# Subject Name (SUBJECT001) - Sample Term Solution

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Month Day, Year

## Contents

# 1 Question 1

## 1.1 Question 1(a) [3 marks]

**Write a Java program to find the maximum of three numbers.**

### 1.1.1 Solution

To find the **maximum** of three numbers, we use **conditional statements** (if-else) to compare values. The program takes three numbers as input and returns the *largest value* among them.

Listing 1: Find Maximum of Three Numbers

**Java Program:**

```java
public class MaxOfThree {
    public static void main(String[] args) {
        int a = 25, b = 40, c = 15;
        int max;

        // Compare first two numbers
        if (a > b) {
            max = a;
        } else {
            max = b;
        }

        // Compare result with third number
        if (c > max) {
            max = c;
        }

        System.out.println("Maximum number is: " + max);
    }
}
```

**Output:**

```
Maximum number is: 40
```

**Key Points:**

**Logic:** First compare `a` and `b`, store larger in `max`

**Second Comparison:** Compare `max` with `c` to get final maximum

**Alternative:** Can use `Math.max(a, Math.max(b, c))` for concise code

**Comparison Methods:** Three approaches exist: nested if-else (shown above), ternary operator `max = (a>b) ? ((a>c)?a:c) : ((b>c)?b:c)`, or built-in `Math.max()` method.

**Mnemonic:** *MAX: Compare in pairs, update Maximum At eXamination*

## 1.2 Question 1(b) [4 marks]

**Calculate the cutoff frequency of an RC low-pass filter with $R = 1.5\,k\Omega$ and $C = 100\,nF$. Also find the output voltage if input is 10V at cutoff frequency.**

#### 1.2.1 Solution

**Given Data:**

- Resistance: $R = 1.5\,k\Omega = 1500\,\Omega$
- Capacitance: $C = 100\,nF = 100 \times 10^{-9}\,F$
- Input Voltage: $V_{in} = 10\,V$

**Step 1: Calculate Cutoff Frequency** The **cutoff frequency** formula for RC low-pass filter is:

$$f_c = \frac{1}{2\pi RC}$$

Substituting values:

$$f_c = \frac{1}{2\pi \times 1500 \times 100 \times 10^{-9}}$$

$$f_c = \frac{1}{2\pi \times 1.5 \times 10^{-4}}$$

$$f_c = \frac{1}{9.42 \times 10^{-4}} = 1061.57\,Hz \approx 1.06\,kHz$$

**Step 2: Calculate Output Voltage at Cutoff** At cutoff frequency, output voltage is **0.707 times** (or $\frac{1}{\sqrt{2}}$) the input voltage:

$$V_{out} = 0.707 \times V_{in} = 0.707 \times 10 = 7.07\,V$$

**Results:**

**Cutoff Frequency:** $f_c = 1.06\,kHz$

**Output Voltage:** $V_{out} = 7.07\,V$ at cutoff

**Attenuation:** $-3\,dB$ at cutoff frequency

**Phase Shift:** $-45°$ at cutoff frequency

**Filter Behavior:** Below cutoff, signal passes with minimal attenuation. Above cutoff, attenuation increases at $-20\,dB/decade$ roll-off rate.

**Mnemonic:** *RC-Formula:* $f_c = \frac{1}{2\pi RC}$, $V_{out} = 0.707 \times V_{in}$ at $f_c$

## 1.3 Question 1(c) [7 marks]

**Compare active and passive electronic components with suitable examples.**

#### 1.3.1 Solution

Electronic components are classified into **active** and **passive** categories based on their ability to control or amplify electrical energy.

Table 1: Active vs Passive Components Comparison

| **Characteristic** | **Active Components** | **Passive Components** |
|---|---|---|
| Energy Source | Require external power source | Do not require external power |
| Control Ability | Can control/amplify current flow | Cannot amplify, only regulate |
| Directionality | Usually unidirectional | Bidirectional |
| Power Gain | Provide power gain ($> 1$) | Power gain is always $\leq 1$ |
| Examples | Transistors (BJT, FET), Diodes (LED, Zener), ICs (Op-Amp, 555), SCR | Resistors, Capacitors, Inductors, Transformers |
| Function | Amplification, switching, oscillation, rectification | Resistance, capacitance, inductance, filtering |
| Linearity | Can be linear or non-linear | Generally linear |

**Active Components in Detail:**

**Transistors:** Used for amplification and switching. BJT uses current control, FET uses voltage control.

**Diodes:** Allow current in one direction. LED emits light, Zener regulates voltage.

**ICs:** Integrated circuits like `555 timer` (oscillator), op-amps (amplifier).

**Power Requirement:** All active components need DC bias/supply to operate.

**Transistor Types:** BJT (Bipolar Junction Transistor) has NPN and PNP variants. FET (Field Effect Transistor) includes JFET and MOSFET types.

**Passive Components in Detail:**

**Resistors:** Oppose current flow, dissipate power as heat. Value in Ω.

**Capacitors:** Store energy in electric field. Value in Farads (F), blocks DC, passes AC.

**Inductors:** Store energy in magnetic field. Value in Henry (H), opposes AC changes.

**Transformers:** Transfer energy between circuits via magnetic coupling.

**Resistor Types:** Fixed resistors include carbon composition, metal film, and wire-wound types. Variable resistors are potentiometers and rheostats.

**Capacitor Types:** Capacitors include electrolytic (polarized, high capacitance), ceramic (small, stable), and film (precision) types.

**Key Distinction:** The fundamental difference is that active components can *inject power* into a circuit (amplification), while passive components can only *absorb or store* energy, never increase it.

**Mnemonic:** *ACTIVE = Amplify, Control, Transform; PASSIVE = Resist, Store, Filter*

## 1.4 Question 1(c) OR [7 marks]

**Draw and explain the working of a half-wave rectifier circuit with input and output waveforms.**

### 1.4.1 Solution

A **half-wave rectifier** converts AC voltage to pulsating DC by allowing only one half-cycle (positive or negative) of the input AC waveform to pass through.

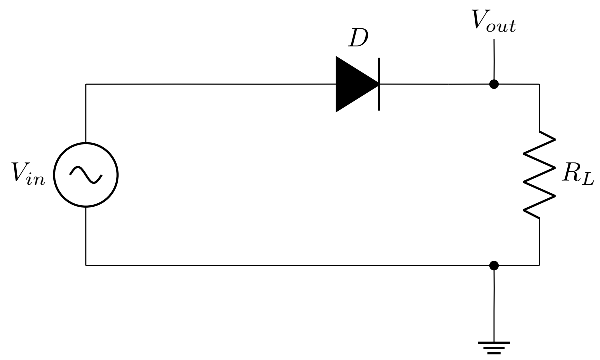


Figure 1: Half-Wave Rectifier Circuit

**Circuit Diagram:**

**Working Principle:**

**Positive Half-Cycle:** When input AC is positive, diode is forward-biased (conducts). Current flows through load resistor $R_L$, producing output voltage.

**Negative Half-Cycle:** When input AC is negative, diode is reverse-biased (blocks). No current flows, output voltage is zero.

**Result:** Only positive half-cycles appear at output, creating pulsating DC.

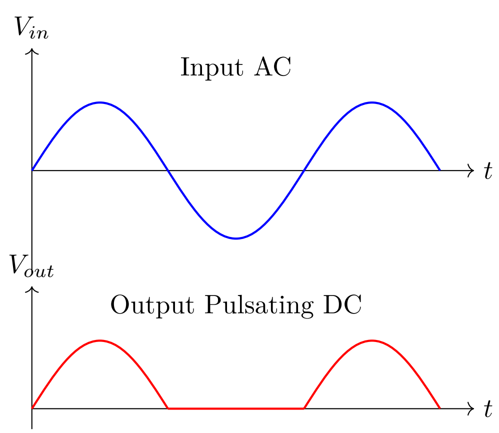


Figure 2: Input and Output Waveforms

**Waveform Representation:**

**Key Parameters:**

**Efficiency:** $\eta = 40.6\%$ (theoretical maximum)

**Ripple Factor:** $r = 1.21$ (high ripple content)

**Peak Inverse Voltage (PIV):** $PIV = V_m$ (maximum reverse voltage across diode)

**DC Output:** $V_{DC} = \frac{V_m}{\pi} = 0.318V_m$ where $V_m$ is peak AC voltage

**Efficiency Derivation:** Efficiency $\eta = \frac{P_{DC}}{P_{AC}} = \frac{(V_{DC})^2/R_L}{(V_{rms})^2/R_L} = \frac{(V_m/\pi)^2}{(V_m/2)^2} = \frac{4}{\pi^2} = 0.406 = 40.6\%$

**Applications:** Half-wave rectifiers are used in low-power applications like battery charging, signal demodulation, and voltage multipliers. They are *not suitable* for high-power applications due to poor efficiency.

**Mnemonic:** *HWR: Half-Wave = Half output, 40.6% efficiency, PIV = Vm*