = 1+ 15k\Omega/5k\Omega = 1+3 = 4$

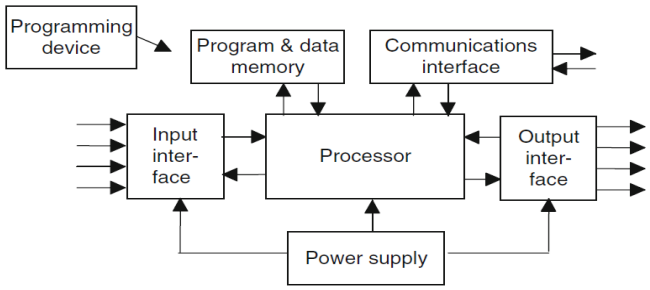
$A_v = 4$ **(2Marks)**

iii) PLC : Programmable Logic Controller (PLC) or programmable controller is a digital computer used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many machines, in many industries. **Or** **(2Marks)**

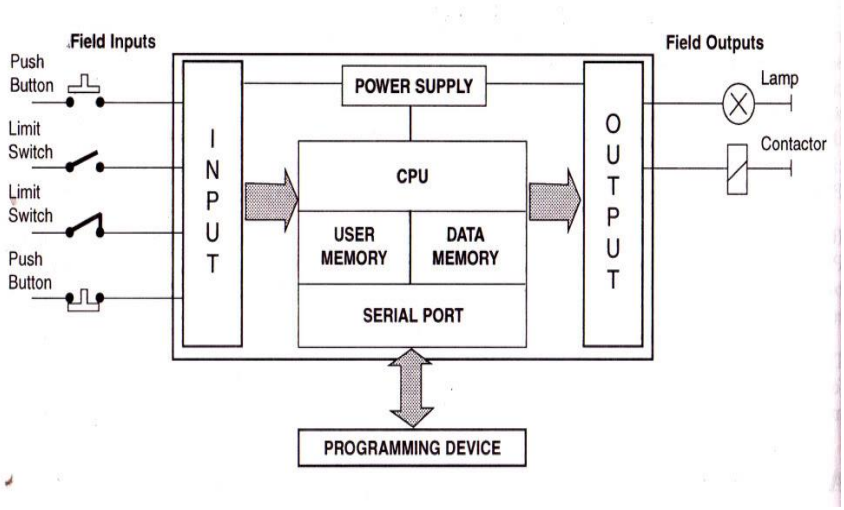
"A digitally operated electronic system, designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic sequencing, timing counting and arithmetic to control through digital or analog inputs and outputs, various types of machines or processes."

(Any other appropriate definition may also be considered.)

Architecture: **(2Marks)**



OR



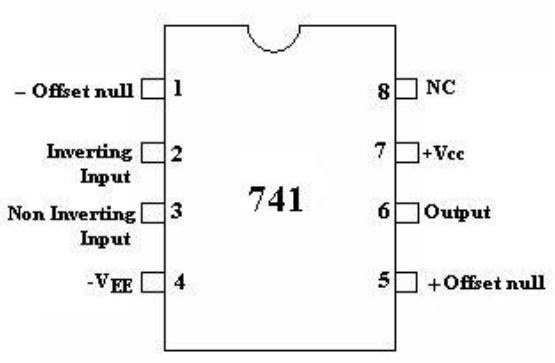
Question 2: Attempt any four

a) Comparison of BJT and FET

(Any four points) Each point carries 1 Marks **(4 Marks)**

	JFET	BJT
1.	Unipolar device (current conduction is only due to one type of majority carrier either electron or hole).	Bipolar device (current condition, by both types of carriers, i.e., majority and minority- electrons and holes)
2.	The operation depends on the control of a junction depletion width under reverse bias.	The operation depends on the injection of minority carriers across a forward biased junction.
3.	Voltage driven device. The current through the two terminals is controlled by a voltage at the third terminal (gate).	Current driven device. The current through the two terminals is controlled by a current at the third terminal (base).
4.	Low noise level.	High noise level.
5.	High input impedance (due to reverse bias).	Low input impedance (due to forward bias).
6.	Gain is characterised by transconductance.	Gain is characterized by voltage gain.
7.	Better thermal stability.	Less thermal stability.

b) Pin diagram of IC 741 **(2 Marks)**



Function of each pin **(2 Marks)**

Pin 1 (Offset Null):

. Offset voltage is nullified by applying a voltage of opposite polarity to the offset. An offset null-adjustment potentiometer may be used to compensate the offset voltage. The

null-offset potentiometer also compensates the irregularities in operational amplifier manufacturing process which may cause an offset. Consequently, the null potentiometer is recommended.

Pin 2 : (Inverting Input)

All input signals at this pin gets inverted at output pin 6. When input signal is applied to this pin the output voltage is out of phase with input. Negative sign (-) represents the Inverting input terminal.

Pin 3 : (Non-Inverting Input):
All input signals at this pin will be processed normally without inversion. The rest is the same as pin 2. When input signal is applied to this pin the output voltage is in phase with input.

Pin 4: ($-V_{EE}$):
This pin is also referred as -Vss) which is negative supply voltage terminal. Supply-voltage operating range for the 741 is -4.5 volts (minimum) to -18 volts (max), and it is specified for operation between -5 and -15 Vdc. The device will operate essentially the same over this range of voltages without change in timing period. Sensitivity of time interval to supply voltage change is low, typically 0.1% per volt. (Note: Do not confuse the -V with ground).

Pin 5 (Offset Null):

Connecting 10KΩ potentiometer between pin 1 & 5 makes offset voltage zero.

Pin 6: (Output)

Output signal´s polarity will be the opposite of the input´s when this signal is applied to the op-amp´s inverting input. The output of op-amp is derived at this terminal with respect to ground.

Pin 7 :($+V_{CC}$):
This pin is the positive supply voltage terminal of the 741 Op-Amp IC. Supply-voltage operating range for the 741 is +4.5 volts (minimum) to +18 volts (maximum), and it is specified for operation between +5 and +15 Vdc. The device will operate essentially the same over this range of voltages without change in timing period. Actually, the most significant operational difference is the output drive capability, which increases for both current and voltage range as the supply voltage is increased. Sensitivity of time interval to supply voltage change is low, typically 0.1% per volt.

Pin 8 :(NC) Not Connected.

NC means Not Connected´. There is no other explanation. There is nothing connected to this pin, it is provided to make the IC as standard 8-pin package.

c) Thermal runway: (2 Marks)

- Destruction of transistor due to excessive temperature is thermal runaway
- The self-destruction of a transistor is known as thermal runway. It is the cyclic process, which destroys the transistor.
- The rise in collector-base junction takes place due to two reason:
  Due to increase in the ambient temperature and due to internal Heating

An increase in collector current increases the power dissipated in the collector-base junction of the transistor. This will increase the temperature of C-B junction. As the transistor has a negative temperature coefficient of resistivity, increased junction temperature reduces the resistance. The reduced resistance will increase the collector current further. This becomes cumulative process which will finally damage the transistor due to excessive internal heating. This process is known **as "Thermal Runaway".**

Use of heat sink: (2 Marks)

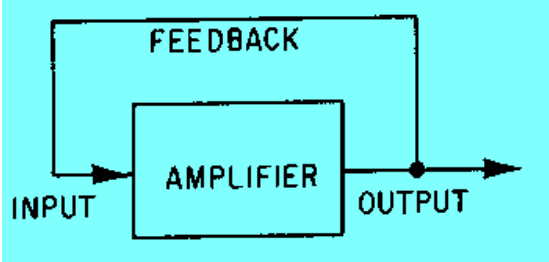
A heat-sink is designed to remove heat from a transistor and dissipate it into the surrounding air as efficiently as possible. Heat-sinks have many different forms, such as finned aluminium or copper sheets or blocks, often painted or anodised matt black to help dissipate heat more quickly. Good physical contact between the transistor and heat-sink is essential, and a heat transmitting grease (heat-sink compound) is smeared on the contact area before clamping the transistor to the heat-sink.

Where it is necessary to maintain electrical insulation between transistor and heat-sink a mica layer is used between the heat-sink and transistor. Mica has excellent insulation and very good heat conducting properties.

d) Oscillator: (1 Marks)

Oscillator is ac signal generator which is used in laboratories. It generates alternating voltage of desired shape at desired frequency. The output voltage and frequency of an oscillator can be variable. **OR**

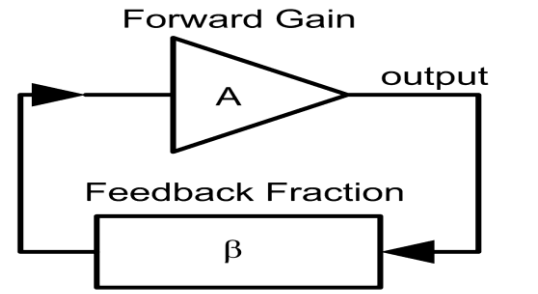
A circuit which generates oscillations (waveforms of desired frequency) at output or generates output without any input is known as oscillator.



The oscillator operates on dc supply and produces alternating output voltage without any alternating input voltage.

Barkhausen criteria for oscillation: **(2 Marks)**

An amplifier will work as an oscillator when it satisfies a set of conditions called 'Barkhausen Criteria"



Basic Oscillator Block Diagram

Barkhausen criteria states that:

- An oscillator will operate at that frequency for which the total phase shift introduced, as the signal proceeds from the input terminals, through the amplifier and feedback network and back again to the input is precisely 0 degree or 360 degree.
- At the oscillator frequency, the magnitude of the product of open loop gain of amplifier (A) and the feedback factor (β) is equal to or greater than unity

$$A\beta \geq 1$$

List types of oscillator: **(1 Marks)**

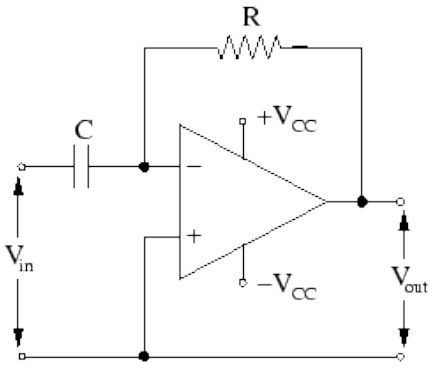
On the basis of components used in the feedback network the oscillators are classified into following categories:

1. RC oscillators
   i)Phase shift oscillator ii) Wien bridge oscillator

2. LC oscillators
   i) Hartley oscillator ii) Colpitt's oscillator iii) Clapp oscillator

3. Crystal oscillator

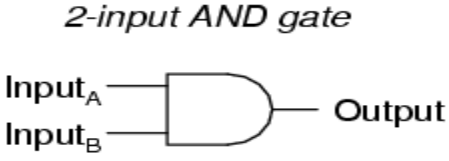
e) Differentiator circuit: **(3 Marks)**



$$V_{out} = -RC\frac{dV_{in}}{dt}.$$ **(1 Mark)**

f) Symbols:

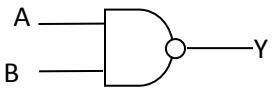
AND Gate



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

(1+1 Mark)

NAND Gate

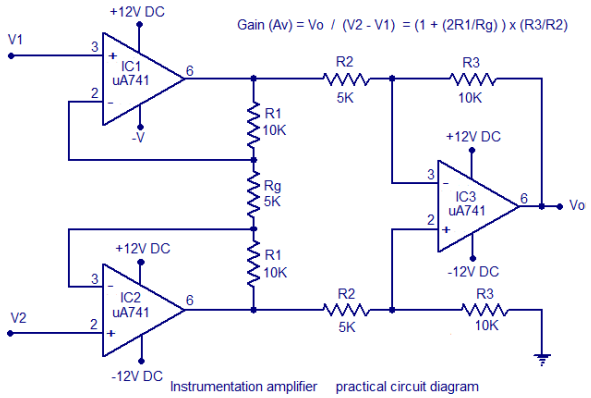


A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

(1+1 Mark)

Question 3: Attempt any four: **(16 Marks)**

(a) Instrumentation Amplifier **(3 Marks)**

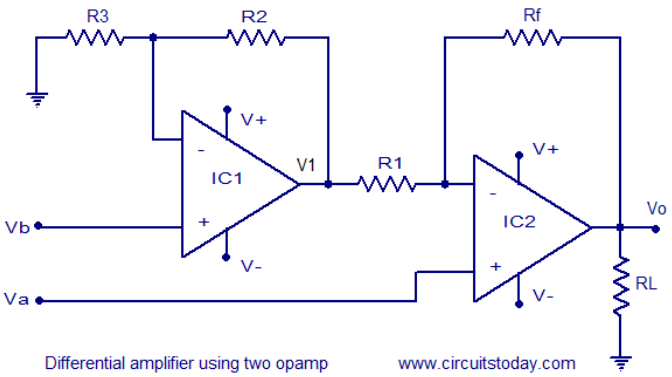


(Component Values are optional)

Voltage Equation **(1 Mark)**

$$V_o = A_v(V_2-V_1)$$

OR



Voltage equation **(1 Mark)**

$$V_o = A_v(V_a-V_b)$$

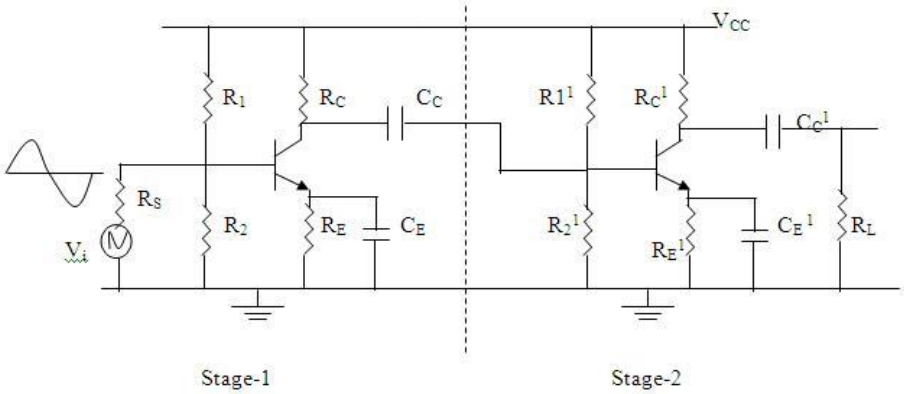
b)Comparison of Microprocessor and Microcontroller (4 Marks)

Any four appropriate points (1 Mark for each appropriate point)

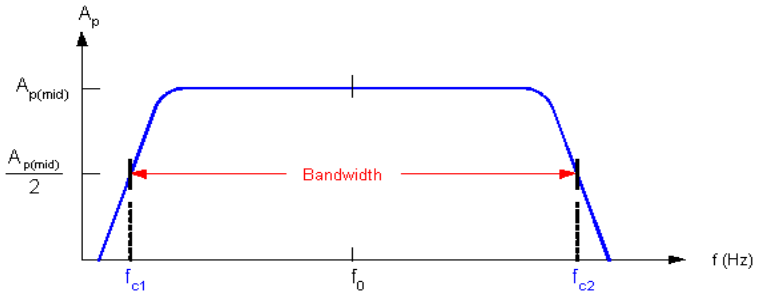
Microprocessor	Microcontroller
1. Contains only CPU; RAM, ROM, I/O, timer are separately interfaced.	1. CPU, RAM, ROM, I/O and timer are all on a single chip
2. Designer decides on the amount of ROM, RAM and I/O ports.	2. Fix amount of on-chip ROM, RAM, I/O ports
3. High cost	3. Low cost
4. General-purpose	4. Single-purpose
5. High speed	5. Low speed
6. Higher Power Consumption	6. Low Power Consumption
ex – 8085, 8086	ex – 8051,AVR

Any other appropriate point may also be considered.

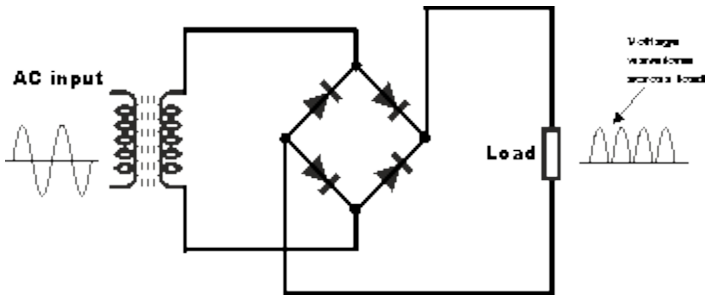
c) Two stage RC coupled amplifier circuit: (3 Marks)



Frequency Response: (1 Mark)



d) Full Wave Bridge rectifier circuit and waveforms: (3+1 Mark)



e) Mechatronics: (2 Marks)

Mechatronics is a synergistic combination of precision engineering, electronic control and mechanic systems. It is the science, that exists at the interface among the other five disciplines:

- mechanics
- electronics
- informatics
- automation
- robotics

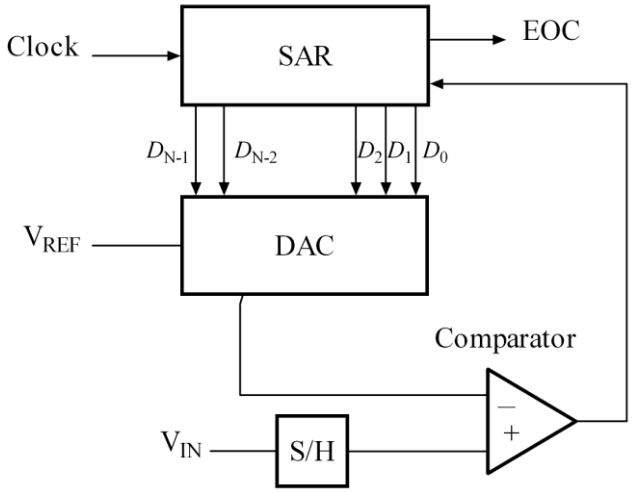
Applications of Mechatronics: (2 Marks)

Any four (Half mark each relevant application)

- Artificial Intelligence and Expert Systems
- Medical Imaging
- Robotic applications
- Military applications
- Control applications
- Automotive systems
- Satellite system

(Any other appropriate application may also be considered.)

f) Block diagram of ADC (2 Marks)

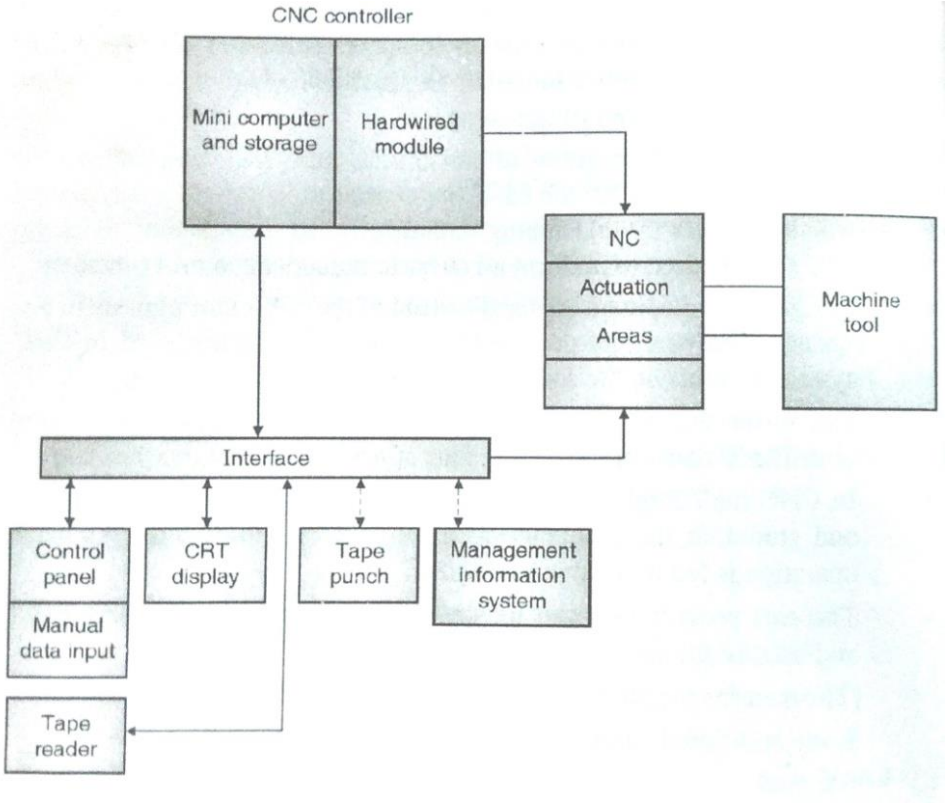


Function : **(2 Marks)**

- A sample and hold circuit to acquire the input voltage (V_{in}).
- An analog voltage comparator that compares V_{in} to the output of the internal DAC and outputs the result of the comparison to the successive approximation register (SAR).
- A successive approximation register subcircuit designed to supply an approximate digital code of V_{in} to the internal DAC.
- An internal reference DAC that, for comparison with V_{REF}, supplies the comparator with an analog voltage equal to the digital code output of the SAR_{in}

Question 4: Attempt any four: **(16 Marks)**

a) Block diagram of CNC **(2 Marks)**



Functions : **(2 Marks)**

- Minicomputer with associated software performs the machine control unit (MCU) functions of data decoding, control, buffering, feed rate control, etc.
- In CNC many programmed can be stored which is executed according to requirement & applications. It is possible to write program in high level language.
- In CNC system computer is actuated simultaneously several programs and the interrupt signals causes switching from one to other according to priority.
- In CNC system computer is actuated simultaneously two programs i.e. NC & AC.

b) Data Logger: **(2 Marks)**

A data logger (also data recorder) is an electronic system that records data over time or in relation to location either with a built in instrument or sensors or via external instruments and sensors. They are based on a digital processor (or computer).

Applications: **(2 Marks)**

- Agriculture, Horticulture, Environmental Studies

- Refrigeration and Freezer
- Server Room Monitoring
- Industrial Processes
- Building Monitoring/HVAC/Energy Usage

(Any other relevant applications may also be considered)

c) Transducer**:** **(1 Mark)**

A transducer **is a device that converts one form of energy to another form.**

Selection criteria: **(2 Mark)**

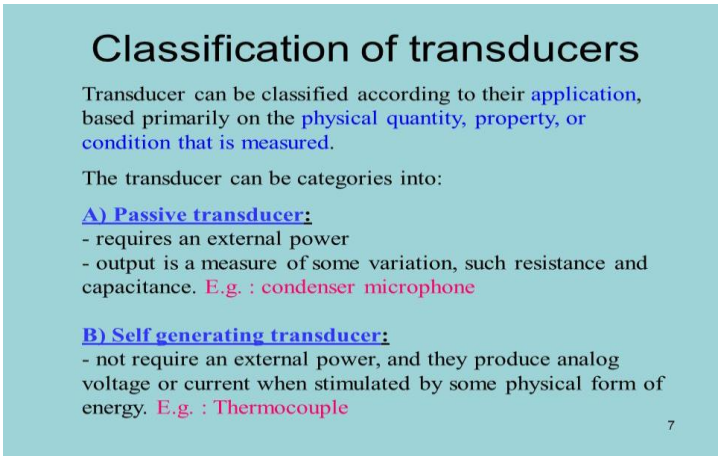
The following points should be considered, while selecting a transducer for any application or a particular application.

Selection criteria for transducer: **(Any four)**

1. Type and nature of the physical quantity.
2. Accuracy of the transducer should be high.
3. Working principle of the transducer i.e. resistive, inductive, capacitive etc.
4. Transducer should have flat and stable frequency response.
5. Operating temperature of the transducer.
6. Transducer should have ability to withstand against shocks and vibrations
7. Transducer should not produce any loading effect on the next stages.
8. Transducers should have better linearity and stability.
9. Transducers should have high accuracy.
10. Transducers should not be affected by any type of noise and drift.

(Any other appropriate criterion may also be considered)

Classification: **(1 Marks)**



Primary and Secondary

Analog and digital

d) Any four features: (4 Marks)

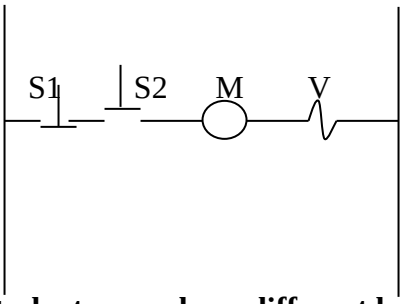
Features of 8085

- It is an 8-bit microprocessor
- It operates on +5V power supply
- It operates on clock cycle with 50% duty cycle
- It has on chip clock generator
- It operates at 3MHz clock frequency
- It has 16 address lines, hence it can access (2^16) 64kb of memory
- It provides 8-bit I/O address to access (2^8) 256 I/O ports

(Any other appropriate feature may also be considered)

e) Ladder diagram: (4 Marks)

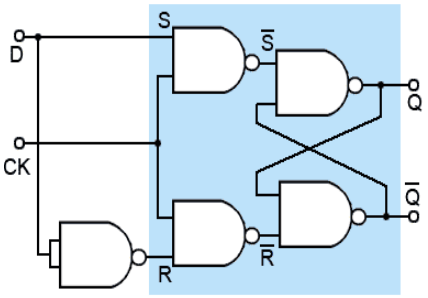
Ladder diagram for start stop logic with one input push button for start and one push button for stop and output motor to activate solenoid valve.



S1 – Stop button
S2 – Start button
M- motor
V- Solenoid valve

Students may draw different ladder diagram as per their logic, if logic is correct it may also be considered.

f) D-Flip flop: (2+2Marks)



Logical diagram

Inputs		Outputs	
CK	D	Q	$\overline{Q}$
0	X	No change	
1	0	0	1
1	1	1	0

Truth Table

Question 5: Attempt any four: (16 Marks)

a) Load regulation (2 marks)

Load regulation is the capability to maintain a constant output voltage despite changes in the supply's load current from no load to full load.

$$\%\text{Load Regulation} = 100\% \frac{V_{min-load} - V_{max-load}}{V_{nom-load}}$$

Line regulation (2 marks)

Line regulation is the change in the regulated load voltage due to change in line voltage in a specified range of 230V ±10% at constant load current.

% Line regulation $= V_{LH} - V_{LL} / V_{nom} * 100$

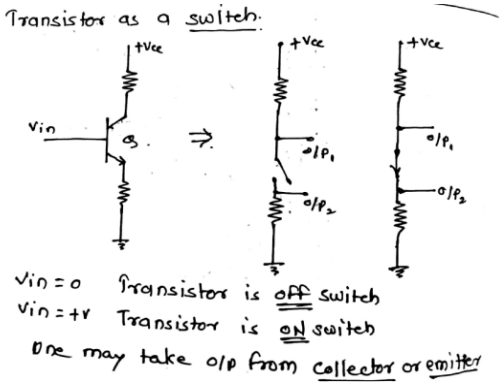
b) Comparison of HWR and FWR : (4 Marks)

Sr. No.	Parameter	HWR	FWR
1	**Ripple factor**	**1.21**	**0.48**
2	**Efficiency**	**40.6%**	**81.2%**

c) BJT as a switch:

Diagram : (2 Marks)

BJT as a Switch

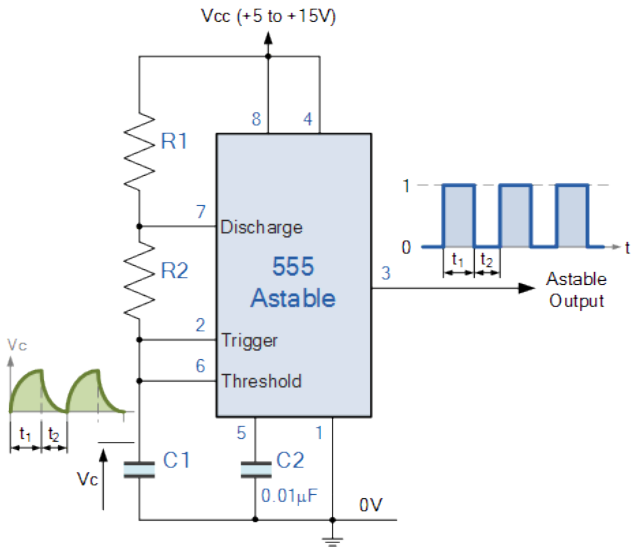


Case I: When V_{in} =0 then base current of transistor will be zero hence collector current is zero which indicates that the switch is OFF.

Case II: When V_{in} is applied then base and collector current flows through the circuit which indicates that the Switch is ON. **(2 Marks)**

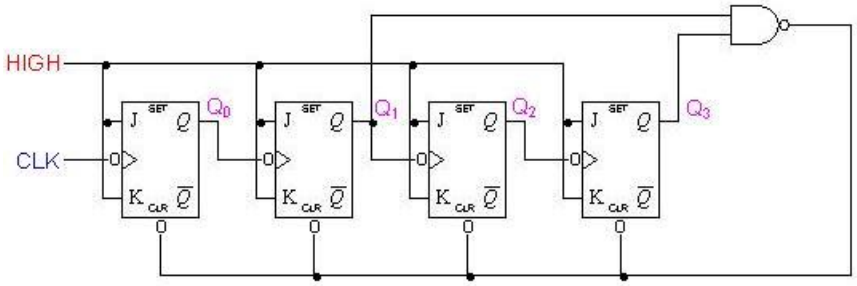
d) Astable Multivibrator using IC 555:

Circuit diagram & waveforms **(3+1 Marks)**



e) Decade counter using T-Flip-flop:

Circuit Diagram: **(2 Marks)**



(For T-Flip-flop J=K=1)

Truth Table: **(2 Marks)**

Clock Count	Output bit Pattern				Decimal Value
	Q3	Q2	Q1	Q0	
1	0	0	0	0	0
2	0	0	0	1	1
3	0	0	1	0	2
4	0	0	1	1	3
5	0	1	0	0	4
6	0	1	0	1	5
7	0	1	1	0	6
8	0	1	1	1	7
9	1	0	0	0	8
10	1	0	0	1	9
11	Counter Resets its Outputs back to Zero				

f) Reasons: **(1 Mark)**

Any two reasons:

- Flexibility: Mechatronic product can be modified easily to fit changing requirement and situation.
- Multi functionality: Attributed to the software defined functions of the microprocessor.
- Intelligence related to the control functions of the mechatronic systems.

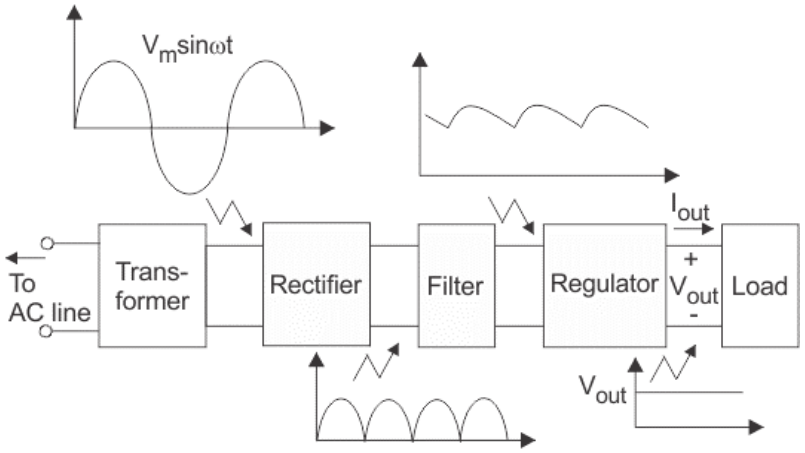
(**Any other relevant reasons may also be considered.)**

Basic Elements of mechatronics: (3 Mark)

- Actuators: Solenoid, voice coils, DC Motors, stepper motor, etc
- Sensors: switches, MEMS, strain gauges, etc
- Input signal conditioning & Interfacing: filters, amplifiers, ADC, DAC,etc
- Output signal conditioning & Interfacing: filters, amplifiers, ADC, DAC, PWM, etc
- Graphical Display: LED, LCD, CRT, etc
- Digital control Architecture: Logic ckts, uC, PLC, etc.

Question 6: Attempt any four: (16 Marks)

a) Block diagram of regulated power supply & functions of each block. (2+2 Marks)



Functions:

AC supply and transformer: A transformer changes the ac mains (line) voltage to a required value. It is used to step the voltage up or down. Transformer provides isolation from the power line.

Rectifier: A rectifier converts ac into pulsating dc. It may be a half-wave rectifier, a full-wave rectifier using a transformer with centre-tapped secondary winding or a bridge rectifier.

Filter: A filter circuit is used remove ripple contents (ac variations) from the rectified voltage. There are four types of filters: 1) Capacitor filter, 2) Inductor filter, 3) L-C filter and 4) π filter.

Voltage regulator: A voltage regulator is necessary to maintain a constant output dc voltage by providing line regulation and load regulation.

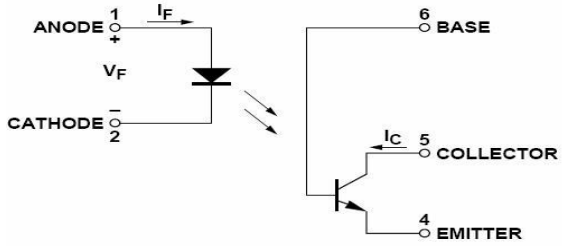
b) PLC selection criteria: **(4 Marks)**

Any four

1. Number of inputs and number of outputs of PLC.
2. Nature of input and output i.e. Analog or Digital.
3. Speed of operation
4. Programming Flexibility
5. Power consumption.
6. Cost of PLC

{any other relevant and appropriate criteria may also considered}

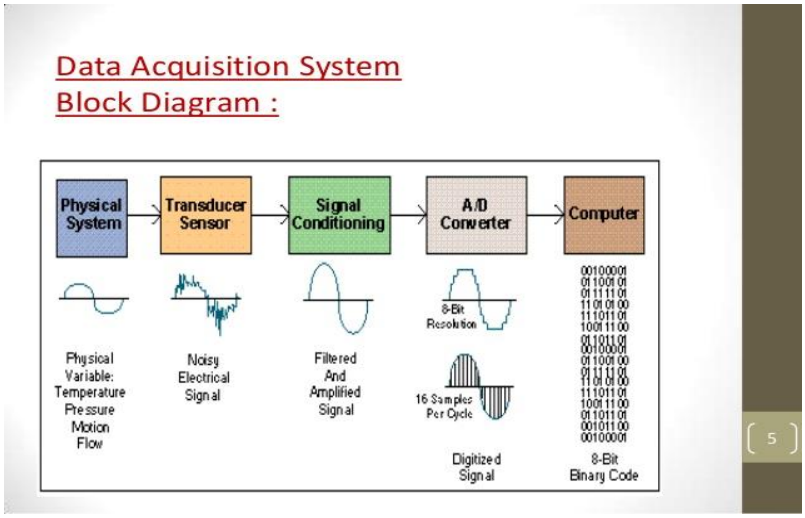
c) Optocoupler as an Isolator: **(4 Marks)**



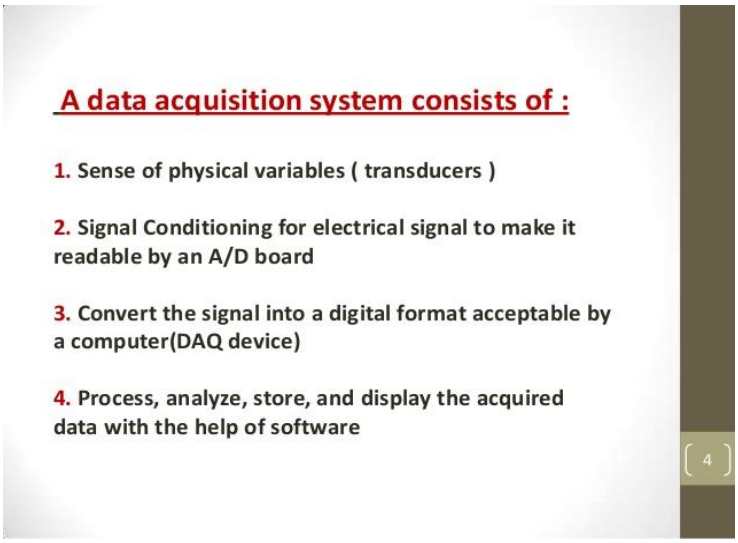
- Optocoupler is a combination of light source and light detector in the same package.
- They are used to couple signal from one point to other optically by providing complete electrical isolation between them.
- This kind of isolation is provided between low power control circuit and high power control circuit to protect the control circuit.

d) Single channel DAS:

Block diagram: **(2 Marks)**



Explanation: **(2 Marks)**

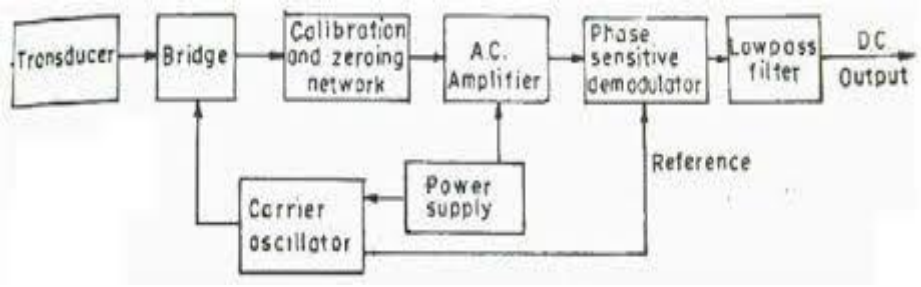


e) Need of signal conditioning: **(2 Marks)**

- The output produced by a transducer is not in proper form or condition or suitable to apply further so it has to bring in a proper condition to process further. Hence signal conditioning is required.
- One common form of signal conditioning is amplification -- making a tiny signal big enough to do something. For example, take the very tiny radio signal from a satellite, and amplify it enough to "drive" the detector in a computer system.

- Buffering is another signal conditioning trick. In some electronic circuits their very high impedance signals would be "loaded down" but attaching a voltmeter or oscilloscope. So electronic voltmeters and scopes have Signal Buffers in them to protect the signal from the "loading effects" of the meter or scope.

AC signal conditioning system: **(2 Marks)**



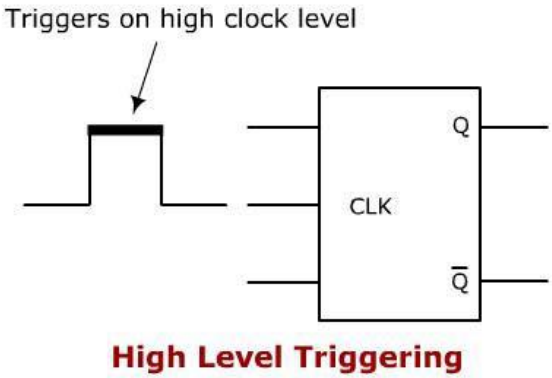
f)Triggering mechanism :

In the latches and flip flops, we use additional signal called Clock signal. Depending on which portion of the Clock signal the latch or FF respond to, we can classify them into two types:

1.Level triggered circuit **(2 Mark)**

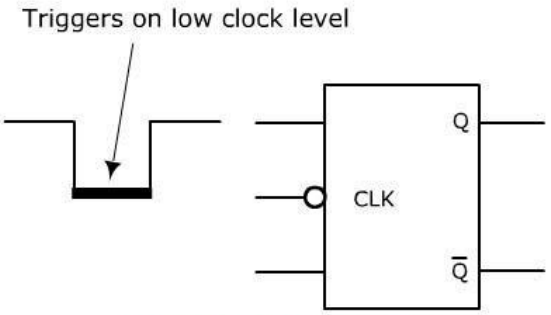
Types of Level triggered circuit:

i)High/Positive Level triggered circuit



High Level Triggering

ii) Low/Negative Level triggered circuit

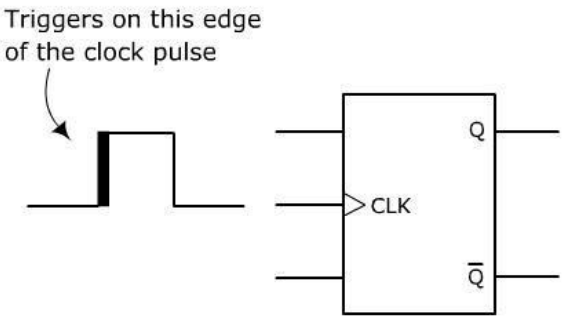


Low Level Triggering

2.Edge triggered circuit. (2 Marks)

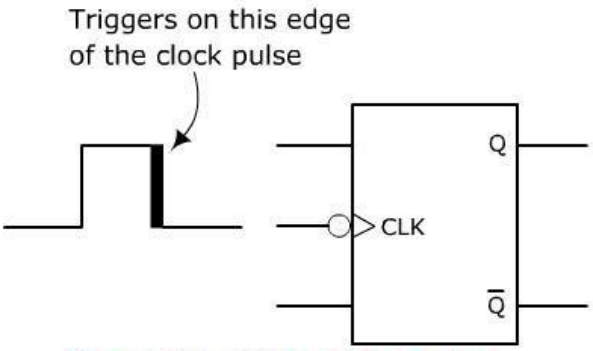
Types of Edge triggered circuit:

i)Positive Edge triggered circuit



Positive Edge Triggering

ii)Negative Edge triggered circuit



Negative Edge Triggering

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Subject Code : **17302** **Model Answer**
