Subject Name (SUBJECT001) - Sample Term Solution

Milav Dabgar

Month Day, Year

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.

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

  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 at cutoff frequency if input is 10V.

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

  Mnemonic: *RC-Formula: fc = 1/(2π RC), Vout = 0.707 Vin at fc*

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 ≤ 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.

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), block DC, pass AC.
- **Inductors**: Store energy in magnetic field. Value in Henry (H), oppose AC changes.
- **Transformers**: Transfer energy between circuits via magnetic coupling.

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.

Circuit Description: The circuit consists of:

- AC voltage source (V_{in})
- Diode (D)
- Load resistor (R_L)

Working Principle:

1. **Positive Half-Cycle**: When input AC is positive, diode is forward-biased (conducts). Current flows through load resistor R_L, producing output voltage.
2. **Negative Half-Cycle**: When input AC is negative, diode is reverse-biased (blocks). No current flows, output voltage is zero.
3. **Result**: Only positive half-cycles appear at output, creating pulsating DC.

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

Applications: Half-wave rectifiers are used in low-power applications such as 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*