• First, connect the battery connector to the breadboard (do not connect the 9 volt battery yet)

• At the opposite end of the bread board connect the red or positive buses together, and then the negative or blue buses together.
• Connect two resistors to the negative or blue bus: one 100Ω resistor (Brown-Black-Brown), and one 100 kΩ resistor (Brown-Black-Yellow). These will be used to connect the finger clip to the circuit. Resistors are bi-directional, so it is okay to connect either terminal to ground.
• Connect the red wire from the infrared LED's (the one on the same side as the screw) to the positive or red bus; then connect the black wire to the 100Ω resistor (Brown-Black-Brown). Then connect the photodiode in a reverse manner, by connecting the black wire to the positive or red bus, then connecting the red wire to the 100 kΩ resistor (Brown-Black-Yellow).

• Now that the finger clip is connected to the bread board, it is time to test the finger clip. Since the human eye cannot see infrared light, there is a fun way to check that infrared L.E.D. is working. Start by connecting the 9 volt battery to the breadboard, then use either a digital photo camera or a cellular phone with a digital photo camera. Aim the camera at the infrared L.E.D.; if it is working the L.E.D. will appear lit up through the viewer of the digital camera. If the L.E.D. does not appear lit up, test the battery connections and verify that the connections from the clip to the bread board are correct.
• Next, gently and carefully align and place the op-amp IC chip in the middle of the breadboard, align the pins with the holes of the breadboard, and then slowly press the chip into the breadboard. Use a wire to connect pin 8 to the positive or red bus of the bread board. In the same manner, connect pin 4 to the negative or blue bus.

Now, make a connection from the 100kΩ resistor (Brown-Black-Yellow) to pin 5 of the IC chip. (Connections to the I.R. L.E.D. & photodiode were removed to facilitate photography).

Potentiometers are variable resistors. In this experiment, two potentiometers will be used. The first potentiometer will be used to control the amount of gain in the first operational amplifier.
Although the actual package used may be different than the one in the picture, the potentiometer for this experiment will have three terminals. Only two of the three pins will be used, the third pin will be left “floating”, or left unconnected. The screw on the top will be used to control the amount of resistance between the two pins. In this type of potentiometer, since pin 1 & 2 are being used, the resistance is increased as the screw is turned clockwise.

- Now, set up a negative feedback loop by aligning and connecting a potentiometer about 5 spaces away from the op-amp chip. Connect a 10 kΩ resistor (Brown-Black-Orange) from pin 7 of the op-amp chip to pin 1 of the potentiometer, and a return wire from pin 1 the potentiometer to pin 6 of the op-amp chip. Next, use another wire to connect pin 2 of the potentiometer to ground.
One way to tell the difference between the anode and the cathode is by the length of the terminals: the anode is the longer terminal. Another way to tell the difference is to look for the “flat spot” at the bottom of the plastic case; the cathode will be closest to it.

- Connect the first light emitting diode to the op-amp chip. Connect the cathode (the shorter lead or the lead closest to the ‘flat spot’) to pin 7, and the anode to a 330Ω (Orange-Orange-Brown) resistor. Connect the other end of the resistor to the red or positive bus of the breadboard.
• Connect the output of the first op-amp, or pin 7, to the input of the second op-amp or pin 3. This sends the signal from the first op-amp (amplifier) to the second op-amp (comparator).

![Image of circuit diagram]

• Now, setup a variable DC voltage source by aligning and connecting the second potentiometer onto the breadboard. Just as before we will use pins 1 & 2, and leave pin 3 “floating”. Connect pin 1 of the potentiometer to pin 2 of the op-amp chip. Then, connect a 2.4kΩ resistor (Red-Yellow-Red) from pin 1 of the potentiometer to the positive or red bus of the breadboard. Now, connect pin 2 of the potentiometer to the negative or blue bus.

![Image of breadboard setup]
• Connect the second light emitting diode (the one displaying the human pulse) by connecting its anode to pin 1 of the op-amp chip, then connect the cathode to a 100Ω resistor (Brown-Black-Brown), and connect the resistor to the negative or blue bus.

• Place finger in the clip, and adjust the screw so it applies a minimal amount of pressure on the finger. Adjust the first potentiometer so that the first diode becomes dim. Finally, adjust the second potentiometer so that the second LED flashes with each heart beat.