Subject Name (SUBJECT001) - Sample Term Solution

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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.

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

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

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), 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.

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.

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.

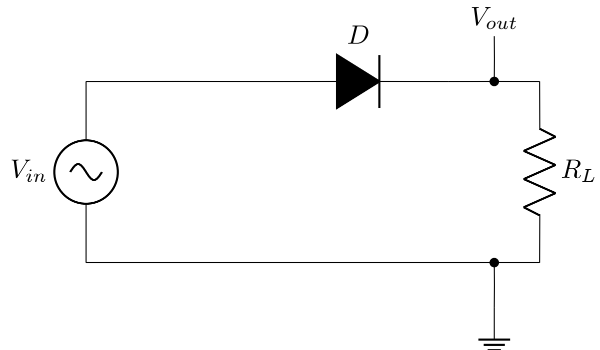

Figure 1. Half-Wave Rectifier Circuit

Circuit Diagram:

Working Principle:

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.

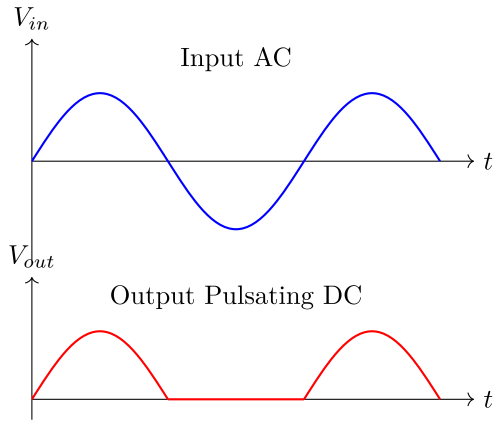

Figure 2. Input and Output Waveforms

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

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.

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