

1. Explain briefly:
- What is a four-winding basic machine,
  - What is Runge-Kutta method used for,
  - What are root locii and what are they used for,
  - What are state-space equations and state variables,
  - What are the time constants of a synchronous machine denoted by  $T_d'$ ,  $T_d''$  and  $T_a$ . What can you say about the relative magnitude of these time constants?

2. Show that the instantaneous power can be calculated in terms of vector quantities as

$$P = \frac{3}{2} \operatorname{Re} \{ \underline{u} \underline{i}^* \}.$$

3. Derive the small-signal space-vector model for a cage induction motor (voltage equations and equation of motion). 11

4. a) What is an operator inductance and what is it used for?  
b) Derive the equation of operator inductance  $L_q(s)$  for a salient-pole synchronous machine equipped with a damper winding.

5. A salient pole synchronous motor is started by connecting its stator winding to a three-phase grid. How and from which components is the starting torque produced, and how can we affect the starting torque? Sketch the average torque versus speed curve of a synchronous motor during a slow starting.