

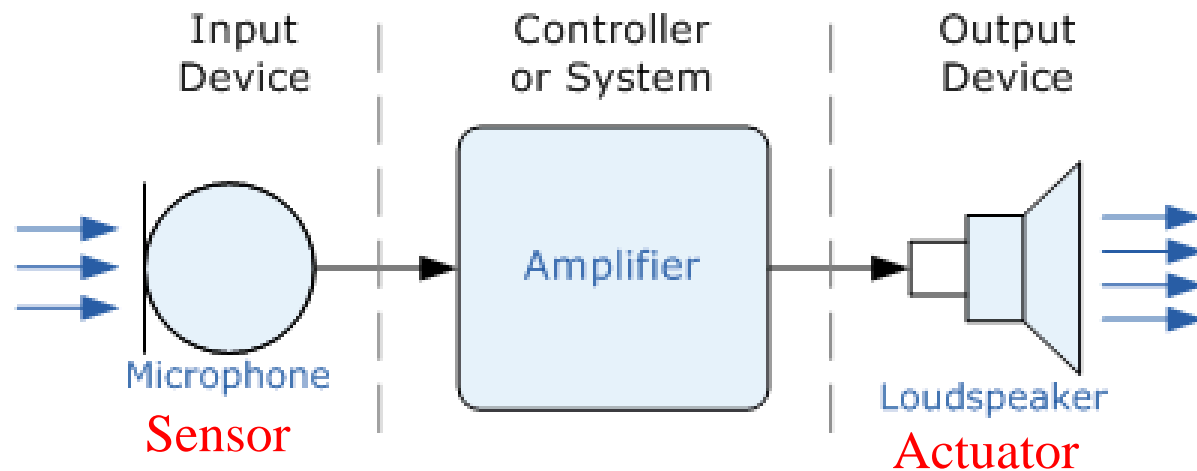
# Transducers

PHYS3360/AEP3630

Lecture 33

# Terminology

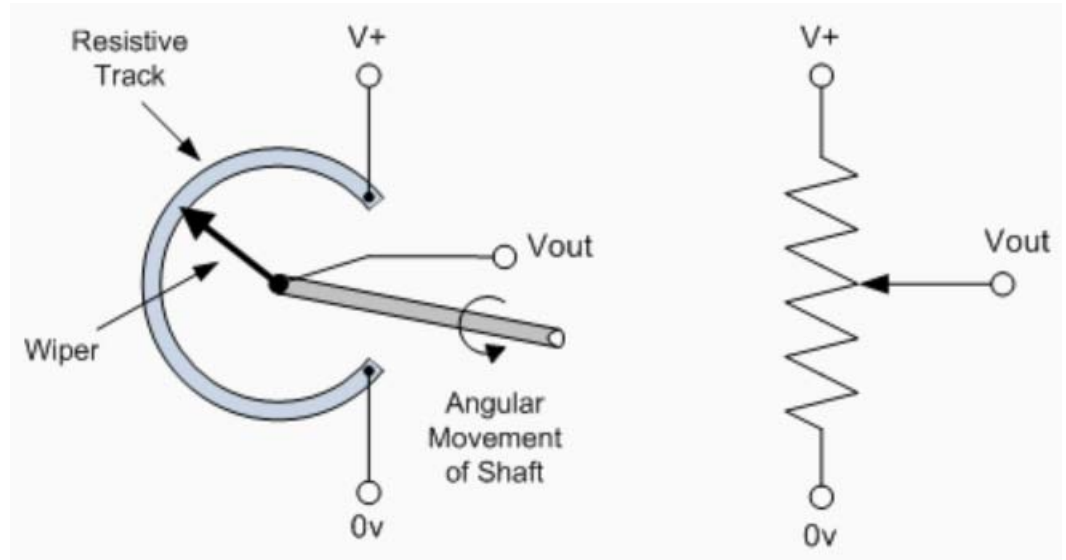
- **Transducers** convert one form of energy into another
- **Sensors/Actuators** are input/output transducers
- Sensors can be *passive* (e.g. change in resistance) or *active* (output is a voltage or current level)
- Sensors can be *analog* (e.g. thermocouples) or *digital* (e.g. digital tachometer)



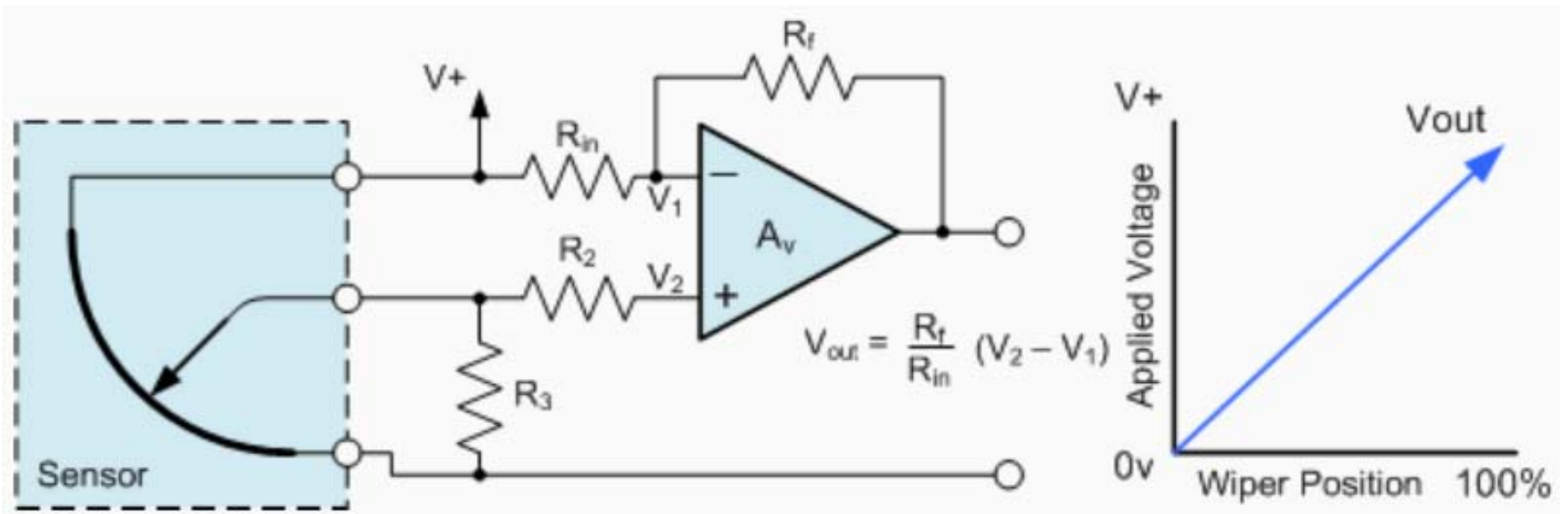
# Transducer types

Quantity being Measured	Input Device (Sensor)	Output Device (Actuator)
Light Level	Light Dependant Resistor (LDR), Photodiode, Phototransistor, Solar Cell	Lights & Lamps, LED's & Displays, Fiber Optics
Temperature	Thermocouple, Thermistor, Thermostat, Resistive temperature detectors (RTD)	Heater, Fan, Peltier Elements
Force/Pressure	Strain Gauge, Pressure Switch, Load Cells	Lifts & Jacks, Electromagnetic, Vibration
Position	Potentiometer, Encoders, Reflective/Slotted Opto-switch, LVDT	Motor, Solenoid, Panel Meters
Speed	Tacho-generator, Reflective/Slotted Opto-coupler, Doppler Effect Sensors	AC and DC Motors, Stepper Motor, Brake
Sound	Carbon Microphone, Piezo-electric Crystal	Bell, Buzzer, Loudspeaker

# Positional Sensors: potentiometer

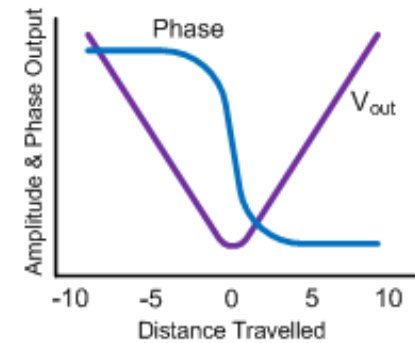
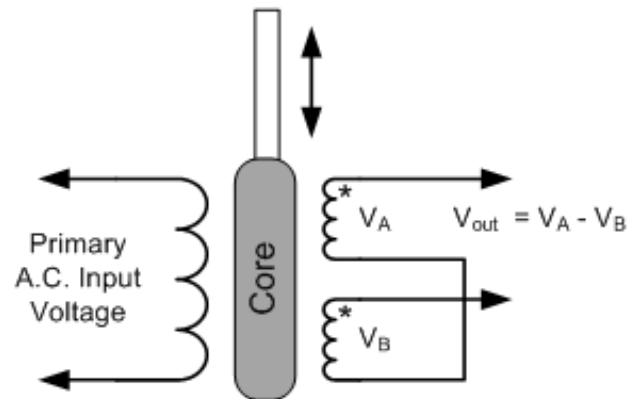
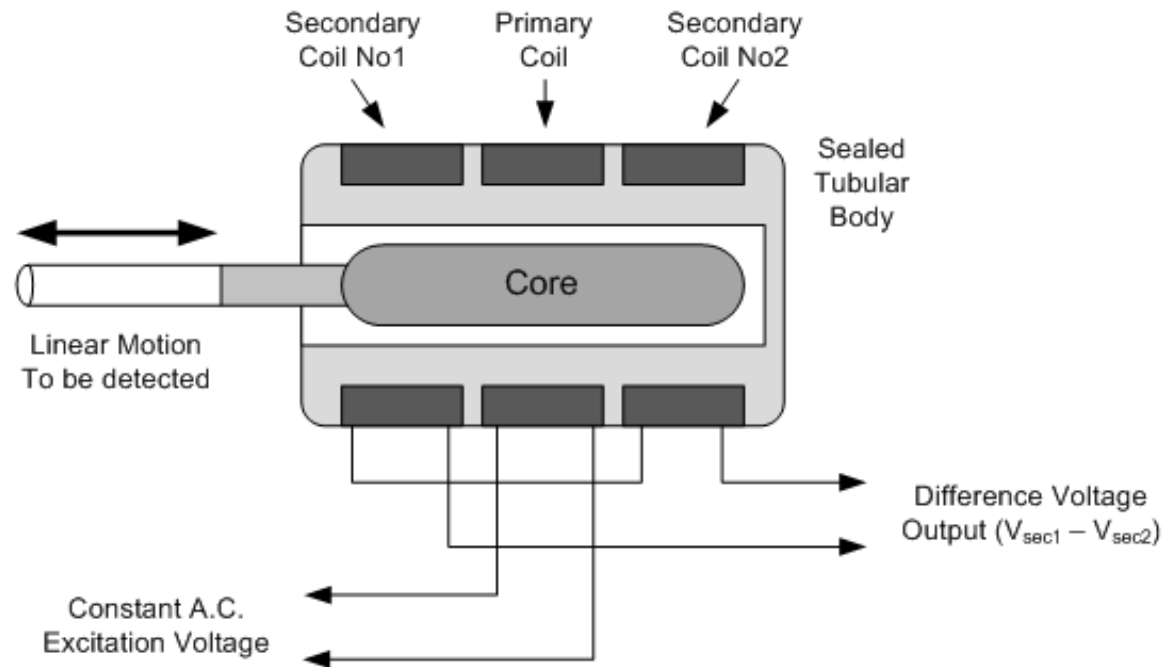


## Processing circuit



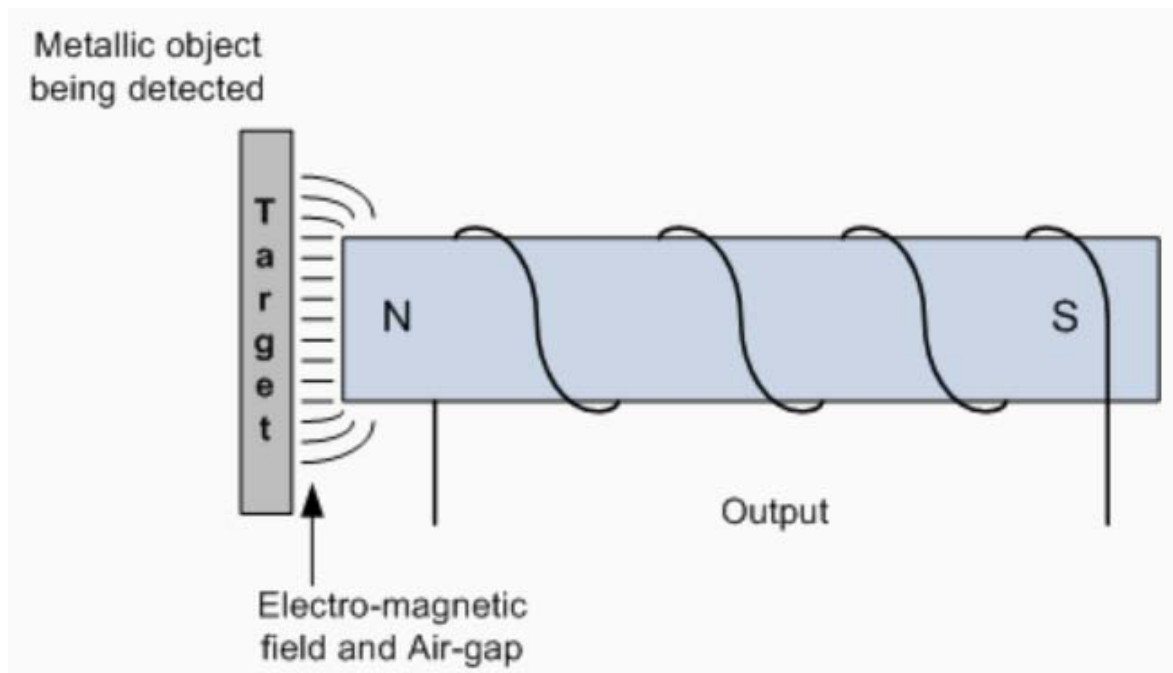
# Positional Sensors: LVDT

Linear Variable  
Differential  
Transformer



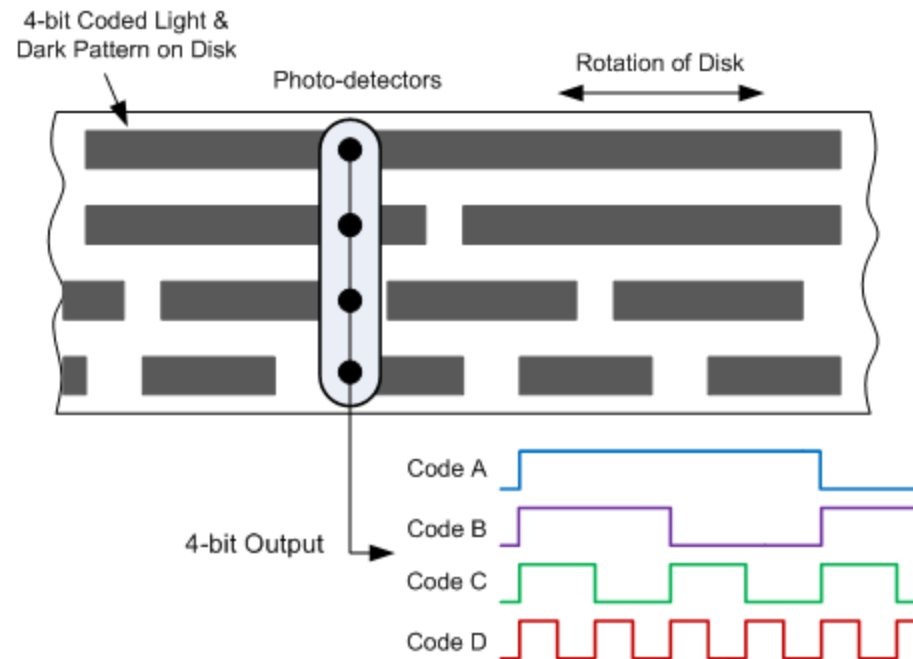
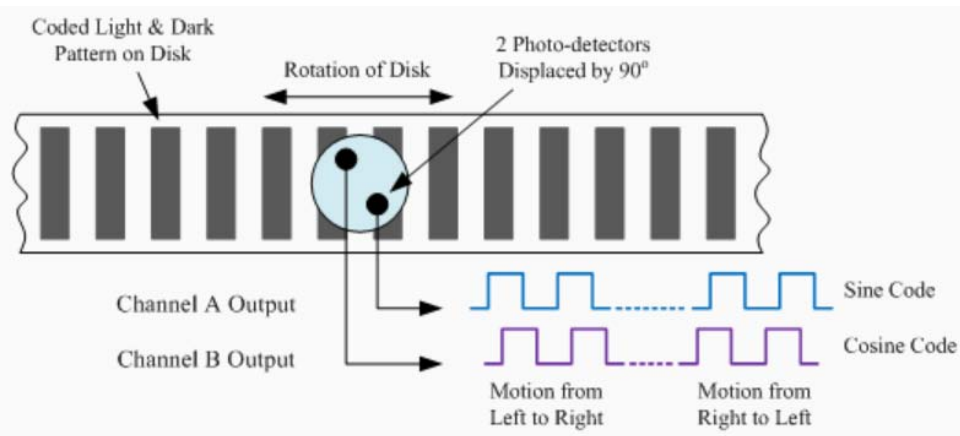
# Positional Sensors: Inductive Proximity Switch

- Detects the presence of metallic objects (non-contact) via changing inductance
- Sensor has 4 main parts: field producing **Oscillator** via a **Coil**; **Detection Circuit** which detects change in the field; and **Output Circuit** generating a signal (NO or NC)



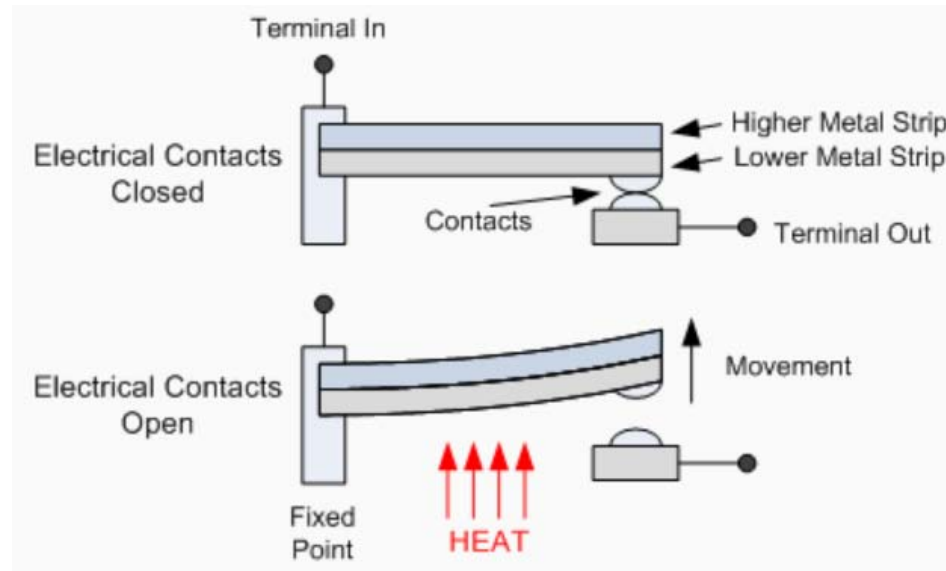
# Positional Sensors: Rotary Encoders

- **Incremental** and **absolute** types
- Incremental encoder needs a counter, loses absolute position between power glitches, must be re-homed
- Absolute encoders common in CD/DVD drives



# Temperature Sensors

- **Bimetallic switch** (electro-mechanical) – used in thermostats. Can be “creep” or “snap” action.

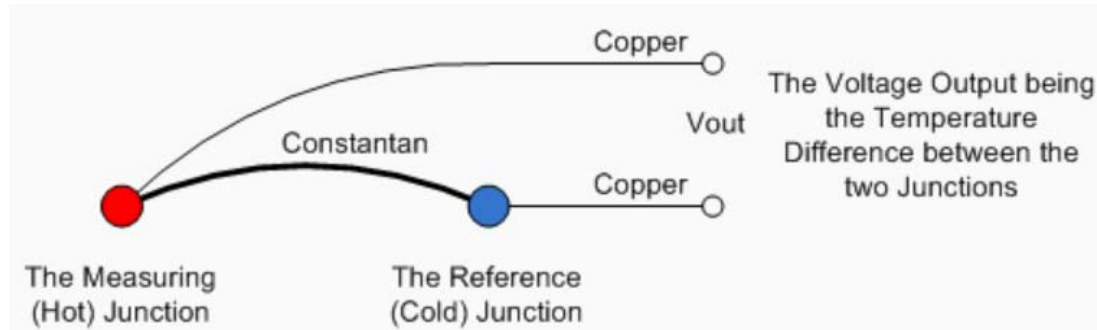


- **Thermistors** (thermally sensitive resistors); **Platinum Resistance Thermometer** (PRT), very high accuracy.



# Thermocouples

- Two dissimilar metals induce voltage difference (few mV per 10K) – electro-thermal or Seebeck effect



- Use op-amp to process/amplify the voltage
- Absolute accuracy of 1K is difficult

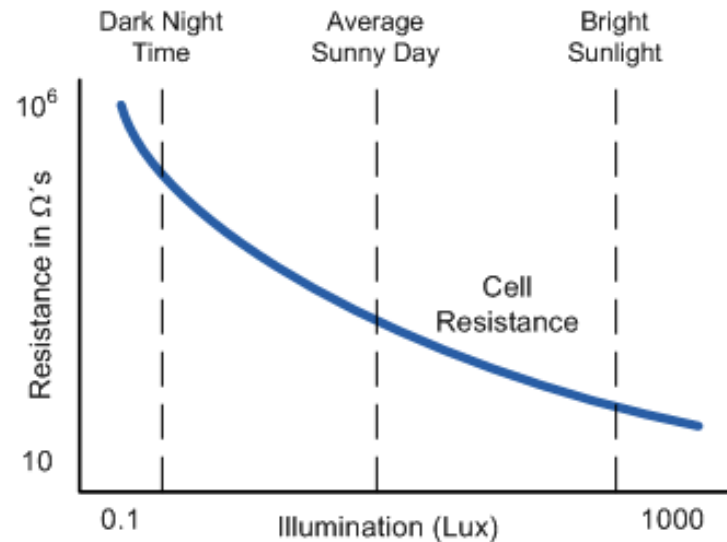
## Thermocouple Sensor Colour Codes

### *Extension and Compensating Leads*

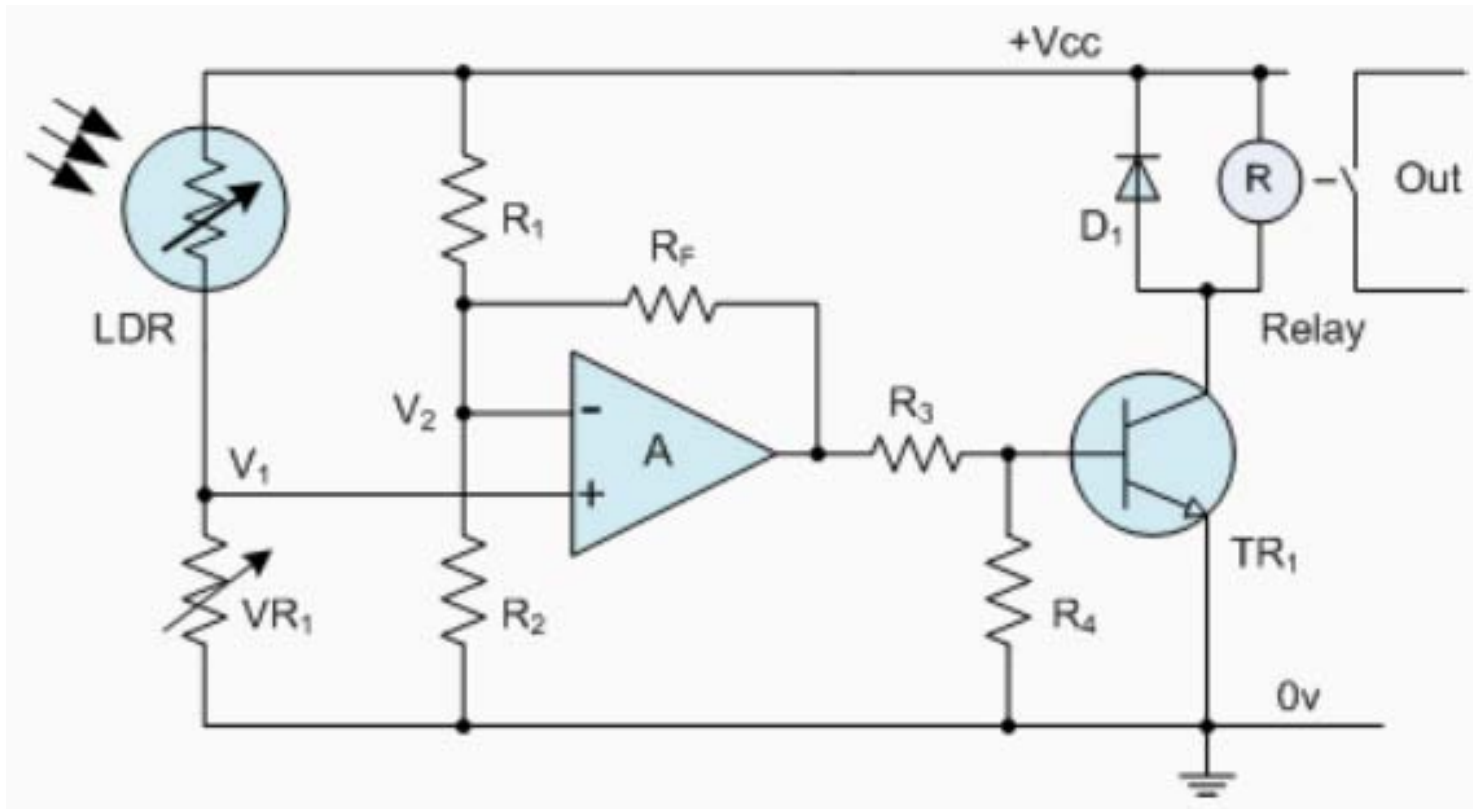
Code Type	Conductors (+/-)	Sensitivity	British BS 1843:1952
<b>E</b>	Nickel Chromium / Constantan	-200 to 900°C	
<b>J</b>	Iron / Constantan	0 to 750°C	
<b>K</b>	Nickel Chromium / Nickel Aluminium	-200 to 1250°C	
<b>N</b>	Nicrosil / Nisil	0 to 1250°C	
<b>T</b>	Copper / Constantan	-200 to 350°C	
<b>U</b>	Copper / Copper Nickel Compensating for "S" and "R"	0 to 1450°C	

# Light sensors: photoconductive cells

- Light dependent resistor (LDR) cell

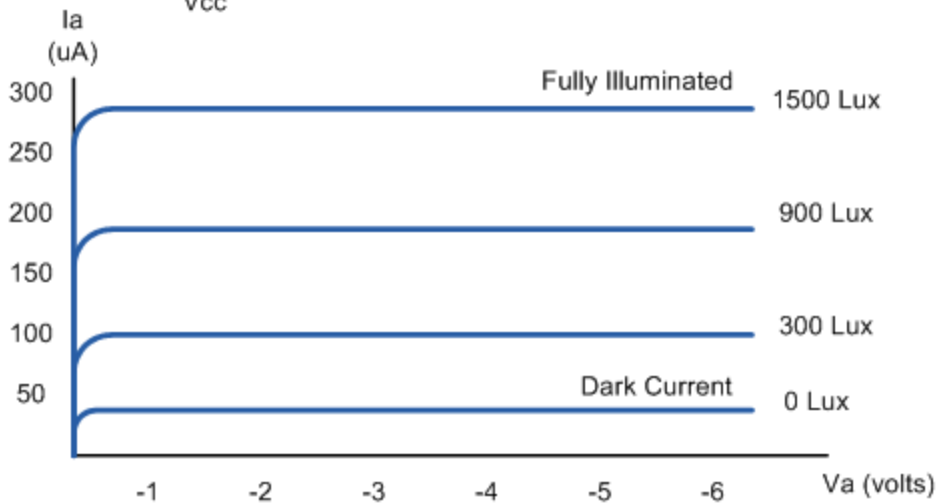
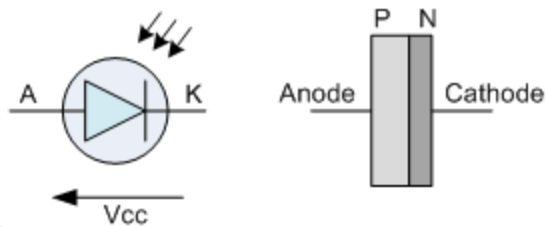


# Light level sensitive switch

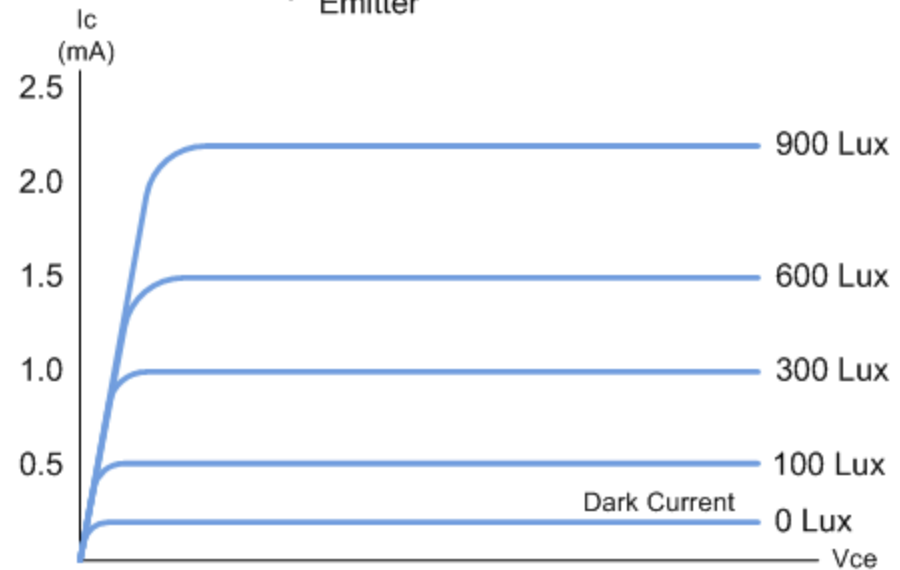
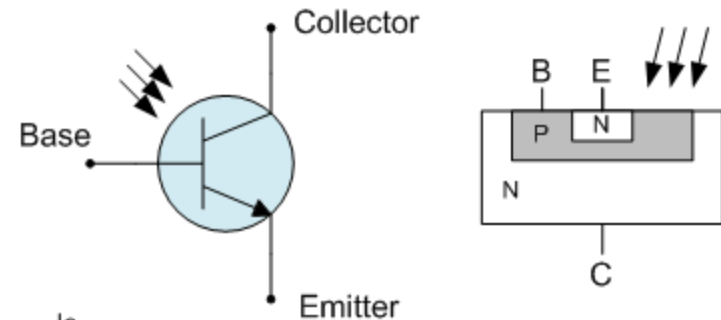


# Photojunction devices

## photodiode

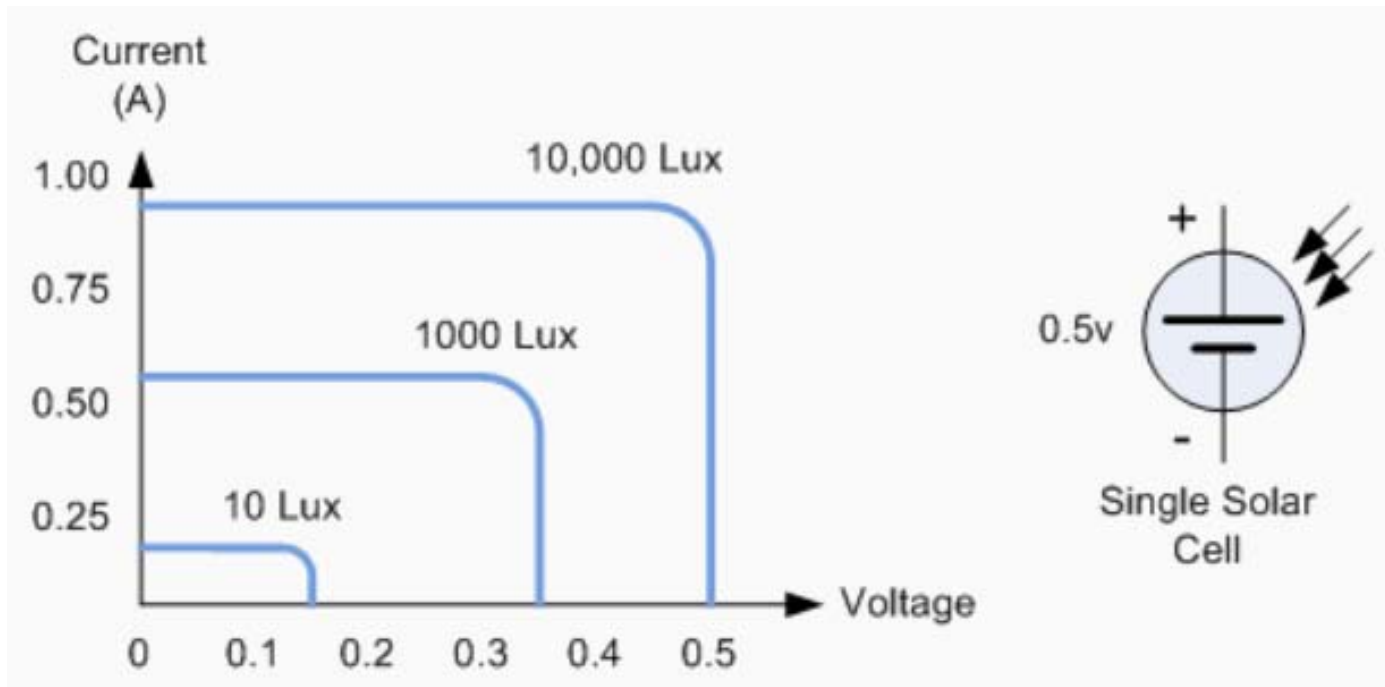


## phototransistor



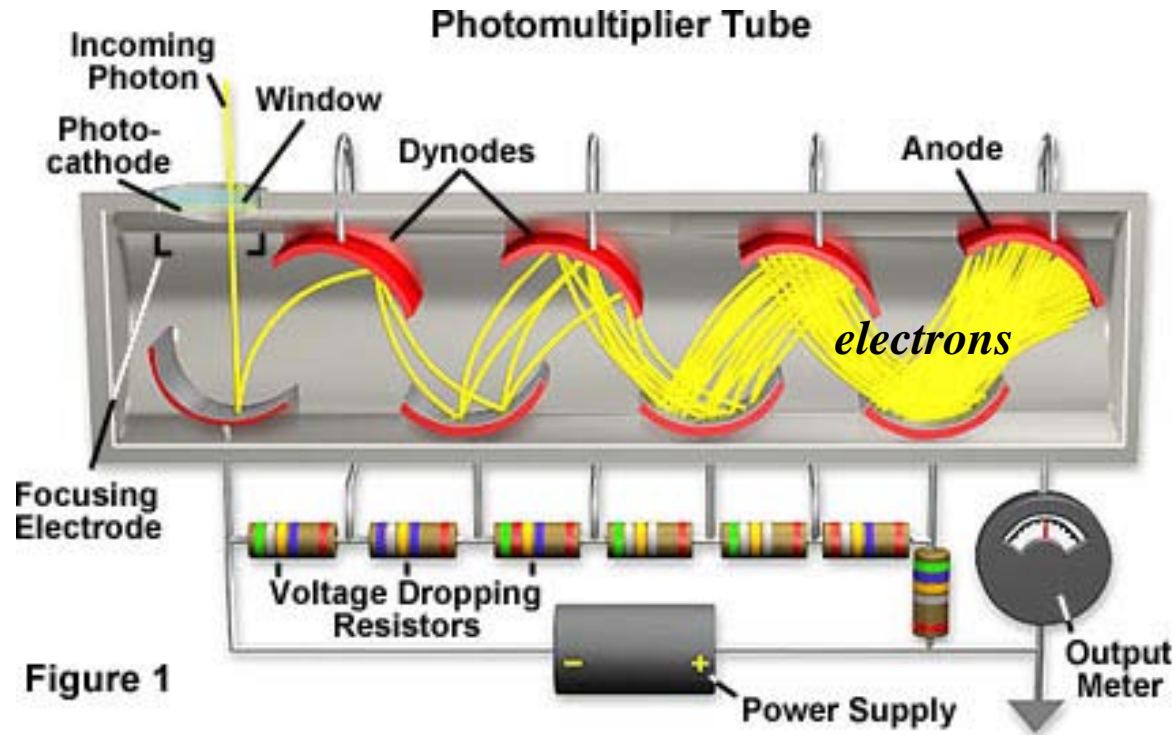
# Photovoltaic Solar Cells

- Can convert about 20% of light power into electricity
- Voltage is low (diode drop,  $\sim 0.6\text{V}$ )



# Photomultiplier tubes (PMT)

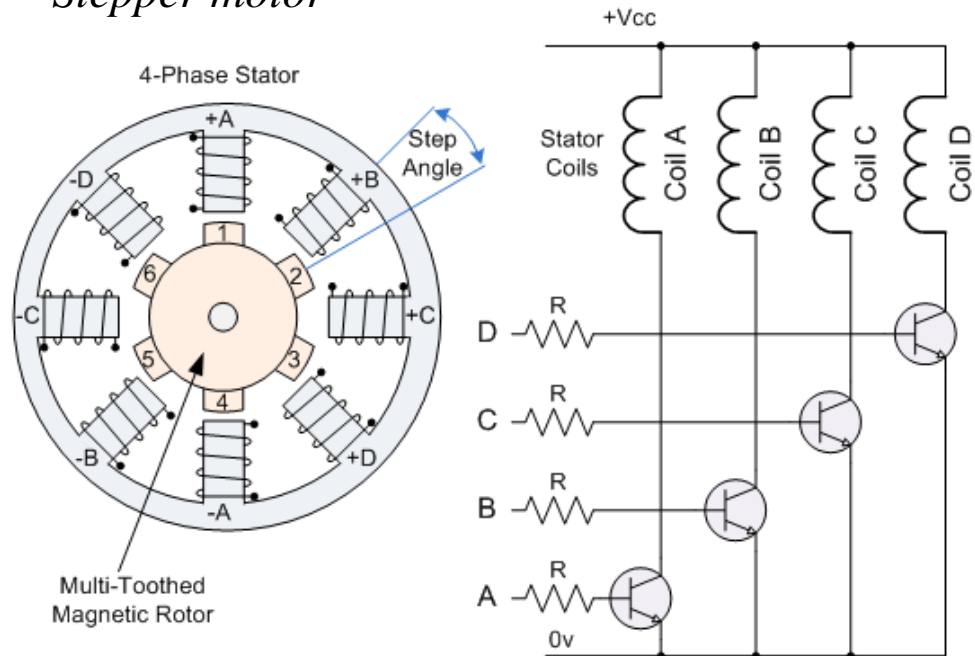
- Most sensitive of light sensors (can detect individual photons)
- Acts as a current source



# Motion sensors/transducers

- Switches, solenoids, relays, motors, etc.
- Motors
  - DC
    - Brushed/brushless
    - Servo
    - Stepper motors
  - AC

*Stepper motor*

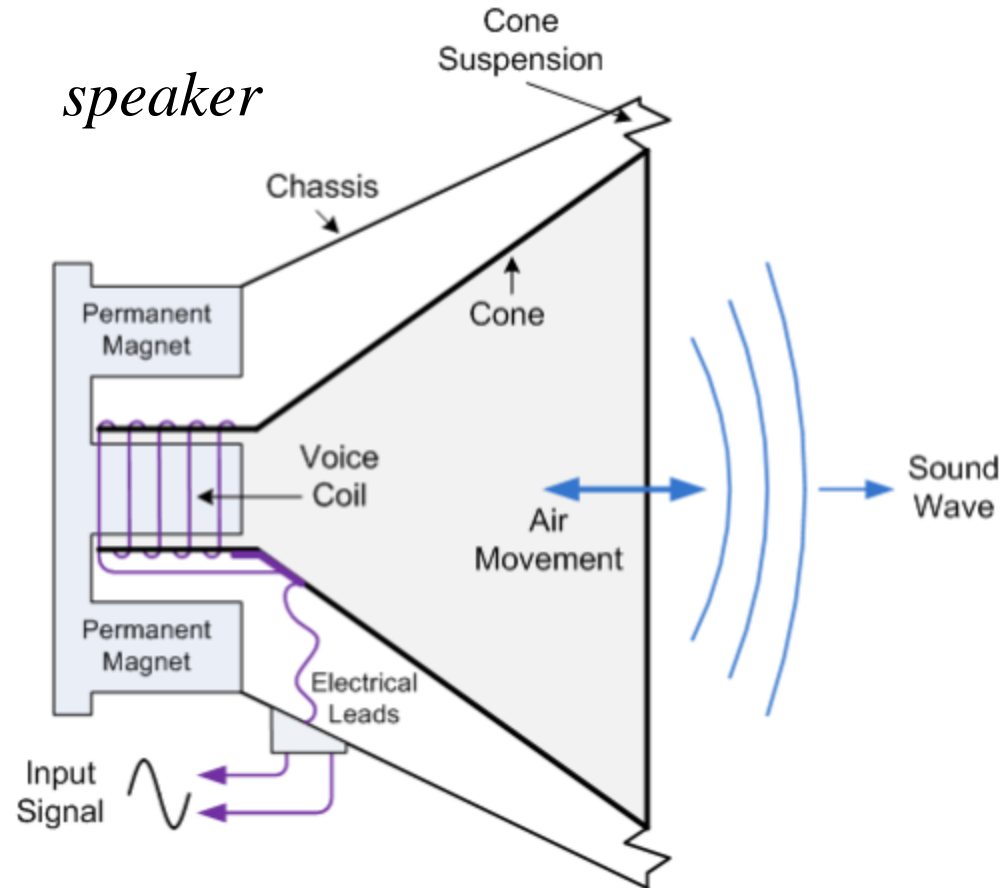
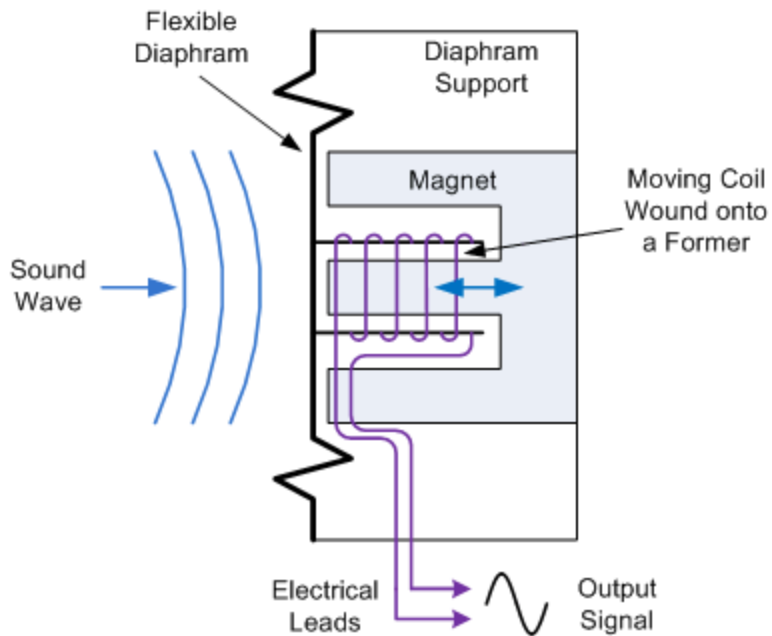




# Sound transducers

*microphone*

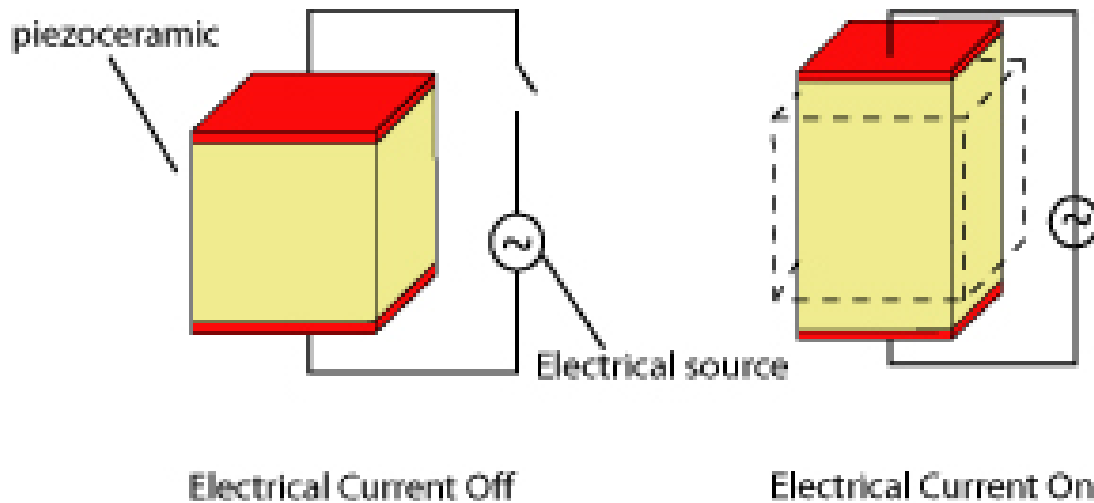
*speaker*



- Note: voice coil can also be used to generate fast motion

# Piezo transducers

- Detect motion (high and low frequency)
- Sound (lab this week), pressure, fast motion
- Cheap, reliable but has a very limited range of motion



# Summary

- We've only briefly touched on most basic types
- Many other transducers are used/common, almost for any physical quantity one can think of
- Processing electronics is often essential: output of many sensors is not linear, needs impedance transform, filtering, etc.
- For additional references see
  - [http://www.electronics-tutorials.ws/io/io\\_1.html](http://www.electronics-tutorials.ws/io/io_1.html)
  - Handbook of Transducers by H.N. Norton