

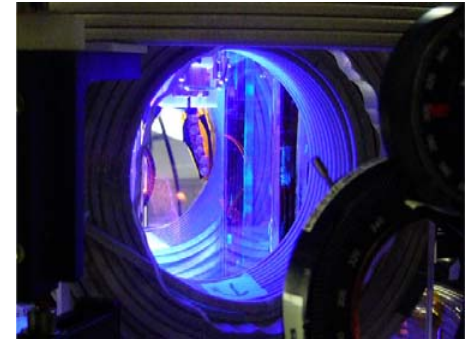
Summer Research

- Research is fun.
- Most physics summer research involves electronics.
- The following fellowships are available:
 - Charles Center Summer Scholarships*
 - Cummings Memorial Summer Scholarship in the Sciences*
 - W & M Student Research Grants*
 - Chappell Undergraduate Research Fellowships*
 - REU (NSF): Research Experience for Undergraduates*
- Scholarships/grants typically provide ~\$3k + housing.
- Deadline: March 20, 2007.

Benefits:

- Good way to see what sort of Physics is interesting to you.
- Good preparation for grad school.
- Looks good on applications/CV.

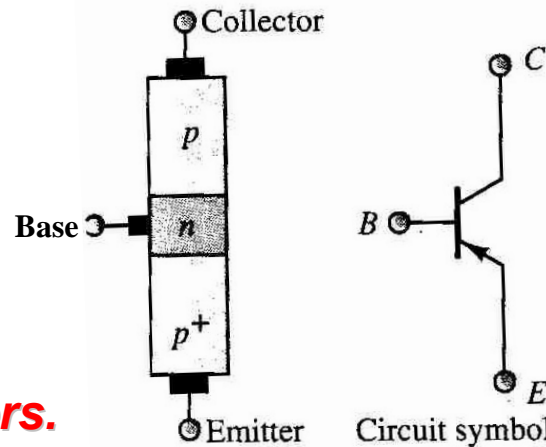
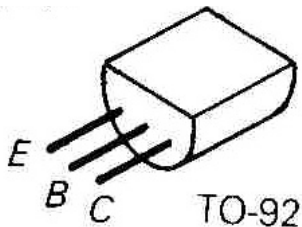
More info at: <http://www.wm.edu/charlescenter/?id=1351>



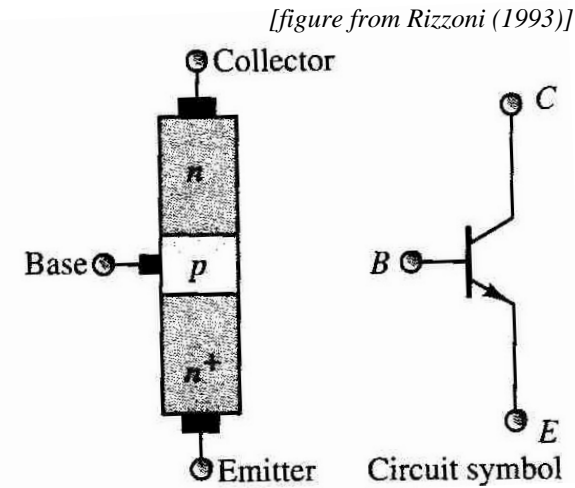
Introduction to Transistors

Bipolar Junction Transistors (BJTs)

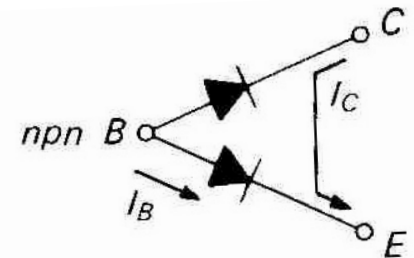
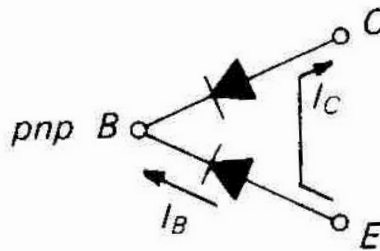
- Transistor = Trans- resistor
- 3-terminal device
- BJTs are made from 3 types of silicon.
- Sort of like back to back diodes.
- **BJTs are current amplifiers. Base-Emitter current controls Collector-Emitter current.**



PNP



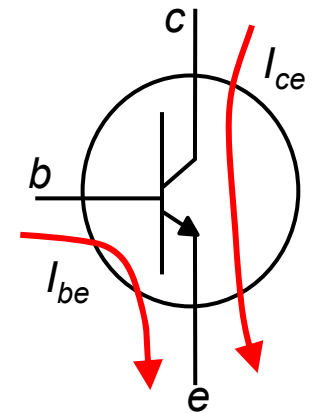
NPN



[images from Horowitz and Hill (1999)]

Basic Transistor Model (I)

- Conventional notation
 - Collector-emitter current (I_{ce})
 - Base-emitter current (I_{be})
- In a *npn* transistor
 - Base current flows to the emitter when $V_b > V_e$
 - Collector current flows to the emitter when $V_c > V_e$



npn transistor

Basic Transistor Model (II)

“**transistor rules**” for an npn transistor to conduct current:

1. $V_{be} > 0$

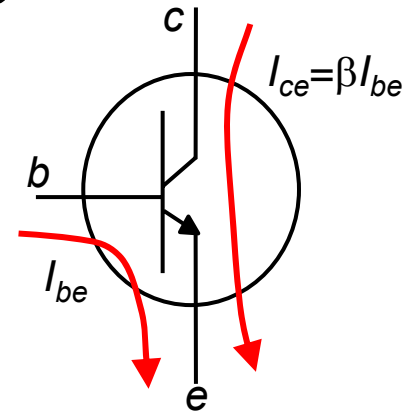
- Since this is a diode, normally $V_{be} \approx 0.6V$

2. $V_{bc} < 0$

- Since this is a back-biased diode, base current will normally flow to the emitter.
- If $V_{bc} > 0$ then transistor goes into saturation.

3. Gain

- $I_{ce} = \beta I_{be}$
- “ β ” or h_{fe} is the gain - typical 100 ~ 200
- **A BJT is a current amplifier**

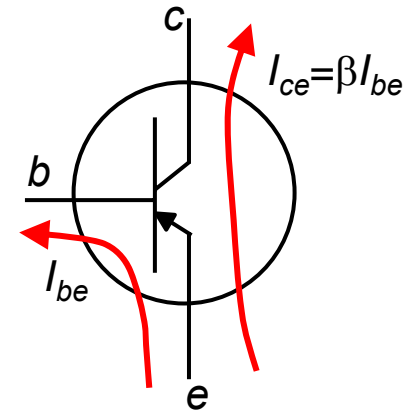


npn transistor

Basic Transistor Model (III)

The “**transistor rules**” are reversed for *pnp* transistors:

→ The arrow on the emitter indicates the way current is supposed to flow.



pnp transistor

Design Note: Circuit performance should not depend on β too much !!!

- β depends on conditions (like temp.)
- β varies greatly from device to device

Don't Rely on β (h_{fe})

From the 2N3904 NPN BJT spec sheet

