Rotating Machines

Quick Selection Notes:

- Use $u = 2\pi Rn$ when you need the speed of a moving conductor.
- Use $e = Blu$ for induced voltage in a single conductor.
- Use $e_{\text{coil}} = N \cdot e$ for total induced voltage in a coil.
- Use $e_{\text{avg}} = \frac{pZ\phi n}{60}$ for average DC machine voltage.
- Use $T = \frac{pZ\phi I}{2\pi c}$ for torque in a rotating machine.

Miscellaneous

1. **Voltage with Winding Factors (RMS):**

$$e_{\text{rms}} = 2.22 \cdot f \cdot Z_s \cdot k \cdot \phi$$

   Use when:

   - Calculating RMS voltage in an AC machine with sinusoidal output.
   - Given the frequency f, series conductors Z_s, winding factor k, and flux per pole ϕ.

2. **Effect of Poles or Pole Pairs on Speed:**

   - **Doubling the number of poles**: Halves the speed.
   - **Doubling the frequency of applied or induced voltage**: Doubles the speed.

General Relationships

1. **Speed of Conductor**:

$$u = 2\pi Rn$$

   Use when:

   - You need the linear speed of a conductor in a rotating system.
   - Given the radius R and rotational speed n in revolutions per second.

2. **Frequency of Induced Voltage:**

$$f = p \cdot n$$

   Use when:

   - You need to calculate the frequency of induced voltage.
   - Given the number of pole pairs p and rotational speed n in revolutions per second.

Induced Voltage

1. **Voltage Induced in a Conductor:**

$$e = Blu$$

   Use when:

   - You need the voltage induced in a single conductor moving in a magnetic field.
   - Given the flux density B, conductor length l, and speed u.

2. **Voltage Induced in a Coil (Multiple Turns):**

$$e_{\text{coil}} = N \cdot e$$

   Use when:

   - You have a coil with multiple turns, and you know the induced voltage per turn e.
   - Multiply e by the number of turns N.

3. **Average Voltage for a DC Machine:**

$$e_{\text{avg}} = \frac{pZ\phi n}{60}$$

   Use when:

   - Calculating the average voltage for a DC machine.
   - Given the number of poles p, conductors Z, flux per pole ϕ, and speed in revolutions per minute n.

Torque and Force

1. **Force on a Conductor in a Magnetic Field:**

$$F = BlI$$

   Use when:

   - You need the force acting on a current-carrying conductor in a magnetic field.
   - Given flux density B, conductor length l, and current I.

2. **Torque in a Rotating Machine:**

$$T = \frac{pZ\phi I}{2\pi c}$$

Use when:

- Calculating torque in a rotating machine.
- Given the number of poles p, total conductors Z, flux per pole ϕ, current I, and the number of parallel paths c.