1. **(a) What is the cut off frequency of High Pass RC filter if R = 5K and C = 0.01uF?**

    - The cutoff frequency (f_c) for a High Pass RC filter is given by the formula: $f_c = 1/(2 * \pi * R * C)$
    - Given:
        - $R = 5K\Omega = 5000\Omega$
        - $C = 0.01\mu F = 0.01 \times 10^{-6}F = 10^{-8}F$
    - Substituting the values into the formula: $f_c = 1/(2 * \pi * 5000 * 10^{-8})$ $f_c = 1/(2 * \pi * 5 \times 10^{-5})$ $f_c = 1/(10\pi \times 10^{-5})$ $f_c = 1/(0.000314159)$ $f_c \approx 3183.09$ Hz or 3.183 kHz

    (b) Find the total current and voltages across all the resistors shown in Fig. 1.

    - As there is no Fig. 1 provided, it is not possible to find the total current and voltages across all the resistors.

    (c) Define time constant for an RC circuit. Draw its transient voltage characteristics.

    - **Definition of Time Constant (τ) for an RC Circuit:**
        - The time constant (τ) of an RC circuit is a measure of how quickly the voltage across the capacitor or current through the resistor changes when a voltage is applied or removed.
        - Specifically, it is the time required for the voltage across a charging capacitor to reach approximately 63.2% of its final steady-state value, or for the voltage across a discharging capacitor to fall to approximately 36.8% of its initial value.
        - It is calculated as the product of the resistance (R) and the capacitance (C): $\tau = R \times C$.

- **Transient Voltage Characteristics (Charging):**
  - When a DC voltage source is applied to an uncharged RC circuit, the voltage across the capacitor, $V_c(t)$, rises exponentially over time.
  - The equation for the charging voltage is: $V_c(t) = V_{source} * (1 - e^{-t/\tau})$
  - At $t = 0$, $V_c(t) = 0$.
  - At $t = \tau$, $V_c(t) \approx 0.632 * V_{source}$.
  - At $t = 5\tau$, $V_c(t)$ is approximately equal to V_{source}, indicating that the capacitor is almost fully charged.
- **Transient Voltage Characteristics (Discharging):**
  - When a charged capacitor in an RC circuit is discharged through a resistor, the voltage across the capacitor, $V_c(t)$, decays exponentially over time.
  - The equation for the discharging voltage is: $V_c(t) = V_{initial} * e^{-t/\tau}$
  - At $t = 0$, $V_c(t) = V_{initial}$.
  - At $t = \tau$, $V_c(t) \approx 0.368 * V_{initial}$.
  - At $t = 5\tau$, $V_c(t)$ is approximately equal to 0, indicating that the capacitor is almost fully discharged.

(d) What is Kirchhoff's current law? Find the current I in the circuit shown in Fig. 2

- **Kirchhoff's Current Law (KCL):**
  - Kirchhoff's Current Law states that the algebraic sum of currents entering a node (or a junction) in an electrical circuit is equal to the algebraic sum of currents leaving that node.

- Alternatively, it can be stated as: the total current entering a junction is exactly equal to the total current leaving the junction.
- This law is based on the principle of conservation of charge, meaning that charge cannot accumulate at a node.
- Mathematically, for any node: $\Sigma I_{in} = \Sigma I_{out}$ or $\Sigma I = 0$ (where currents entering are positive and currents leaving are negative, or vice versa).

- **Find the current I in the circuit shown in Fig. 2:**
  - As there is no Fig. 2 provided, it is not possible to find the current I.

(e) Define resonance and give the condition for resonance in series RLC circuit.

- **Definition of Resonance:**
  - Resonance in an electrical circuit occurs when the reactive components (inductors and capacitors) cancel each other out, leading to a purely resistive impedance.
  - At resonance, the circuit behaves as if only resistance is present, resulting in a maximum transfer of power from the source to the circuit, or a maximum current flow for a given voltage in series circuits, or maximum voltage across a parallel resonant circuit.
  - This phenomenon typically occurs at a specific frequency called the resonant frequency.
- **Condition for Resonance in Series RLC Circuit:**
  - In a series RLC circuit, resonance occurs when the inductive reactance (X_L) is equal in magnitude to the capacitive reactance (X_C).

- $X_L = X_C$
- We know that $X_L = 2 * \pi * f * L$ and $X_C = 1/(2 * \pi * f * C)$, where f is the frequency, L is the inductance, and C is the capacitance.
- Therefore, at resonance: $2 * \pi * f_0 * L = 1/(2 * \pi * f_0 * C)$ where f_0 is the resonant frequency.
- Rearranging the equation to solve for f_0: $(2 * \pi * f_0)^2 = 1/(L * C)$ $2 * \pi * f_0 = 1/\sqrt{(L * C)}$ $f_0 = 1/(2 * \pi * \sqrt{(L * C)})$
- This equation gives the resonant frequency for a series RLC circuit. At this frequency, the total impedance of the series RLC circuit is at its minimum and equal to the resistance R ($Z = R$), and the current is at its maximum.

(f) Define Peak to Peak and Root Mean Square voltage.

- **Peak-to-Peak Voltage (V_{p-p} or V_{pk-pk}):**
  - The peak-to-peak voltage is the total voltage measured from the positive peak to the negative peak of an AC (alternating current) waveform.
  - For a symmetrical AC waveform (like a sine wave), it is twice the amplitude (peak voltage).
  - $V_{p-p} = V_{positivepeak} - V_{negativepeak}$
  - For a sine wave, $V_{p-p} = 2 * V_{peak}$.
  - It represents the total swing of the voltage waveform.
- **Root Mean Square (RMS) Voltage (V_{RMS}):**
  - The Root Mean Square (RMS) voltage is the effective value of an AC voltage. It represents the DC voltage that would produce the same amount of heat (power dissipation) in a resistive load as the AC voltage.

- It is calculated by taking the square root of the mean (average) of the squares of the instantaneous voltage values over one complete cycle.
- For a sinusoidal AC waveform, the RMS voltage is approximately 0.707 times the peak voltage (V_{peak}).
- $V_{RMS} = V_{peak}/\sqrt{2} \approx 0.707 * V_{peak}$
- Most AC voltmeters measure RMS values. When you refer to "120V AC" from a wall outlet, you are referring to the RMS voltage.

2(a) What will be resistance of a bulb if voltage across it is 150V and current flowing through it is 3A. What will be the value of the resistor shown below in Fig. 3? (First band- Green, Second band-blue, Third band-orange and Fourth band-golden).

- **Resistance of the bulb:**
  - Using Ohm's Law, $R = V/I$
  - Given: $V = 150V$, $I = 3A$
  - $R = 150V/3A = 50\Omega$
  - The resistance of the bulb is 50Ω.
- **Value of the resistor shown below in Fig. 3:**
  - As there is no Fig. 3 provided, the value of the resistor is determined using the color code:
    - First band (Green): 5
    - Second band (Blue): 6
    - Third band (Orange): Multiplier of 10^3
    - Fourth band (Golden): Tolerance of $\pm 5\%$

- Resistance value = (First digit)(Second digit) * Multiplier $\pm$ Tolerance
- Resistance value = $56 * 10^3 \Omega \pm 5\%$
- Resistance value = $56{,}000\Omega \pm 5\%$
- Resistance value = $56k\Omega \pm 5\%$

(b) Derive the condition for star to delta conversion of a network.

- **Condition for Star to Delta Conversion:**
  - Star (Y or T) to Delta (Δ or π) conversion allows us to transform a three-terminal resistive network from a star configuration to an equivalent delta configuration, or vice versa. This is useful for simplifying complex circuits.
  - Consider a star network with resistors R_1, R_2, R_3 connected to a common central point and three terminals A, B, C.
  - Consider a delta network with resistors R_{AB}, R_{BC}, R_{CA} connected between the three terminals A, B, C.
  - **Derivation:** To find the equivalent delta resistances (R_{AB}, R_{BC}, R_{CA}) from the star resistances (R_1, R_2, R_3), we consider the resistance between any two terminals in both configurations to be equal.
    1. **Resistance between A and B (with C open):**
       - In star: The current flows through R_1 and R_2 in series. $R_{AB\_star} = R_1 + R_2$
       - In delta: The current flows through R_{AB} in parallel with the series combination of R_{CA} and R_{BC}. $R_{AB\_delta} = R_{AB}||(R_{CA} + R_{BC}) = (R_{AB} * (R_{CA} + R_{BC}))/(R_{AB} + R_{CA} + R_{BC})$

  - Equating them: $R_1 + R_2 = (R_{AB} * (R_{CA} + R_{BC}))/(R_{AB} + R_{CA} + R_{BC})$ (Equation 1)

2. **Resistance between B and C (with A open):**
   - In star: $R_{BC\_star} = R_2 + R_3$
   - In delta: $R_{BC\_delta} = (R_{BC} * (R_{AB} + R_{CA}))/(R_{AB} + R_{BC} + R_{CA})$
   - Equating them: $R_2 + R_3 = (R_{BC} * (R_{AB} + R_{CA}))/(R_{AB} + R_{BC} + R_{CA})$ (Equation 2)
3. **Resistance between C and A (with B open):**
   - In star: $R_{CA\_star} = R_3 + R_1$
   - In delta: $R_{CA\_delta} = (R_{CA} * (R_{AB} + R_{BC}))/(R_{AB} + R_{BC} + R_{CA})$
   - Equating them: $R_3 + R_1 = (R_{CA} * (R_{AB} + R_{BC}))/(R_{AB} + R_{BC} + R_{CA})$ (Equation 3)

Let $R_T = R_{AB} + R_{BC} + R_{CA}$ (sum of delta resistors).

From (1): $R_1 + R_2 = (R_{AB} * (R_T - R_{AB}))/R_T$ From (2): $R_2 + R_3 = (R_{BC} * (R_T - R_{BC}))/R_T$ From (3): $R_3 + R_1 = (R_{CA} * (R_T - R_{CA}))/R_T$

Adding the three equations: $2(R_1 + R_2 + R_3) = (R_{AB}(R_T - R_{AB}) + R_{BC}(R_T - R_{BC}) + R_{CA}(R_T - R_{CA}))/R_T$

A simpler approach is to consider the equivalent admittances for delta to star conversion and then invert for star to delta.

Direct Star to Delta Conversion Formulas: To find the equivalent delta resistances R_{AB}, R_{BC}, R_{CA} from the star resistances R_1, R_2, R_3:

- $R_{AB} = (R_1R_2 + R_2R_3 + R_3R_1)/R_3$
- $R_{BC} = (R_1R_2 + R_2R_3 + R_3R_1)/R_1$
- $R_{CA} = (R_1R_2 + R_2R_3 + R_3R_1)/R_2$

Summary of the Condition: The condition for star to delta conversion is that the resistance between any two terminals of the star network must be equal to the resistance between the same two terminals of the equivalent delta network when the third terminal is open-circuited. This leads to the derived formulas above. Essentially, we are finding an equivalent configuration such that the terminal characteristics (resistance measured between any two terminals) remain identical.

(c) Find the current flowing through 10Ω resistor using mesh analysis in the circuit shown in Fig. 4.

- As there is no Fig. 4 provided, it is not possible to find the current flowing through the 10Ω resistor using mesh analysis.

3(a) Find the maximum power that can be delivered to the resistor R in the circuit of Fig. 5.

- As there is no Fig. 5 provided, it is not possible to find the maximum power delivered to the resistor R.

(b) For the circuit shown in Fig. 6, find power factor, apparent power, and reactive power.

- As there is no Fig. 6 provided, it is not possible to find the power factor, apparent power, and reactive power.

(c) Find the Millman's equivalent across the terminals AB for the following circuit shown in Fig. 7:

- As there is no Fig. 7 provided, it is not possible to find the Millman's equivalent across the terminals AB.

4(a) Find the node voltages V_1 and V_2 for the circuit shown in Fig. 8.

- As there is no Fig. 8 provided, it is not possible to find the node voltages V1 and V2.

(b) Using the superposition theorem, find the current flowing in resistor 5 Ω in the circuit shown in Fig. 9.

- As there is no Fig. 9 provided, it is not possible to find the current flowing in resistor 5Ω using the superposition theorem.

(c) Explain quality factor (Q) in parallel RLC circuits.

- **Quality Factor (Q) in Parallel RLC Circuits:**
  - The quality factor (Q) in a parallel RLC circuit is a dimensionless parameter that characterizes the circuit's selectivity, or its ability to distinguish between the resonant frequency and frequencies away from resonance.
  - It is a measure of the "goodness" or "sharpness" of the resonance peak. A higher Q factor indicates a sharper and more selective response, meaning the circuit is more effective at filtering out frequencies away from resonance.
  - **Definition:** Q is defined as the ratio of the reactive power (stored energy) to the real power (dissipated energy) at resonance.
  - **Formulas for Parallel RLC Circuit (at resonance):**
    - $Q = R/X_L = R/(\omega_0 L)$
    - $Q = R/X_C = R * \omega_0 C$
    - where R is the parallel resistance, X_L is the inductive reactance, X_C is the capacitive reactance, and ω_0 is the angular resonant frequency ($2\pi f_0$).

- Alternatively, $Q = R * \sqrt{(C/L)}$

▪ **Significance:**

- **Selectivity/Bandwidth:** A higher Q factor implies a narrower bandwidth ($BW = f_0/Q$). This means the circuit will respond strongly only to a narrow range of frequencies around the resonant frequency, making it useful for tuning and filtering applications.
- **Voltage Magnification (across L and C):** In a parallel RLC circuit, at resonance, the circulating current between the inductor and capacitor can be Q times greater than the source current. This also implies that the voltage across the parallel combination at resonance is Q times the applied voltage for a current source.
- **Energy Storage vs. Dissipation:** A high Q circuit stores more energy in its reactive components (inductor and capacitor) for each cycle compared to the energy it dissipates in its resistive component. This indicates a low energy loss per cycle.
- **Damping:** A low Q factor implies a highly damped circuit, meaning oscillations decay quickly. A high Q factor implies a lightly damped circuit, where oscillations persist for a longer time.

5(a) The switch in Fig. 10 has been in position A for a long time. At time t=0, the switch moves to B. Determine v(t) for t > 0 and calculate its value at t=4 seconds.

- As there is no Fig. 10 provided, it is not possible to determine v(t) or its value at t=4 seconds.

(b) Explain the working of band pass filter with the diagram. Draw its frequency response.

- **Working of a Band-Pass Filter:**
  - A band-pass filter is an electronic filter that passes frequencies within a certain range and attenuates (reduces the amplitude of) frequencies outside that range.
  - It can be constructed by cascading a high-pass filter and a low-pass filter. The high-pass filter blocks frequencies below its cutoff frequency, and the low-pass filter blocks frequencies above its cutoff frequency. The "band" of frequencies that passes through is between these two cutoff frequencies.
  - Alternatively, a band-pass filter can be realized using resonant circuits (e.g., series or parallel RLC circuits). In this case, the filter's center frequency is the resonant frequency, and its bandwidth is determined by the quality factor (Q) of the circuit.
  - Frequencies well below the lower cutoff frequency are attenuated, and frequencies well above the upper cutoff frequency are also attenuated. The range of frequencies between the lower cutoff (f_L) and upper cutoff (f_H) frequencies, where the signal power is at least half of the maximum power (or voltage is 0.707 times the maximum), is called the passband or bandwidth ($BW = f_H - f_L$).
  - The central frequency of the passband is often referred to as the resonant frequency or center frequency (f_0).
- **Frequency Response:**
  - The frequency response of a band-pass filter is typically represented by a graph of gain (or output voltage/current) versus frequency.

- The x-axis represents frequency (often on a logarithmic scale), and the y-axis represents the gain (often in decibels, dB).
- **Characteristics of the frequency response:**
  - **Passband:** The region where the gain is relatively high (close to the maximum). This is the range of frequencies that the filter is designed to pass. The 3dB cutoff frequencies (f_L and f_H) define the edges of this band, where the power is half the maximum, or the voltage/current is 0.707 times the maximum.
  - **Stopbands:** The regions outside the passband, where the gain is significantly attenuated. These are the frequencies that the filter is designed to block.
  - **Center Frequency (f_0):** The frequency within the passband where the gain is typically maximum. For symmetrical filters, $f_0 = \sqrt{(f_L * f_H)}$.
  - **Bandwidth (BW):** The difference between the upper and lower cutoff frequencies ($BW = f_H - f_L$). It represents the width of the passband.
  - **Roll-off:** The slope of the filter's response outside the passband, indicating how rapidly the gain decreases as frequency moves away from the passband.

(c) Find the equivalent inductance for the network shown below in Fig. 11.

- As there is no Fig. 11 provided, it is not possible to find the equivalent inductance.

6(a) Given Z_11=30Ω, Z_12=15Ω, Z_21=45Ω and Z_22=35Ω. Find Y and ABCD parameters for a two-port network.

- **Given Z-parameters:**
  - $Z_{11} = 30\Omega$
  - $Z_{12} = 15\Omega$
  - $Z_{21} = 45\Omega$
  - $Z_{22} = 35\Omega$
- **Calculate Delta Z (Δ_Z):**
  - $\Delta_Z = Z_{11}Z_{22} - Z_{12}Z_{21}$
  - $\Delta_Z = (30 * 35) - (15 * 45)$
  - $\Delta_Z = 1050 - 675$
  - $\Delta_Z = 375$
- **Find Y-parameters (from Z-parameters):**
  - $Y_{11} = Z_{22}/\Delta_Z = 35/375 = 7/75$ S ≈ 0.0933 S
  - $Y_{12} = -Z_{12}/\Delta_Z = -15/375 = -1/25$ S $= -0.04$ S
  - $Y_{21} = -Z_{21}/\Delta_Z = -45/375 = -3/25$ S $= -0.12$ S
  - $Y_{22} = Z_{11}/\Delta_Z = 30/375 = 2/25$ S $= 0.08$ S
- **Find ABCD-parameters (from Z-parameters):**
  - $A = Z_{11}/Z_{21} = 30/45 = 2/3$
  - $B = \Delta_Z/Z_{21} = 375/45 = 25/3\Omega \approx 8.333\Omega$
  - $C = 1/Z_{21} = 1/45$ S ≈ 0.0222 S
  - $D = Z_{22}/Z_{21} = 35/45 = 7/9$

(b) Explain step response of an RC circuit.

- **Step Response of an RC Circuit:**

- The step response of an RC circuit refers to the behavior of the voltage or current in the circuit when a sudden DC voltage (a "step" input) is applied. This typically involves charging an uncharged capacitor through a resistor, or discharging a charged capacitor through a resistor.

- **Charging an RC Circuit (Voltage Response across Capacitor):**
  - Consider an RC series circuit where a switch is closed at $t = 0$, connecting a DC voltage source (V_S) to an initially uncharged capacitor (meaning $V_C(0^-) = 0$).
  - **Initial Condition ($t = 0^+$):** At the instant the switch closes, the capacitor acts like a short circuit because it has no charge. Thus, all the source voltage drops across the resistor, and the current is maximum ($I(0^+) = V_S/R$). The voltage across the capacitor is $V_C(0^+) = 0$.
  - **Transient Behavior ($t > 0$):** As time progresses, current flows, and the capacitor begins to charge. The voltage across the capacitor, $V_C(t)$, increases exponentially from 0 towards the source voltage V_S. Simultaneously, the current through the circuit and the voltage across the resistor decrease exponentially.
  - **Steady-State ($t \to \infty$):** After a long time (theoretically infinite, practically about 5τ), the capacitor becomes fully charged to the source voltage ($V_C(\infty) = V_S$). At this point, the capacitor acts like an open circuit (it blocks DC current), so the current in the circuit becomes zero.
  - **Equation for Capacitor Voltage during Charging:** $V_C(t) = V_S * (1 - e^{-t/\tau})$ for $t \geq 0$ where $\tau = RC$ is the time constant.

    - **Equation for Current during Charging:** $I(t) = (V_S/R) * e^{-t/\tau}$ for $t \geq 0$

- **Discharging an RC Circuit (Voltage Response across Capacitor):**
    - Consider an RC circuit where a fully charged capacitor (to an initial voltage V_0) is allowed to discharge through a resistor when a switch is closed at $t = 0$.
    - **Initial Condition ($t = 0^+$):** At the instant the switch closes, the voltage across the capacitor is its initial value, $V_C(0^+) = V_0$. The current is $I(0^+) = V_0/R$.
    - **Transient Behavior ($t > 0$):** As time progresses, the capacitor discharges, and its voltage, $V_C(t)$, decreases exponentially from its initial value V_0 towards zero. The current also decreases exponentially.
    - **Steady-State ($t \to \infty$):** After a long time, the capacitor fully discharges, and its voltage becomes zero ($V_C(\infty) = 0$). The current in the circuit also becomes zero.
    - **Equation for Capacitor Voltage during Discharging:** $V_C(t) = V_0 * e^{-t/\tau}$ for $t \geq 0$ where $\tau = RC$ is the time constant.
    - **Equation for Current during Discharging:** $I(t) = (V_0/R) * e^{-t/\tau}$ for $t \geq 0$

- **Key points for Step Response:**
    - The time constant ($\tau = RC$) dictates the speed of the response. A smaller τ means a faster response.
    - The response is exponential, meaning the circuit reaches about 63.2% of its final change in one time constant, and virtually reaches its final steady-state value in about five time constants (5τ).

(c) Find the Z parameters for the following circuit shown in Fig. 12.

- As there is no Fig. 12 provided, it is not possible to find the Z parameters.

(a) Verify the reciprocity theorem for the following circuit shown in Fig. 13 for the current flowing in resistor 3Ω.

- As there is no Fig. 13 provided, it is not possible to verify the reciprocity theorem.

(b) Find Thevenin's equivalent for circuit shown in Fig. 14 across terminals A-B.

- As there is no Fig. 14 provided, it is not possible to find Thevenin's equivalent.

(c) Find the value of resistance that gives Maximum power of the circuit shown in Fig. 15 across terminals A-B.

- As there is no Fig. 15 provided, it is not possible to find the value of resistance that gives maximum power.