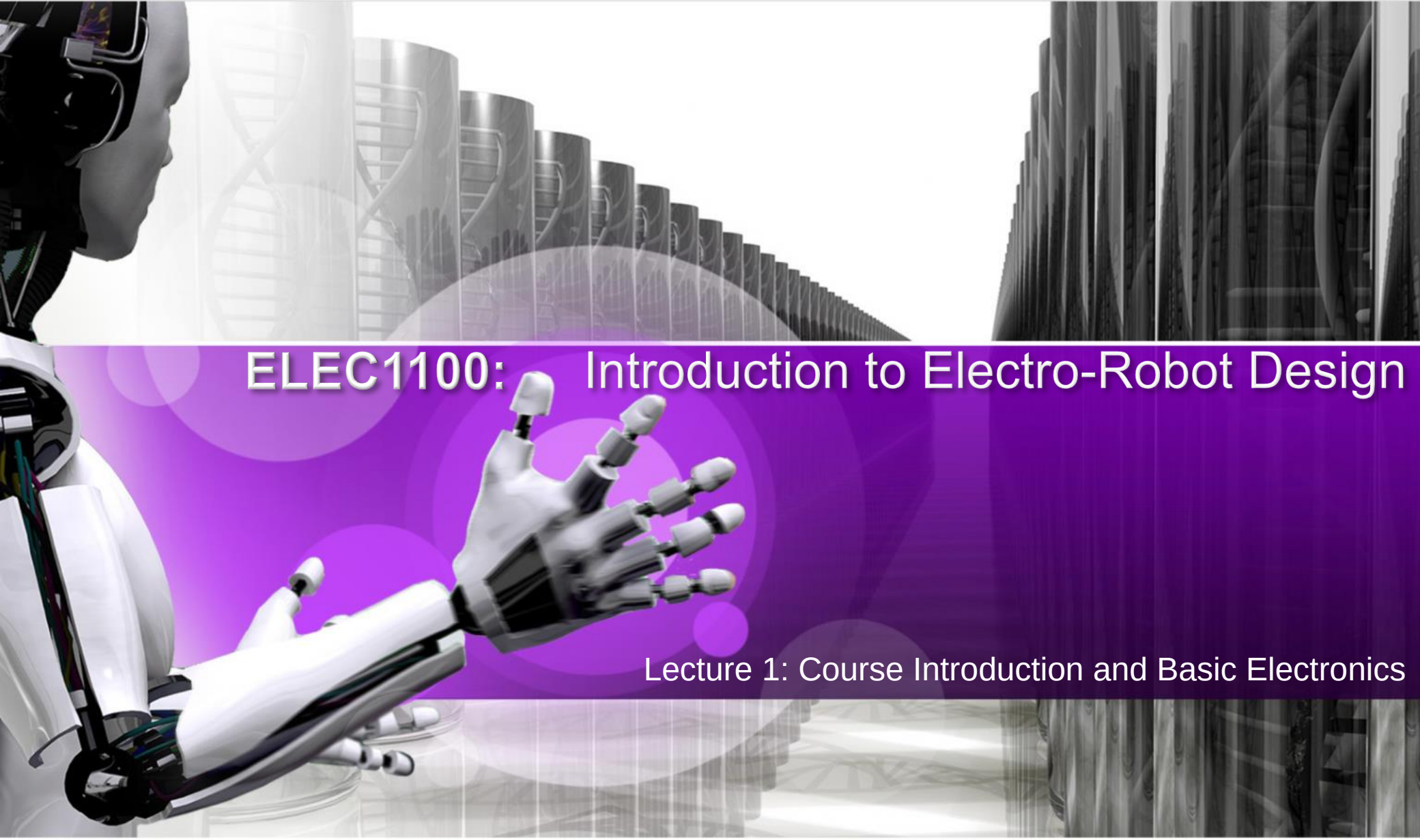


ELEC1100: Introduction to Electro-Robot Design

Lecture 1: Course Introduction and Basic Electronics

SONG Shenghui and MURCH Ross, Dept. of ECE, HKUST

COURSE DESCRIPTION

- ELEC1100 is designed to provide fundamental knowledge in electrical engineering, basic electronic components and the skills needed for the design, implementation and evaluation of a robot and its subsystems.
- It covers basic electronic engineering principles and techniques.
- Hands-on laboratory sessions, complemented with lectures and tutorials, are provided to allow students to have a systematic view of electronic engineering principles.
- Students apply the knowledge and principles learnt to design and build a functional robot by themselves.

INTENDED LEARNING OUTCOME

- Through hands-on labs and a term project, complemented with lectures and tutorials, you will be able to:
  - *Analyze* and *design* simple analog circuits, combinatorial and sequential logic circuits, and *design* and *implement* simple feedback control strategies.
  - *Build* and *debug* real engineering system following a hierarchical design principle.
  - *Work* in a team environment: learn and practice effective project and time management.
  - *Execute* a complete project from problem formulation, design/implementation, up to verification and documentation.

TEACHING METHODOLOGY

- Limitations with traditional teaching:
  - The traditional education system was developed in the industrial revolution and does not evolve well to the information era
  - Teaches knowledge, but not how to apply knowledge
  - School does not warn students that the knowledge taught may become obsolete upon graduation
  - Many skill based non-evolving jobs will eventually be replaced by AI
- Question to think about:
  - One month after taking a class, how much material can you still recall?

REVERSE ENGINEERING APPROACH

- Traditional approach:
  - Mathematics ➔ Physics ➔ Engineering
- Reverse engineering approach:
  - Engineering ➔ Physics ➔ Mathematics
  - Many things can be learned, but not taught
  - Learning requires an objective, which is usually from needs and experience

Tell me and I forget.
Teach me and I remember.
Involve me and I learn.

WHAT IS THIS CLASS ABOUT?

- It is NOT a LEGO robot programming class

- We start from the most basic concepts and construct a robot from basic components
- You will learn the following
  - managing power supply
  - driving motors
  - reading sensor output
  - logic control and decision making
- You will construct an autonomous "robot" to finish a task

CLASS SCHEDULE

Go to Canvas to join ZOOM meeting for each class

(Course website: http://canvas.ust.hk/)

- Lectures:
  - L1: Mon & Wed 09:30-10:20 by Prof. SONG, Shenghui
  - L2: Mon & Wed 12:00-12:50 by Prof. SONG, Shenghui
  - L3: Tue & Thu 12:00-12:50 by Prof. MURCH, Ross
- Labs:
  - LA1: Wed 12:00-14:50 LA2: Thu 09:00-11:50 LA3: Mon 13:30-16:20
- Tutorials:
  - T1: Thu 18:00-18:50 by TANG Yimeng
  - T2: Tue 18:00-18:50 by WU Fox
  - T3: Thu 19:00-19:50 by TANG Yimeng

TEXT AND REFERENCE BOOK

- Major Text: No major text, mainly use hand-outs provided by the instructors

- Major Reference:
  - L. Richard Carley and Pradeep Khosla, “Introduction to Electrical and Computer Engineering- taught in Context”, The McGraw-Hill Companies, Inc.
  - G. Rizzoni “Principles and Applications of Electrical Engineering,” 5th edition, McGraw Hill, 2007
  - D. V. Kerns and J.D. Irwin, “Essentials of Electrical and Computer Engineering”, Pearson, 2004
  - M. M. Mano, C.R. Kime, “Logic and Computer Design fundamentals”, 3rd edition, Prentice-hall, 2004

TENTATIVE COURSE SCHEDULE

Week	Start (Mon)	Lecture#1	Lecture#2	Tutorial	Lab
1	17-Feb	No Lecture (Feb 17 &18)	01: Course Introduction (Feb 19 & 20)	No Tutorial	No Lab
2	24-Feb	02: Basic Components	03: Energy & Power	Introduction to Lab#1	No Lab
3	02-Mar	04: DC Sources	05: Pulses Generation	Introduction to Lab#2	Lab#1: Equipment
4	09-Mar	06: PWM Control	07: Transistor	Introduction to Lab#3	Lab#2: Diode & DC Regulation
5	16-Mar	08: H-bridge	09: KCL & KVL	Introduction to Lab#4	Lab#3: Pulse & Counter
6	23-Mar	10: Sensor	11: Logics	No Tutorial	Lab#4: Transistor & H-bridge
7	30-Mar	12: K-map	13: MCU, Arduino Hardware & Software	Introduction to Lab **Homework**	Lab Homework
8	06-Apr	14: Arduino Code (I): Functions	15: Arduino Code (II): Variables & Structure	Introduction to Lab#5	Lab Homework
9	13-Apr	No Lecture (Apr 13 & 14) **Easter Monday**	16: Arduino Code (III): Conditional Statement	Introduction to Lab#6	LA3: **Easter Monday** **No Lab** LA1 & LA2 (Wed & Thu): Lab#5: Sensor & MCU
10	20-Apr	17: Final Project	18: **Online Exam Review**	Intro. to **Project & Online Exam**	LA3 (Mon): Lab#5: Sensor & MCU LA1 & LA2(Wed & Thu): Lab#6: Logic Design
11	27-Apr	Project Period	Project Period	Project Period	LA3 (Mon): Lab#6: Logic Design
12	04-May	Project Period	Project Period	Project Period	Project Period
13	11-May	Early Demo (11 May)	Project Period	Project Period	Project Period
13	18-May	Final Demo (18 May)			Report Deadline (22 May)

Check the Full Schedule on Canvas

Check your HKUST email account frequently

****Online Exam: May 02 (Sat), 10:00am-12:00noon**

TEACHING TEAM [1]

- Instructor (L1 & L2)

Prof. SONG Shenghui
Office: Room 2524
Tel: 2358-5033
E-mail: eeshsong@ust.hk

Office hour: By appointment

- Instructor (L3)

Prof. MURCH Ross
Office: Room 2417
Tel: 2358-7044
E-mail: eermurch@ust.hk

Office hour: By appointment

TEACHING TEAM [2]

- Instructional Assistant
  (Administrative matters, Tutorials)

TANG Yimeng
Office: Room 2395
E-mail: eetangy@ust.hk

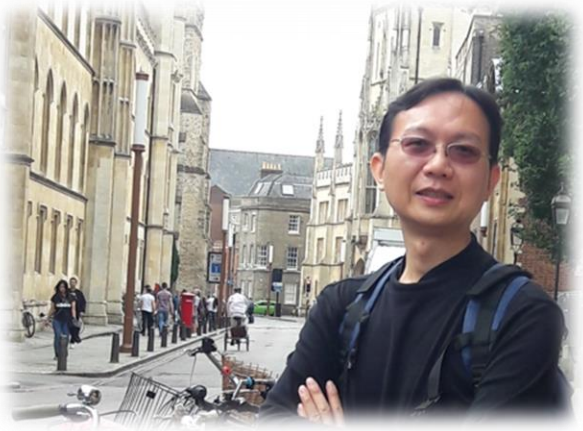
- Teaching Associate
  (Administrative matters, Tutorials)

WU Fox
Office: Room 2395
E-mail: eefox@ust.hk

TEACHING TEAM [3]

- Technical Officer:

NG Allen
E-mail: eeallen@ust.hk



- Technical Officer:

CHENG Joseph
E-mail: cscheng@ust.hk

CLASS EXPECTATION

- Attend lectures, tutorials & labs on time and be ready to learn.
- Be active during classes: ask questions and try to think before you ask.
- Use lab equipment properly and cooperate with others.
- Enjoy the experience and have a good time!

MIXED MODE COURSE DELIVERY

- From March 16, 2020 the university, subject to confirmation, may switch to mixed mode delivery.
  - Lectures and Tutorials: In mixed mode delivery you may attend the lectures and tutorials online using zoom or physically in the assigned classroom. You may decide and switch on a lecture by lecture basis.
  - Labs: In mixed mode delivery you may perform labs online using the circuit simulator, **Tinkercad** or physically attend the labs.
    - You will however need to find a lab partner to do the ***physical lab***.
    - You may decide and switch on a lab by lab basis as long as both you and your lab partner switch together.
- Further details provided once mixed mode starting date is confirmed.

COURSE GRADING

- LABS (mixed-mode): 6 lab assignments (30% total), online submission;
- HOMEWORK: 1 lab homework (15%), online submission;
- QUIZ: Pop-up In-class quizzes (open book, 15% total), stick with your enrolled lecture session, ***no marks*** given to any attempt at the other two.
- EXAMS: 1 online exam (15%)
- PROJECT (mixed-mode):
  - Physical Class: Project demo (20%) and project report (5%)
  - Online Class: Coding project (20%) and project report (5%)

GRADING POLICY

- About late submission:
  - 50% penalty mark will be given to a late submission within 3 hours.
  - Zero mark will be given to more than 3-hour late submission.
- About make-up:
  - NO make-up of Pop-up Quiz, only the top 70% performance will be counted.
  - For any other grading components, if you missed one due to a justified reason, please submit the proof to your IA Yimeng (eetangy@ust.hk) within one week for arrangement of a make-up session.

All requests for special accommodation for medical reasons must be accompanied by the **hard copy of the original medical certificate**

LAB ARRANGEMENT - ONLINE

- Before the lab:
  - Attend Tutorial to be prepared for the lab.
  - Read over the lab manual.
  - Get your PC ready for running circuit simulation online Tinkercad https://www.tinkercad.com/.
- During lab: TA Check & Lab Summary Sheet
  - Complete the circuits online and show demo to your TA at **lab ZOOM meeting.**
  - **Each student** should complete his/her own **lab sheet** and submit on Canvas: http://canvas.ust.hk/ before the **deadline**.
    - LA1: Wed 12:00-14:50 (Deadline)
    - LA2: Thu 09:00-11:50 (Deadline)
    - LA3: Mon 13:30-16:20 (Deadline)
  - Failure to do so may result in a **zero mark**

LAB ARRANGEMENT - PHYSICAL

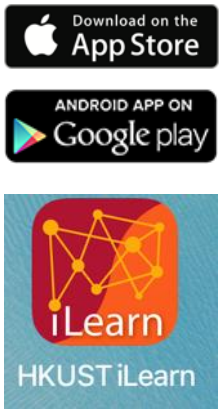
- Form teams for the labs & final project (2 students per group)

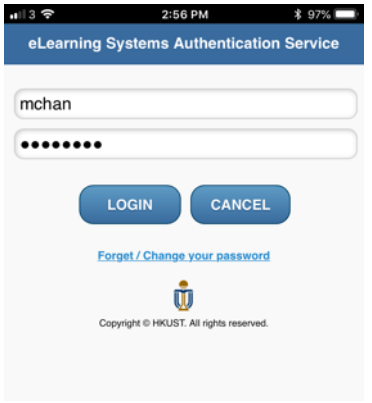
- Before the lab:
  - Attend Tutorial to be prepared for the lab.
  - Read over the lab manual.
  - Print out lab sheets by yourself if needed.

- During lab: TA Check & Lab Summary Sheet
  - Complete the circuits on a given breadboard and show demo to your TA.
  - **Each student** should complete his/her own **lab sheet** and submit on Canvas: http://canvas.ust.hk/ before the **deadline**.
    - LA1: Wed 12:00-14:50 (Deadline)
    - LA2: Thu 09:00-11:50 (Deadline)
    - LA3: Mon 13:30-16:20 (Deadline)
  - Failure to do so may result in a **zero mark**

ACCESSING iPRS

- You need a mobile device
  - Download HKUST iLearn app for iPRS





- **You are responsible for the connection and performance of your own mobile device**

TRIAL QUIZ [1]: not for distribution

- Which fictional robot (s) you like the most?

1. C-3PO & R2 D2
(Star Wars)

2. Doraemon

3. Wall-E & Eve
(Disney)

4. T-800
(The Terminator)

TRIAL QUIZ [2]: not for distribution

- What field you think a robot would be more useful?

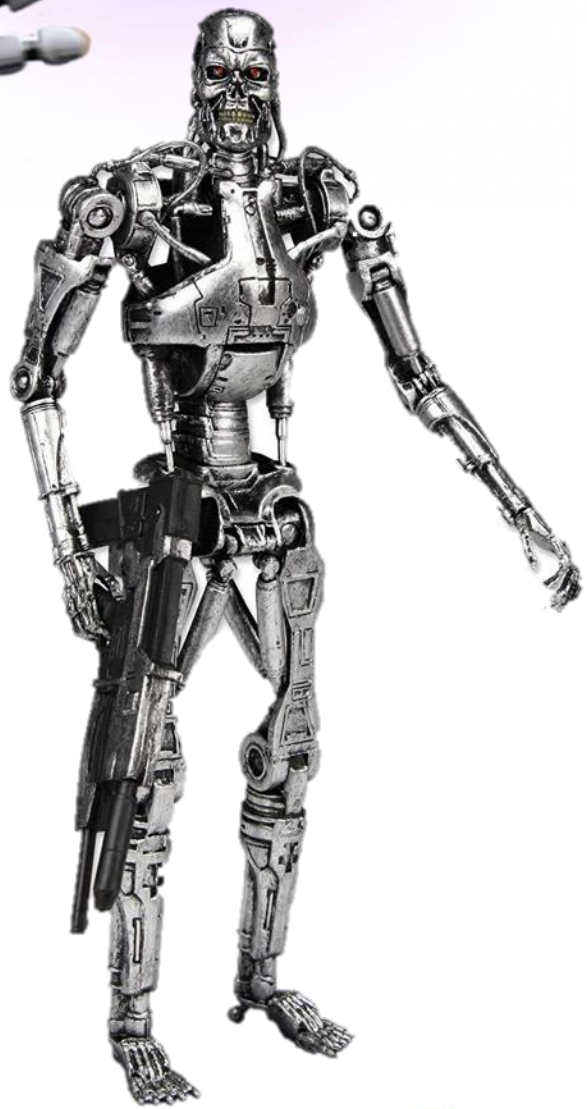
1. To do space exploration
2. To do surgery assistance
3. To do cargo delivery
4. To do house clean work

THE HKUST ACADEMIC HONOR CODE

- Honesty and integrity are central to the academic work of HKUST.
  - Students of the University must observe and uphold the highest standards of academic integrity and honesty in all the work they do throughout their program of study.
  - As members of the University community, students have the responsibility to help maintain the academic reputation of HKUST in its academic endeavors.
  - Sanctions will be imposed on students, if they are found to have violated the regulations governing academic integrity and honesty.

http://tl.ust.hk/integrity/honor.html

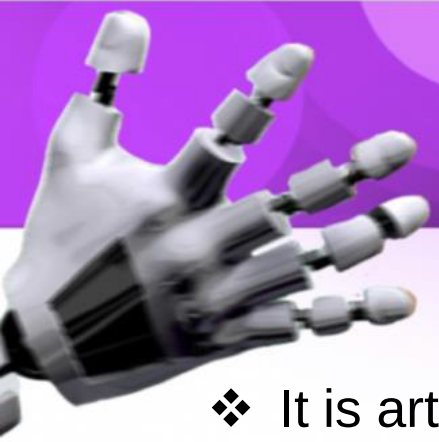
WHAT IS A ROBOT?



Robots in the movies

ORIGIN OF ROBOT

- The word "**robot**" was first introduced in Czech playwriter Karel Capek's play R.U.R. (Rossum's Universal Robots) in 1921.
- The word "**robotic**" was first used in Runaround, a short story published by Issac Asimov in 1942.
- These were way before modern ECE technologies, such as computer, IC, transistors, and AI, became well-developed and impacted on our daily life.



FEATURES OF A ROBOT

- It is artificially created and programmable
  - Q: are animals robots?
- It can sense its environment, and manipulate or interact with things in it
  - Q: is a motorcycle a robot?
- It has some abilities to make choice based on the environment, often using automatic control or preprogrammed sequence
- It moves without direct human interaction
  - Q: is a helicopter a robot?

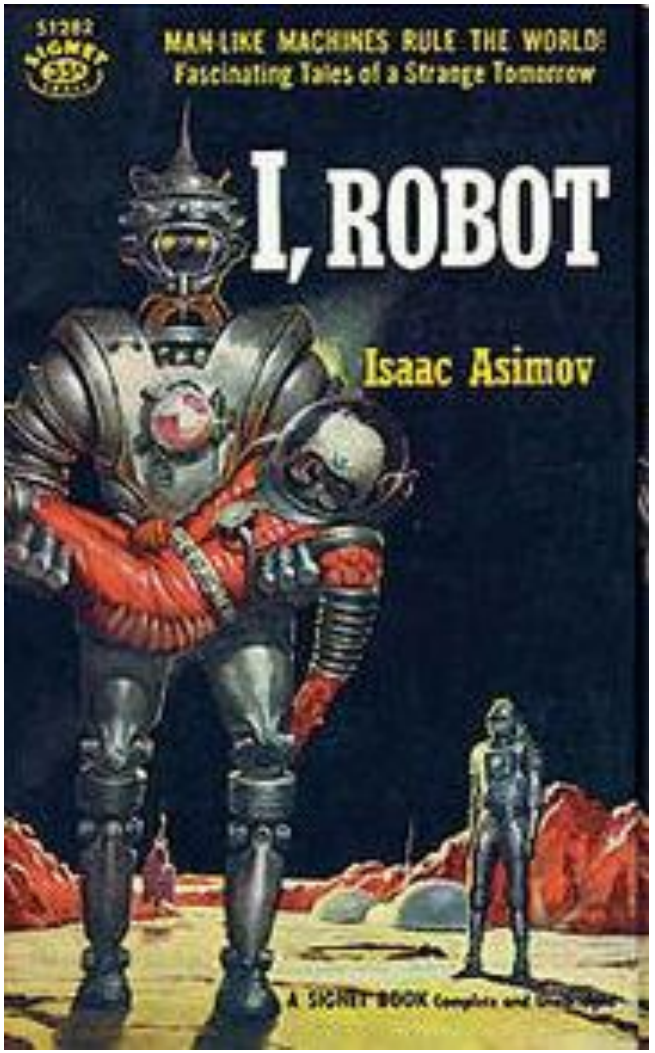
- Can you list some other features?

THE THREE LAWS OF ROBOTIC (1950)

- Defined by Isaac Asimov in 1950
- A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- A robot must obey any orders given to it by human beings,

  except where such orders would conflict with the First Law.
- A robot must protect its own existence

  as long as such protection does not conflict with the First or Second Laws.



MORE RECENT DEFINITION OF ROBOTS

- According to the Robot Institute of America (1979), a robot is:

  "*A reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks*"

- A more inspiring definition can be found in Webster:

  "*An automatic device that performs functions normally ascribed to humans or a machine in the form of a human*"

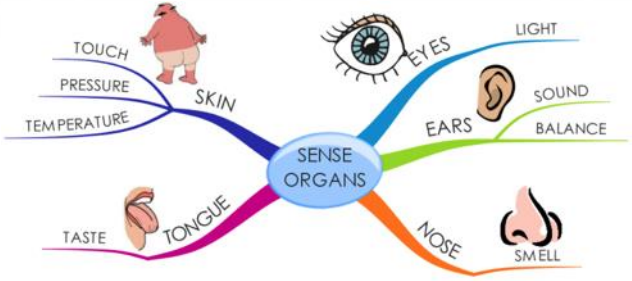
- **Robotics:** the science of perceiving and manipulating the physical world through computer-controlled mechanical devices.

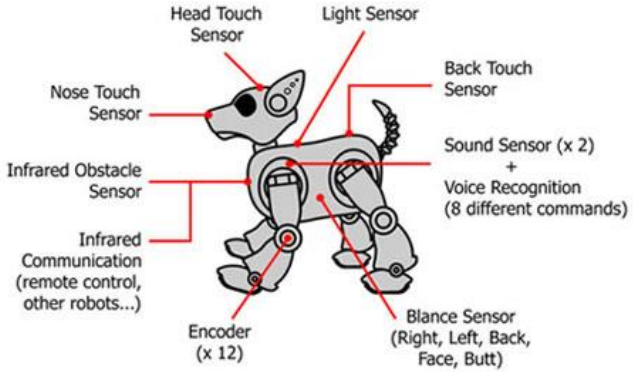
FIRST REAL ROBOT

- Inspired by Issac Asimov's, Joseph F. Engelberger (also known as the father of robotics) started working on real robot in 1956 with G. C. Deveol.
- In 1961, first commercial robot "Unimate" was deployed in GM car manufacturing plant to work with heated die-casting machines.
- From then onwards, more robotics were being designed and developed with the help of micro-electronics.

HUMAN VERSUS ROBOT

- Perceiving





- Computation

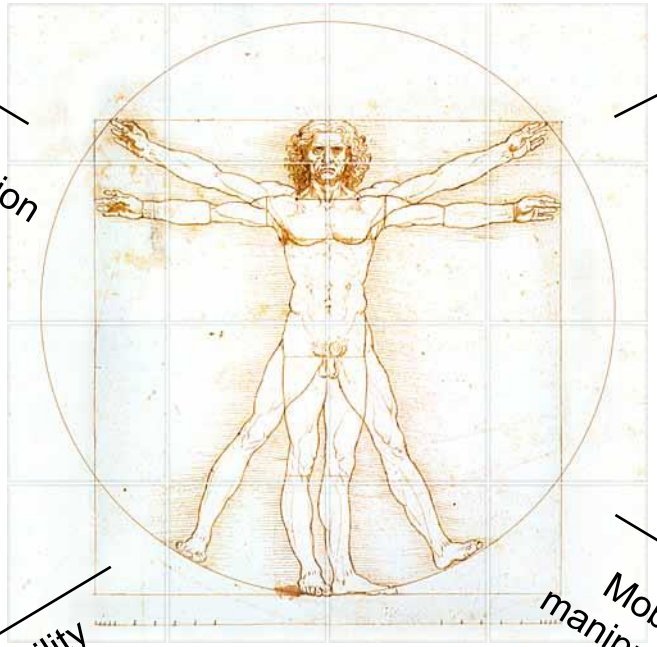
- Manipulation

ANALOGUE OF ROBOT WITH HUMAN BODY

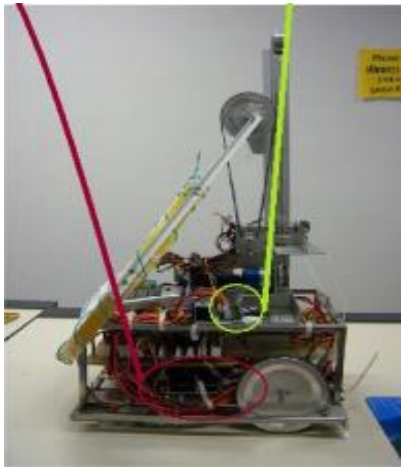
	Human	Robot
Sensing	eyes, ears, nose, tongue, skin	light sensor, microphone, temperature sensor, chemical sensor, motion detector
Structure	head, body, arm leg …	motion parts, joints
Motion	muscles, bones	motors, actuators, relays
Fuel	food, oxygen	battery, natural gases, solar cells
Control	brain	logic unit, micro-controller
Internal communication	nerve	wires, optical links
External communication	speech, actions	signal lines, sensor signals, wireless

TYPE OF ROBOTS

Manipulation



Humanoid



Mobility

Mobile manipulation

MOBILE ROBOTS

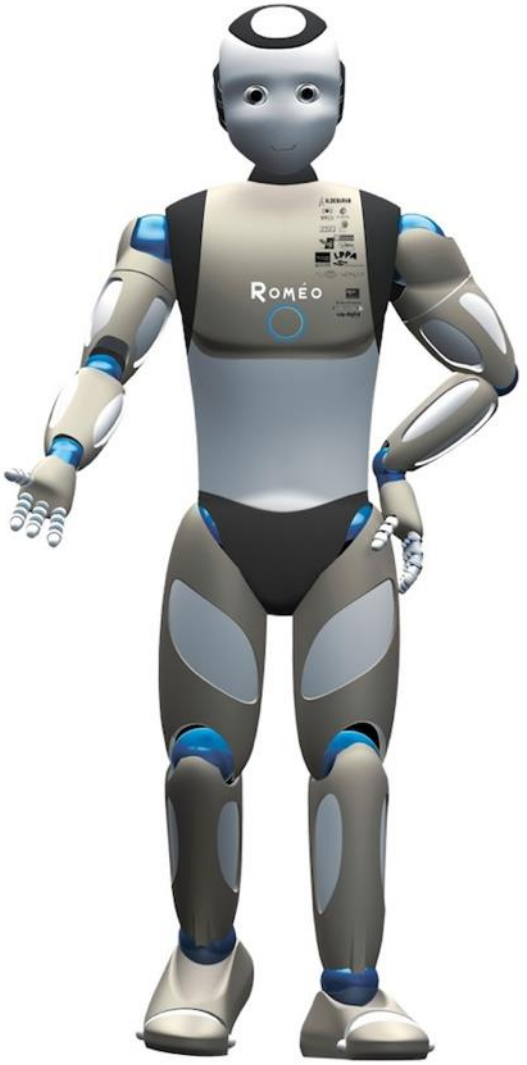
- Sensing
  - Vision, Sonar, GPS, Gyro Compass
- Controller
  - Signal processing, map in memory, planned motion command, control algorithm
- Power
  - DC Power for analog & digital circuits
  - Solar and portable energy source
- Mechanical motion
  - Wheels/ axles, structures

MOBILE MANIPULATORS

- Sensing
  - Vision, Sonar, GPS, Gyro Compass
- Controller
  - Signal processing, map in memory, planned motion command, control algorithm
- Power
  - DC Power for analog & digital circuits
  - Solar and portable energy source
- Mechanical motion
  - Wheels/ axles, structures, manipulator

HUMANOID

- Sensing
  - Vision, Sonar, Gyro, microphone, pressure, temperature, chemical etc.
- Controller
  - Signal processing, control algorithm, motion pattern generation
- Power
  - DC Power for analog & digital circuits
  - Solar and portable energy source
- Mechanical motion
  - Motors and structure
  - Head, arm, body, legs



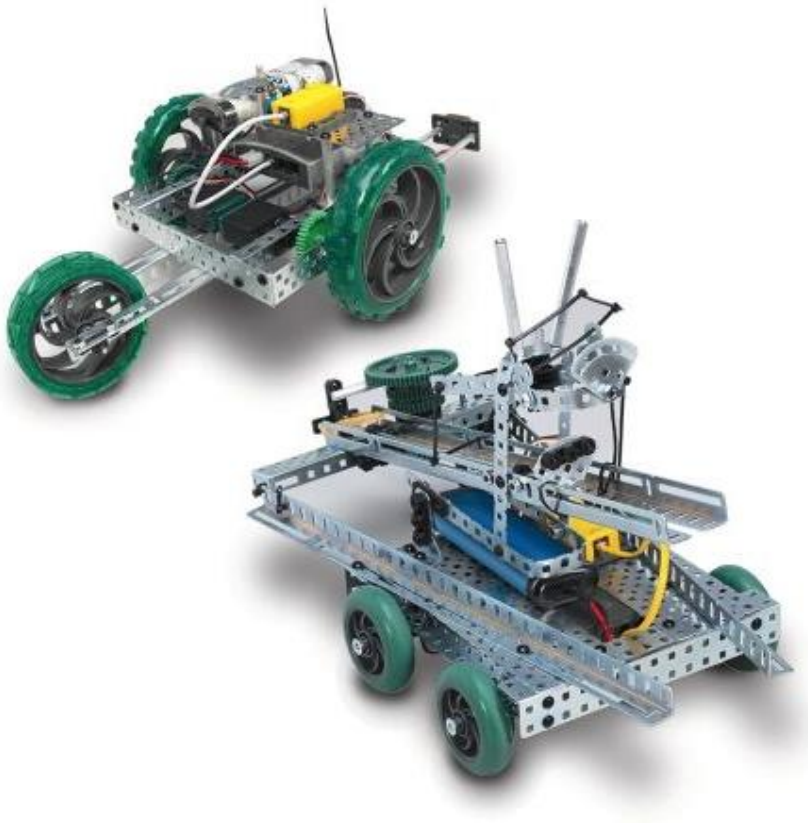
SUMMARY

- Robots can be classified into 4 main types:
  - Manipulators
  - Mobile manipulators
  - Mobile robot
  - Humanoid
- Robot has some basic components:
  - Power subsystem
  - Sensors
  - Controller
  - Mechanical motion system

HIERARCHICAL DESIGN

- Complex systems (e.g. robot) are usually composed of numerous sub-systems

- To make the design more manageable, we usually use a "divide-and-conquer" approach for designing complex system
- The divide-and-conquer approach is also used in the sub-system design
- We call this hierarchical decomposition of designs

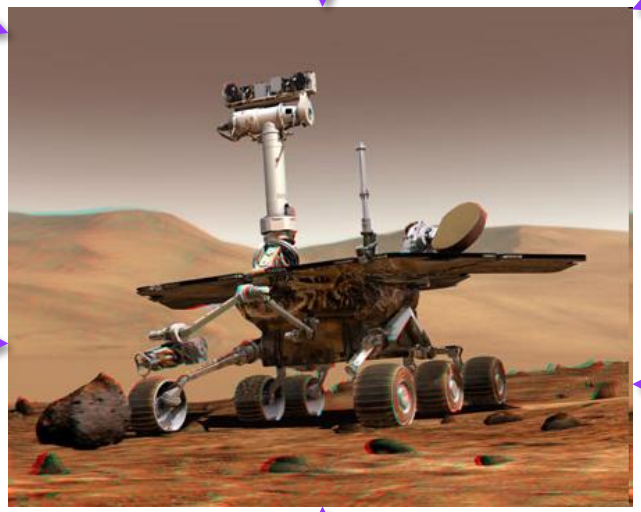


MARS ROVER

Communication Team

Control Team

Signal Processing

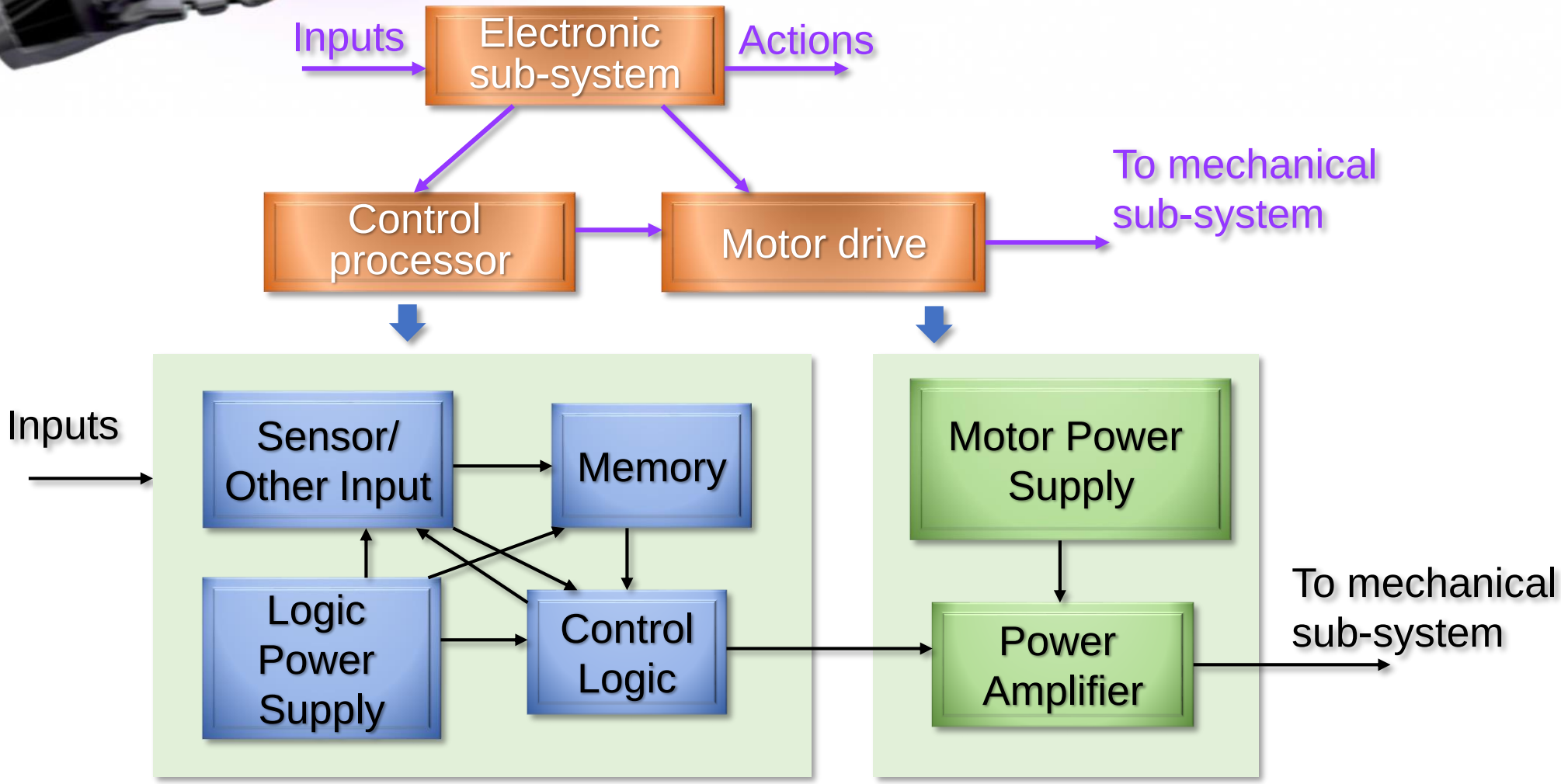


Mechanical Team

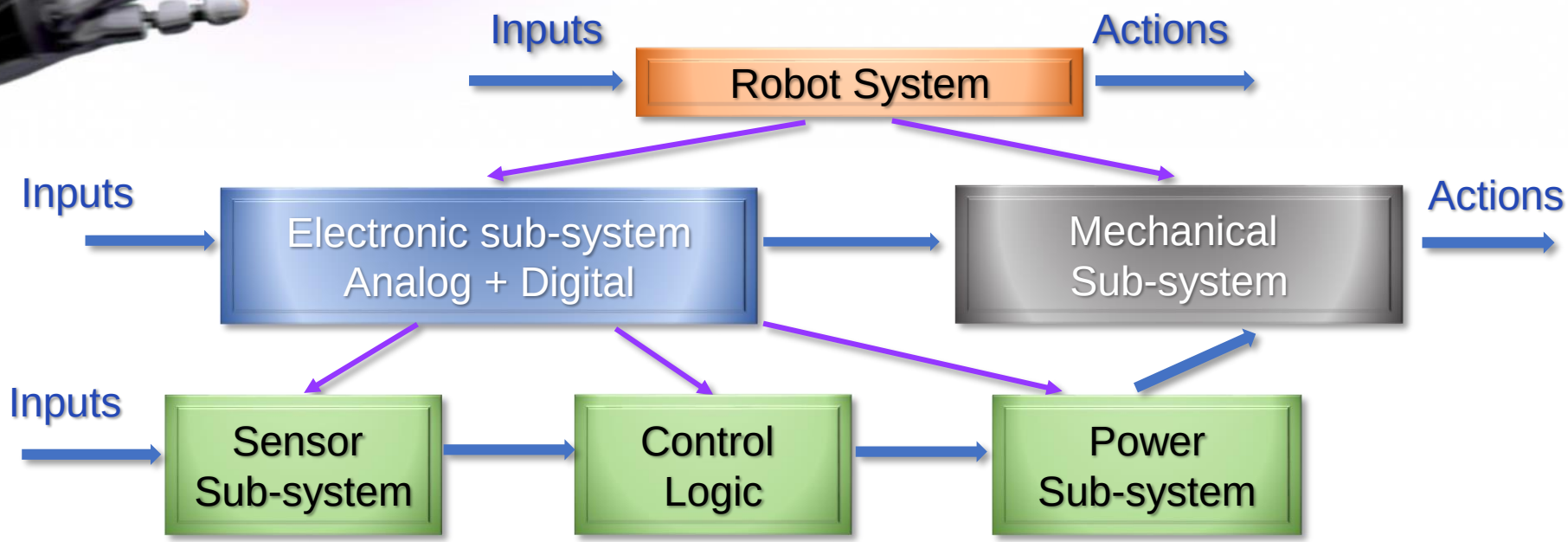
Rocket Team

.....

FURTHER DECOMPOSITION OF ELECTRONIC SUBSYSTEMS



ELEC1100 ROADMAP



Sensor Basics:

Wk6: Sensor Basic – Sensor/Line/ADC

Combinational/Sequential Logic:

Wk6-7: Robot Brain: Logic Gate and Logic Operation
Wk7: MCU & Arduino
Wk8-9: Programming Language

Basic electronics:

Wk2: Basic Electronics- Charge/Current/Voltage/Resistor
Wk2-3: Energy/Power and DC Sources

Motor Power Supply:

Wk3-4: Pulse Signal and PWM Control
Wk4-5: Transistor and H-Bridge

NEXT WEEK?

- Tutorials (T1 & T2 & T3) start at Week 2 (Lab#01 briefing)
- Labs (LA1 & LA2 & LA3) start at Week 3

QUESTIONS?