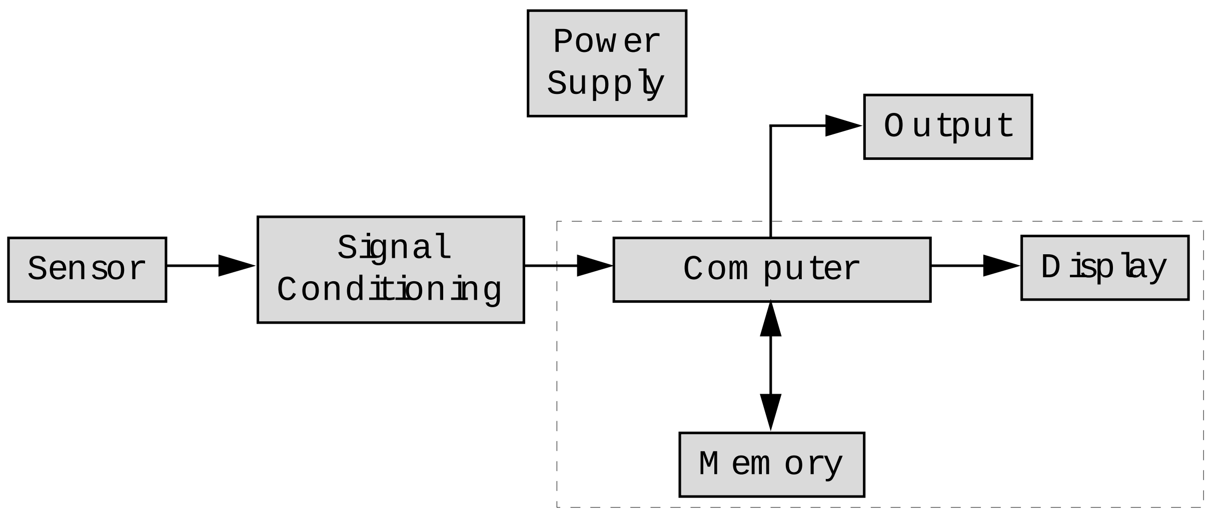
PC-based Biomedical Instrument



Sensor: Measures the signal of interest

Signal Conditioning: Amplifiers
Filters

Computer: Has an analog to digital (A/D) board to acquire analog data
Has a serial port to acquire digital data
Processes the acquired data

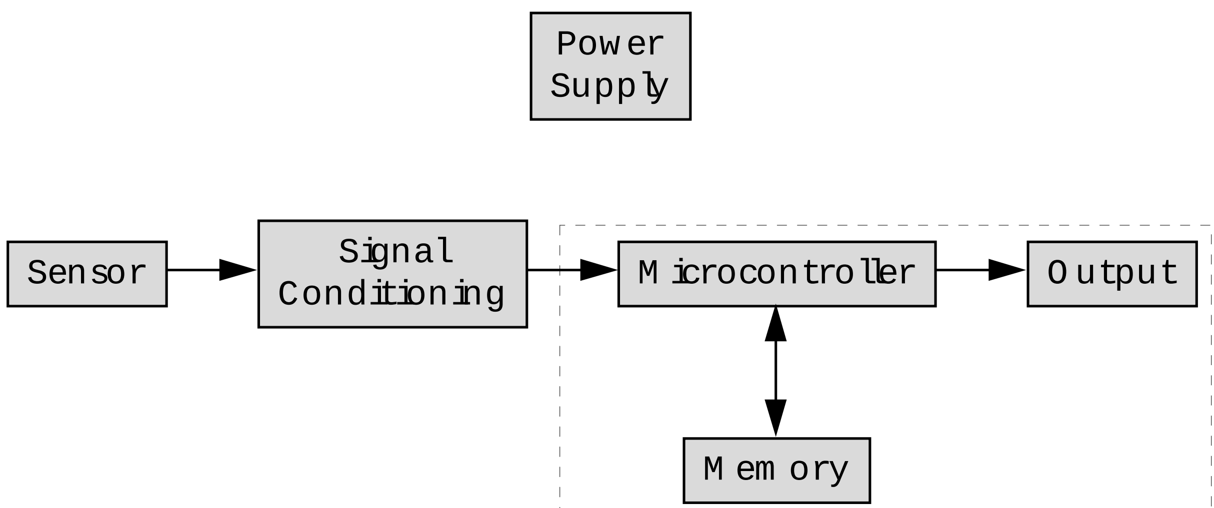
Memory: To save the obtained data (RAM or hard drive)

Display: On the screen or as a printout

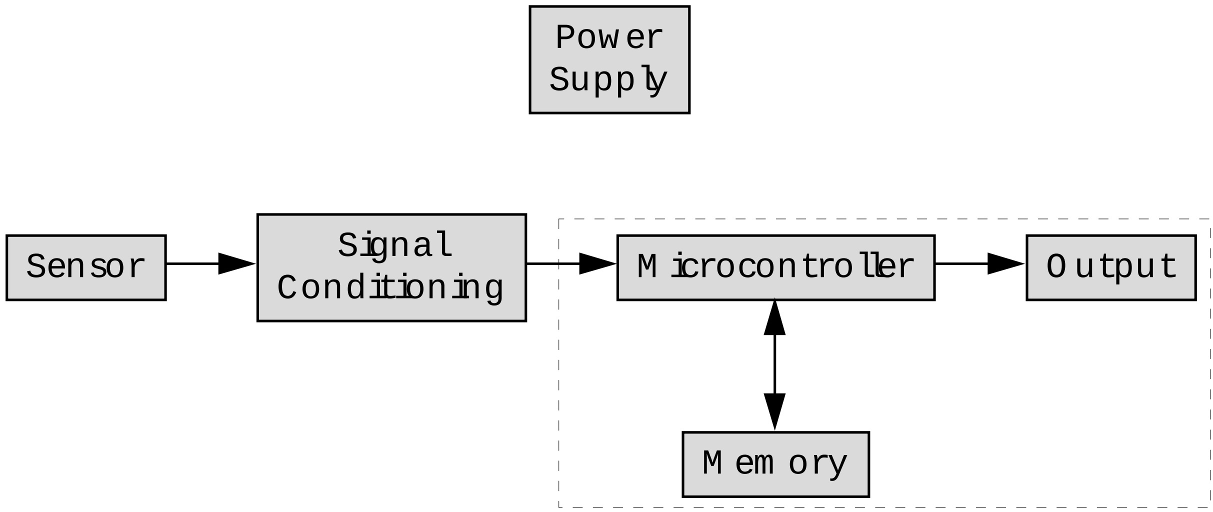
Microcontroller Based Biomedical Instrument

1. A general purpose computer does a lot of things that are unnecessary for some dedicated biomedical instruments
2. A computer is large in size and limits portability
3. Several applications require the use of a dedicated instrument: portable (home measurement devices) or otherwise (ultrasound, MRI, CT, etc.)

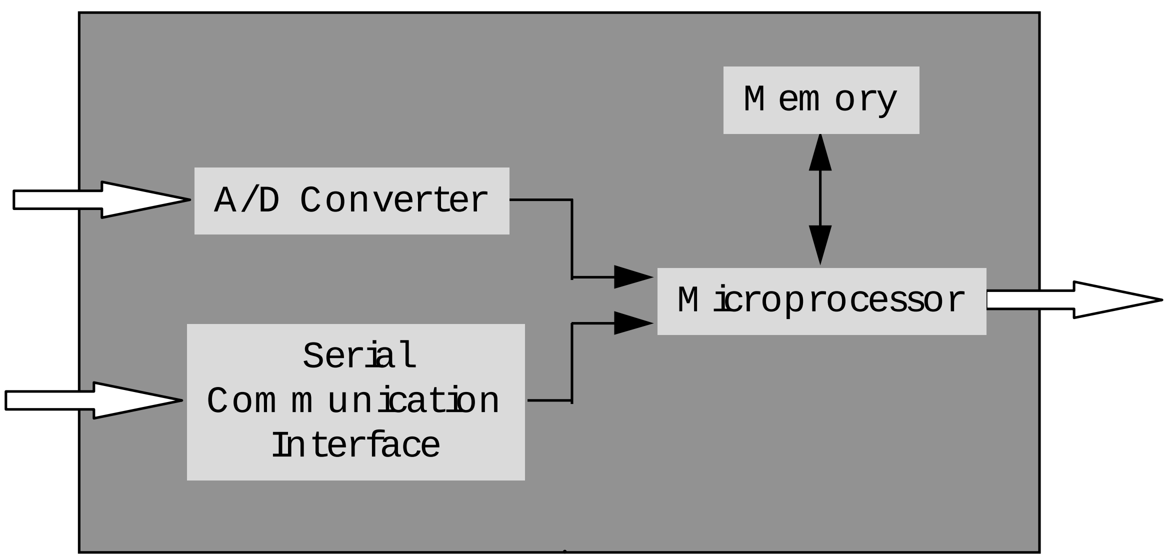
- Portable systems require the use of a microcontroller
- Larger systems necessitate the design of a dedicated computer system (hard drive, display monitor, elaborate controls)



Microcontroller Based Biomedical Instrument



Microcontroller



Example:	MC68HC11	
	M	Motorola's general mcu family
	68HC	Motorola HCMOS (high-density complementary metal oxide semiconductor)
	11	MC68HC11 family

Microprocessors

Examples: 8085, 8086, 8088, 80286, 80386, 80486, Pentium

The inside of a microprocessor contains hardware that processes the data based on commands from the software.

A microprocessor performs

- a small set of very simple tasks.
- a pre-determined series of steps according to a set of instructions (assembly language)
- the operations very quickly

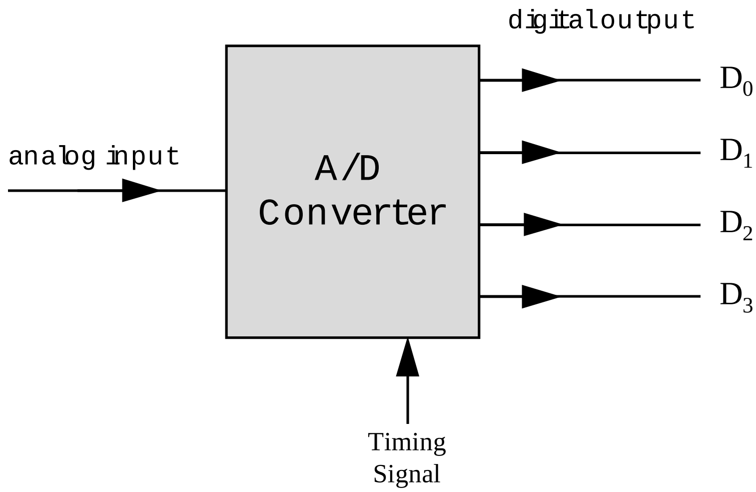
All that a microprocessor can do is to do simple standardized operations over and over at a very fast rate, in proper order

Digital hardware consists of a few cheap and simple building blocks, cleverly interconnected and repeated over and over again.

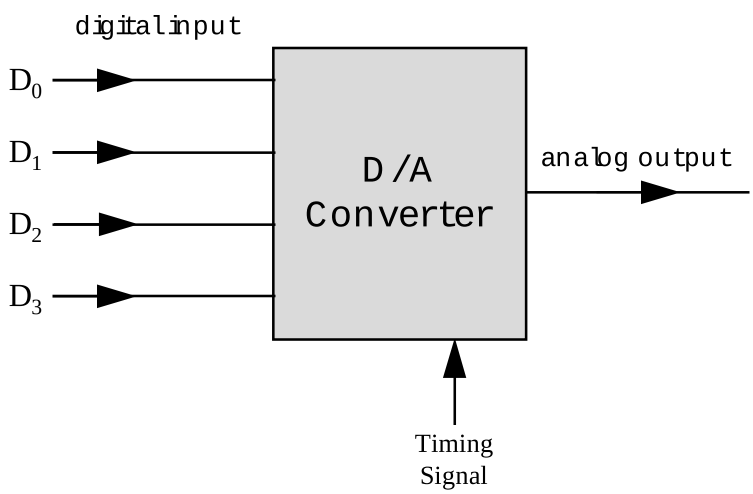
Digital data (represented by 0s and 1s) are processed by elements called logic gates.

A/D and D/A Converters

Analog to Digital: convert analog voltage to a binary representation



Digital to Analog: convert a digital word into an analog voltage



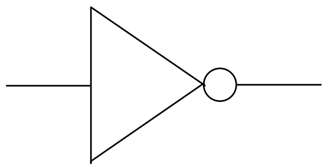
Parameters to be concerned about:

max. voltage level (analog) number of bits (digital)

when should it sample

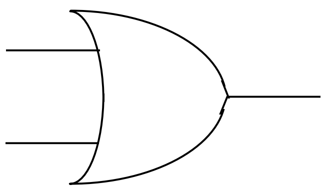
Logic Gates

NOT



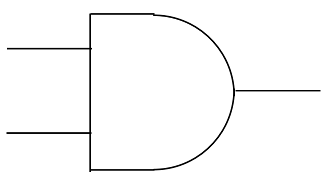
A	B
0	1
1	0

OR



A_1	A_2	B
0	0	0
0	1	1
1	0	1
1	1	1

AND



A_1	A_2	B
0	0	0
0	1	0
1	0	0
1	1	1

NOT: inverts

OR: 1 if ***any*** of its inputs is 1
0 if ***all*** inputs are 0

AND: 1 if ***all*** inputs are 1
0 if ***any*** of the input is 0

Semiconductors

Conductors	Semiconductors	Insulators

Resistors V=IR

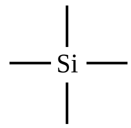
linear characteristics

Passive circuits: contain resistors, capacitors and inductors

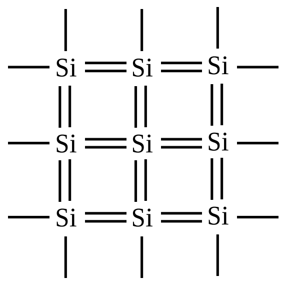
Active circuits: contain passive elements and active elements (diodes and transistors)

Semiconductors

Silicon, Germanium, Gallium Arsenide, etc.



Individual silicon atom



Si Atoms in Lattice

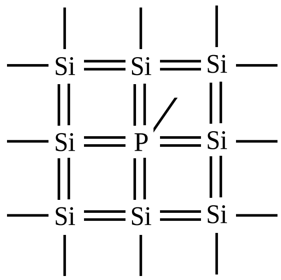
- Very few charge carriers
- Poor electrical conductor
- called an *intrinsic semiconductor*

To make them carry current semiconductors are *doped* with impurities called *dopants*.

Impurities may be *donors* or *acceptors*

Semiconductors

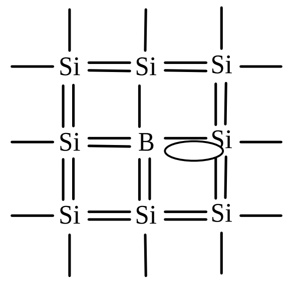
n-type



Phosphorus doped Si

Electron

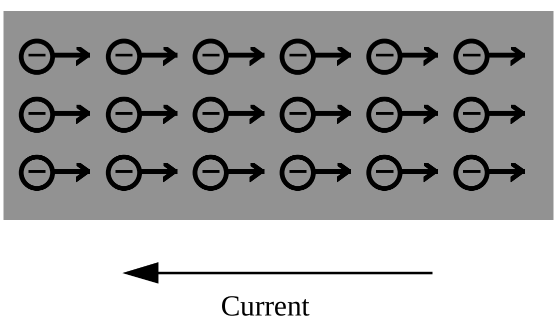
p-type



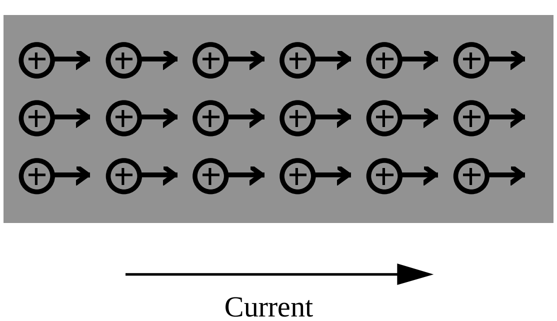
Boron doped Si

Hole

Electrons and holes are the particles that conduct current in solid state electronic devices



Electron movement



Hole movement

Semiconductors

If a donor-type impurity is added to the extent of 1 part in 10^8, the conductivity of germanium at $30^O C$ is multiplied by a factor of 12.

Adding n-type impurities decreases the number of holes

Adding p-type impurities decreases the number of electrons

	majority carrier	minority carrier
n-type	electrons	holes
p-type	holes	electrons

Mass Action Law: $n\ p = n_i^2$

for Si at $300^O K$, $n_i = 1.6x10^{10}$ electrons / cm^3

Doping

i) increases conductivity

ii) produces a conductor in which the electric carriers are either predominantly holes or electrons

$$N_D + p = N_A + n$$

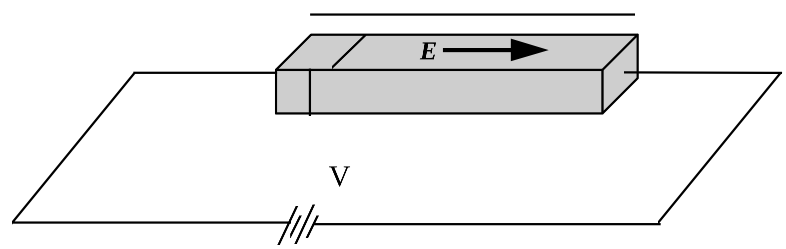
for n-type material: $n \approx N_D$ (donor atom density)

for p-type material: $p \approx N_A$ (acceptor atom density)

Semiconductors

Current Conduction

Drift



$$|\boldsymbol{E}| = \frac{V}{L} \quad volts/cm$$

Drift Velocity (electrons and holes)

$$v_n = \mu_n |\boldsymbol{E}|$$

Where μ_n is the electron mobility constant. The same equation applies to holes.

Conductivity

$$\sigma = conductivity = q(n\mu_n + p\mu_p)$$

Resistance

$$R = \frac{L}{A\sigma} = \rho \frac{L}{A}$$

Where ρ is resistivity, the inverse of conductivity.

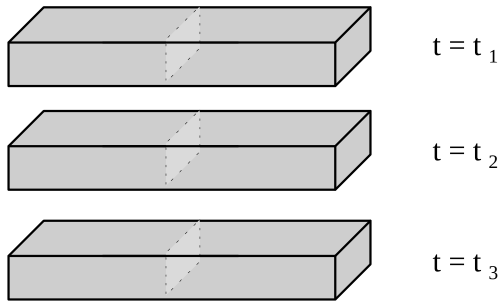
Current Density

$$\boldsymbol{J} = \sigma \boldsymbol{E}$$

Semiconductors

Current Conduction

Diffusion



Diffusion Current

$$J_n = qD_n\left[\frac{dn}{dx}\right]$$

The above expression applies to a current density of electrons; the same expression applies to holes.