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1. Which coordinate system and method of solution you would choose, when modelling
 - a) the maximum current and torque of a cage induction motor when switched to the line voltage,
 - b) the whole start-up process of a cage induction motor,
 - c) currents of a synchronous machine after a sudden three-phase short circuit at its terminals,
 - d) stability of a synchronous machine during connection phenomena in network,
 - e) effect of torque oscillations of the prime mover on the operation of a synchronous generator? (Instruction: A brief explanation with some reasoning is enough.)

2. Derive the space-vector equation for the torque starting from the equation of power.

3. A prime mover is rotating a two-pole slip-ring generator at a constant speed ω . The generator is not connected to the grid. At the beginning, there are no currents in the star-connected, three-phase rotor winding but at an instant of time $t = 0$, a DC voltage U_r is connected between the terminals of two phase windings. Derive the equations for the rotor currents and the voltage u_{sa} of a stator phase winding.

4. After a three-phase short circuit at the terminals of a synchronous machine, the stator current in phase a and field winding current are

$$i_{sa} = -\hat{u}_{s0} \left\{ \left[\frac{1}{X_d} + \left(\frac{1}{X'_d} - \frac{1}{X_d} \right) e^{-t/T'_d} + \left(\frac{1}{X''_d} - \frac{1}{X'_d} \right) e^{-t/T''_d} \right] \cos(\omega t + \vartheta_{r0}) - \frac{1}{2} \left(\frac{1}{X''_d} + \frac{1}{X''_q} \right) e^{-t/T_a} \cos \vartheta_{r0} - \frac{1}{2} \left(\frac{1}{X''_d} - \frac{1}{X''_q} \right) e^{-t/T_a} \cos(2\omega t + \vartheta_{r0}) \right\}$$

$$i_f = i_{f0} \left[1 + \left(\frac{X_d}{X'_d} - 1 \right) e^{-t/T'_d} - \left(\frac{X_d}{X'_d} - 1 \right) e^{-t/T_a} \cos \omega t \right]$$

- a) To which windings are the current components and time constants associated with?
 - b) What can you say about the relative magnitude of the time constants?
 - d) How do the currents change if we neglect the resistances?
5. A synchronous motor is started by connecting the stator winding directly to a line voltage. What kinds of torque component are active during the start-up of the motor, and how can you affect the starting time (torque) of the motor?