Procedures adapted from Jonathan Newport, American University:

Exercise #1: Lighting an LED ("forward bias")

A Light-Emitting Diode (LED) is a *non*-linear circuit element that can produce a controlled amount of light. The current flowing through the diode is *not* linearly proportional to the voltage across the diode, and yet in spite of that nonlinearity, model AND114R provides luminous intensity that is linearly proportional to the current flowing through the LED.

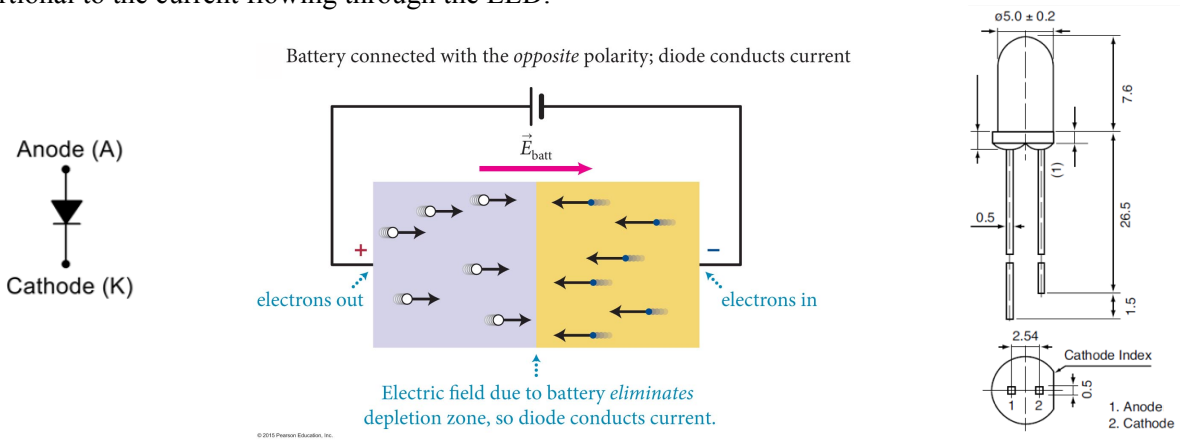
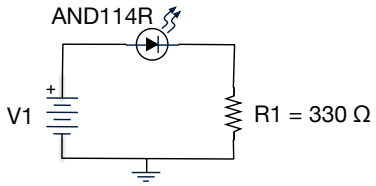


Fig. 1. Forward-biased PN junction diode schematic symbol (left), physical cartoon (center) [after Mazur, Principles & Practice of Physics], and **pinout diagram** (right)

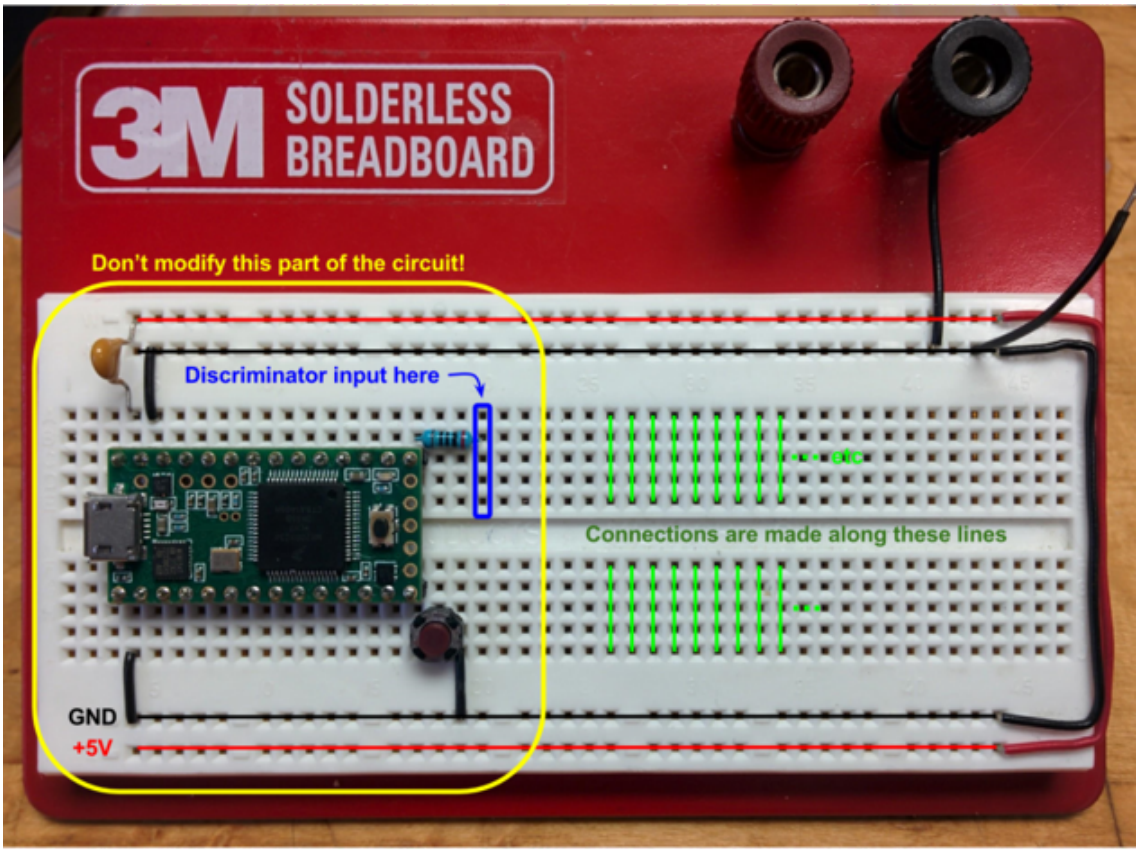
Diodes behave like a one-way valve for current. When the voltage applied to the *anode* is more positive than the voltage on the *cathode*, then the diode is said to be in *Forward Bias*. Under these conditions, electrons from one side of the PN junction, and holes from the other side, flow into the depletion zone, and recombine, a process which results in the emission of light.



When forward biased, as the voltage across the diode increases, the current through the diode increases *dramatically*. The heat generated by this current can easily destroy the device. It is always wise to install a current-limiting resistor *in series* with the diode (as shown above) to prevent thermal runaway.

Procedure:

1. Before starting, adjust your power supply, V1, so that the voltage control is near 0 Vdc, and so that you can **monitor the current** it outputs with the *built-in* ammeter (***NOT*** an external ammeter!)
2. Construct the circuit shown above, using the proto-board shown on the next page.



Using an electrical breadboard

A *solderless* breadboard is used, here, to make connections between components and provide connections to external power. Individual rows at the top and bottom of the breadboard are electrically connected, and are generally reserved for power connections. In the photo above, the inner rows denoted with black lines are used for zero potential (a.k.a. "ground" or "0V") and the outer rows denoted with red lines are used for positive voltage supplied by the Teensy (in this case +3.3V). — In the central portion of a breadboard, individual columns of **five** insertion points are electrically connected (think of them as the five fingers of a single "hand"). These are denoted with green lines in the diagram above. The central "trough" is useful to separate connections on standard integrated chips.

3. Using a Digital Multimeter (DMM), measure and ***record*** the voltage drop just across the LED.
4. Slowly increase the voltage control until the LED begins to produce light, making sure that you. ***DO NOT EXCEED 20 mA of current***. [As always, **plot your data *as you take it!***]
5. Does your "voltage drop" across the diode at 20 mA *agree* with the values found by other students? (To what degree is it "*invariant*" across different devices?)