CONTROL I

ELEN3016

System Modelling

(Lecture 4)

Overview

- First Things First!
- Electromechanical Energy Conversion
- Modelling of a PM DC Motor
- Tutorial Exercises & Homework

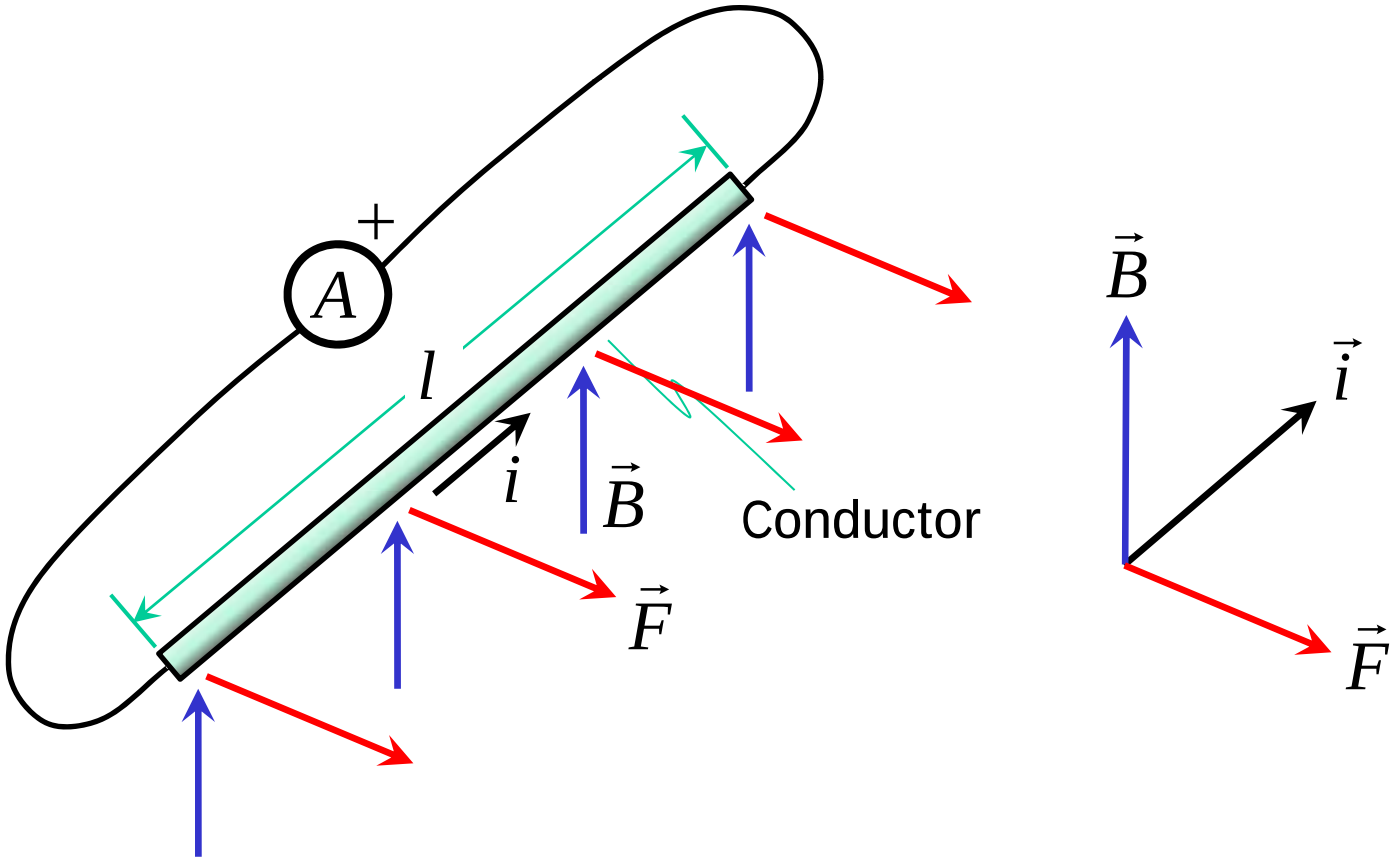
- Next Attraction!

First Things First!

- Undergrad Lab – Postgrad Course Clash
  - Tuesday's postgrad lectures end at 16:00
  - Possible additional timeslot to consult with student assistants?
- Lab Due Date(s)
  - To be finalised this Thursday.
- Special Arrangement
  - Mr Viv Crone requested to use ELEN3016's Thursday lecture timeslot.

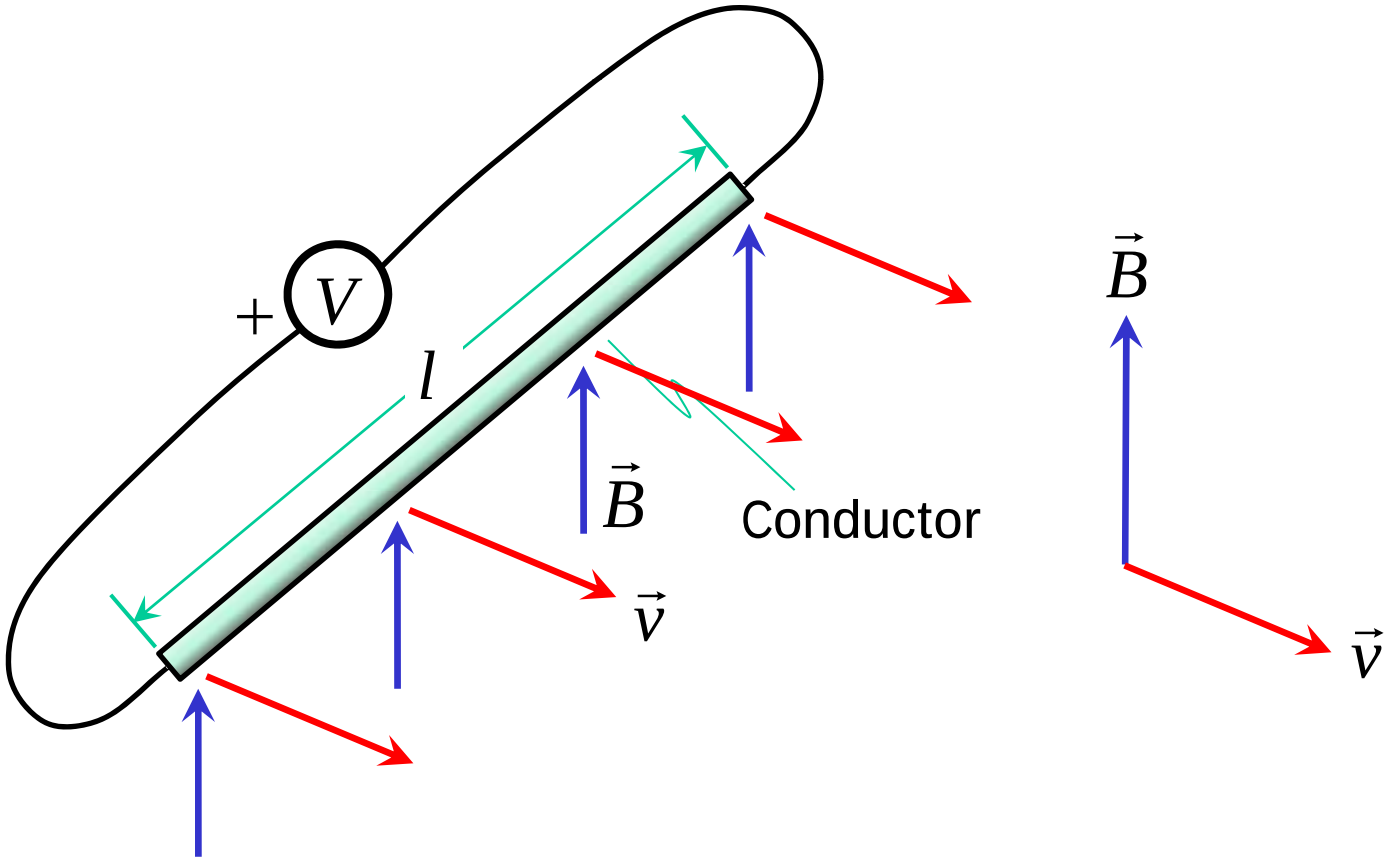
Electromechanical Systems

- Motor Law: $F = Bli$



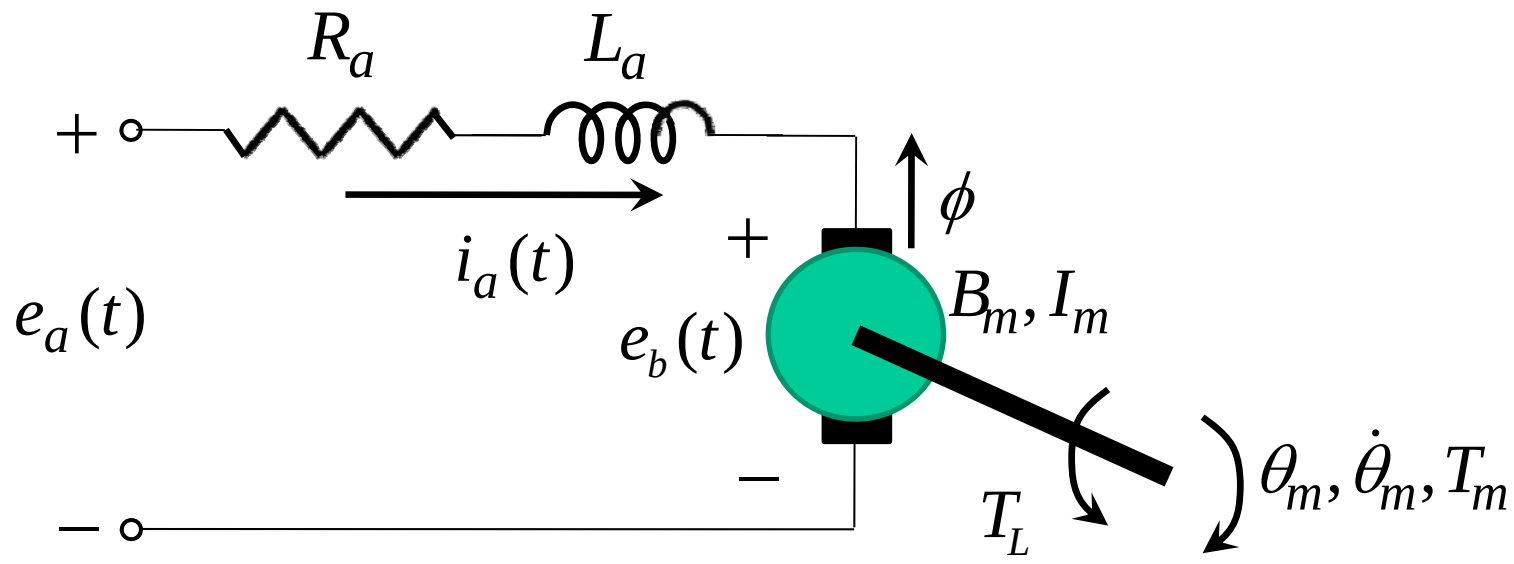
Electromechanical Systems

- Generator Law: $e = Blv$



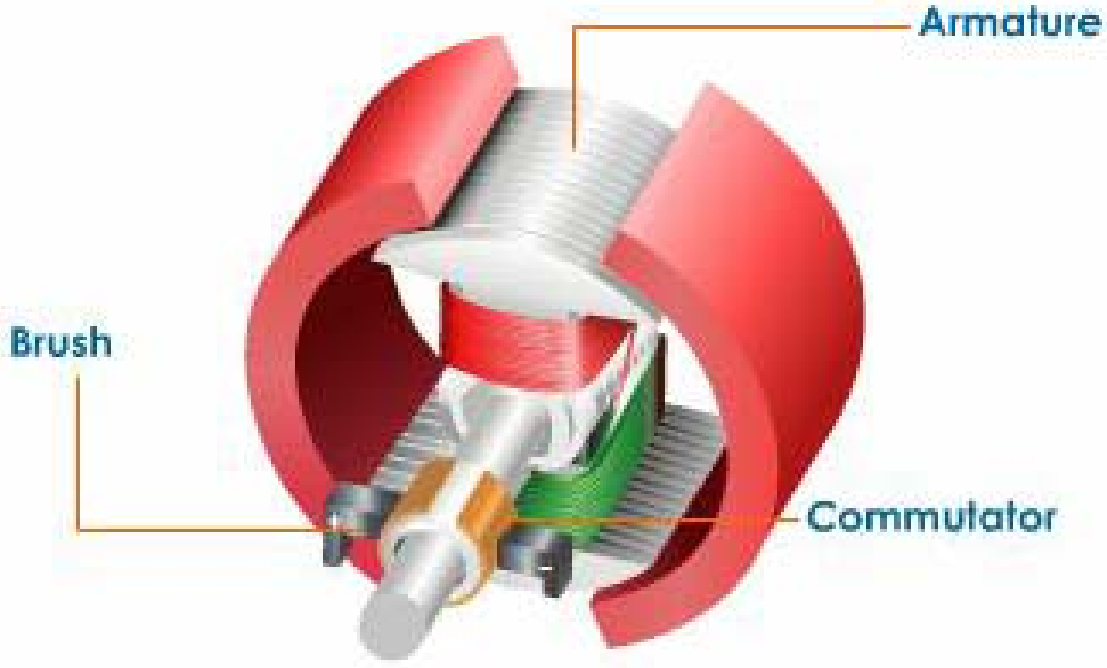
Electromechanical Systems

- Permanent-Magnet Direct-Current Motor



PM DC Motor

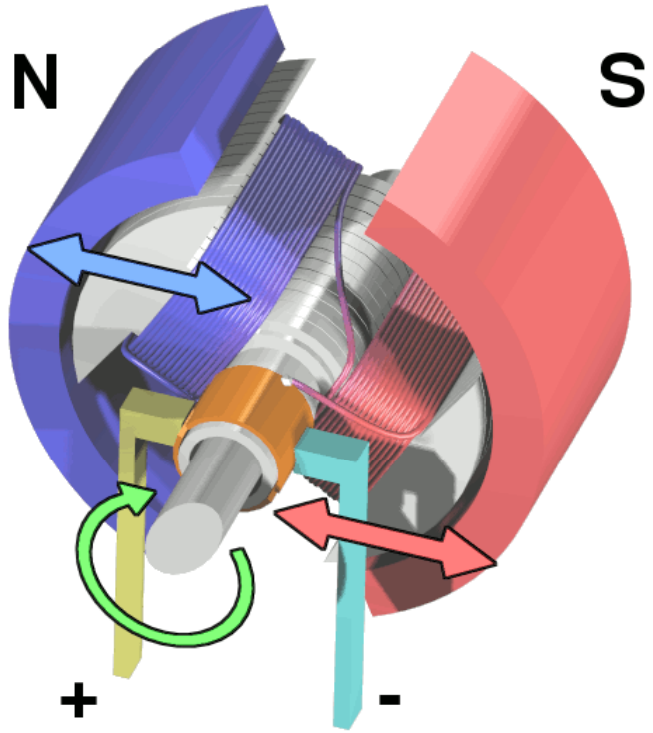
- Graphical Depiction of Construction



Parts of a DC Motor

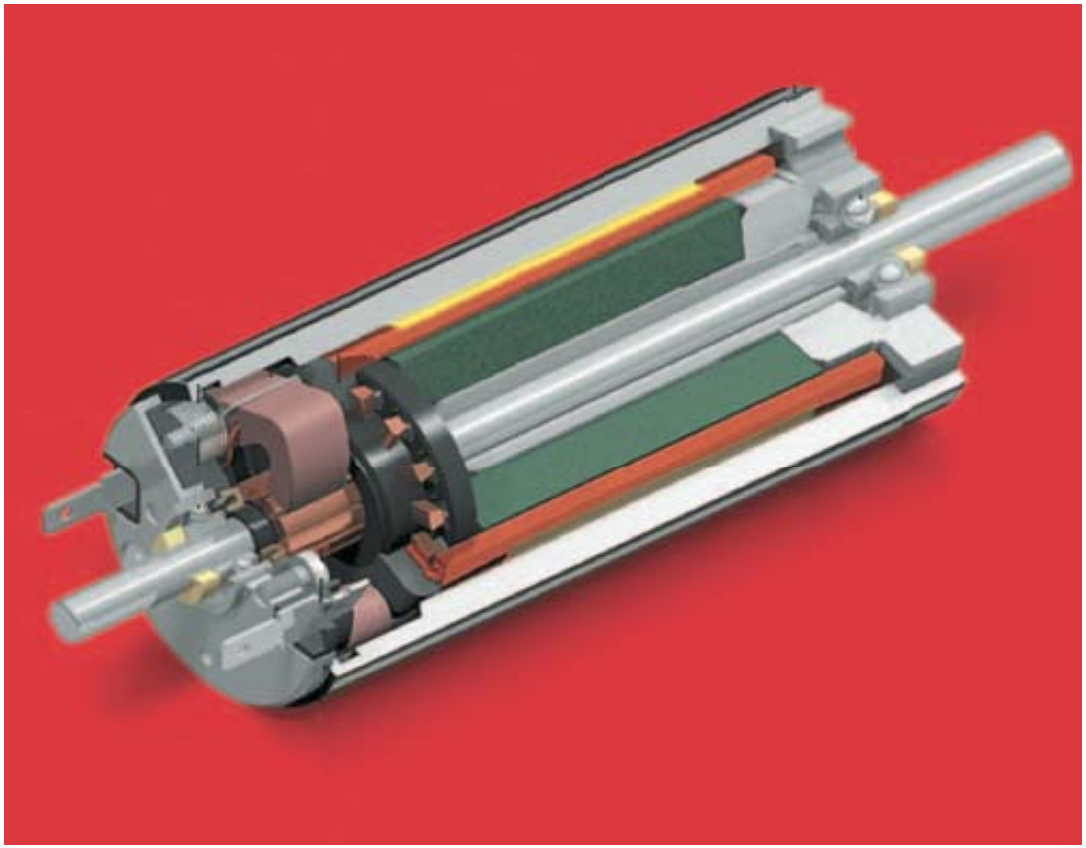
PM DC Motor

- Electromagnetic Forces



PM DC Motor

- Cross-Sectional View of a Real Motor



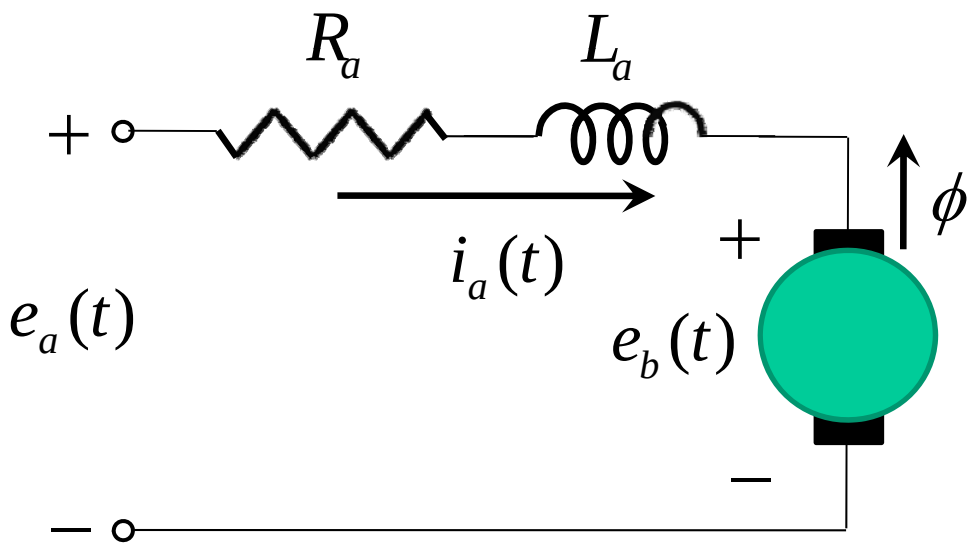
PM DC Motor

- Typical Specifications

. . . Precious Metal Brushes CLL, 1.6 W, sleeve bearings, 1 shaft		118643
1 Assigned power rating	W	1.6
2 Nominal voltage	Volt	3.00
3 No load speed	rpm	7740
4 Stall torque	mNm	4.07
5 Speed/torque gradient	rpm/mNm	1950
6 No load current	mA	27.0
7 Starting current	mA	1130
8 Terminal resistance	Ohm	2.66
9 Max. permissible speed	rpm-1	11000
10 Max. continuous current	mA	500
11 Max. continuous torque	mNm	1.81
12 Max. power output at nominal voltage	mW	811
13 Max. efficiency	%	71.9
14 Torque constant	mNm/A	3.61
15 Speed constant	rpm/V	2640
16 Mechanical time constant	ms	10.3
17 Rotor inertia	gcm²	0.503
18 Terminal inductance	mH	0.05
19 Thermal resistance housing-ambient	K/W	35.00
20 Thermal resistance rotor-housing	K/W	8.20

Electromechanical Systems

- Electrical Side:



PM DC Motor

- Analysis of Electrical Side:

$$e_a(t) = v_{R_a}(t) + v_{L_a}(t) + e_b(t)$$

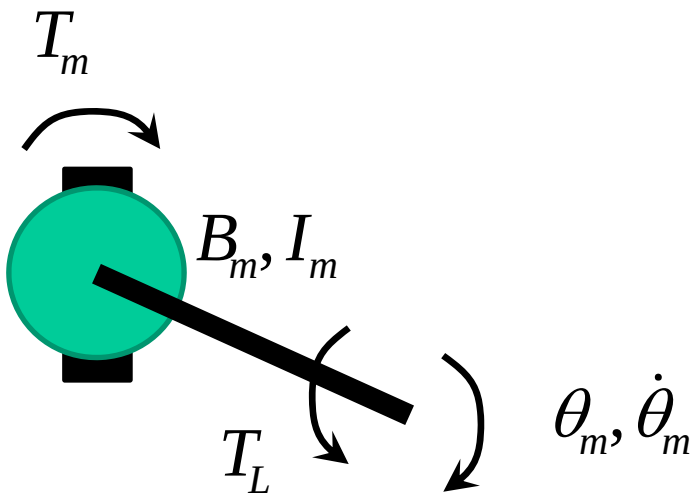
$$\frac{di_a(t)}{dt} = -\frac{R_a}{L_a} i_a(t) - \frac{1}{L_a} e_b(t) + \frac{1}{L_a} e_a(t)$$

$$e_b(t) = K_b \dot{\theta}_m(t) \quad \text{(Generator law)}$$

$K_b =$ Back-emf constant [Vs/rad]

Electromechanical Systems

- Mechanical Side:



PM DC Motor

- Analysis of Mechanical Side:

$$T_m(t) - T_L(t) - B_m\,\dot{\theta}_m(t) - I_m\,\ddot{\theta}_m(t) = 0$$

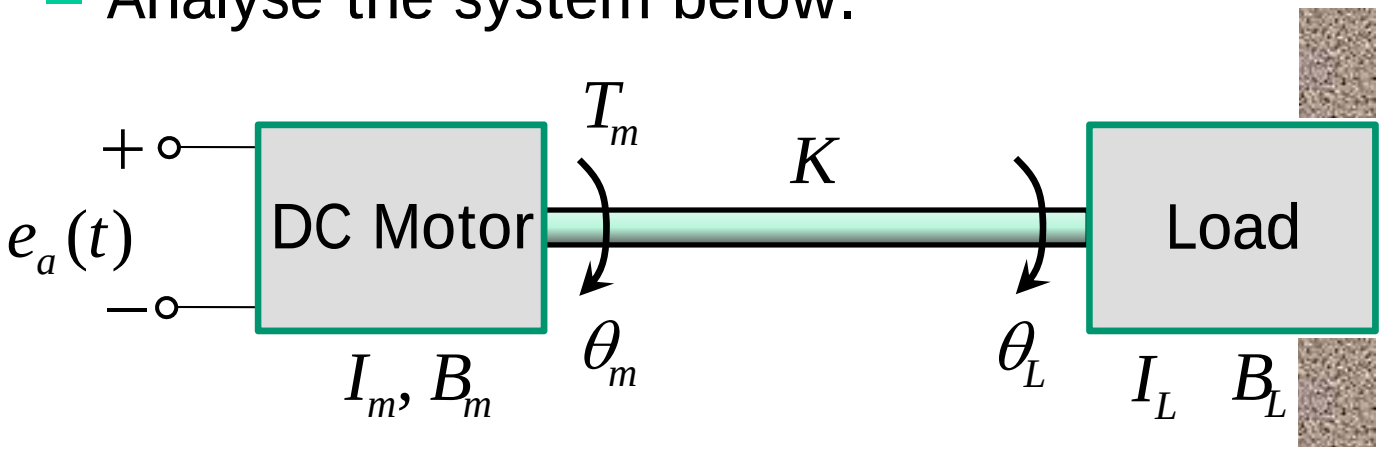
$$\ddot{\theta}_m(t) = \frac{1}{I_m}T_m(t) - \frac{1}{I_m}T_L(t) - \frac{B_m}{I_m}\dot{\theta}_m(t)$$

$$T_m(t) = K_i\,i_a(t) \qquad \text{(Motor law)}$$

$K_i =$ Torque constant [Nm/A]

Tutorial Exercises & Homework

- Tutorial Exercises
  - Analyse the system below.



- Homework
  - None

Conclusion

- Electromechanical Systems
  - Principles of Electromechanical Energy Conversion
  - Modelling of a PM DC Motor
- Tutorial Exercises & Homework

Next Attraction! – Miss It & You'll Miss Out!

- Time Domain Analysis (Burns, Chapter 3)

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Thank you!

Any Questions?