

Here are 10 numerical questions based on the formulas and principles provided in the lecture slides, along with their step-by-step solutions.

Question 1: Power Demand Calculation

A commercial building has three main loads: Lighting (150 kW) with a demand factor of 85%, HVAC (300 kW) with a demand factor of 100%, and electrical outlets (200 kW) with a demand factor of 30%. Calculate the total power demand (P_{max}).

- **Solution:** * The formula for power demand is the sum of the products of installed power and demand factor for each load ($P_{max} = P_i \times g_i$).

$$\circ P_{max} = (150 \times 0.85) + (300 \times 1.0) + (200 \times 0.30)$$

$$\circ P_{max} = 127.5 + 300 + 60 = 487.5 \text{ kW}$$

Question 2: Transformer Sizing

Using the total power demand calculated in Question 1 (487.5 kW), determine the required transformer rating in kVA if the average power factor of the commercial building is 0.85.

- **Solution:** * Transformer rating in kVA is found by dividing the power demand in kW by the average power factor.

$$\circ \text{Transformer Rating} = \frac{487.5 \text{ kW}}{0.85}$$

$$\circ \text{Transformer Rating} \approx 573.53 \text{ kVA}$$

Question 3: Power Demand with Motors

An industrial plant operates two large motors. Motor 1 is rated at 45 kW with a demand factor of 80%, a utilization factor of 75%, and an efficiency of 92%. Motor 2 is rated at 60 kW with a demand factor of 70%, a utilization factor of 85%, and an efficiency of 95%. Calculate the total power demand resulting from these motor loads.

- **Solution:**

- The power demand equation for motors incorporates the rated power (P_{rM}), demand factor (g_i), utilization factor (a_i), and efficiency (η_i).

$$\circ P_{max} = \left[\frac{45 \times 0.80 \times 0.75}{0.92} \right] + \left[\frac{60 \times 0.70 \times 0.85}{0.95} \right]$$

$$\circ P_{max} = 29.35 + 37.58 = 66.93 \text{ kW}$$

Question 4: Individual Motor Power Demand

Calculate the power demand of a single 25 kW induction motor operating with a demand factor of 90%, a utilization factor of 60%, and an efficiency of 88%.

- **Solution:**

- Using the motor power demand equation:

- $P_{max} = \frac{25 \times 0.90 \times 0.60}{0.88}$
- $P_{max} = \frac{13.5}{0.88} = 15.34 \text{ kW}$

Question 5: Diversity Factor

A residential complex is divided into four blocks. The individual maximum demands for the blocks are 250 kW, 300 kW, 150 kW, and 400 kW. If the overall maximum demand of the entire complex is observed to be 950 kW, what is the diversity factor of the system?

• **Solution:**

- The diversity factor is the ratio of the sum of individual maximum demands to the maximum demand of the whole system.
- Diversity Factor = $\frac{250+300+150+400}{950}$
- Diversity Factor = $\frac{1100}{950} \approx 1.158$

Question 6: Calculating Maximum System Demand

A factory has various subdivisions whose individual maximum demands sum up to 2400 kW. If the factory operates with a known diversity factor of 1.25, what is the maximum demand of the whole factory system?

• **Solution:**

- Rearranging the diversity factor formula: System Maximum Demand = $\frac{\text{Sum of Individual Maximum Demands}}{\text{Diversity Factor}}$.
- System Maximum Demand = $\frac{2400}{1.25} = 1920 \text{ kW}$

Question 7: Main Transformer Demand Load with Diversity Factor

An electrical switchgear setup has three feeder breakers with calculated demand loads of 1500 kVA, 1200 kVA, and 800 kVA. If the diversity factor for the main transformer is given as 1.15, what is the Main Transformer Demand Load?

• **Solution:**

- First, calculate the Main Breaker Demand by summing the feeder loads.
- Main Breaker Demand = $1500 + 1200 + 800 = 3500 \text{ kVA}$
- Next, divide the Main Breaker Demand by the Diversity Factor to find the Main Transformer Demand Load.
- Main Transformer Demand Load = $\frac{3500}{1.15} \approx 3043.48 \text{ kVA}$

Question 8: Average Load Calculation

A daily load curve for a small town shows a load of 10 MW for 8 hours, 30 MW for 10 hours, and 15 MW for 6 hours. Calculate the average load over this 24-hour period.

• **Solution:**

- Average load is determined by calculating the total area under the daily load curve (total energy) divided by the total hours (24).
- Average Load = $\frac{(10 \times 8) + (30 \times 10) + (15 \times 6)}{24}$
- Average Load = $\frac{80 + 300 + 90}{24} = \frac{470}{24} \approx 19.58 \text{ MW}$

Question 9: Load Factor Calculation

Using the data from Question 8 (Average Load = 19.58 MW, Peak Load = 30 MW), calculate the daily load factor as a percentage.

• Solution:

- The load factor is the ratio of the average load to the peak load.
- Load Factor = $\frac{19.58}{30}$
- Load Factor = 0.6527 or 65.27%

Question 10: Combined Average Load and Load Factor

A manufacturing facility has a 12-hour operational shift. Its load profile is 5 MW for the first 3 hours, 12 MW for the next 6 hours, and 4 MW for the last 3 hours. Calculate both the average load for the shift and the load factor.

• Solution:

- First, calculate the average load over the 12-hour period.
- Average Load = $\frac{(5 \times 3) + (12 \times 6) + (4 \times 3)}{12}$
- Average Load = $\frac{15 + 72 + 12}{12} = \frac{99}{12} = 8.25 \text{ MW}$
- Next, calculate the load factor using the peak load of 12 MW.
- Load Factor = $\frac{8.25}{12} = 0.6875$ or 68.75%