Python

Question 1: Resistance at Different Temperatures (Copper)

A copper power cable has a resistance of $0.5\ \Omega$ at an ambient temperature of $20^\circ\mathrm{C}$. Given that the temperature coefficient constant (M) for copper is 241.5, calculate its resistance at an operating temperature of $70^\circ\mathrm{C}$.

- **Solution:**
  - The formula relating resistance to temperature is: $\frac{R_{t2}}{R_{t1}} = \frac{M+t_2}{M+t_1}$
  - Rearranging to solve for the new resistance R_{t2}:
  - $R_{t2} = 0.5 \times \frac{241.5+70}{241.5+20}$
  - $R_{t2} = 0.5 \times \frac{311.5}{261.5}$
  - $R_{t2} = 0.5 \times 1.1912 \approx 0.5956\ \Omega$

Question 2: Resistance at Different Temperatures (Aluminum)

An aluminum overhead conductor has a measured resistance of $1.2\ \Omega$ during summer at $30^\circ\mathrm{C}$. If the temperature drops to $0^\circ\mathrm{C}$ in the winter, what is its new resistance? (Assume $M = 228.1$ for Aluminum).

- **Solution:**
  - Using the temperature-resistance proportionality formula:
  - $R_{t2} = R_{t1} \times \frac{M+t_2}{M+t_1}$
  - $R_{t2} = 1.2 \times \frac{228.1+0}{228.1+30}$
  - $R_{t2} = 1.2 \times \frac{228.1}{258.1}$
  - $R_{t2} = 1.2 \times 0.88376 \approx 1.06\ \Omega$

Question 3: Effective AC Resistance

A solid copper conductor has a measured DC resistance (R_{DC}) of $0.04\ \Omega$. If the skin effect factor (Y_s) is 0.02 and the proximity effect factor (Y_p) is 0.015, calculate the effective AC resistance (R_{AC}) of the conductor.

- **Solution:**
  - The formula for alternating current resistance is: $R_{AC} = R_{DC} \times (1 + Y_s + Y_p)$
  - $R_{AC} = 0.04 \times (1 + 0.02 + 0.015)$
  - $R_{AC} = 0.04 \times 1.035$
  - $R_{AC} = 0.0414\ \Omega$

Question 4: Apparent Power Capacity of a General Cable

A “Rose” aluminum conductor has a maximum current carrying capacity of $110\ \mathrm{A}$. In a perfectly balanced three-phase system with a phase-to-neutral voltage (V_{L-N}) of 220 V, calculate the maximum apparent power (S_{max}) it can carry in kVA.

- **Solution:**
  - The formula for maximum apparent power using L-N voltage is: $S_{max} = 3 \times V_{L-N} \times I$
  - $S_{max} = 3 \times 220 \times 110 = 72,600\text{ VA}$
  - $S_{max} = 72.6\text{ kVA}$

Question 5: Three-Phase Apparent Power with Line-to-Line Voltage

A medium voltage underground power cable has a maximum current rating of 250 A. If it operates in a three-phase system with a line-to-line voltage (V_{L-L}) of 10 kV, calculate the maximum apparent power it can safely transmit in kVA.

- **Solution:**
  - The formula for three-phase apparent power using L-L voltage is: $S_{max} = \sqrt{3} \times V_{L-L} \times I$
  - $S_{max} = \sqrt{3} \times 10,000 \times 250$
  - $S_{max} \approx 1.732 \times 2,500,000 = 4,330,000\text{ VA}$
  - $S_{max} \approx 4330\text{ kVA}$

Question 6: Final Correction Coefficient for Ampacity

An XLPE underground cable is being laid under specific conditions. By checking the manufacturer's tables, an engineer finds the temperature factor $f_1 = 0.81$, the grouping factor $f_2 = 0.60$, and the depth factor $f_3 = 0.88$. Factors for ducting and piping are $f_4 = f_5 = f_6 = f_7 = 1$. Calculate the final correction coefficient (f).

- **Solution:**
  - The final correction factor is the product of all individual condition factors:
  - $f = f_1 \cdot f_2 \cdot f_3 \cdot f_4 \cdot f_5 \cdot f_6 \cdot f_7$
  - $f = 0.81 \times 0.60 \times 0.88 \times 1 \times 1 \times 1 \times 1$
  - $f = 0.42768$

Question 7: Corrected Maximum Current Capacity

According to a catalog table, a $3 \times 70\text{ mm}^2$ XLPE cable has a base maximum current capacity (I_{max}) of 252 A under ideal conditions. If the final correction coefficient for its actual underground laying conditions is calculated as $f = 0.456$, what is the corrected maximum current ($I_{max\_corrected}$) that the cable can safely carry?

- **Solution:**
  - The formula for real-world ampacity is: $I_{max\_corrected} = I_{max} \times f$

- $I_{max\_corrected} = 252 \times 0.456$
- $I_{max\_corrected} = 114.912 \text{ A}$

Question 8: Required Table Ampacity for a Specific Load

A commercial facility requires a continuous load current (I_{load}) of 251 A. The environmental underground laying conditions result in a final correction coefficient of $f = 0.62$. Calculate the minimum theoretical table current (I_{max}) the engineer must look for when selecting a cable from the catalog.

- **Solution:**
  - Rearranging the capacity formula to solve for the table rating: $I_{max} = \frac{I_{load}}{f}$
  - $I_{max} = \frac{251}{0.62}$
  - $I_{max} \approx 404.84 \text{ A}$ (The engineer must select a cable rated for at least this much current).

Question 9: Load Splitting Across Parallel Cable Systems

An industrial facility draws a massive load current (I_{load}) of 866 A. Because a single cable cannot carry this, the design uses 2 parallel systems ($s_s = 2$). The new overall correction factor f^* (which accounts for a harsher grouping factor due to multiple cables) is 0.635. Calculate the required table ampacity (I_{max}) per cable.

- **Solution:**
  - First, divide the load by the number of systems to find the current each cable must carry: $\frac{I_{load}}{s_s} = \frac{866}{2} = 433 \text{ A}$.
  - Next, divide by the new correction factor to find the required catalog rating: $I_{max} = \frac{433}{f^*}$
  - $I_{max} = \frac{433}{0.635}$
  - $I_{max} \approx 681.89 \text{ A}$

Question 10: Fault Distance using Murray Loop Test

A Murray loop test is performed to locate an earth fault on an underground cable that is 300 m long. At balance, the adjustable resistance connected to the faulty core is $15 \ \Omega$ and the resistance connected to the sound (healthy) core is $45 \ \Omega$. Calculate the distance of the fault point from the test end.

- **Solution:**
  - The total length of the conductor loop is twice the cable length: $2 \times L = 2 \times 300 = 600 \text{ m}$.
  - The distance (x) to the fault is proportional to the resistances, given by: $x = (2L) \times \left(\frac{R_{faulty}}{R_{faulty} + R_{sound}}\right)$
  - $x = 600 \times \left(\frac{15}{15+45}\right)$
  - $x = 600 \times \left(\frac{15}{60}\right) = 600 \times 0.25$
  - $x = 150 \text{ meters}$