Here are 10 numerical questions based on the formulas and principles provided in the Lecture 5 slides regarding Voltage Drop and Power Loss Calculations, along with their step-by-step solutions.

Question 1: DC Percentage Voltage Drop

A DC distribution line supplies a 50 kW load. The distance between the source and the load is 100 meters, the copper conductor conductivity (σ) is $56 \text{ m}/\Omega.\text{mm}^2$, and the cross-sectional area (A) is 25 mm^2. Calculate the percentage voltage drop assuming the nominal system voltage (V_n) is equal to the load voltage of 600 V.

- **Solution:** * The formula for the percentage voltage drop in a DC system is $\%e = \frac{200 \times P_{load} \times L}{V_n^2 \times \sigma \times A}$.
  - $\%e = \frac{200 \times 50000 \times 100}{600^2 \times 56 \times 25}$
  - $\%e = \frac{1{,}000{,}000{,}000}{360000 \times 1400} = \frac{1{,}000{,}000{,}000}{504{,}000{,}000}$
  - $\%e \approx 1.98\%$

Question 2: DC Power Loss

Using the data from Question 1 (load of 50 kW, distance of 100 m, load voltage of 600 V, $\sigma = 56 \text{ m}/\Omega.\text{mm}^2$, and $A = 25 \text{ mm}^2$), calculate the total power loss in Watts.

- **Solution:**
  - First, calculate the line current: $I = \frac{P_{load}}{V_{load}} = \frac{50000}{600} = 83.33 \text{ A}$.
  - Next, calculate the one-way resistance: $R = \frac{L}{\sigma \times A} = \frac{100}{56 \times 25} \approx 0.0714 \ \Omega$.
  - The power loss formula is $P_{loss} = 2RI^2$.
  - $P_{loss} = 2 \times 0.0714 \times (83.33)^2 = 0.1428 \times 6943.88 \approx 991.6 \text{ W}$.

Question 3: Conductor Sizing for DC System

A 200-meter DC underground feeder operates at a nominal voltage of 400 V to supply a 40 kW load. Find the minimum required cross-sectional area (A) for a copper conductor ($\sigma = 56 \text{ m}/\Omega.\text{mm}^2$) to ensure the percentage voltage drop does not exceed 5%.

- **Solution:**
  - Rearranging the DC percentage voltage drop formula to solve for A: $A = \frac{200 \times P_{load} \times L}{V_n^2 \times \sigma \times \%e}$.
  - $A = \frac{200 \times 40000 \times 200}{400^2 \times 56 \times 5}$
  - $A = \frac{1{,}600{,}000{,}000}{160000 \times 280} = \frac{1{,}600{,}000{,}000}{44{,}800{,}000}$
  - $A \approx 35.7 \text{ mm}^2$. (In practice, you would select the next standard size up).

Question 4: Single-Phase AC Percentage Voltage Drop

A single-phase AC line supplies a 10 kW load at 220 V with unity power factor ($f(\phi) = 1$). The line length is 50 meters. Assuming the conductor conductivity is $\sigma = 35 \text{ m}/\Omega.\text{mm}^2$ and the cross-sectional area is 16 mm^2, calculate the percentage voltage drop.

- **Solution:**
  - The formula for single-phase AC percentage voltage drop is $\%e = \frac{200 \times P_{load} \times L}{V_{load}^2 \times \sigma \times A} \times f(\phi)$.
  - $\%e = \frac{200 \times 10000 \times 50}{220^2 \times 35 \times 16} \times 1$
  - $\%e = \frac{100{,}000{,}000}{48400 \times 560} = \frac{100{,}000{,}000}{27{,}104{,}000}$
  - $\%e \approx 3.69\%$

Question 5: Three-Phase AC Percentage Voltage Drop

A three-phase line supplies a 100 kW load at an L-L voltage of 400 V. The line length is 150 meters, conductor conductivity $\sigma = 56 \text{ m}/\Omega.\text{mm}^2$, cross-section $A = 50 \text{ mm}^2$, and the power factor is unity ($f(\phi) = 1$). Find the percentage voltage drop.

- **Solution:**
  - The formula for three-phase AC percentage voltage drop using L-L voltage is $\%e = \frac{100 \times P_{load} \times L \times f(\phi)}{V_{load(LL)}^2 \times \sigma \times A}$.
  - $\%e = \frac{100 \times 100000 \times 150 \times 1}{400^2 \times 56 \times 50}$
  - $\%e = \frac{1{,}500{,}000{,}000}{160000 \times 2800} = \frac{1{,}500{,}000{,}000}{448{,}000{,}000}$
  - $\%e \approx 3.35\%$

Question 6: Three-Phase AC Maximum Length Calculation

For a three-phase system with $V_{LL} = 380 \text{ V}$, a load of 50 kW at unity power factor ($f(\phi) = 1$), $\sigma = 35 \text{ m}/\Omega.\text{mm}^2$, and conductor cross-section $A = 25 \text{ mm}^2$, what is the maximum length (L) for a maximum percentage voltage drop of 4%?

- **Solution:**
  - Rearrange the three-phase percentage voltage drop formula to solve for L: $L = \frac{\%e \times V_{load(LL)}^2 \times \sigma \times A}{100 \times P_{load} \times f(\phi)}$.
  - $L = \frac{4 \times 380^2 \times 35 \times 25}{100 \times 50000 \times 1}$
  - $L = \frac{4 \times 144400 \times 875}{5{,}000{,}000} = \frac{505{,}400{,}000}{5{,}000{,}000}$
  - $L = 101.08 \text{ meters}$

Question 7: Three-Phase AC Active Power Loss

In a three-phase system, a load draws a line current of 50 A. The per-phase resistance of the distribution line is $0.1\ \Omega$. Calculate the total three-phase active power loss.

- **Solution:**
  - The formula for three-phase active power loss is $P_{loss} = 3 \times R \times I^2$, where R is the per-phase resistance.

- $P_{loss} = 3 \times 0.1 \times 50^2$
- $P_{loss} = 3 \times 0.1 \times 2500$
- $P_{loss} = 750 \text{ W}$

Question 8: Calculating Active Power from Apparent Power

A "Rose" conductor carries its maximum apparent power of 72.6 kVA in a three-phase system. If the power factor is 0.8 lagging, calculate the maximum active power (P_{max}) in kW.

- **Solution:**
  - Active power is the product of apparent power and the power factor.
  - $P_{max} = S_{max} \times \cos\theta$
  - $P_{max} = 72.6 \text{ kVA} \times 0.8$
  - $P_{max} = 58.08 \text{ kW}$

Question 9: Source Voltage in a DC System

A DC distribution system supplies a load operating at 200 V. The total two-way voltage drop on the distribution line (ΔV) is calculated to be 12 V. What is the voltage of the DC source (V_s)?

- **Solution:**
  - Based on Kirchhoff's Voltage Law (KVL) for the DC line, the voltage drop is $\Delta V = V_s - V_{load}$.
  - Rearranging to solve for the source voltage: $V_s = V_{load} + \Delta V$.
  - $V_s = 200 + 12 = 212 \text{ V}$.

Question 10: Percentage Efficiency of a DC Line

A DC distribution line receives an input power (P_{in}) of 52 kW from the source. The total power loss on the line (P_{loss}) is 2 kW. Calculate the percentage efficiency of the distribution line.

- **Solution:**
  - First, calculate the output power to the load: $P_{out} = P_{in} - P_{loss} = 52000 - 2000 = 50000 \text{ W}$.
  - The formula for percentage efficiency is $\%\eta = (\frac{P_{out}}{P_{in}}) \times 100$.
  - $\%\eta = (\frac{50000}{52000}) \times 100$
  - $\%\eta \approx 96.15\%$