**Problem 1** The circuit below is from MAKE magazine and is designed as a lie detector using galvanic skin response. Resistors marked 3M3 are 3.3 MΩ. You should assume the baseline resistance of the skin is about 200 kΩ. 

- **V+ = 5V** (this is the positive supply).
- **V- = 0V** (ground).

Assume the constant drop model for all diodes. D1-D3 drop = 0.6 Volts each, when on. LED1 drop = 2.8 volts when on.

Two electrodes labeled SKIN-1 and SKIN-2 are attached to two fingers and forms a voltage divider to ground (V-) through R4. If you experience stress, you sweat a little and the resistance between the electrodes decreases because of the increased conductivity at the skin-electrode interface. This is filtered (IC1A) and then amplified (IC2B). If the signal at the output of the amplifier is high enough, the LED turns on.

a) What is the voltage at the non-inverting terminals of the op amps? Explain your reasoning.

b) If the skin resistance has been constant for a long time, what is the baseline voltage at the output of IC1B? Explain your reasoning. Is the LED on or off?

c) Find the transfer function between points A and B and verify the cutoff frequencies.

d) Plot the overall frequency response (i.e., the Bode plot, both magnitude and phase) between A and C.

**Problem 2** The diagram below shows the results of the device in action as different questions are asked. From the circuit diagram explain why a drop in resistance increases the output voltage of the amplifier (Pin 7, IC1B).

b) If the skin resistance starts at 200 kΩ and then drops suddenly, how low must the resistance go to light the LED (i.e., assume a step change in resistance)? State any assumptions.
Problem 3) 16.15

Problem 4) Derive the transfer function of figure 16.22 c.

Problem 5) Show that the circuit in Figure 16.37 have identical transfer function and explain why the second circuit uses one fewer op-amps.

Problem 6) Problem 16.71

Using the solution to problem C, we can further simplify the schematic with a PWM block controlled by the throttle with an "inhibit:" input that will set the PWM output to zero. The "inhibit" is activated by the "Brake" switch.

**Problem D)** The battery voltage is nominally 24V but will drop as the batteries wear down, or if the load on the batteries is too large. The circuit is designed to set the PWM output to 0 if the battery voltage drops too low. At what battery voltage will the PWM be inhibited. You may consider only the circuitry shown below.