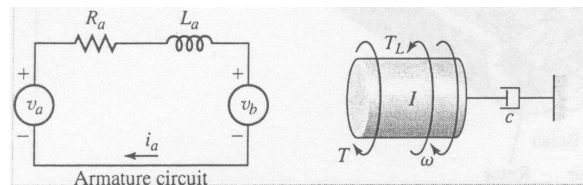
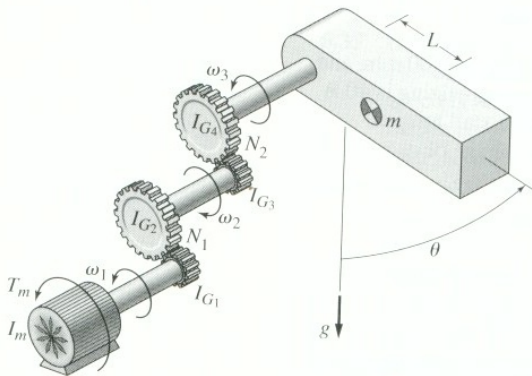
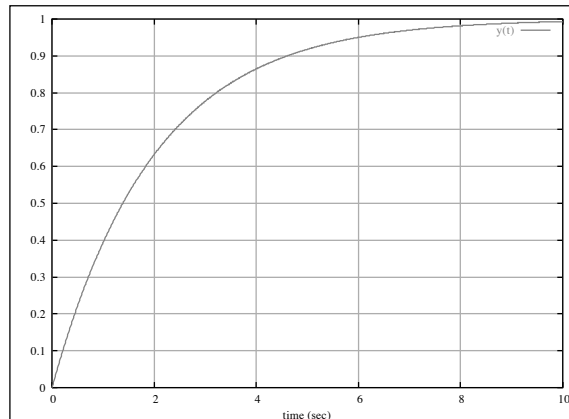


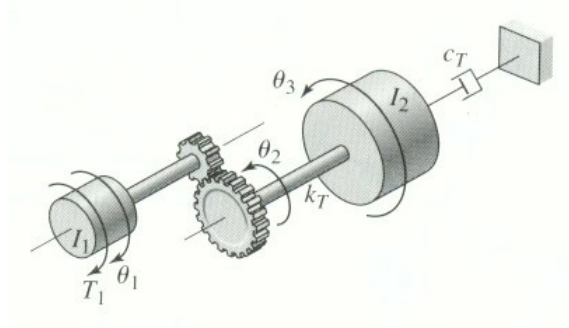
1. State the function of the following system components (e.g. potential energy storage, energy dissipation, kinetic energy storage, flow source, potential source). Explain why.
 - (a) Intravenous drug pumps.
 - (b) A space heater (with a thermostat) in a small insulated room.
 - (c) Stepper motor.
 - (d) Water tower.
 - (e) A long large diameter pipe with a relatively low flow rate.
2. For a stepper motor, define:
 - (a) Holding Torque
 - (b) Detent torque
 - (c) Step angle
 - (d) Maximum pull-in torque
 - (e) Pull-out torque
3. Determine the governing equations for the following system presuming the electrical input is voltage. To the right is shown an schematic of the armature controlled motor connected when not connected to a load. **Neglect gravity!**



4. Estimate a model for the system for which the step response is given as follows:



5. Derive the equations of motion for the system below presuming a deadband. Sketch the force between the gears as a function of angular position of the two gears. Label it with necessary explanations. Generate the system simulink model.



6. Derive the equations of motion for the system below and put them in state space form for the cases:
- (a) assuming linear resistances and negligible inertance.
 - (b) using the Darcy equation.

Remember to use consistent variables. i.e. q_m for flow rate.

