2. (16 pts) A 208-V. four-pole, 60-Hz, Y-connected, induction motor is rated at 20 hp.
Its equivalent circuit components are

$N_{poles} := 4$ $R_1 := 0.20\cdot\Omega$ $R_2 := 0.12\cdot\Omega$

$X_1 := 0.40\cdot\Omega$ $X_2 := 0.40\cdot\Omega$ $X_M := 15\cdot\Omega$

$P_{mech} := 300\cdot W$ $P_{misc} := 0\cdot W$ $P_{core} := 0\cdot W$

For a slip of 0.06, the following values have been calculated for you: $s := 0.06$

$\mathbf{E_1} := (101.49 - 13.961\cdot j)\cdot V$ $|\mathbf{E_1}| = 102.446\cdot V$ The line current magnitude: $I_L := 52\cdot A$

Find the following:

a) The stator copper losses

$$P_{SCL} := 3\cdot\left(I_L^{\,2}\cdot R_1\right) \qquad P_{SCL} = 1.622\cdot kW$$

b) The air-gap P_{AG}

$$I_2 := \frac{|\mathbf{E_1}|}{\sqrt{X_2^{\,2} + \left(\frac{R_2}{s}\right)^2}} \qquad P_{AG} := 3\cdot\left(I_2^{\,2}\cdot\frac{R_2}{s}\right) \qquad P_{AG} = 15.137\cdot kW$$

c) The power converted from electrical to mechanical form

$$P_{conv} := (1 - s)\cdot P_{AG} \qquad P_{conv} = 14.229\cdot kW$$

d) The motor speed in revolutions per minute and radians per second

$$n_{sync} := \frac{7200\cdot rpm}{N_{poles}} \qquad n_{sync} = 1800\cdot rpm \qquad \omega_{sync} := n_{sync}\cdot\left(2\cdot\pi\cdot\frac{rad}{rev}\right)\cdot\left(\frac{min}{60\cdot sec}\right)$$

$$\omega_{sync} = 188.496\cdot\frac{rad}{sec} \qquad \text{OR} \qquad \frac{377}{2} = 188.5\ \frac{rad}{sec}$$

$$n_m := (1 - s)\cdot n_{sync} \qquad n_m = 1692\cdot rpm \qquad \omega_m := n_m\cdot\left(2\cdot\pi\cdot\frac{rad}{rev}\right)\cdot\left(\frac{min}{60\cdot sec}\right) \qquad \omega_m = 177.186\cdot\frac{rad}{sec}$$

e) The induced torque τ_{ind}

$$\tau_{ind} := \frac{P_{conv}}{\omega_m} \qquad \text{OR:} \qquad \tau_{ind} := \frac{P_{AG}}{\omega_{sync}} \qquad \tau_{ind} = 80.305\cdot N\cdot m$$

f) The load torque τ_{load}

$$P_{out} := P_{conv} - P_{core} - P_{mech} - P_{misc} \qquad P_{out} = 13.929\cdot kW$$

$$\tau_{load} := \frac{P_{out}}{\omega_m} \qquad \tau_{load} = 78.612\cdot N\cdot m$$

2. (16 pts) A 480-V. four-pole, 60-Hz, Y-connected, induction motor is rated at 20 hp.
Its equivalent circuit components are

$N_{poles} := 4$ $\quad R_1 := 1\cdot\Omega$ $\quad R_2 := 0.6\cdot\Omega$

$X_1 := 2\cdot\Omega$ $\quad X_2 := 2\cdot\Omega$ $\quad X_M := 75\cdot\Omega$

$P_{mech} := 300\cdot W$ $\quad P_{misc} := 0\cdot W$ $\quad P_{core} := 0\cdot W$

For a slip of 0.06, the following values have been calculated for you: $s := 0.06$

$\mathbf{E_1} := (234.208 - 32.217\cdot j)\cdot V$ $\quad |\mathbf{E_1}| = 236.413\cdot V$ $\quad$ The line current magnitude: $I_L := 24\cdot A$

Find the following:

a) The stator copper losses

$$P_{SCL} := 3\cdot\left(I_L^{\,2}\cdot R_1\right) \qquad P_{SCL} = 1.728\cdot kW$$

b) The air-gap P_{AG}

$$I_2 := \frac{|\mathbf{E_1}|}{\sqrt{X_2^{\,2} + \left(\frac{R_2}{s}\right)^2}} \qquad P_{AG} := 3\cdot\left(I_2^{\,2}\cdot\frac{R_2}{s}\right) \qquad P_{AG} = 16.122\cdot kW$$

c) The power converted from electrical to mechanical form

$$P_{conv} := (1 - s)\cdot P_{AG} \qquad P_{conv} = 15.155\cdot kW$$

d) The motor speed in revolutions per minute and radians per second

$$n_{sync} := \frac{7200\cdot rpm}{N_{poles}} \qquad n_{sync} = 1800\cdot rpm \qquad \omega_{sync} := n_{sync}\cdot\left(2\cdot\pi\cdot\frac{rad}{rev}\right)\cdot\left(\frac{min}{60\cdot sec}\right)$$

$$\omega_{sync} = 188.496\cdot\frac{rad}{sec} \qquad \text{OR} \qquad \frac{377}{2} = 188.5\ \frac{rad}{sec}$$

$$n_m := (1 - s)\cdot n_{sync} \qquad n_m = 1692\cdot rpm \qquad \omega_m := n_m\cdot\left(2\cdot\pi\cdot\frac{rad}{rev}\right)\cdot\left(\frac{min}{60\cdot sec}\right) \qquad \omega_m = 177.186\cdot\frac{rad}{sec}$$

e) The induced torque τ_{ind}

$$\tau_{ind} := \frac{P_{conv}}{\omega_m} \qquad \text{OR:} \qquad \tau_{ind} := \frac{P_{AG}}{\omega_{sync}} \qquad \tau_{ind} = 85.533\cdot N\cdot m$$

f) The load torque τ_{load}

$$P_{out} := P_{conv} - P_{core} - P_{mech} - P_{misc} \qquad P_{out} = 14.855\cdot kW$$

$$P_{out} = 19.921\cdot hp$$

$$\tau_{load} := \frac{P_{out}}{\omega_m} \qquad \tau_{load} = 83.839\cdot N\cdot m$$

g) The overall machine efficiency $\eta = \frac{P_{out}}{P_{SCL} + P_{AG}} = 83.22\cdot\%$

h) Is this motor running close to it's rated output?

Yes, $P_{out} = 19.921\cdot hp$ rating is 20 hp