1. A crystal microphone has an impedance (Z) of 100K. We need an amplifier for it, for a voice-priority application such as a telephone. For this we will limit the bandwidth of the amplifier to the principle range of voice frequencies, 300Hz-3500Hz.

Design (do not build) a bandpass filter and amplifier, consisting of a high-pass filter with a knee frequency of ~300Hz and a low-pass filter with a knee frequency of ~3500Hz. Remember $\omega=2\pi f$ Use opamps; use several if you wish. Be sure to observe Low Z feeds high Z. The output impedance of your bandpass amplifier should be low. The overall voltage gain of your amplifier should be $g=10$.

![Filter and Amplifier Diagram]

2. Design (do not build) a flood detector that sounds an alarm when a sensor gets wet. Your circuit runs on a just a single 9V battery and should draw no current (or extremely little) when there is no flood, so that the battery lasts a long time. When the sensor gets wet, the fingers of the water sensor conduct. When the sensor is wet it has a resistance of 100-1000 ohms depending on the amount and salinity of the water on it. When the sensor is dry it has a resistance of greater than $10^{6}$ ohms; essentially infinite. There is an alarm buzzer that works best at 9V and has a resistance of 50 ohms. Design a circuit using one or more transistors, opamps, phototransistors, LEDs, diodes, light bulbs, capacitors, or whatever you think is appropriate. The simpler the better. You have only a single 9V battery as a power supply. The circuit below is way too complex, but it shows the sensor, and a symbol for a buzzer, and for a 9V battery. Your circuit should be very simple.

![Flood Detector Circuit Diagram]
3. After closing the switch, what is the eventual voltage at point A? **2.5 V**

How long does it take to get most of the way there? **15 mSec**

Units please! Those are 47KΩ resistors, and a 0.33μF capacitor. Approximate answers are good enough.

4. Design & draw & build; raise your hand for scoring and stickers. Use a phototransistor and one or two transistors. No opamps.

In ambient room lighting a red LED is on, and the current through it is 5-10mA. When holding your hand over the phototransistor (just shadowing it, not putting it in darkness) the LED gets dimmer. That's the basic behavior. Add these for more credit:

- Even if we increase the illumination on the phototransistor, the LED current does not increase further. **8.5V/330Ω = 10mA**
- When the phototransistor is shaded, the LED goes off, not just dimmer.
- Whenever the red LED is off, a green LED is on, and vice versa.