Problem 1. 33 pts. Consider a 3-phase induction motor. Starting with the phasor equivalent circuit, derive an expression for the phasor representing the $a$-phase rotor current in terms of the phasor representing the $a$-phase stator current, the radian slip frequency, and the lumped-circuit machine parameters.

Problem 2. 34 pts. Consider a 3-phase salient permanent magnet ac machine. Starting from the machine $qd$ voltage equations, the $qd$ flux linkage equations, and the $qd$ torque equation in terms of machine currents, derive an expression for steady-state torque in terms of the applied $q$- and $d$-axis voltage (in the rotor reference frame), the electrical rotor speed, and the lumped-circuit machine parameters.

Problem 3. 33 pts. Consider a 3-phase synchronous machine with one damper winding in the $q$-axis. Starting with the $qd$ machine model damper voltage equations and $qd$ machine model stator and rotor flux linkage equations, find an expression for the time derivative of the $q$-axis damper flux linkage in terms of the stator and rotor $q$-axis flux linkages and the lumped-circuit machine parameters.