Basic Ham Radio Licensing Course

ACTIVE DEVICES

Mark Bramwell
VE3PZR VE3UWO

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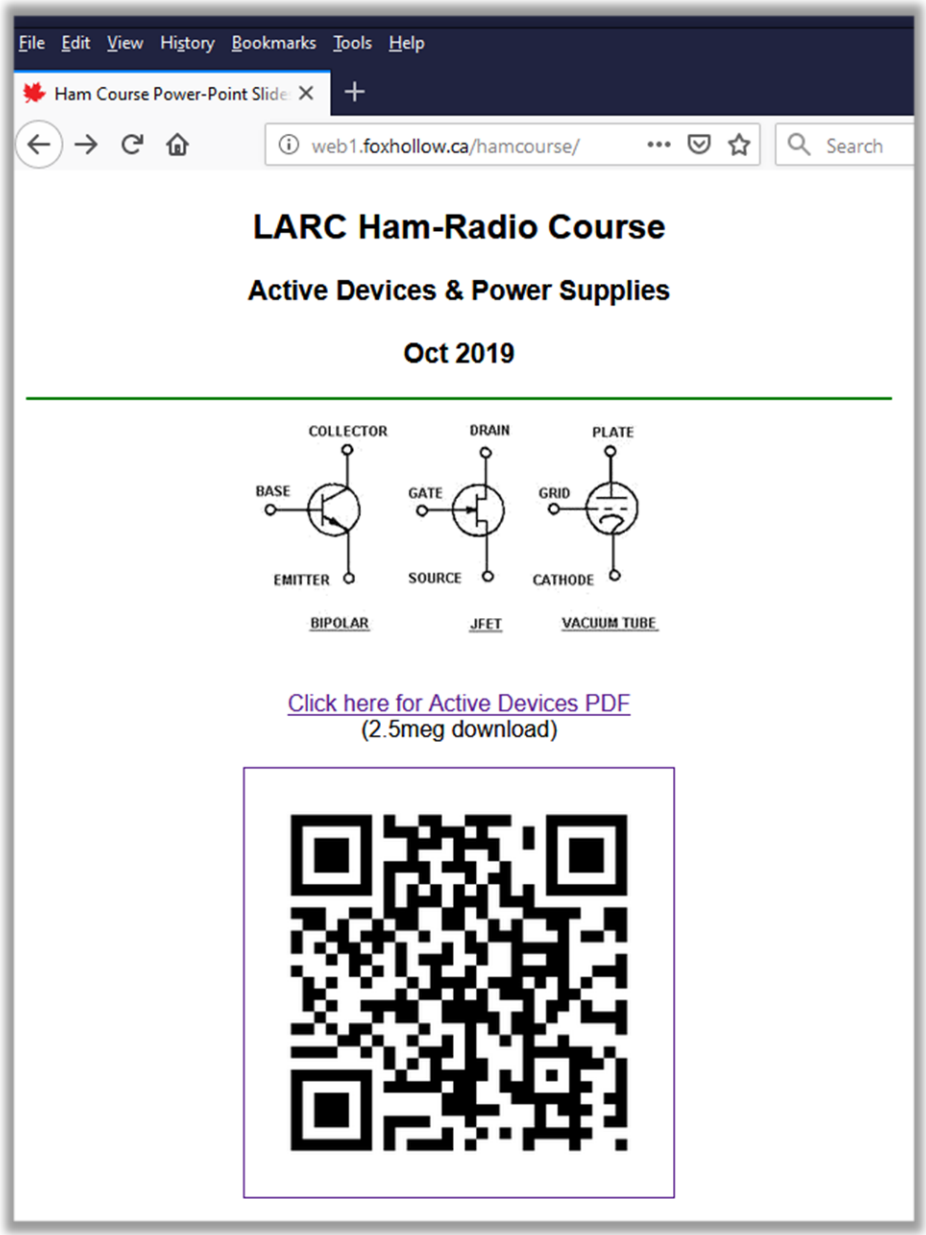
http://foxhollow.ca/hamcourse/



Topics to be covered…

- Active Devices: Diodes, Transistors and Tubes

Next week:

- Power Supplies: Changing AC to DC

Review Question 1 of 3

B-003-020-011 What precaution should you take when installing a ground-mounted antenna?

a) It should be installed so no one can come in contact with it
b) It should be painted so people or animals do not accidentally run into it
c) It should not be installed in a wet area
d) It should not be installed higher than you can reach

Review Question 2 of 3

- B-006-003-004; What common connector type usually joins RG-213 coaxial cable to an HF transceiver?

a) A PL-259 connector
b) An F-type cable connector
c) A banana plug connector
d) A binding post connector

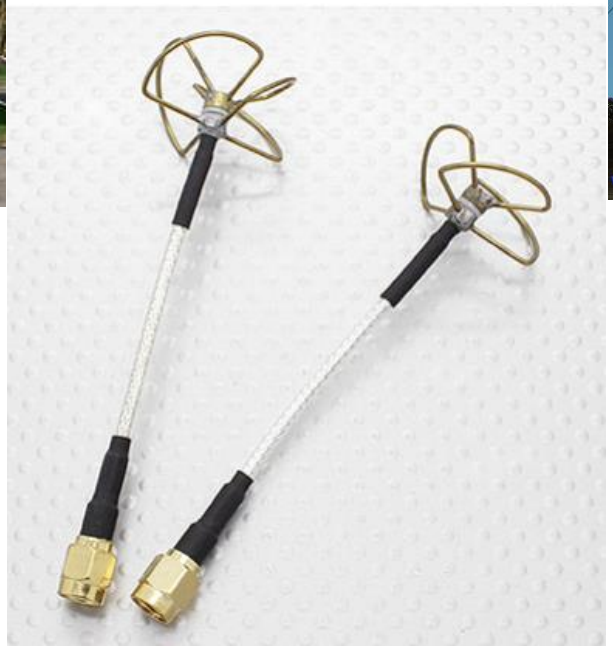
Connectors

Review Question 3 of 3

- B-006-007-003;What electromagnetic wave polarization does a Yagi antenna have when its elements are parallel to the Earth's surface?

a) Horizontal
b) Helical
c) Vertical
d) Circular

Circular Polarization



Objectives…

- Become familiar with the basics of semiconductors and tubes
- Name the parts of each
- Compare tubes and solid state devices

From wiki…

- The **semiconductor industry** is the aggregate collection of companies engaged in the design and fabrication of semiconductors

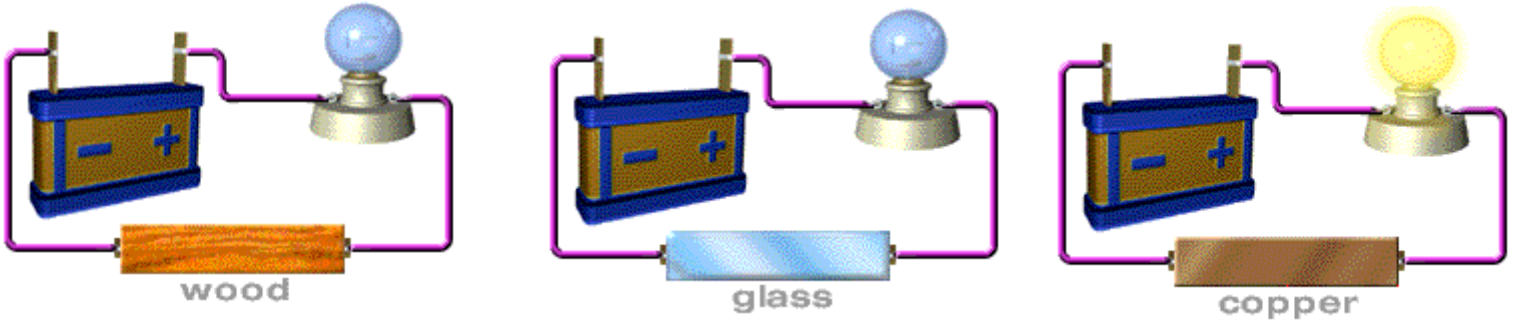
- annual consumer electronics sales expected to reach $2.9 trillion by 2020,[4] tech industry sales expected to reach $5 trillion in 2019,[5] and e-commerce with over $29 trillion

What is a semiconductor?

- The purpose of electronics is to control the flow of current in one way or another so that intelligence or information can be impressed upon the current flow

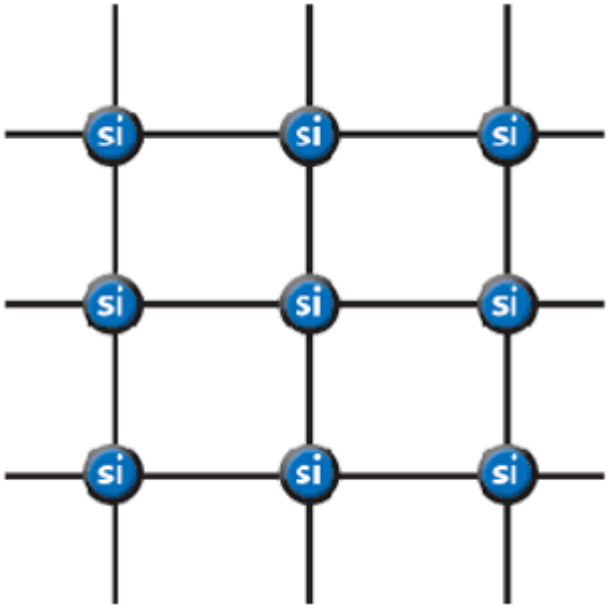
- What is a conductor?
- What is an insulator?
- Is there something that is both?

- A semiconductor allows current to flow under certain conditions



Silicon is an insulator?

- Carbon, silicon and germanium each have four electrons in their outer orbital allowing them to form nice crystals.



Silicon on Dope

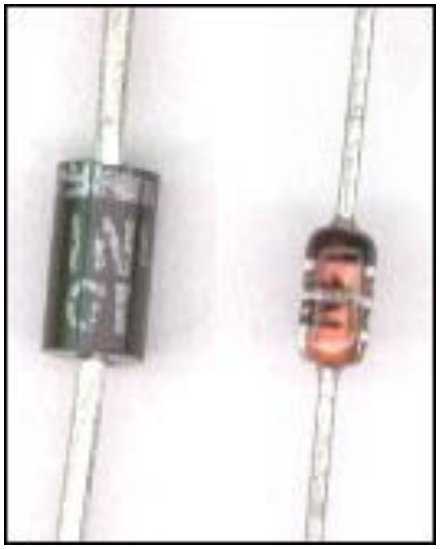
- Doping means adding impurities to modify the behavior of a substance
- Electrons are negative. Removing electrons makes something comparatively ‘positive’
- Electrons and water both want to seek their own level; under the proper circumstances, the current will flow

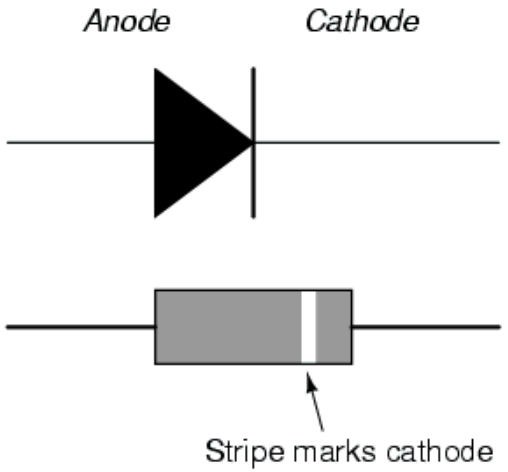
Types of Doped material...

- N-Type: Extra electron added; can not bond to anything; free to move around
- P-Type: Electron missing from crystal lattice; a nice hole to accept free moving electrons

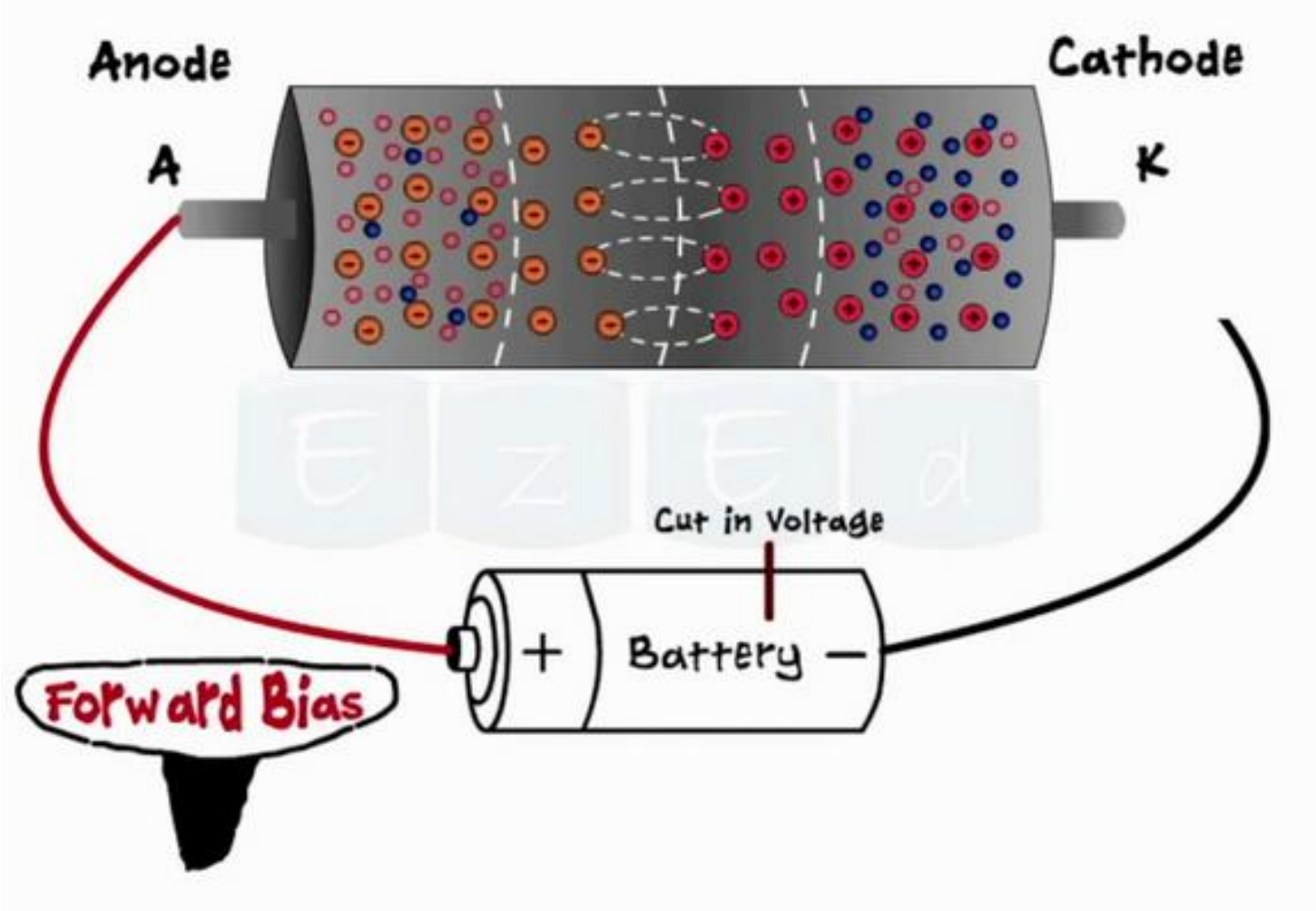
Diodes

- Created by the junction of N + P type material.
- Part Numbers: 1N4001, 1N914
- “1” means one junction

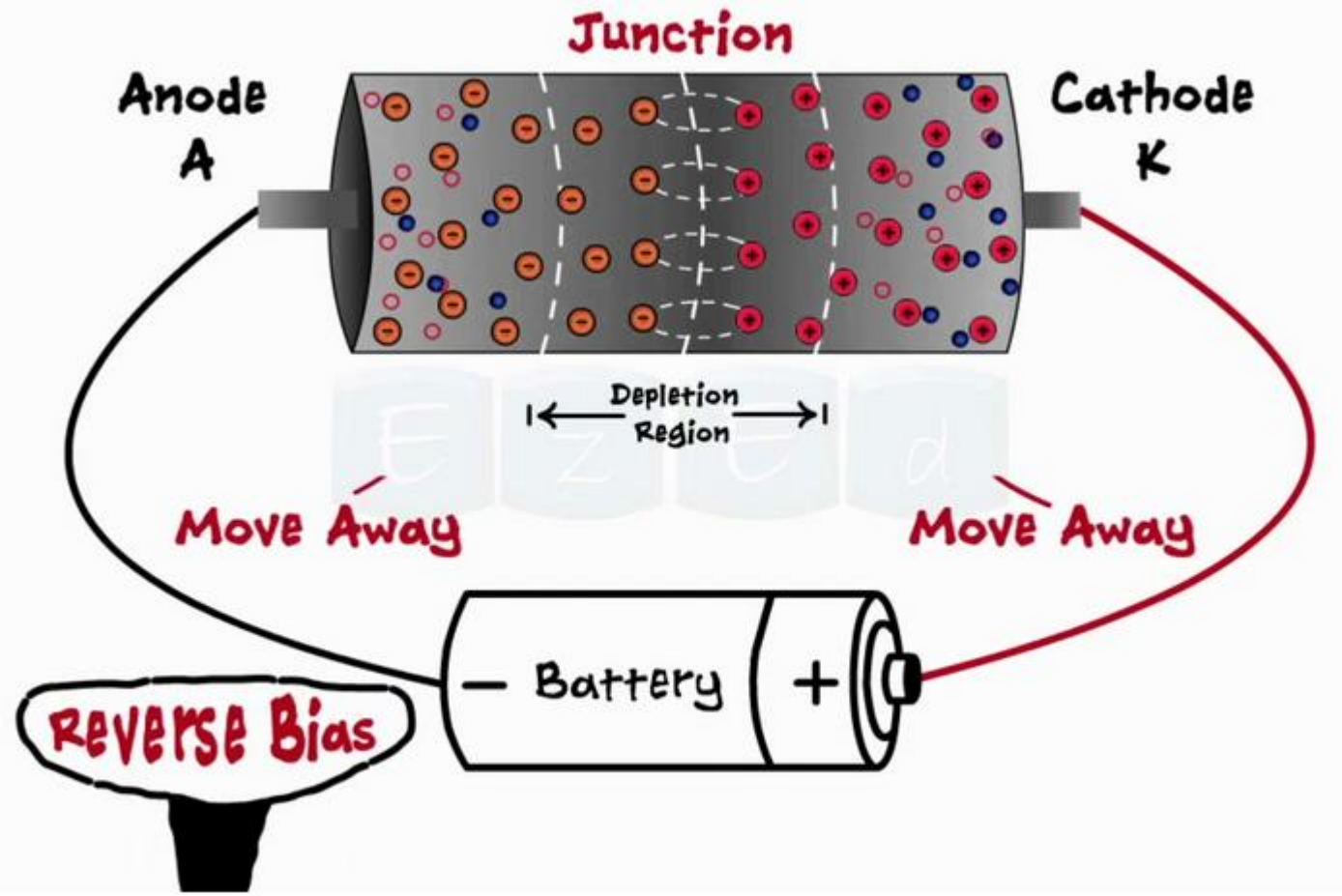




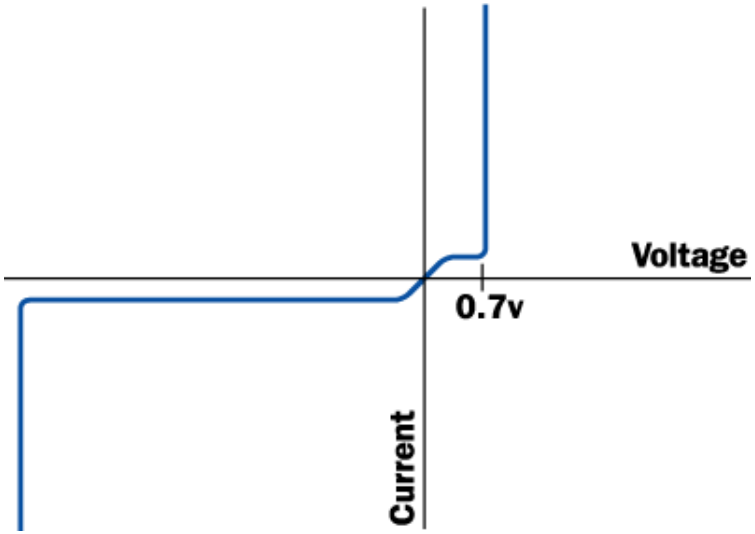
Diode Operation - Working

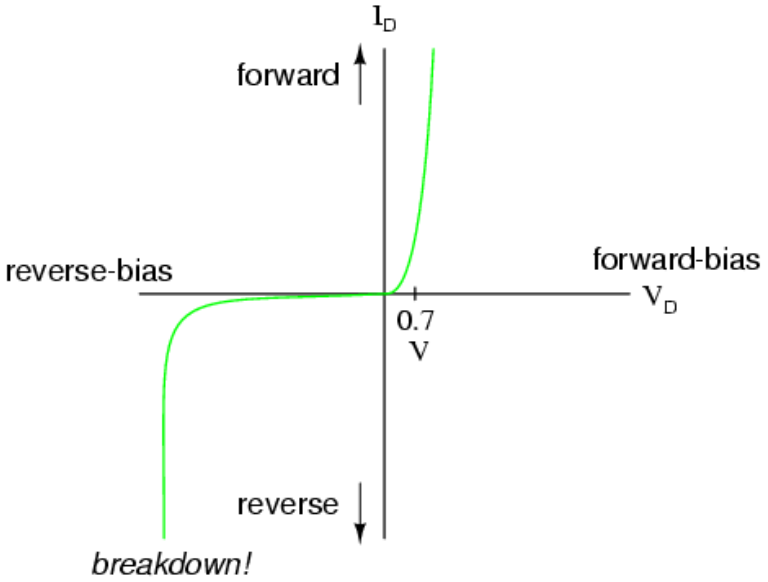


Diode Operation - Blocked



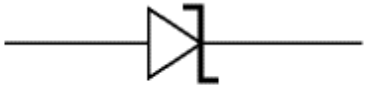
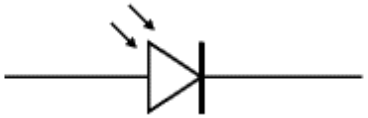
Diode Voltage Drop





All Diodes have a voltage drop, in this case it is .7volts

Types of Diodes

Diodes		
Component	**Circuit Symbol**	**Function of Component**
Diode		A device which only allows current to flow in one direction.
LED Light Emitting Diode		A transducer which converts electrical energy to light.
Zener Diode		A special diode which is used to maintain a fixed voltage across its terminals.
Photodiode		A light-sensitive diode.
Varactor		Variable Capacitor

Varactors / Varicaps are commonly used in parametric amplifiers, parametric oscillators and voltage-controlled oscillators as part of phase-locked loops and frequency synthesizers. It is principally used as a voltage-controlled capacitor, and its rectifier function is secondary.

Diode key terms

- A *diode* is an electrical component acting as a one-way valve for current.
- When voltage is applied across a diode in such a way that the diode allows current, the diode is said to be ***forward-biased***.
- When voltage is applied across a diode in such a way that the diode prohibits current, the diode is said to be ***reverse-biased***.
- The voltage dropped across a conducting, forward-biased diode is called the ***forward voltage***. Forward voltage for a diode varies only slightly for changes in forward current and temperature, and is fixed principally by the chemical composition of the P-N junction.
- Silicon diodes have a forward voltage of approximately **0.7** volts.
- Germanium diodes have a forward voltage of approximately **0.3** volts.
- The maximum reverse-bias voltage that a diode can withstand without "breaking down" is called the *Peak Inverse Voltage*, or *PIV* rating. (aka kaboom voltage)

Exam Question

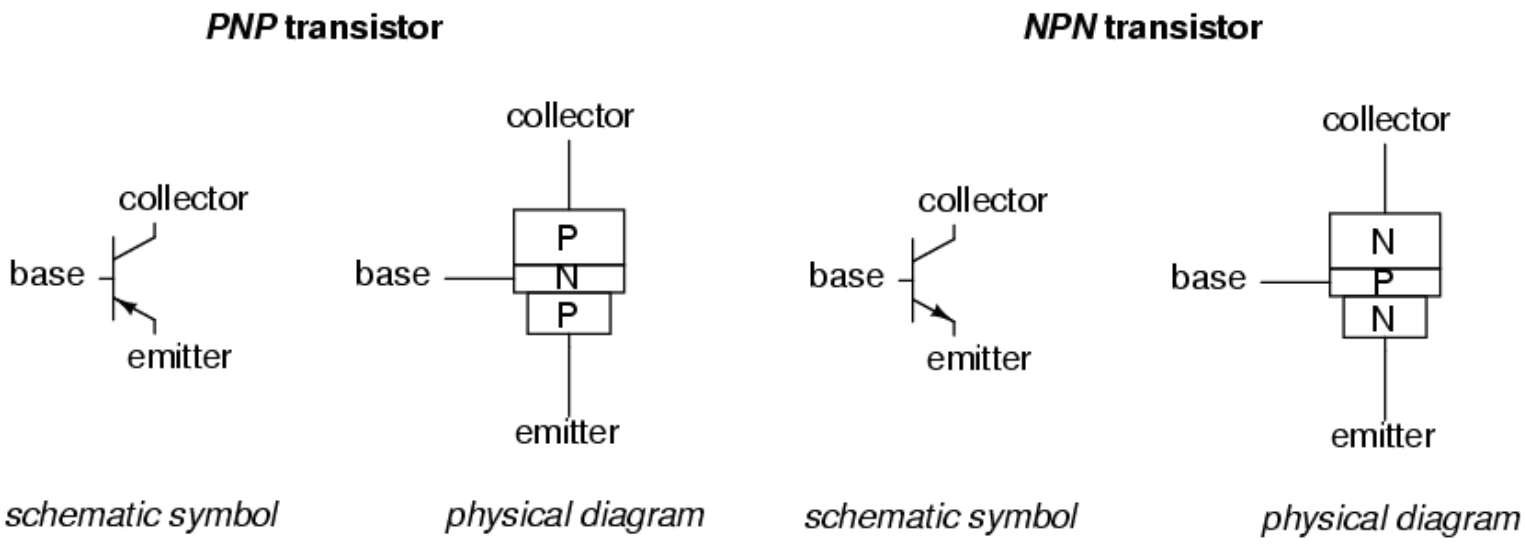
- B-004-002-005;The electrodes of a semiconductor diode are known as:

a) anode and cathode
b) gate and source
c) collector and base
d) cathode and drain

Transistors

- Short for ‘Transfer Resistor’
- 3 materials; 2 junctions
- PNP or NPN
- Bipolar versus Unipolar (FET)
- 2N2222, 2N3904

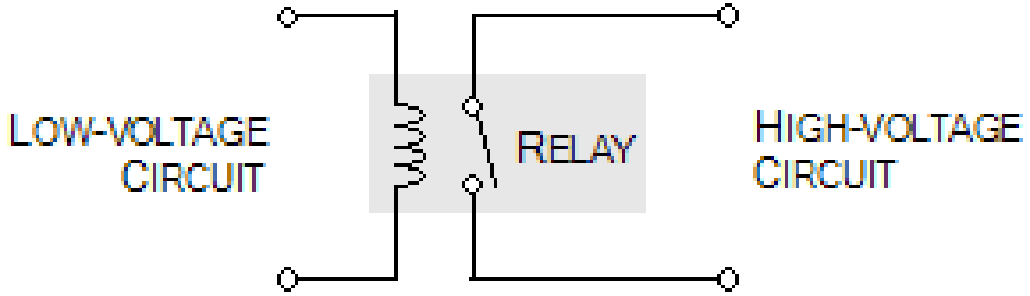
Bipolar Transistors



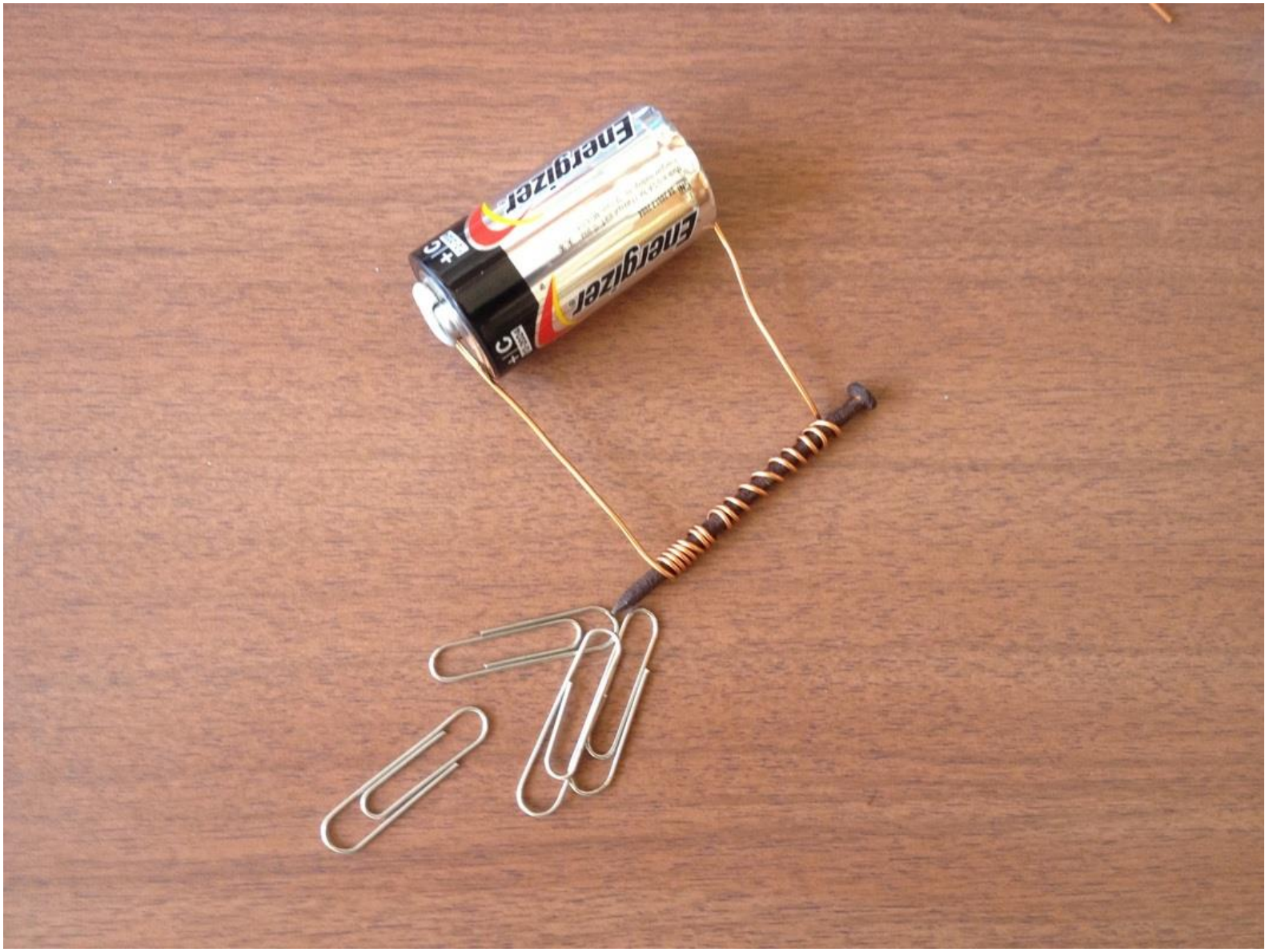
NPN Transistor: A small current flowing from the emitter to the base controls a large current flowing from the emitter through the base to the collector

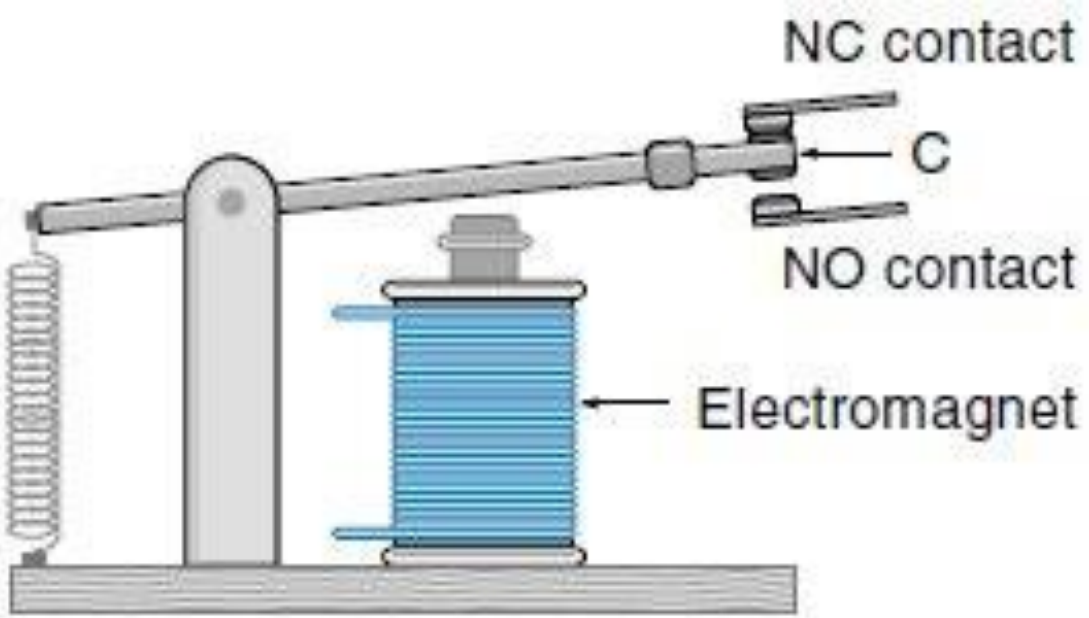
What is a RELAY?

- Let's forget about transistors for a moment….



- Relays are electro-mechanical devices that contain a coil (eletro-magnet) and a clapper-switch that moves


Energizer
Energizer

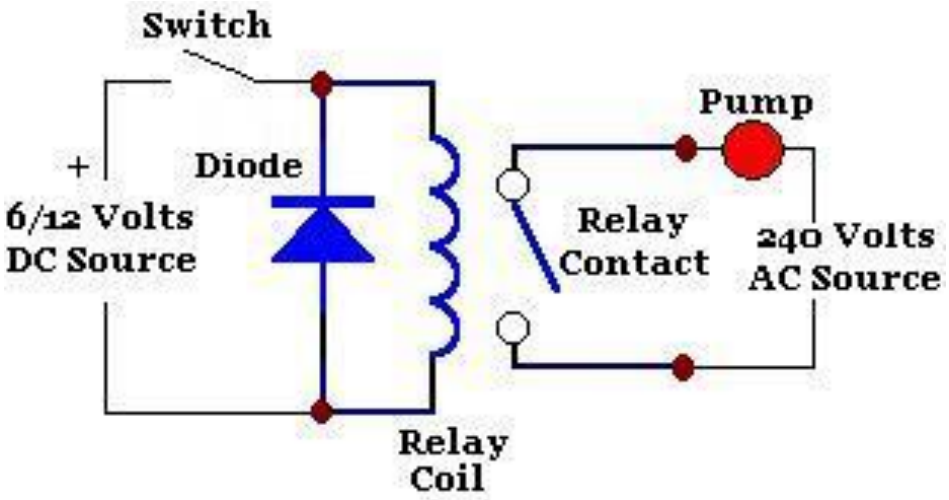

NC contact
C
NO contact
Electromagnet


VDE


OMRON
G5LE-1A
5 VDC
10 A 250 V AC
5 A 250 V AC
08Z4W8

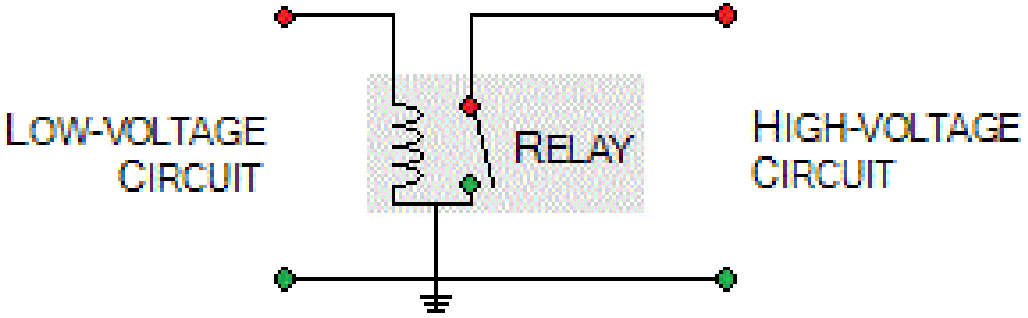

VIAIR
S10-1A-NY 12VDC
12V 40A
85
87
86
30

Relays are common for ‘control’ purposes



- A small voltage on the input causes the clapper to close.
- This switches ‘on’ the output voltage

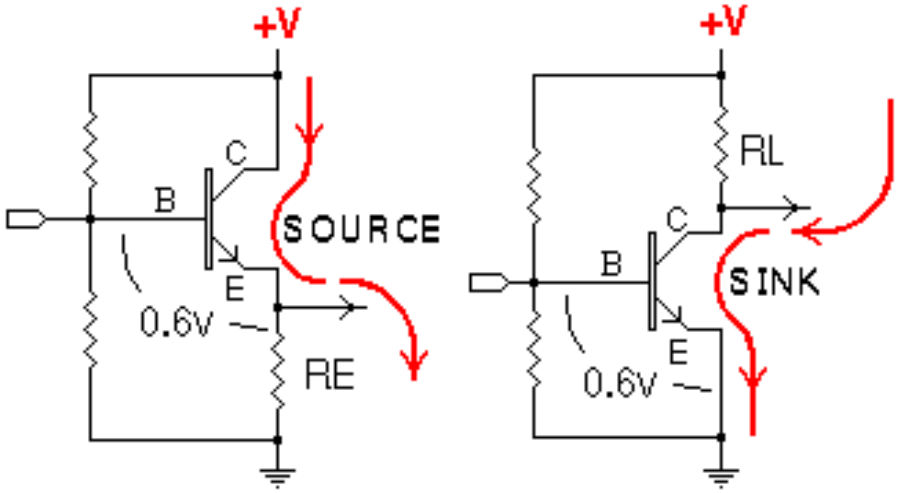
Relays seem to amplify the signal !!



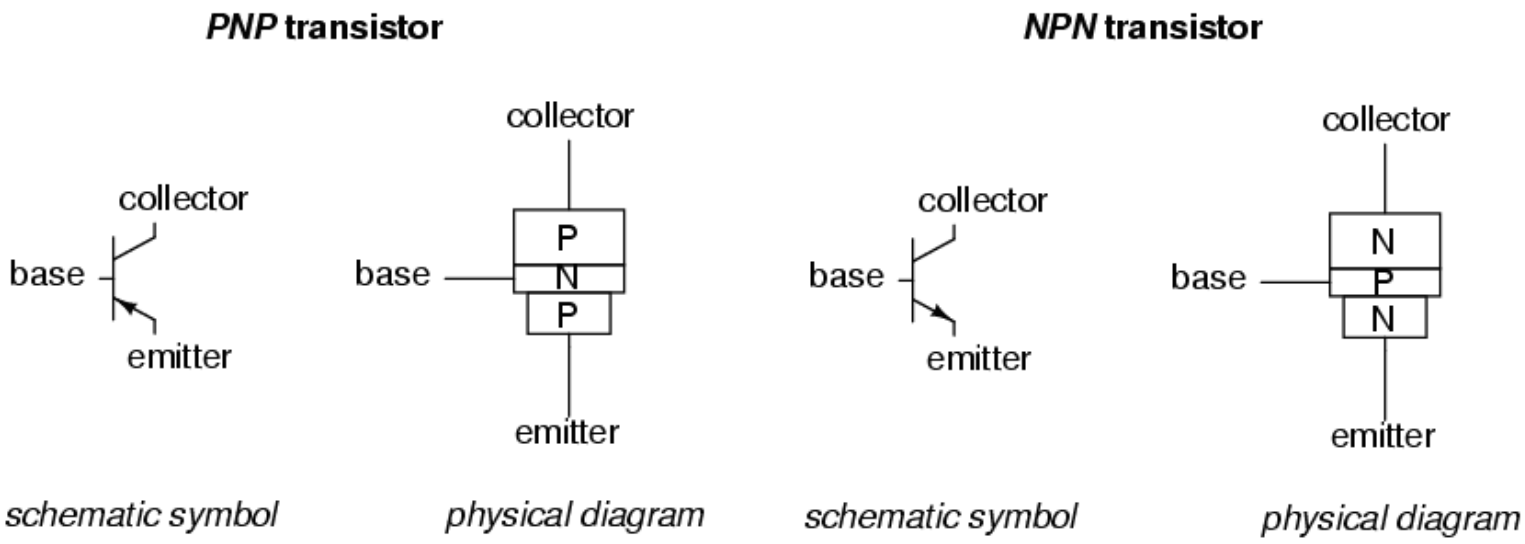
- This relay circuit will take a SMALL voltage as an INPUT
- Gives a LARGE voltage as an OUTPUT

Transistor amplifier circuit

- Small amounts of control current allow large amounts of signal to flow
- Ratio of 'control' to 'output' is the gain

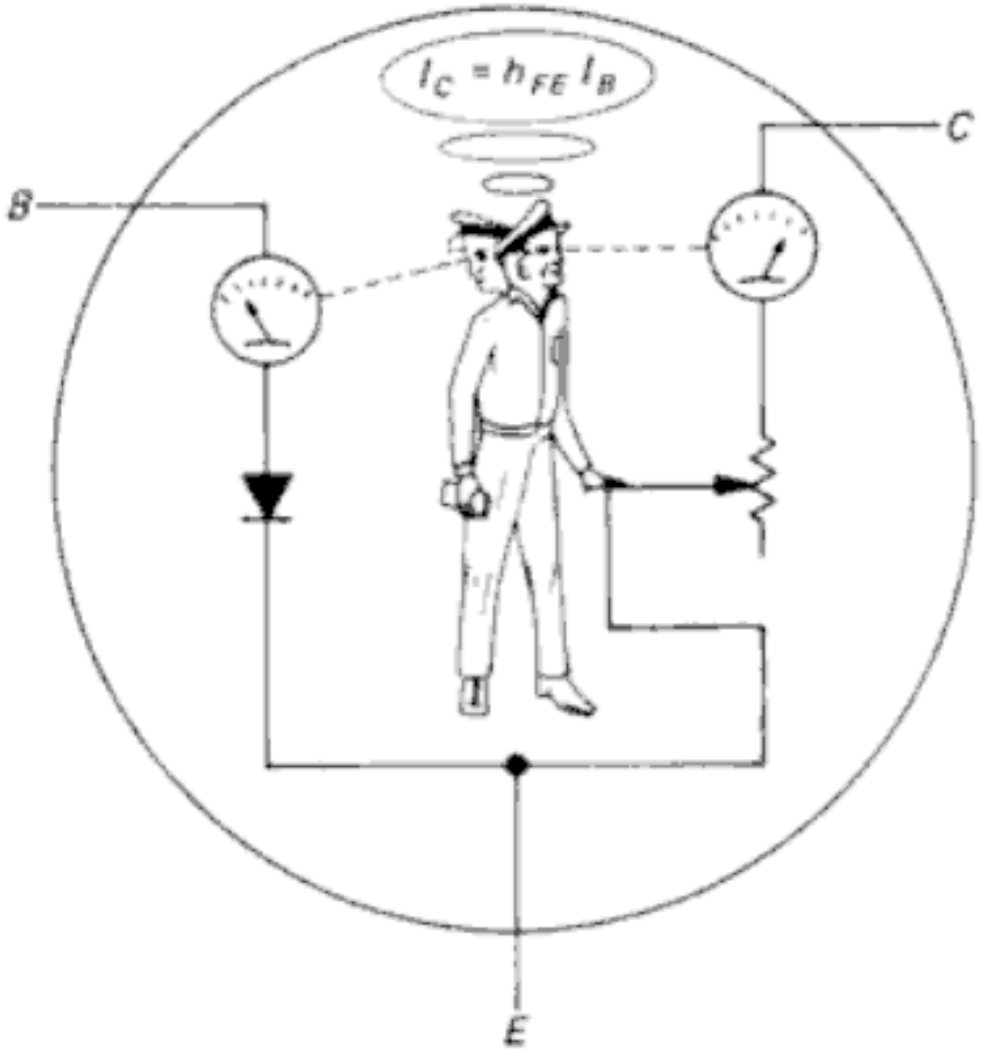


Bipolar Transistors



NPN Transistor: A small current flowing from the emitter to the base controls a large current flowing from the emitter through the base to the collector

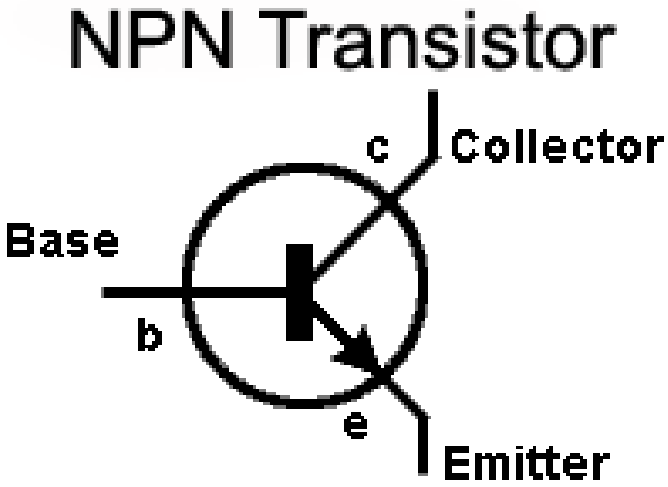
Transistor Man



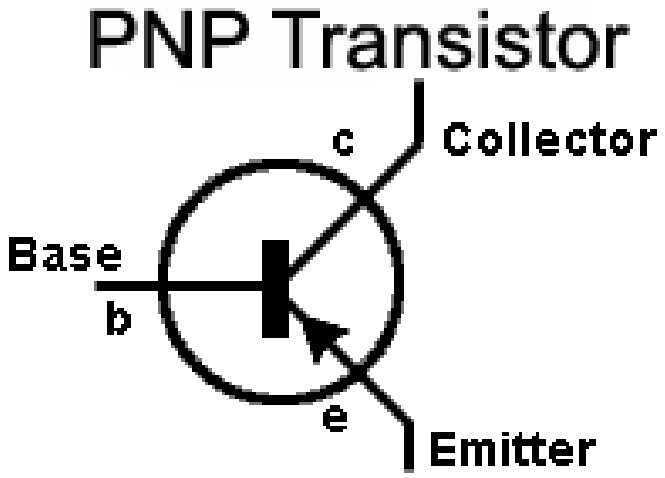
Transistors

- Short for ‘Transfer Resistor’
- 3 materials; 2 junctions
- PNP or NPN
- Bipolar versus Unipolar (FET)
- 2N2222, 2N3904

NPN or PNP symbol?



N Never
P Points
N iN



P Points
N iN
P Permanently

Exam Question 1 of 3

- B-004-003-005;Bipolar transistors usually have:

a) 3 leads
b) 1 lead
c) 2 leads
d) 4 leads

?? What about diodes ??

Exam Question 2 of 3

- B-004-003-006;A semiconductor is described as a "general purpose audio NPN device".

This would be:

a) a bipolar transistor
b) a silicon diode
c) a triode
d) an audio detector

Exam Question 3 of 3

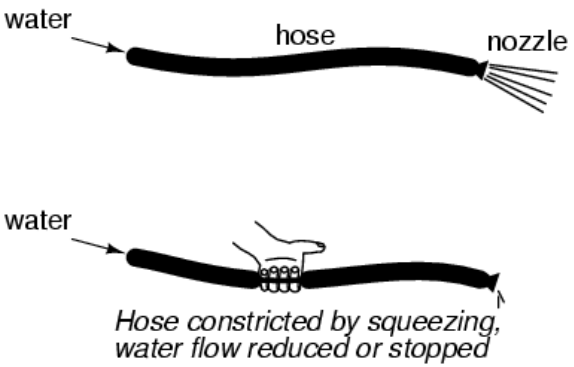
- B-004-003-004;If a low level signal is placed at the input to a transistor, a higher level of signal is produced at the output lead.

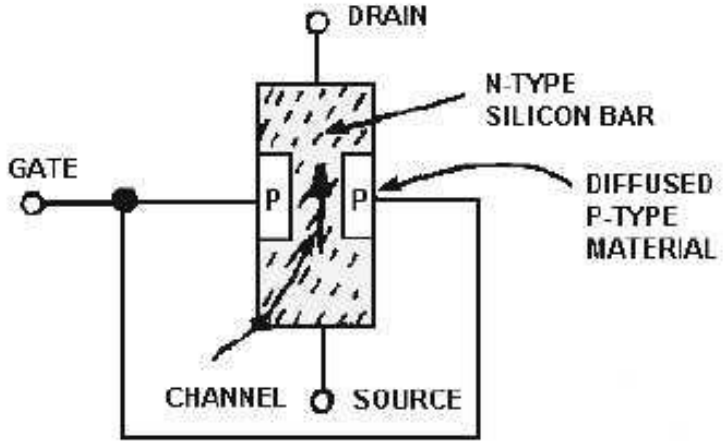
This effect is known as:

a) Amplification
b) Detection
c) Modulation
d) Rectification

Field Effect Transistors

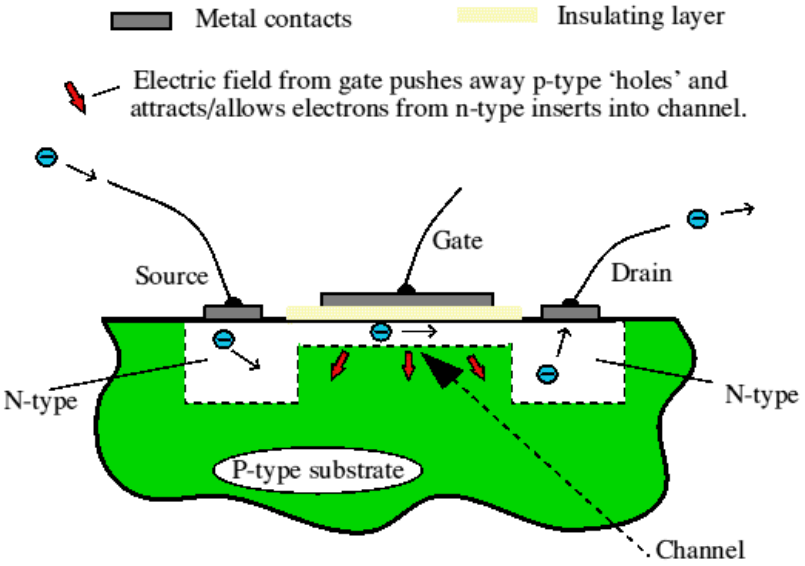
- Unlike bipolar transistors, FETs are normally 'on'
- The control voltage squeezes off the ability of current to flow

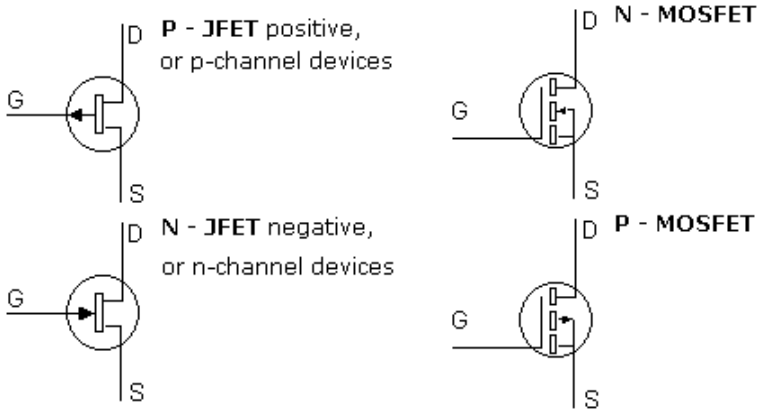




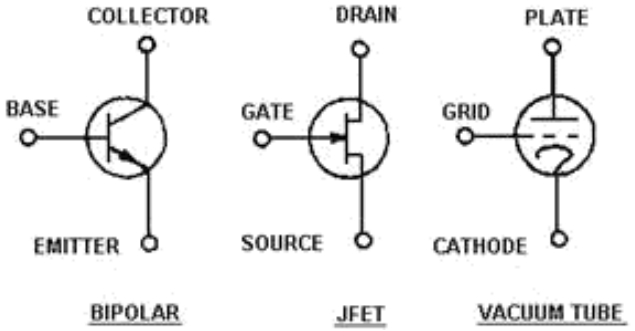
FET Symbols

- Multiple types of FETs, all derivatives of the same basic idea





FET Facts



- Source: point at which the charge enters the channel
- Drain: exit point
- Gate: control point (same idea as the base in a bipolar transistor)
- FET is "ON" until a gate signal turns it off

- JFET – Junction FET (operates reverse biased)
- IGFET – Insulated Gate FET
- MOSFET – Metal Oxide Silicon FET

Transistor Facts

- Breakdown voltage: Max safe voltage under any condition of operation
- Max Voltage: Max safe operating voltage; less than breakdown voltage
- Max Current: most important is $I_{collector}$
- Max Power: Deals with Heat Dissipation

Exam Question 1 of 3

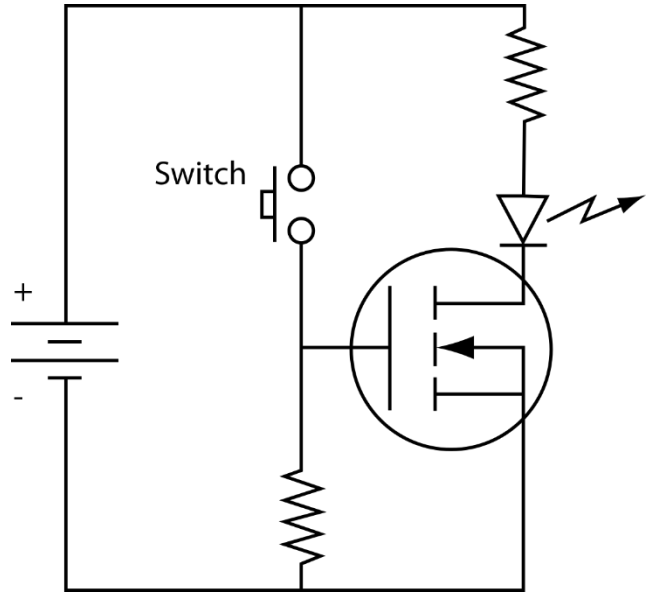
- B-004-004-001;The two basic types of field effect transistors (FET) are:

a) N and P channel
b) NPN and PNP
c) germanium and silicon
d) inductive and capacitive

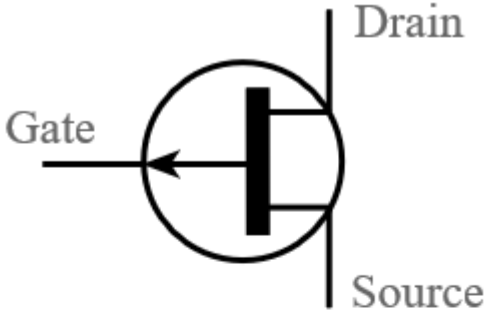
Exam Question 2 of 3

- B-004-004-003;In a field effect transistor, the _____ is the terminal that controls the conductance of the channel.

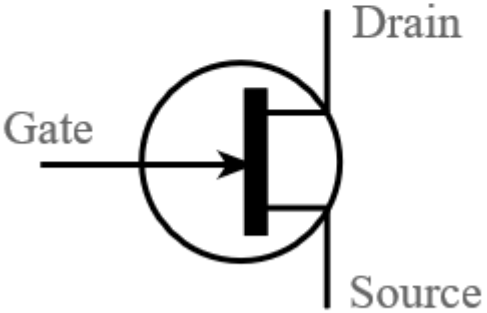
a) Gate
b) Drain
c) Source
d) Collector



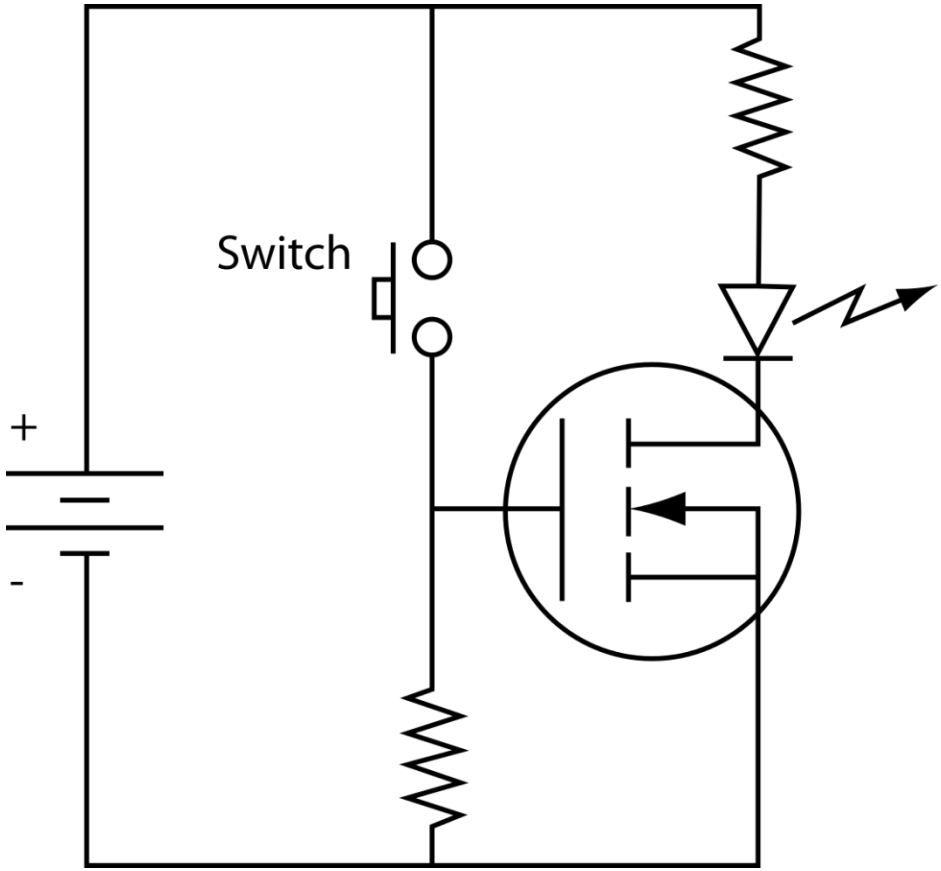
FET used as a switch



P-Channel



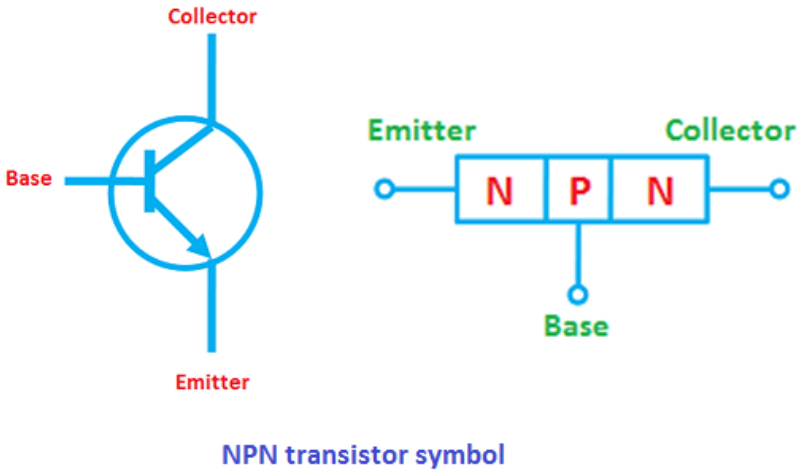
N-Channel



Exam Question 3 of 3

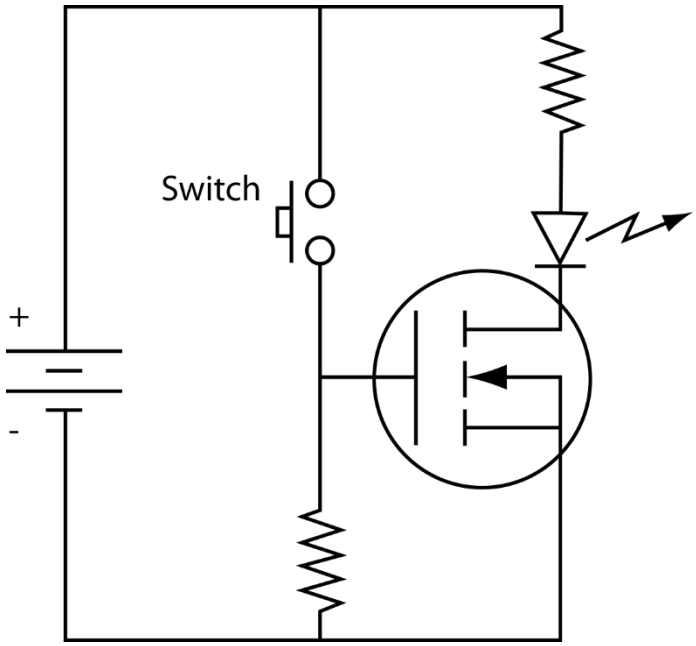
- B-004-004-009;The source of a field effect transistor corresponds to the _____ of a bipolar transistor.

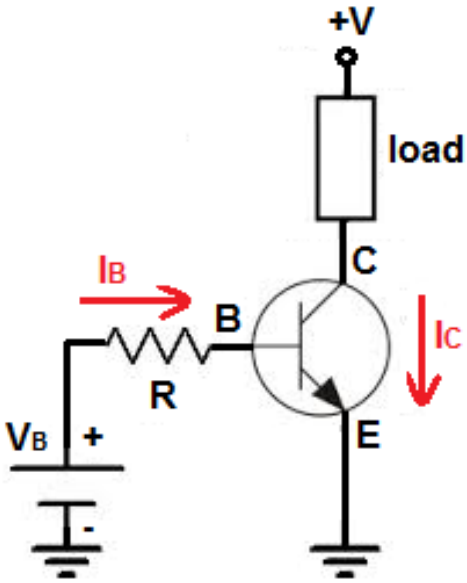
a) Emitter
b) Base
c) Drain
d) Collector



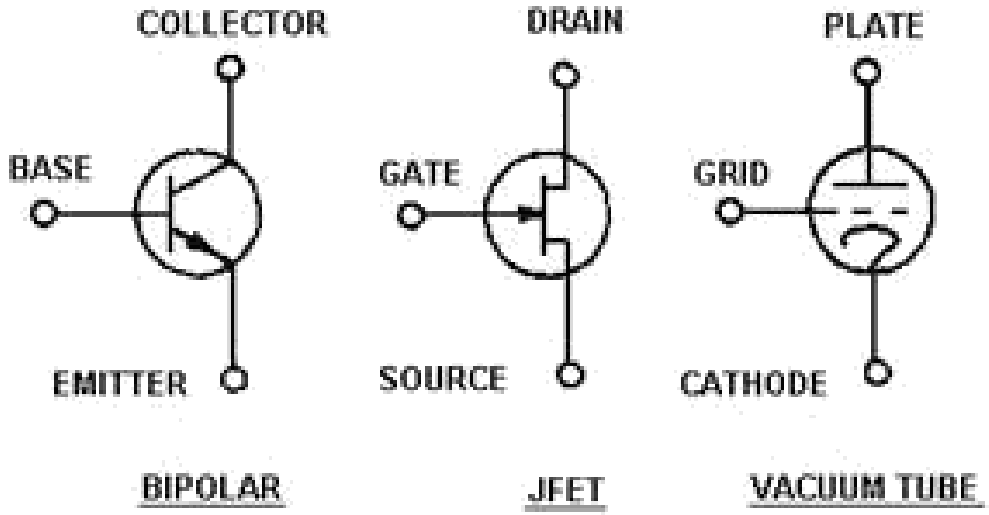
NPN transistor symbol

FET versus Bipolar



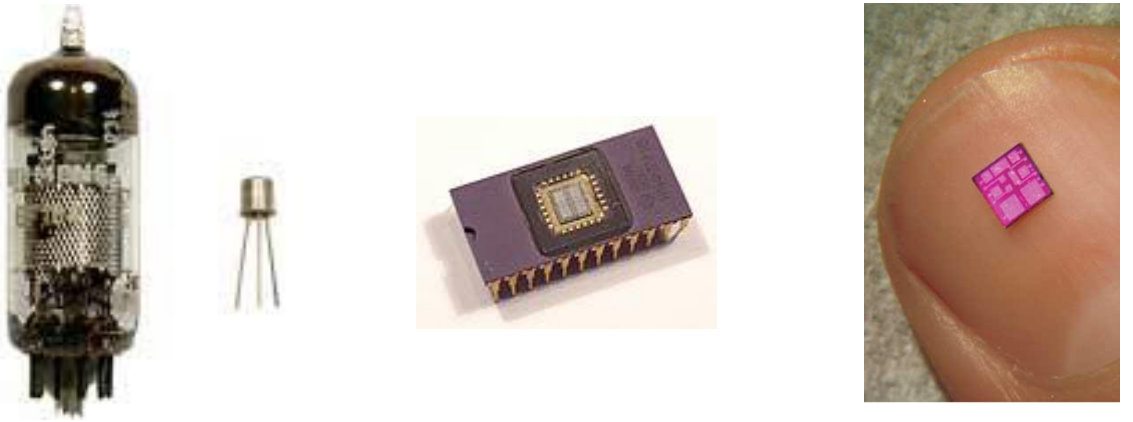


In an NPN transistor, positive voltage is given to the collector terminal and current flows from the collector to the emitter, given there is sufficient base current


COLLECTOR
BASE
EMITTER
BIPOLAR
DRAIN
GATE
SOURCE
JFET
PLATE
GRID
CATHODE
VACUUM TUBE

Integrated Circuits

- Combines multiple devices into a single package
- Miniaturization
- High reliability
- Less costly than separate components

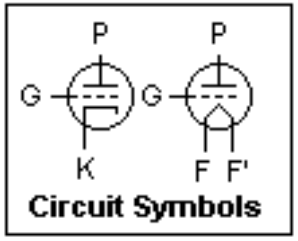


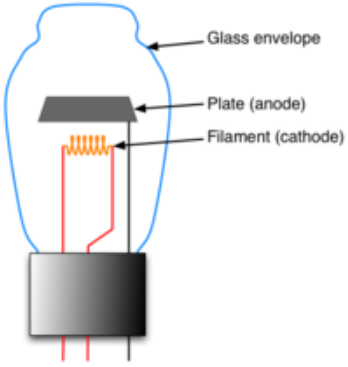
Fun Fact

- How many transistors are in a CPU?
  - 1975: 6502 = 4,528
  - 1980: 8051 = 51,000
  - 2000: P3 Coppermine = 21 million
  - 2019: AMD Epyc = 32 billion

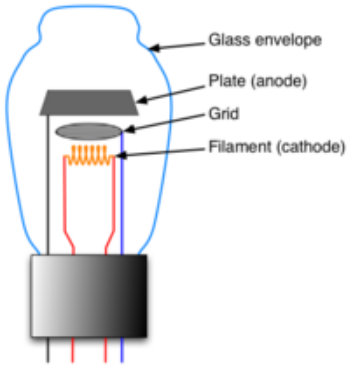
Vacuum Tubes

- Glass 'vacuum filled' container
- Heater filament
- Electrons stream from cathode to plate
- Grid controls flow (like a FET)

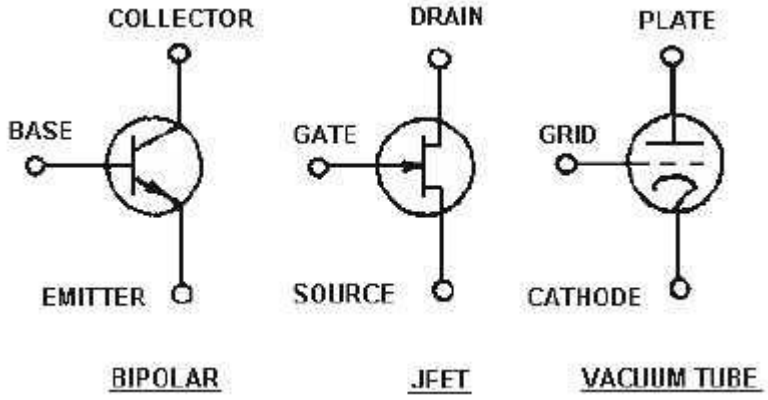




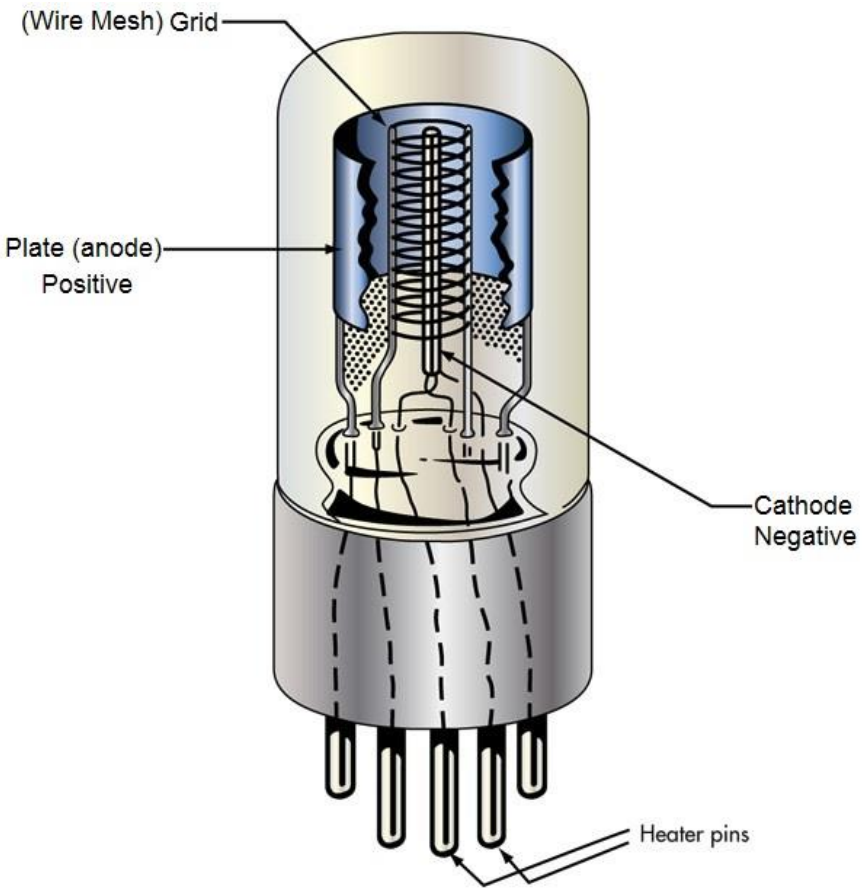
Diode



Triode



Vacuum Tubes



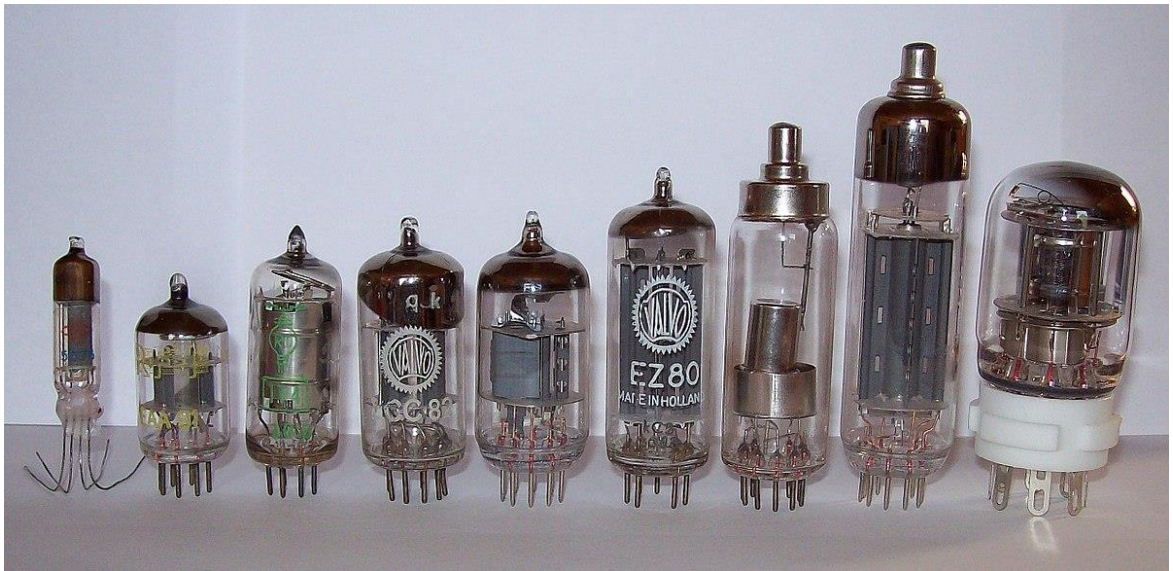
- The heater heats up the Cathode
- Electrons stream off the Cathode towards the Plate
- They must pass through the wire mesh of the Grid
- The Grid controls the flow similar to the Gate on a modern FET

Tube Facts

- Grid voltage = grid bias
- Total blockage occurs at cut-off bias
- Tubes can handle LARGE amounts of power
- Sometimes extra elements are added for stability and to reduce interaction between embedded elements
- Triode=3, tetrode=4, pentode=5

Tube numbering

- 1st digit = number of elements
- Last digit = plate dissipation
- Center letters;
  - X = external anode
  - C = ceramic (instead of glass)



Exam Question 1 of 3

- B-004-004-006;Which semiconductor device has characteristics most similar to a triode vacuum tube?

a) Field effect transistor
b) Junction diode
c) Zener diode
d) Bipolar transistor

Exam Question 2 of 3

- B-004-005-003;A feature common to triode tubes and transistors is that both:

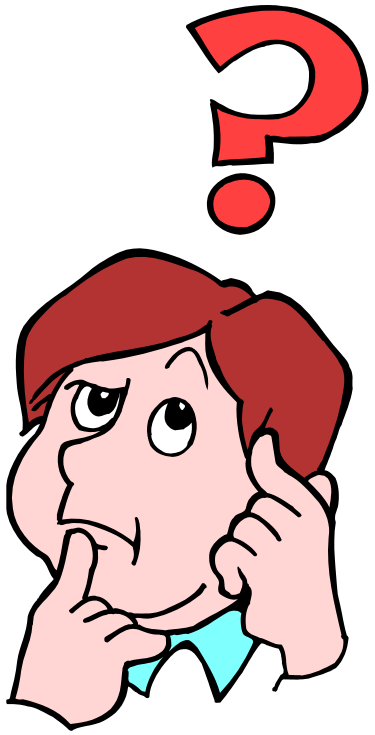
a) can amplify signals
b) have electrons drifting through a vacuum
c) convert electrical energy to radio waves
d) use heat to cause electron movement

Exam Question 3 of 3

- B-004-005-001;What is one reason a triode vacuum tube might be used instead of a transistor in a circuit?

a) It may be able to handle higher power
b) It uses less current
c) It is much smaller
d) It uses lower voltages

Questions?



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