Engineering by Design – Unit 3 – Chapter 6
“Basic Circuitry”

1. force: definition, unit(s), types
2. Newton’s laws
3. net force
4. resultant force
5. gravity
6. tension & springs

References – A large amount of content came directly from the following sites:
• https://startingelectronics.org/beginners/components/
BASIC CIRCUITRY

Breadboard vs. Protoboard/Stripboard/Pinboard/Perfboard
- Breadboards are for temporary circuits using pin-through-hole components
- Connections are made as follows:
  • All pins along a blue line are connected
  • All pins along a blue line are connected
  • Pins along a number are connected. A₂, B₂, C₂, D₂, and E₂ are all connected
  • Deep gorges in the breadboard indicate breaks in connections:
    EXAMPLE – the A₂, B₂, C₂, D₂, and E₂ pins on the left of the deep gorge are not connected to the A₂, B₂, C₂, D₂, and E₂ pins on the right of the deep gorge
    EXAMPLE – the pins connected along the blue line are not connected to any of the pins in column A

NOTE: You can always check connectivity of circuit elements to one another by using a multimeter set to the little speaker-looking icon. It should make a sound if the two elements are connected when placed in a complete circuit.

- Protoboard, Stripboard, Pinboard, and Perfboard are all names for the same item: a material with equally spaced holes through it for making breadboard circuits more permanent by using solder
Various Electric Components

- Power Source
  
  **AC – Alternating Current**: electrons move back and forth rapidly in synch
  
  EXAMPLE – outlets, large generators, power strips, wiring in your home

  **DC – Direct Current**: electrons move from negative terminal (cathode) to the positive terminal (anode)
  
  EXAMPLE – batteries, most (phone or other electronic) chargers

Schematic Symbols:

NOTE: Wall chargers are required by law to have a sticker that specifies their capabilities, constraints, and specifications

- Resistor

  Any object or material that hinders the flow of electrons to some extent

  Schematic Symbols:

  Physical Item:

  Most common resistors are rated for $\frac{1}{4}$ Watt power-consumption and are color coded with bands according to the table on the right and the rules below:
A resistor’s value in ohms is worked out from the first three coloured bands using the table below. Using the resistor above, its bands are brown, black and red. The first colour, brown, has a value of 1. The second colour, black, has a value of 0 (zero). The third colour tells us how many zeros the value has - red = 2 zeros. Putting it all together we get: 1, 0, and two zeros (00) = 1000 ohms or 1k.

More examples:
Resistor colours - Yellow, Violet, Brown = 4, 7, 1 (number of zeros is 1) = 47 and one zero = 470 ohms
Resistor colours - Red, Red, Red = 2, 2, 2 = 22 and 2 zeros = 2200 ohms = 2.2k, usually written as 2k2
Resistor colours - Yellow, Violet, Red = 4, 7, 2 = 4, 7, 00 = 4700 ohms or 4.7k = 4k7
Resistor colours - Brown, Black, Orange = 1, 0, 3 = 1, 0, 000 = 10000 = 10k
Resistor colours - Orange, Orange, Black = 3, 3, 0 (no zeros) = 33 ohms

- **Potentiometer**
  
  A variable resistor; also called “pots”

  **Schematic Diagram:**

  ![Schematic Diagram]

  **Physical Items:**

  ![Physical Items]

  - Rated value of the potentiometer can be found consistently between two outer pins
  - Middle “wiper” pin will move along the resistive material between the two outer pins as the shaft of the potentiometer is rotated, thereby varying the resistance between 1ˢᵗ pin and center as well as center and 3ʳᵈ

- **Capacitor**

  Rechargeable device used to store energy that has the ability to discharge rapidly or slowly based on circuit design

**SAFETY:** CAPACITORS HAVE VOLTAGE AND FARAD VALUES. LARGE NUMBERS ON CAPACITOR INDICATE THE DEVICE MAY KILL YOU!! Always short out capacitors before touching them by connecting its two legs together with a conductive object such as a jumper cable. Seek assistance if unsure!
NOTE: Polarized capacitors have one long leg and one short leg. The long leg is always positive (anode). Incorrect orientation in circuit may destroy components, including the capacitor.

NOTE: When using capacitors in a 9V circuit, they must be rated 16V or more. Rule applies for all circuits and capacitors in use. Voltage rating should be at least 40% greater than supplied voltage to component.

- Semiconductor
  Devices or materials made at least partially of substances that allow/limit the flow of electrons only under specific conditions.

EXAMPLE – **Diode**: Essentially a one-way street for electricity

- Good for turning AC current into DC current
- Has a specific orientation, will not work or will burn out if oriented incorrectly
- Two legs, a band near the negative side.

EXAMPLE – **Light Emitting Diode (LED)**: A special diode that will give off light like a light bulb when current flows through it

Diagram:

- On the physical LED, the longer lead (or leg) of the LED is the anode. The cathode is marked on the rim of the LED body with a flat area shown in the diagram.
- Another way to tell which lead is the anode and which is the cathode is to look at the two plates at the end of the leads inside the body of the LED. The bigger plate will be the cathode.
**Tips and Hints**

Never connect an LED directly across a battery or other power source – it will burn out. LEDs must always be connected in series with a resistor.

LEDs are diodes which means that current can only flow through an LED from the anode to the cathode and not the other way around.

If an LED is connected the wrong way around in a circuit (anode to negative and cathode to positive) it is said to be “reverse biased” and will not emit light. When connected the right way around the LED is said to be “forward biased”.

LEDs, unlike other diodes, can not withstand large reverse bias voltages.

**EXAMPLE – Transistor:** A special diode or set of diodes in a tiny housing that works by first having to turn it on with a bit of electricity. Two major types exist, NPN & PNP. The two behave in opposite ways from one another.

Schematic Symbols:

![Transistor Schematic Symbols](image)

Physical item:

- can have a variety of shapes and sizes, resulting in varied switching capacity and power handling
- three legs, *pin out* is specific to type but legs are always in the same order next to each other
- legs are always referred to as collector, base, and emitter as a result of their functions. Collector will collect the charge but not let it pass to the emitter, unless the base receives a strong enough signal. It works like an electric faucet. It will not let lots of energy flow without a bit of energy input to open the valve.

**NOTE:** Transistors usually *latch open* once triggered. That is, they remain in the open position until you cut power to the collector leg.

**EXAMPLE – Integrated Circuit (IC):** A preconfigured cockroach looking thing made up of a set of transistors. Name and number on item correspond to a *pin-out diagram* that allows you to understand the use of the overall device and the predetermined function of each pin. Notice the standardized pattern used for numbering the pins. Start from the divot and go counter-clockwise counting up by 1.
Understanding Electronic Product Stickers

**PLUG IN CLASS 2 TRANSFORMER**

- UL Certification Number: E135461
- Manufacturer Part Number: DBU060050
- Model No.: 119255
- Input Voltage: 120VAC 60Hz, 6.5W
- Output Voltage: 6VDC, 500mA
- Center Negative Plug
- Inner Positive Plug
- Factory ID: C, Made in China
- UL Functional Safety Listing Marking in the U.S.
- Adapter with a Class 2 Transformer and 2-prong plug
- UL listed adapter

**AC/DC SWITCHING ADAPTER**

- Manufacturer Product Number: OI-1048A2401700U-U(n)
- Input: 100-240VAC
- Output Voltage: 24VDC, 1.7A
- Sine wave implying AC input range of 100-240VAC at 50 or 60Hz frequency
- Input current rating at maximum of 1.5 amps
- Output voltage at 24 volts and maximum output current of 1.7 amps, straight and dashed lines signifies DC output
- FCC symbol signifying this product is FCC approved
- CE symbol signifying this product is CE approved
- Made in China

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- UL Functional Safety Listing Marking in the U.S.