

Electrical Engineering



An overview

What is Electrical Engineering?



- ⌘ Electrical engineering is a field of engineering that generally deals with the study and application of **electricity, electronics, and electromagnetism.**
- ⌘ Electrical engineers design complex power systems on a macroscopic level as well as microscopic electronic devices...
- ⌘ ...and electronic circuitry, which recently achieved the record setting length of 1 nanometer for a single logic gate.

Electricity



- ⌘ Electric charge is the physical property of matter that causes it to experience a force when placed in an electromagnetic field (unit: Coulomb).
 - ⌘ positive
 - ⌘ negative
 - ⌘ neutral
- ⌘ **An electric charge has an electric field.**
- ⌘ **If the charge is moving it also generates a magnetic field.**
- ⌘ The combination of the electric and magnetic field is called the electromagnetic field.
- ⌘ Its interaction with charges is the source of the electromagnetic force, which is one of the four fundamental forces in physics.

Electricity



⌘ Electricity

- ⌘ Static Electricity: an imbalance of electric charges within or on the surface of a material.
- ⌘ Current Electricity: electric charges which flows through wires or other conductors and transmits energy (unit: Ampere).



Electric Currents: DC and AC

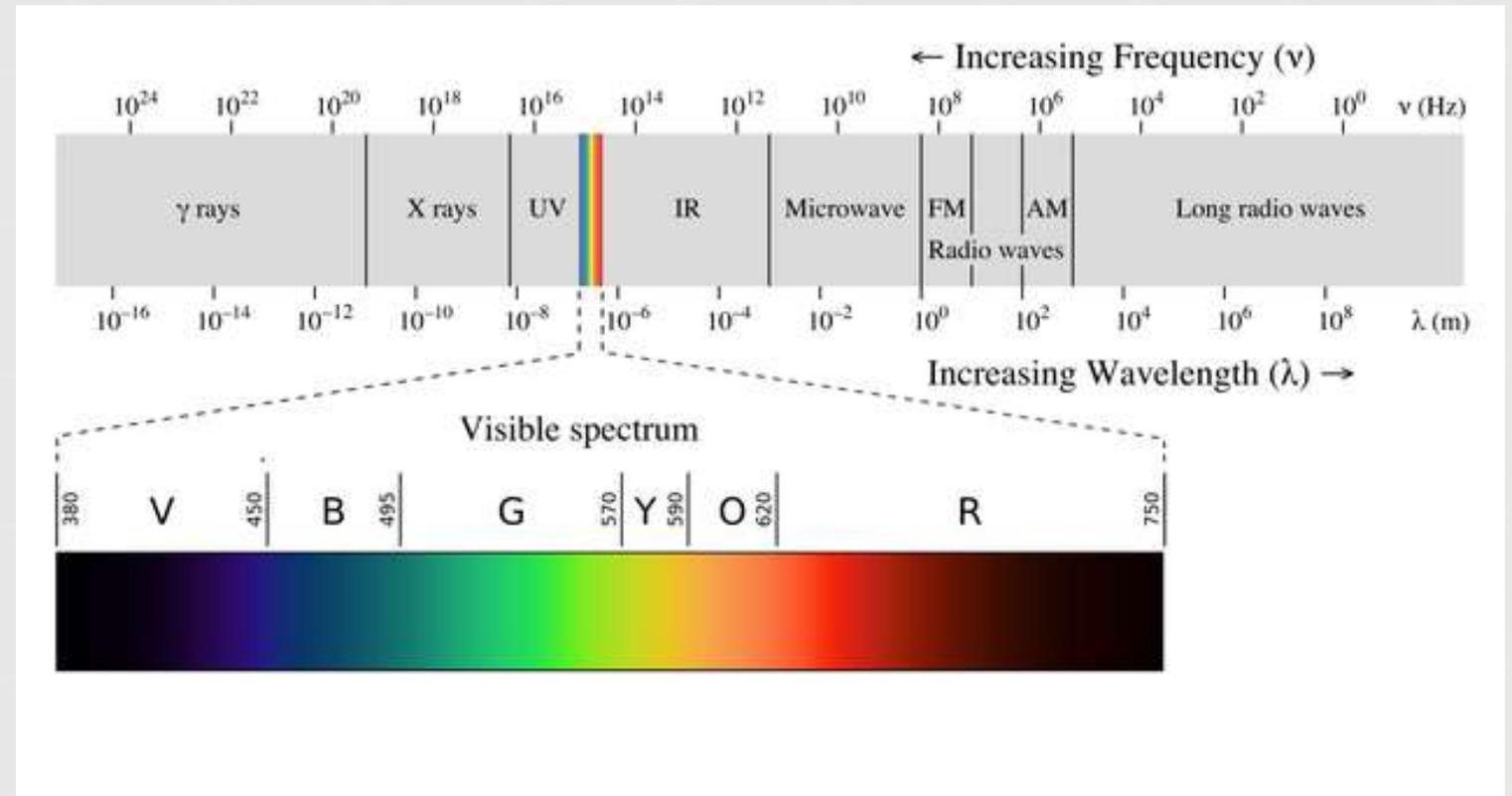
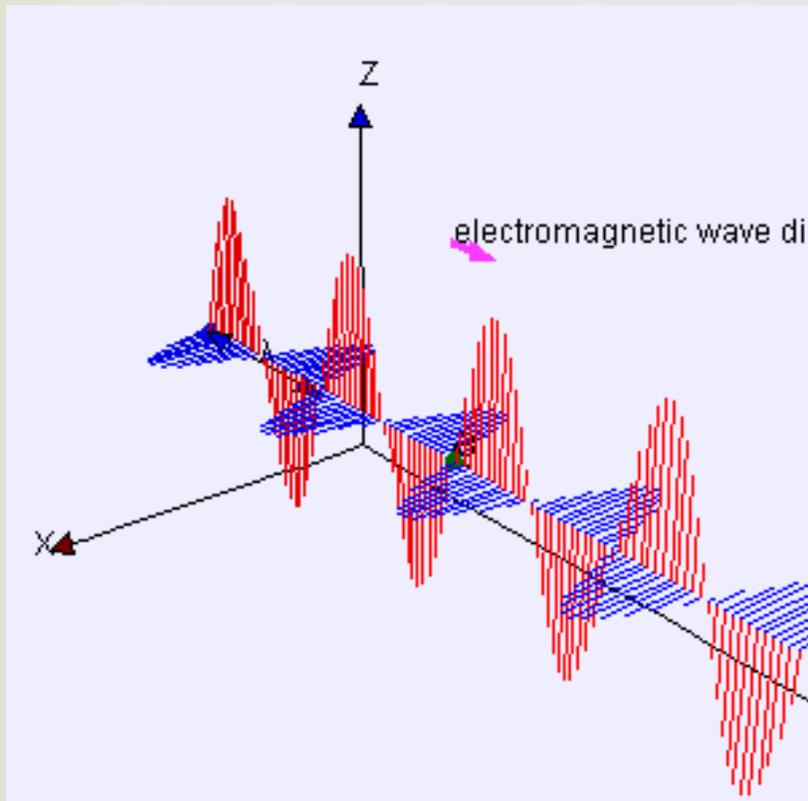


Electromagnetism



- ❧ Electromagnetism is a branch of physics involving the study of the **electromagnetic force**, a type of physical interaction that occurs between **electrically charged particles**.
- ❧ The electromagnetic force is carried by **electromagnetic fields** composed of **electric fields** and **magnetic fields**, is responsible for electromagnetic radiation such as light, and is one of the four fundamental interactions (commonly called forces) in nature.
- ❧ An electromagnetic field (also EMF or EM field) is a physical field produced by moving electrically charged objects.
- ❧ Electromagnetic radiation (EM radiation or EMR) refers to the waves (or their quanta, photons) of the electromagnetic field, propagating (radiating) through space, carrying electromagnetic radiant energy. It includes radio waves, microwaves, infrared, (visible) light, ultraviolet, X-rays, and gamma rays.

Electromagnetic Radiation



Electromagnetic Units and Quantities



Electromagnetic units and quantities :

- ampere (electric current)
- coulomb (electric charge)
- farad (capacitance)
- henry (inductance)
- ohm (resistance)
- siemens (conductance)
- tesla (magnetic flux density)
- volt (electric potential)
- watt (power)
- weber (magnetic flux)

History



- ⌘ Georg Ohm (1827): relationship between the electric current and potential difference in a conductor
- ⌘ Michael Faraday (1831): electromagnetic induction
- ⌘ Werner von Siemens (1866): industrial generator.
- ⌘ James Clerk Maxwell (1873): published a unified treatment of electricity and magnetism in *A Treatise on Electricity and Magnetism* □ Maxwell's equations.

Electrical Engineering Education



- ⌘ Latter part of the 1800s: the study of electricity was a subfield of physics.
- ⌘ 1882: Darmstadt University of Technology □ first chair and the first faculty of electrical engineering.
- ⌘ 1882: Massachusetts Institute of Technology □ the first option of Electrical Engineering within a physics department.
- ⌘ 1883: Darmstadt University of Technology and Cornell University □ the first courses of study in electrical engineering
- ⌘ 1886: University of Missouri □ the first department of electrical engineering
- ⌘ 2000: Jenderal Soedirman University □ Electrical Engineering Department

What is Electrical Engineering?



Subdisciplines

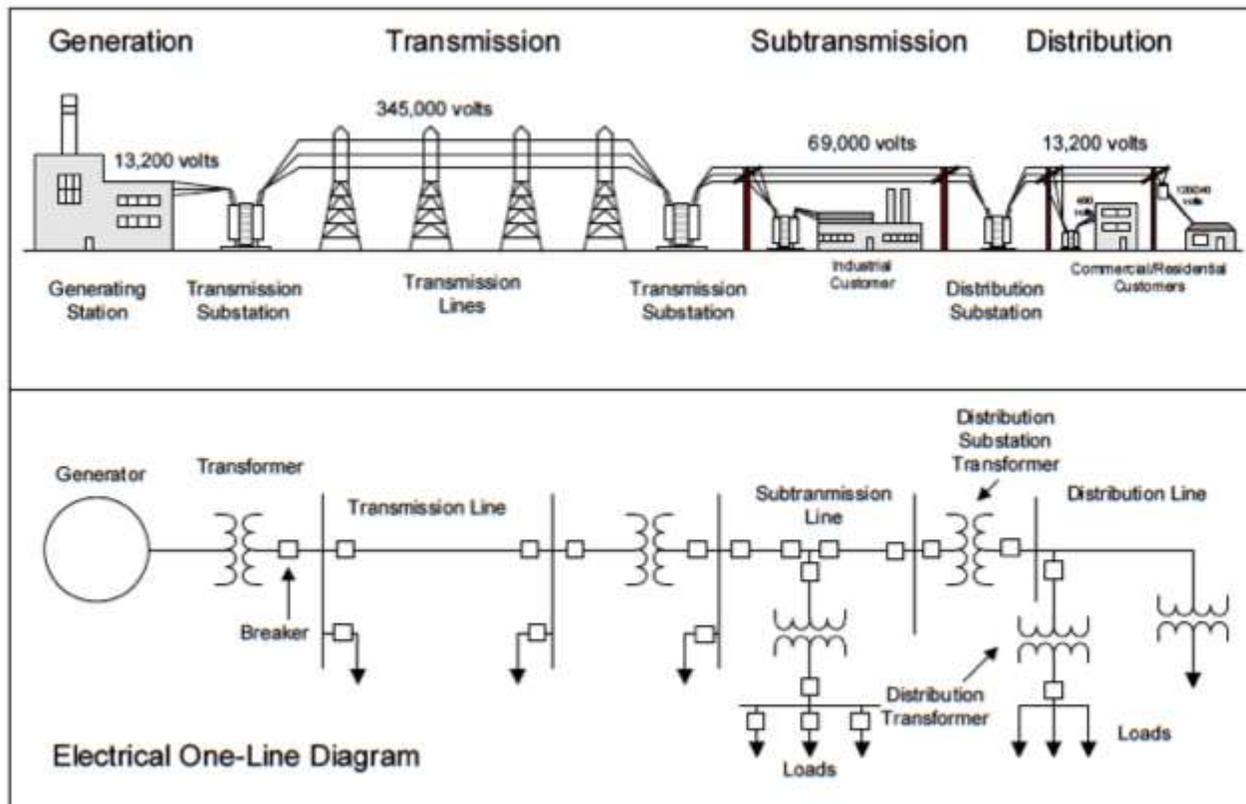


- ⌘ Power
- ⌘ Control
- ⌘ Electronics
- ⌘ Microelectronics
- ⌘ Signal processing
- ⌘ Telecommunications
- ⌘ Computers

Power (Power Engineering)



- ❧ Power engineering deals with the **generation, transmission, and distribution** of electricity as well as the design of a range of related devices
- ❧ Related devices: transformers, electric generators, electric motors, high voltage components, and power electronics.
- ❧ Power grid: an electrical network called that connects a variety of generators together with users of their energy.
 - ❧ on-grid power systems: power systems that connect to power grid.
 - ❧ off-grid power systems: power systems that do not connect to the grid





Integration in the Electricity Network

Overview of Electric Power Systems



Dr. Ir. L.M. (Laura) Ramirez Elzondo





Control Engineering

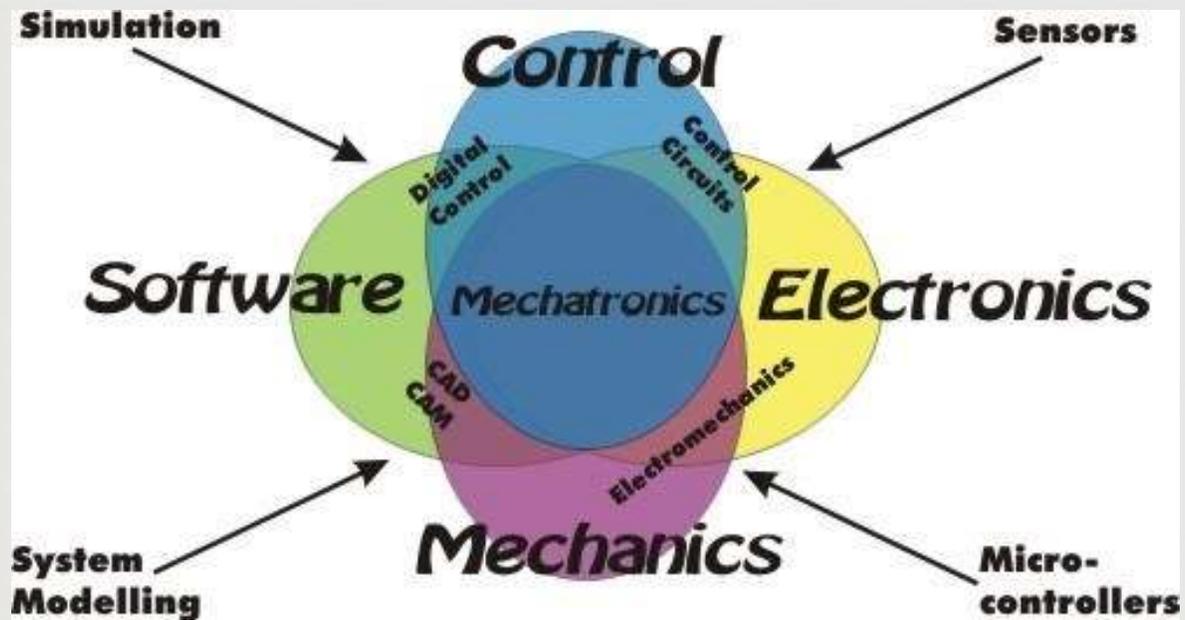


- ❧ Control engineering focuses on **the modeling** of a diverse range of **dynamic systems** and **the design of controllers** that will cause these systems **to behave in the desired manner**.
- ❧ Related devices: electronic circuits, digital signal processors, microcontrollers, and programmable logic controls (PLCs).
- ❧ Applications: flight and propulsion systems of commercial airliners to the cruise control present in many modern automobiles, and industrial automation.

Instrumentation Engineering



- ❧ Instrumentation engineering deals with the **design of devices to measure** physical quantities (such as pressure, flow, and temperature).
- ❧ The design of such instrumentation requires a good understanding of physics, for example, flight instruments measure variables such as wind speed and altitude to enable pilots the control of aircraft analytically.
- ❧ Often instrumentation is not used by itself, but instead as the sensors of larger electrical systems. For example, a thermocouple might be used to help ensure a furnace's temperature remains constant. For this reason, instrumentation engineering is often viewed as the counterpart of control engineering.





PWM

$0.1\mu F$

$3.3k$

10

$3.3k$

$6.8k$

5V

Electronic Engineering

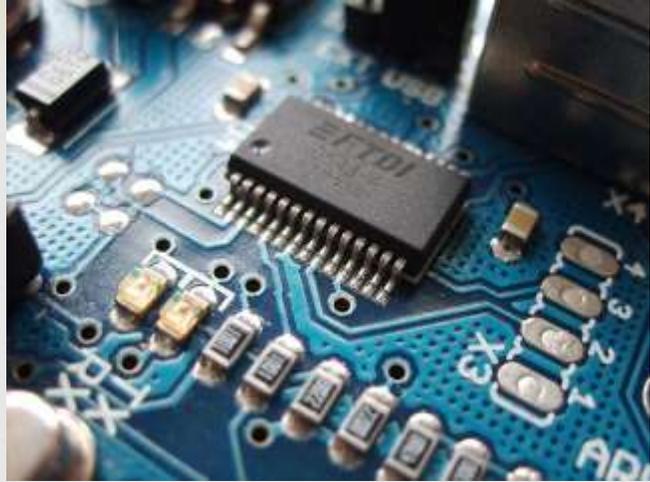


- ❧ Electronic engineering involves **the design and testing of electronic circuits** that use the properties of components such as resistors, capacitors, inductors, diodes, and transistors to achieve a particular functionality.
- ❧ Related devices: radar, radio, television, audio systems, computers, and microprocessors.

Microelectronics



- ❧ Microelectronics engineering deals with **the design and microfabrication of very small electronic circuit components** for use in an integrated circuit or sometimes for use on their own as a general electronic component.
- ❧ Related devices semiconductor transistors and also all main electronic components (resistors, capacitors etc.) at a microscopic level. Nanoelectronics is the further scaling of devices down to nanometer levels. Modern devices are already in the nanometer regime, with below 100 nm processing having been standard since about 2002.
- ❧ The field of microelectronics involves a significant amount of chemistry and material science and quantum mechanics.



Signal Processing



- ❧ Signal processing deals with the **analysis and manipulation of signals**.
- ❧ Signals can be
 - ❧ analog, in which case the signal varies continuously according to the information: amplification and filtering of audio signals for audio equipment or the modulation and demodulation of signals for telecommunications
 - ❧ digital, in which case the signal varies according to a series of discrete values representing the information: compression, error detection and error correction of digitally sampled signals.
- ❧ Related devices: DSP processor ICs (are found in: HDTV, radios and mobile communication devices, Hi-Fi audio equipment, Dolby noise reduction algorithms, GSM mobile phones, mp3 multimedia players, camcorders and digital cameras, automobile control systems, noise cancelling headphones, digital spectrum analyzers, intelligent missile guidance, radar, GPS based cruise control systems)



Telecommunications Engineering



- ❧ Telecommunications engineering focuses on **the transmission of information across a channel** such as a coax cable, optical fiber or free space.
- ❧ Related devices: communication transmitters, receivers (or both: transceivers), modulator.



Computer Engineering



- ❧ Computer engineering deals with **the design of computers and computer systems.**
 - ❧ This may involve the design of new hardware, the design of PDAs, tablets, and supercomputers, or the use of computers to control an industrial plant.
- ❧ Computer engineers may also work on a system's software. However, the design of complex software systems is often the domain of software engineering, which is usually considered a separate discipline.
- ❧ Desktop computers represent a tiny fraction of the devices a computer engineer might work on, as computer-like architectures are now found in a range of devices including video game consoles and DVD players.

Institute of Electrical and Electronics Engineers (IEEE)

- ✧ aerospace and electronic systems
- ✧ antennas and propagation
- ✧ broadcast technology
- ✧ circuits and systems
- ✧ communications
- ✧ components, packaging, and manufacturing technology
- ✧ computational intelligence
- ✧ computers
- ✧ consumer electronics
- ✧ control systems
- ✧ dielectrics and electrical insulation
- ✧ electron devices
- ✧ electromagnetic compatibility
- ✧ engineering in medicine and biology
- ✧ geoscience and remote sensing
- ✧ industrial electronics
- ✧ industry applications
- ✧ information theory
- ✧ instrumentation and measurement
- ✧ intelligent transportation systems

Institute of Electrical and Electronics Engineers (IEEE)

- ✧ magnetics
- ✧ microwave theory and techniques
- ✧ nuclear and plasma sciences
- ✧ oceanic engineering
- ✧ photonics
- ✧ power electronics
- ✧ power and energy
- ✧ product safety engineering
- ✧ reliability
- ✧ robotics and automation
- ✧ signal processing
- ✧ solid-state circuits
- ✧ systems, man, and cybernetics
- ✧ ultrasonics, ferroelectrics, and frequency control
- ✧ vehicular technology

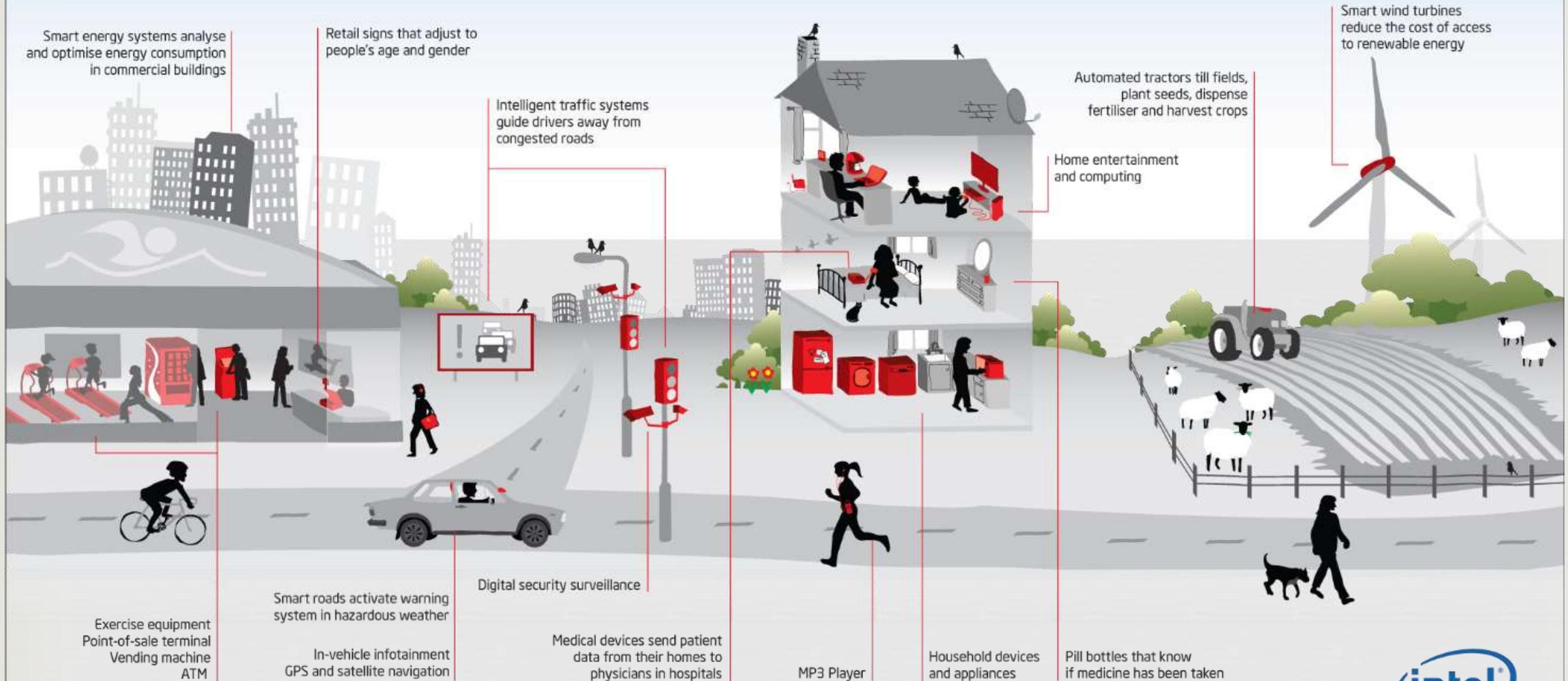
Reference



⌘ Shock and Awe: The Story of Electricity -- Jim Al-Khalili BBC Horizon -
<https://www.youtube.com/watch?v=Gtp51eZkwol&t=193s>

It's a Smart World

Invisible yet ubiquitous, small but mighty, unnoticed but life changing. Forty years ago the microprocessor was born, beginning the quiet but profound process which has radically reshaped our lives. Today, thanks to the microprocessor, we live in a smart world, can do smart things and make smart choices. We don't see them, but these tiny embedded computers shape our world to a remarkable degree. From the cars we drive and tractors that till the fields, to the fresh food delivered to our shops, billboards that advertise and machines that help us stay fit - they're the invisible brains that power our daily being. Long live the smart life.



Thinking about EE



Opinion | At Work | Tech Careers

25 Oct 2016 | 19:00 GMT

The Ever-Evolving Field of Electrical Engineering

What's the single constant? Love of a challenge

By Robert W. Lucky



Illustration: Dan Page

I was at a large hardware store, holding a power cord that I thought would fit my new home generator, when another shopper pointed to the cord in my hand and said that I had chosen the wrong connector. When I looked hesitant, he added, "I'm an electrical engineer, so I know things like that."

Needless to say, I quietly changed my

When I first entered electrical engineering in college, I had very little idea of what EEs actually do.

After all these years, I'm still not sure.

(Robert W. Lucky, 2016)

<https://spectrum.ieee.org/at-work/tech-careers/the-everevolving-field-of-electrical-engineering>

Electrical Engineer Profiles



Has degree in Electrical Engineering....
.... became a comedian

Electrical Engineer Profiles

Has degree in Electrical Engineering....
.... is even more handsome



The Electricity Bender



The Original Electricity Bender in Indonesia



Welcome

The Electricity Benders of 2019

