NTNU

Kunnskap for en bedre verden

Mathematics in a Programme for Electronic Systems Design and Innovation

Torstein Bolstad[1], **Lars Lundheim[1]**, **Morten Nome[2]** and **Frode Rønning[2]**

[1] Department of Electronic Systems

[2] Department of Mathematical Sciences

Norwegian University of Science and Technology

Trondheim

MARTA

MAtematikk som Redskap for TAnken
MAthematics as a Thinking Tool

MATT

- Collaboration between Mathematics and Electronic Systems
  - later this year to be extended to include Chemistry
- Teachers from mathematics and engineering work closely together
- Goals of the project:
  - Strengthen engineering students' experiences of the relevance of mathematics
  - Use mathematics in realistic engineering situations
  - Develop an approach driven by *contextual learning* (CDIO, Crawley et al., 2014)
- Necessary to develop deep conceptual learning (Marton & Säljö, 1976)
- Computational approach to mathematics
  - See CDIO Standards 3.0: Simulation-based mathematics
- One of seven pilots for the NTNU project *Technology Education of the Future*
  - "recommend a framework for development of NTNU's future study programme portfolio within technology"

TIM Examples

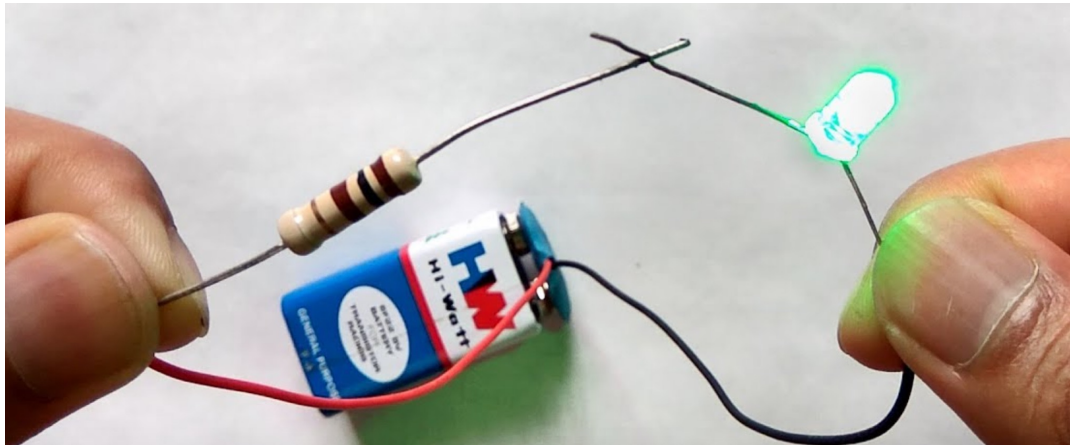
Thematically

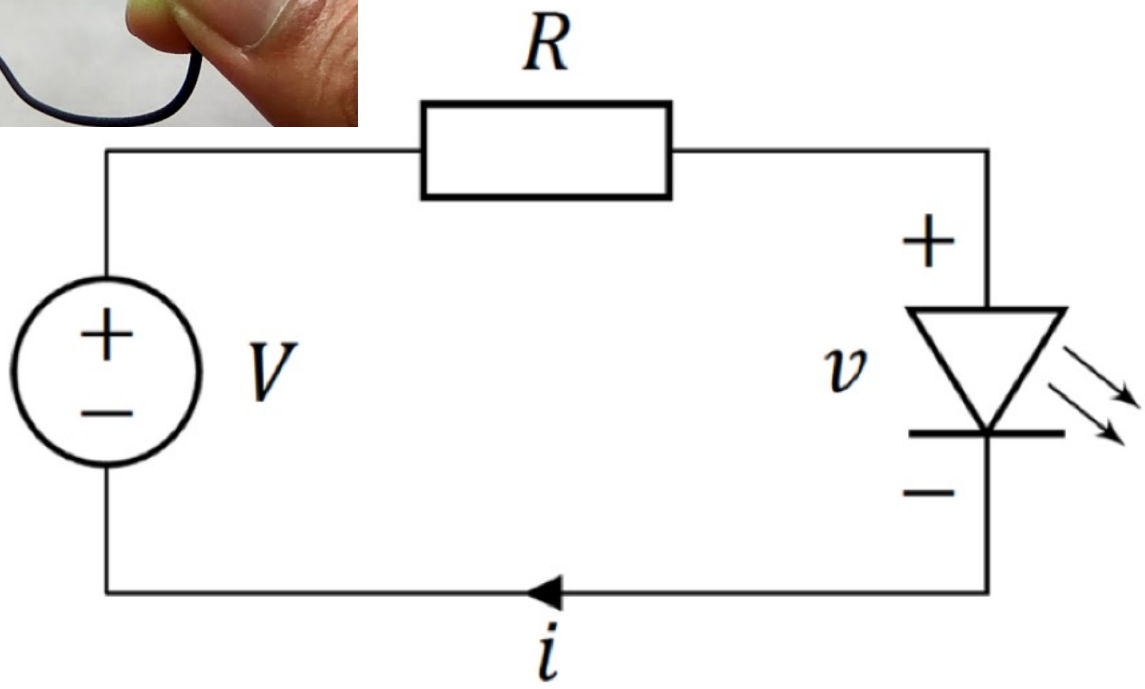
Integrating

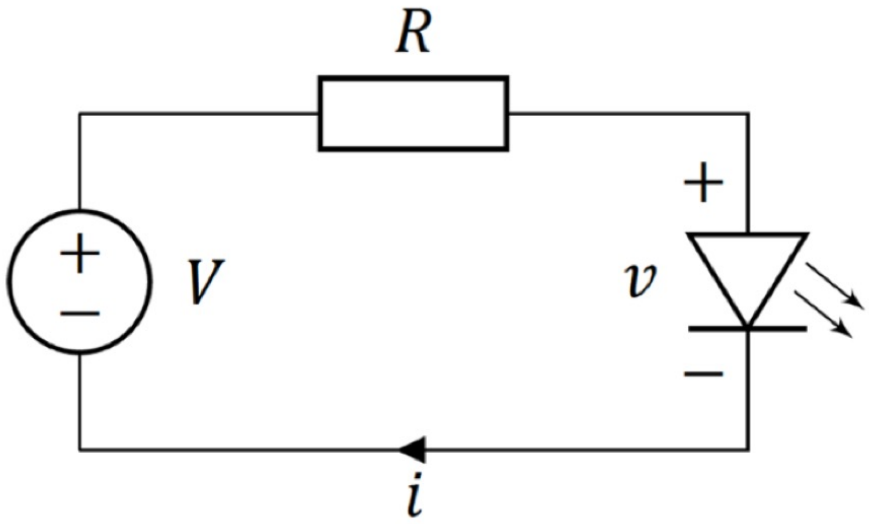
Motivating

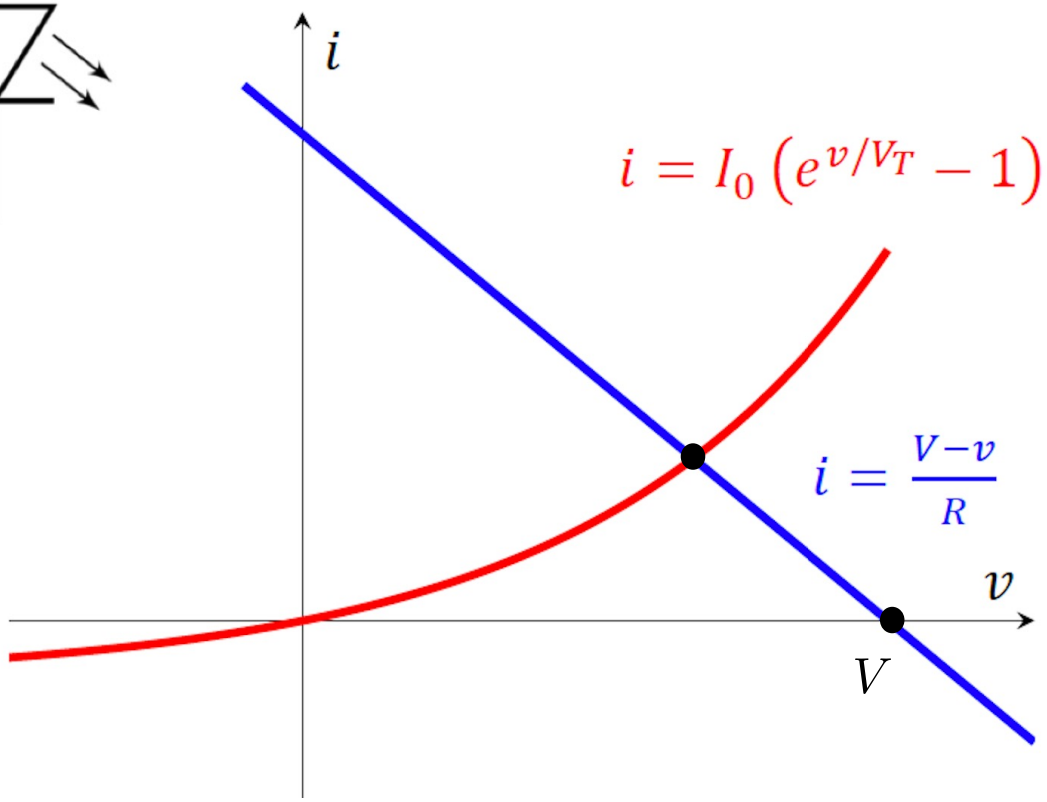
Examples

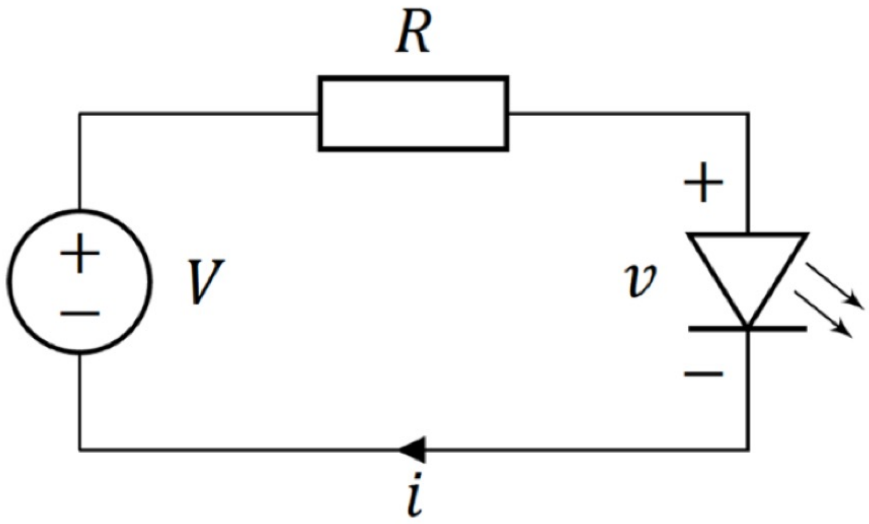
A simple circuit

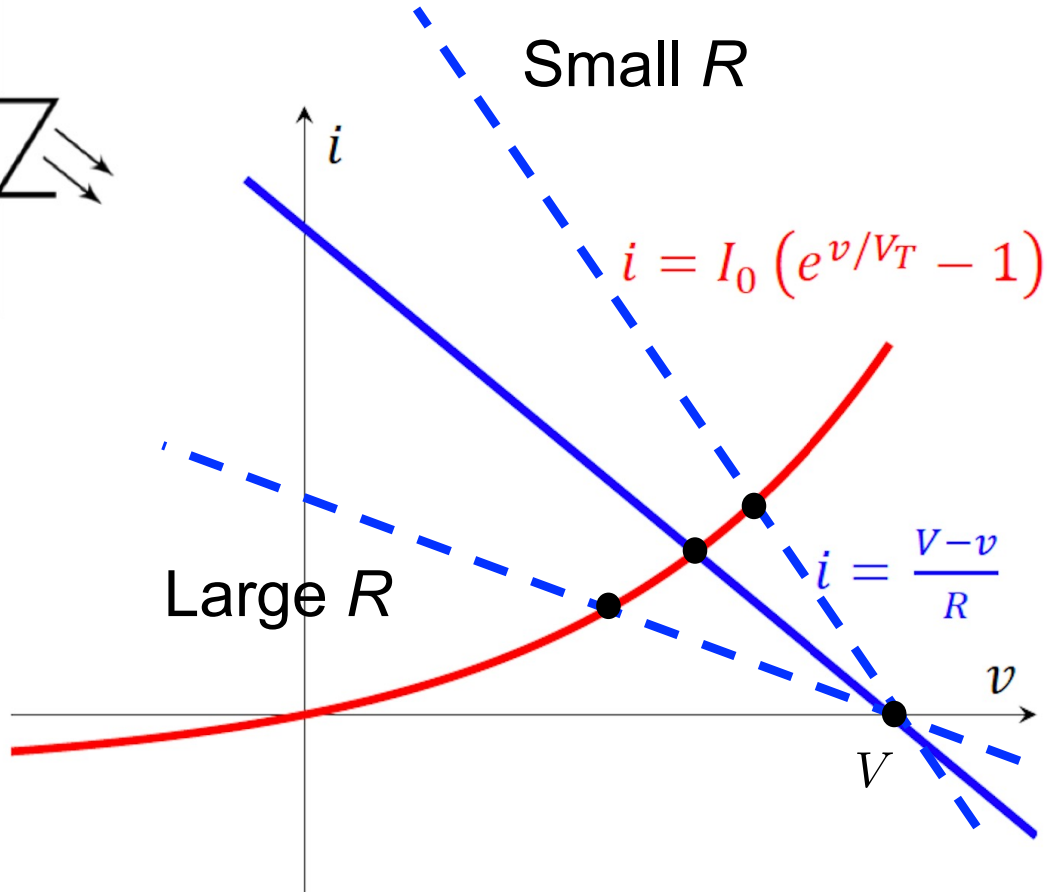





R
+
V
−
+
v
−
i


i
$i = I_0\left(e^{v/V_T} - 1\right)$
$i = \frac{V-v}{R}$
v
V


R
+
V
−
+
v
−
i


Small R
i
$i = I_0\left(e^{v/V_T} - 1\right)$
Large R
$i = \frac{V-v}{R}$
v
V

Thematic Integration

- Circuit theory
  - Kirchhoff's laws
  - Ohm's law
  - Non-linear behaviour (the diode)
- System of equations
- Exponential function
- A (first?) case of problems without an analytic solution
- Calls for numerical treatment

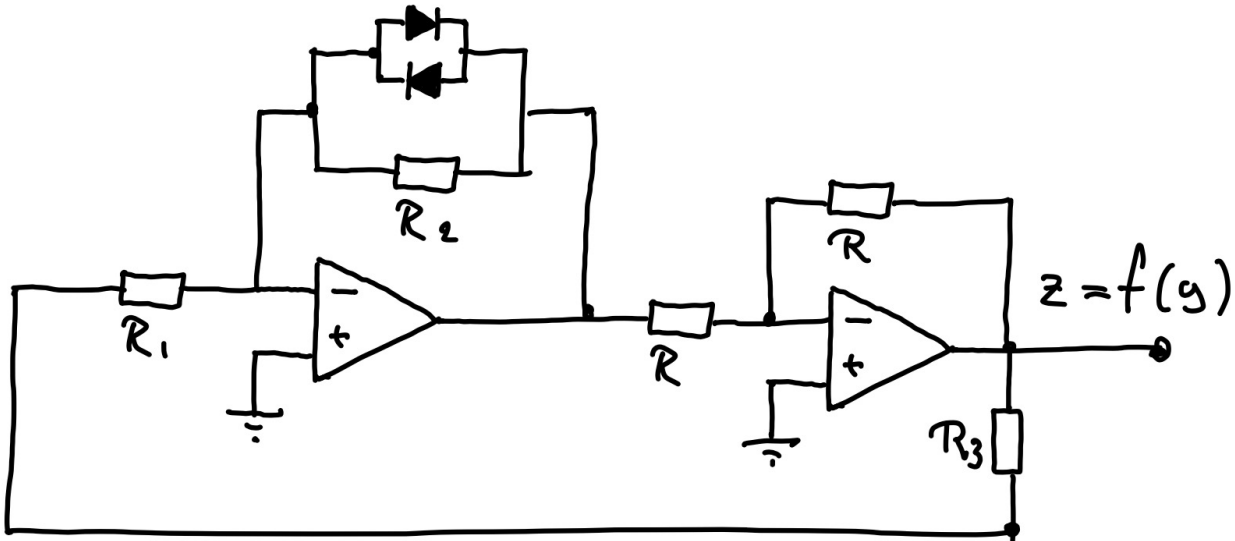
Solving the equation

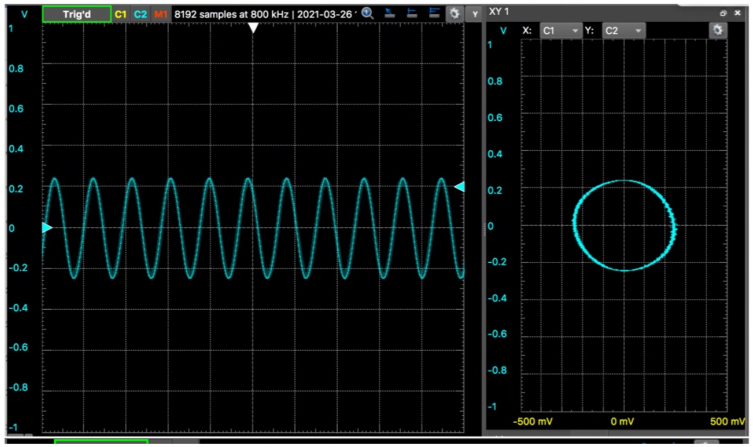
$$v = \ln(2 - v)$$

$$v_{n+1} = \ln(2 - v_n)$$

$$v = \lim_{n \to \infty} v_n \approx 0.442854....$$

A "long term" TIM Example





Mathematics involved in this example

$$\ddot{x} + f(x)\dot{x} + g(x) = 0$$

$$\dot{x} = z$$
$$\dot{z} = -f(x)z - g(x)$$

$$x_{n+1} = x_n + hz_n$$
$$z_{n+1} = z_n - h\left(f(x_{n+1})z_n + g(x_{n+1})\right)$$

TIM Examples for integration of teaching accross disciplines

- Encountered both in mathematics course and application course
- Are used in a planned way
- Instructors in both courses are aware of how the TIMEs are used in the parallell course
- Shared notation and vocabulary

Preliminary experiences and challenges

- It seems that there is much to be gained by seeing mathematics and engineering subjects in connection – and still keep the subjetcs' individual characters
- A close collaboration between teachers in the subjects is required
- NTNU has 17 master programmes in engineering
  - How many different versions of mathematics are necessary and realistic to offer?
  - What measures can be taken to develop contextual learning in a sustainable way?