EE30372 - Electric Machinery and Power Systems Analysis
Miscellaneous formulae

Physics:

Work(W) $=\int F dr = \int \tau d\theta$, Power $= \frac{dW}{dt}$
Flux density: $B = \frac{\mu N i}{l_c}$ for i amperes in coil of N turns and mean flux path length l_c
Total flux(ϕ): $\phi = \int \mathbf{B} \cdot d\mathbf{A}$
Faraday's and Lenz's laws for N turns around flux ϕ: $e_{ind} = -N\frac{d\phi}{dt}$
Force on wire carrying i amperes in field of flux density $\mathbf{B}$: $\mathbf{F} = i(\mathbf{l} \times \mathbf{B})$
Voltage induced in conductor moving at velocity $\mathbf{v}$ in flux density $\mathbf{B}$: $e_{ind} = (\mathbf{v} \times \mathbf{B}) \cdot \mathbf{l}$
Torque between two flux fields $\mathbf{B}_R$ and $\mathbf{B}_S = k\mathbf{B}_R \times \mathbf{B}_S$.

General:

Complex power: $\mathbf{S} = \mathbf{V}\mathbf{I}^* = P + jQ$
Turns ratio of transformer: $a = \frac{N_p}{N_s}$
Referencing of impedance through transformer (ref. to primary): $\mathbf{Z}'_L = a^2\mathbf{Z}_L$
Autotransformer apparent power rating advantage: $\frac{N_{SE}+N_C}{N_{SE}}$
Per-unit analysis: $Z_{base} = \frac{(V_{base})^2}{S_{base}} = \frac{V_{base}}{I_{base}}$, $S_{base} = V_{base} I_{base}$.
Transformer phasor diagrams (ref. to secondary): $\frac{\mathbf{V}_P}{a} = \mathbf{V}_s + R_{eq}\mathbf{I}_S + jX_{eq}\mathbf{I}_S$
Per-unit in 3-phase: $Z_{base} = \frac{3(V_{LN,base})^2}{S_{base}}$, $I_{base} = \frac{S_{base}}{3V_{LN,base}}$
Voltage induced in coils of P-pole stator windings with N_C turns enclosing total flux ϕ_{tot} in P-pole field, and rotating at speed ω_m relative to magnetic field: $N_C \phi_{tot} \omega_e \cos(\omega_e t)$, where $\omega_e = \omega_m P/2$.
Mechanical power in rotating machine: $P_{conv} = \tau_{ind}\omega_m$.
Power output by rotating machine: $P_{out} = \tau_{load}\omega_m$.
"Regulation" of quantity γ: $\frac{\gamma_{no\ load} - \gamma_{full\ load}}{\gamma_{full\ load}} \times 100\%$
Parallel generators: $P = s_P(f_{nl} - f_{sys})$, $Q = s_Q(V_{nl} - V_{fl})$

Motors:

Induction motor speed: $n_{sync} = \frac{120 * f_e}{no.\ poles}$, $s = \frac{n_{sync} - n_m}{n_{sync}}$
Induction rotor internal frequency: $f_r = s f_e$.
Power transferred to induction rotor: $P_{AG} = P_{conv} + P_{RCL} = \tau_{ind}\omega_{sync}$
Three-phase induction motor torque: $\tau_{ind} = \frac{3V_{TH}^2 R_2/s}{\omega_{sync}[(R_{TH}+R_2/s)^2 + (X_{TH}+X_2)^2]}$
DC motor converted power: $P_{conv} = E_A I_A$
Back EMF in DC motor: $E_A = K\phi\omega$.
Induced Torque in DC motor: $\tau_{ind} = K\phi I_A$
Shunt DC motor speed: $\omega = \frac{V_t}{K\phi} - \frac{R_A}{(K\phi)^2}\tau_{ind}$
Series DC motor speed: $\omega = \frac{V_T}{\sqrt{Kc}\sqrt{\tau_{ind}}} - \frac{R_A+R_S}{Kc}$