Introduction to Robotics

Lecture 1: Introduction

17. 9. 2018

ParaDiSe

What Are We Up To

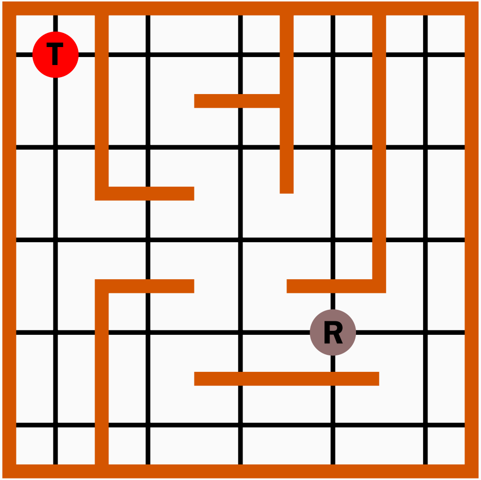
Build an overview in the robotics field from A to Z.

- get familiar with a low-level hardware & learn to tackle hardware-related problems
  - simple (digital) electronics
  - screws, glue, hacksaw...
  - etc.
- learn to program bare-metal MCUs
- get familiar with basic sensors & actuators
- learn the high level theory
- fill the gap between the low level stuff and high level abstracted view on robotics

What Are We Not Up To

- learn to produce industrial-grade robots
- getting tied to a specific platform
    - we will work with Atmel based 8-bit MCUs
    - but in theory we will cover other vendors and solutions
- learning advanced electronics & mechanics
    - no analog circuitry
    - no custom PCBs
    - no (sophisticated) custom mechanics

Project



Build an autonomous robot which is able to:

- move in square grid based maze
  - using guide lines and
  - walls
- explore the maze and fullfil given tasks:
  - find a spot with given property
  - build a map and navigate efficiently
  - possibly move an object around? (sokoban?)

Our Robot

What Is Expected From You

- attend the seminars
- bring you own laptop
- do your homeworks
- be proactive (eg. build test arena)
- use VCS and make your sources public so we can inspire & learn from each other

Electronics Preliminaries

Required Level of Knoweledge

Only a small subset of high-school physics & common sense is required

Voltage and Current

Voltage

- is a *potential* for current to flow
- denoted as U
- measured in volts (V)
- measured between two points

Current

- is an amount of electrons flowing
- denoted as I
- measured in ampers (A)
- measured on a single point

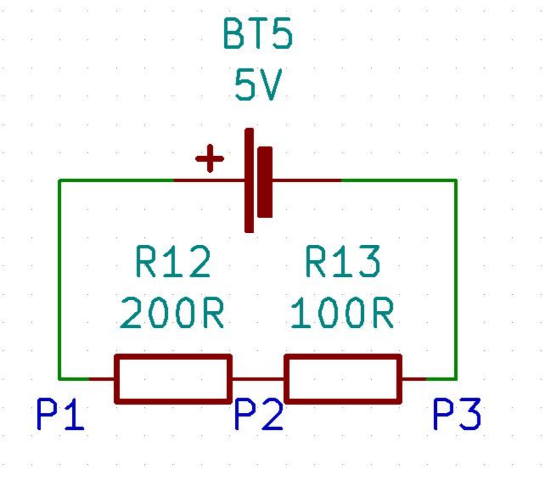
Watefall parable:

- voltage is the height, current is the amount of water
- "the power" is linear to the height and the amount

Current flows from positive to negative potential [1]

[1] electrons actually go the other way

Voltage and Current

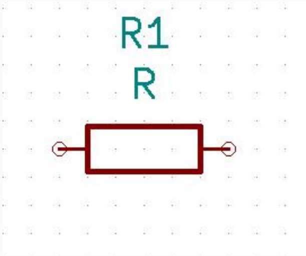


It makes sense to talk about:

- current at point P1
- current at point P2
- current at point P3
- voltage between points P1 and P2
- voltage between points P2 and P3
- voltage between points P1 and P3

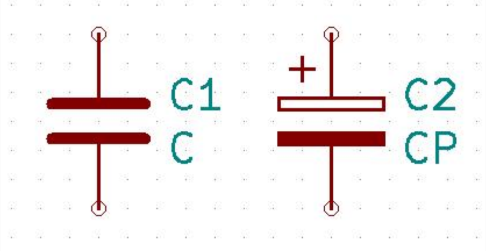
Nothing else makes sense.

Resistor



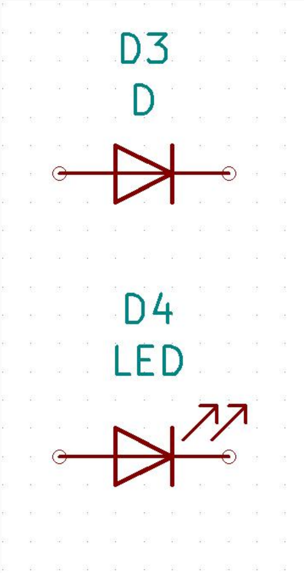
- limits the current flow
- properties:
    - resistance (R), measured in ohms (Ω)
    - maximal power dissipation, measured in watts (W)
- typical usage:
    - limit current (e.g. for LED)
    - divide voltage (pull-up/pull-down)
- notation of the units:
    - $42\ \Omega = 42R$
    - $4200\ \Omega = 4k2$
    - $2500000\ \Omega = 2M5$

Capacitor



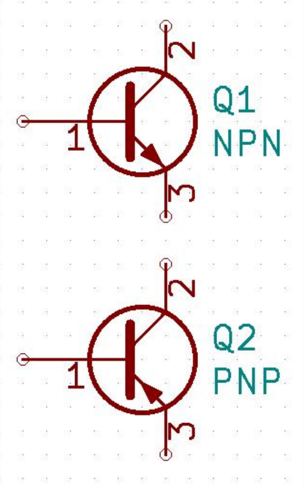
- stores (small amount) of energy
- properties:
  - capacity (C), measured in Farads (F)
  - maximal rated voltage
- typical usage:
  - analog circuitry
  - power filtering
  - oscillators
- notation of the units:
  - 10 pF = 10p
  - 100 nF = 100n
  - 4700 uF = 4u7

Diode



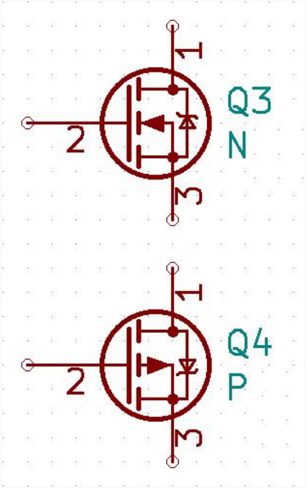
- conducts current only in one direction
- LED – light diode emitting
- properties:
  - forward voltage (V_f)
  - maximal current, (nominal current for LED)
- typical usage:
  - rectification
  - power spike filtering
  - LED – light

Transistor (bipolar)



- acts as a valve (small amount of current controls flow)
  - NPN – current going **into** base opens it
  - PNP – current going **from** base opens it
- properties:
  - maximal current
  - amplification (denoted h_{FE})
  - maximal switching frequency
  - maximal power dissipation
- typical usage:
  - power switch
  - basic element of logic gates

Transistor (unipolar)



- acts as a valve (voltage controls current flow)
    - N-channel – **positive** voltage between gate and source opens it
    - P-channel – **negative** voltage between gate and source opens it
- properties:
    - maximal current
    - maximal switching frequency
    - maximal power dissipation
    - GS-voltage to current characteristic
    - on-resistance
- typical usage:
    - power switching
    - low-power
- better parameters than bipolar, not so foolproof

Ohms law

$$U = I \cdot R$$

Electric power

$$P = U \cdot I$$

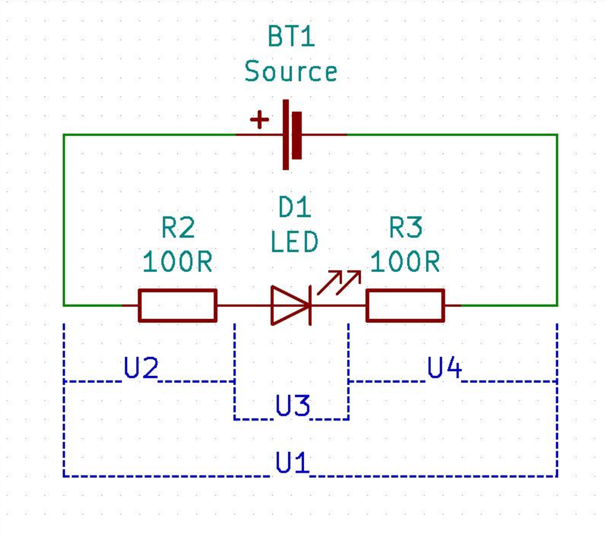
Kirchhoff's law

$$0 = \sum_{k=1}^{n} I_k, 0 = \sum_{k=1}^{m} U_k$$

Usage: everywhere

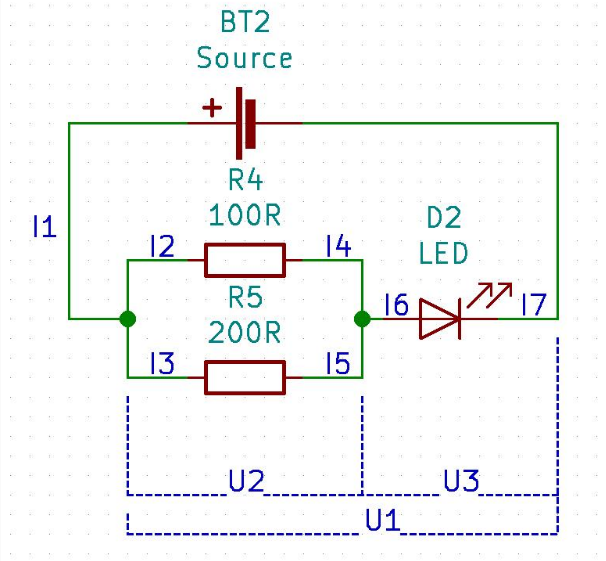
- resitor values
- power losses (thermal dissipation)
- voltage dividers
- etc.

Example – Serial Connection



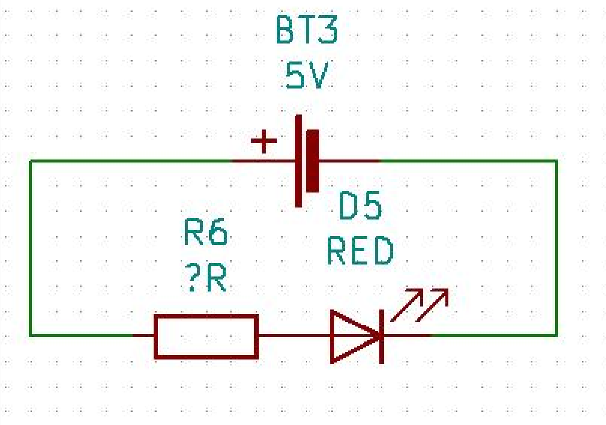
- there is the same current I going through all the points of the circuit
- U_1 is the voltage on the source terminals
- $U_1 = U_2 + U_3 + U_4$

Example – Paralel Connection



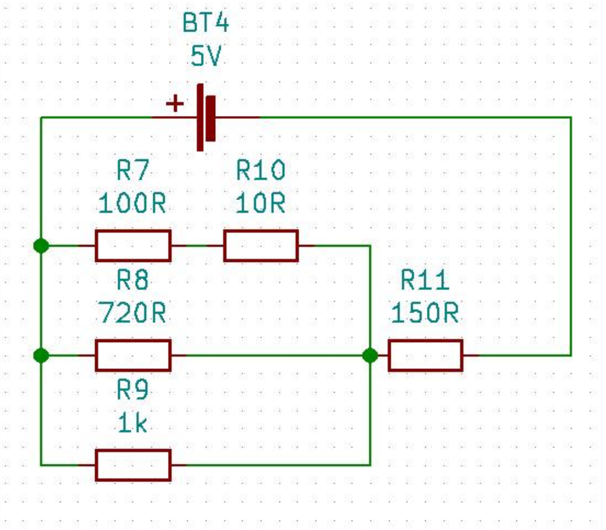
- U_1 is the voltage on the source terminals
- $U_1 = U_2 + U_3$
- $I_1 = I_6 = I_7$
- $I_2 = I_4$
- $I_3 = I_5$
- $I_1 = I_2 + I_3$

HW 1



- there is 5V voltage source
- desired current through LED is 10 mA
- forward voltage drop of red LED at 10 mA is 2.2 V
- what is an appropriate value for R6?

HW 2

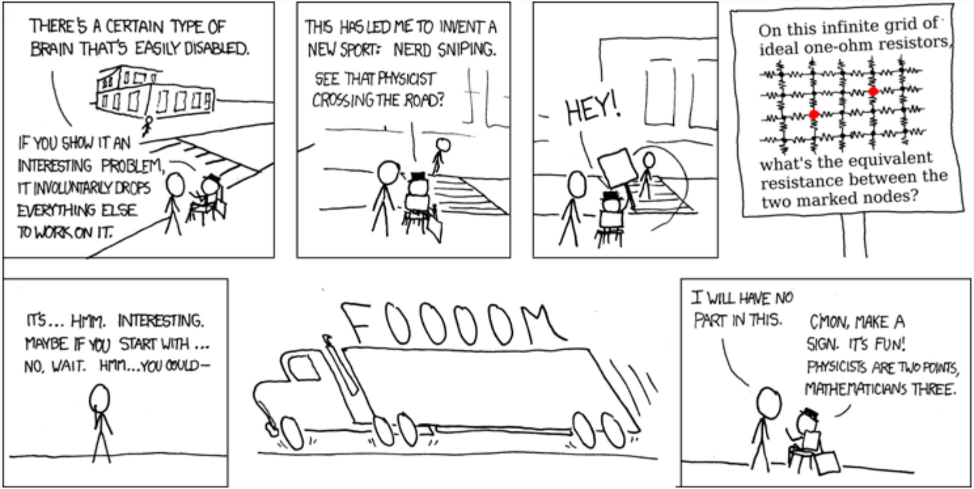


- identify all possible voltages and currents in the circuit
- think about their relations
- determine their values

HW 3

Prepare the PlatformIO toolchain on your machine for the next lecture.

`https://platformio.org/`



Source: `https://xkcd.com/356/`