

# Subject Name (SUBJECT001) - Sample Term Solution

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Month Day, Year

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## 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:
1 public class MaxOfThree {
2     public static void main(String[] args) {
3         int a = 25, b = 40, c = 15;
4         int max;
5
6         // Compare first two numbers
7         if (a > b) {
8             max = a;
9         } else {
10            max = b;
11        }
12
13        // Compare result with third number
14        if (c > max) {
15            max = c;
16        }
17
18        System.out.println("Maximum number is: " + max);
19    }
20 }
```

#### 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  $R = 1.5\text{ k}\Omega$  and  $C = 100\text{ nF}$ . Also find the output voltage if input is 10V at cutoff frequency.

### 1.2.1 Solution

**Given Data:**

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

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

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

Substituting values:

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

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

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

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

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

**Results:**

**Cutoff Frequency:**  $f_c = 1.06 \text{ kHz}$

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

**Attenuation:**  $-3 \text{ dB}$  at cutoff frequency

**Phase Shift:**  $-45^\circ$  at cutoff frequency

**Filter Behavior:** Below cutoff, signal passes with minimal attenuation. Above cutoff, attenuation increases at  $-20 \text{ dB/decade}$  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  $\Omega$ .

**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.

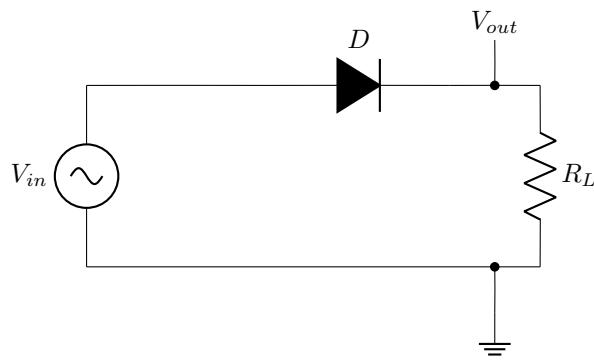


Figure 1: Half-Wave Rectifier Circuit

**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.

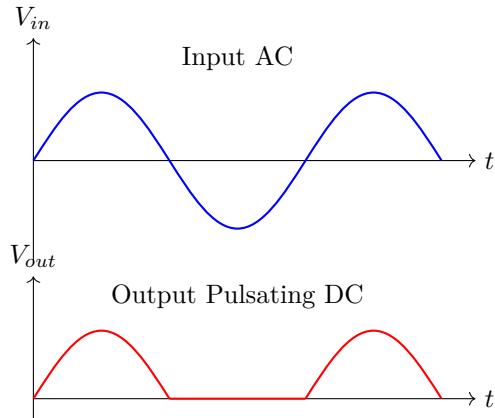


Figure 2: Input and Output Waveforms

**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 = V<sub>m</sub>*