1. An average bolt of lightning carries a current of about 40,000 Amperes. If a lightning strike lasts for about 100 microseconds (0.0001 sec), how much total charge is transferred by one lightning strike.

2. On a dry winter day when you shuffle your feet while walking across a carpet an electrical charge builds up on your body. After crossing a room, as you reach out for a metal doorknob you may be surprised by a large spark! To create a spark the electric field must be greater than $3 \times 10^6$ Volts/meter. Let’s say that the spark is about 1 cm long. How much static charge was built up on your body? (Assume that all of the charge rushes to your finger-tip as you reach out for the doorknob.)

3. A good quality 1.5 Volt AA alkaline battery is capable of providing a current of 0.1 Ampere for about 30 hours before it runs down and stops working. What is the total amount of charge that is available from the battery?

4. A new D-cell battery is 1.5 Volts and has a capacity of about 10 Amp-hours, i.e., it can provide 1 Amp for 10 hours. How much energy does the battery contain?

5. A resistor of unknown resistance is connected across a 1.5 Volt battery and the resulting current is 50 mA (0.05 Amp). What is the value of the resistor (in Ohms)?

6. A voltage divider the battery voltage is $V = 1.5$ Volts and the resistors have values $R_1 = 100$ Ohms, and $R_2 = 900$ Ohms as shown, what is voltage at the node marked ‘b’?

7. Five 100 Ohm resistors are combined in parallel, what is their combined resistance?

8. A voltage source has an open circuit voltage of 15 Volts and it can provide a short circuit current of 30 Amps. What is the maximum power available from this voltage source?

9. You are attempting to build an inverting amplifier op-amp circuit, and although you have plenty of opamps you have a limited supply of resistors. Let’s say that the only resistors available to you are the following: 13 kOhm, 22 kOhm, 47 kOhm, and 82
kOhm. What is the maximum gain of an inverting op amp circuit that you could build with this limited component selection, using only resistor of any value?

10. For this problem, refer to the following op amp circuit diagram, this is a so-called non-inverting amplifier configuration. What is the gain of this circuit, $G = \frac{v_{out}}{v_{in}}$?

11. What is the output voltage, $v_{out}$, of the following op amp circuit.

12. What is the output voltage, $v_{out}$, for the following op amp circuit.
13. What is another way to write \( j^{17} \) (\( j, -1, 1, \text{ or } -j \))?

14. What is the magnitude of \( 3 + 4j \)?

15. Find the polar coordinates for the complex number \( 1 - j \).

16. Convert the polar form complex number \( r = 2, \phi = \pi/6 \) to \((a + jb)\) form.

17. Represent the complex number \( 3e^{j\pi/2} \) in \((a + jb)\) form.

18. Simplify \((3 + 2j)/(2+j)\), i.e., covert to \((a + jb)\) form.

19. How many electrons are stored in a 1 pF capacitor charged up to 3 Volts?

20. A 1 mF capacitor is initially charged up to 10 Volts but after 5 minutes you measure the voltage again and find that it is only 7 Volts. This voltage drop is due to internal “leakage” current in the capacitor, what is this leakage current?

21. A series RC circuit with a 1 GΩ resistor \((10^6 \text{ Ohms})\) and an initially uncharged capacitor of value 100 mF was connected to a 1 Volt DC voltage source precisely at the beginning of this year at an electrical engineers’ New Years Eve celebration, (12:00 AM on January 1, 2013). If we measure the voltage across the capacitor next year on January 1, 2014 at 12:00 AM, what value will we measure?

22. You have a factory that has been producing RC low-pass filters using \( 10^{-6} \text{ F} \) capacitors and 1,000 Ohm resistors. Suddenly the worldwide supply of capacitors dries up and you now have to build filters with the same electrical characteristics but you have to use inductors and resistors rather than capacitors and resistors. If you want to continue using your supply of 1,000 Ohm resistors, what value inductors should you use to build low-pass filters with the same characteristics as the RC filters you were building? Sketch the schematic of the low pass L-R filter.

23. An RC low-pass filter has time constant of \( RC = 10^{-5} \text{ sec} \). What is it the magnitude of its response at 10 kHz?

24. A L-R high-pass filter is constructed of a 0.1 mH inductor and a 10 Ohm resistor. What is the magnitude of its response at 10 kHz?

25. In your own words define Timbre.

26. A low pass RC filter with \( RC = 10^{-4} \text{ seconds} \) is used to filter a recording of a piccolo and a tuba playing a duet. Let’s say that on one particular note the piccolo is playing a high C at 1024 Hz and the tuba is playing a low A at 55 Hz. Assume that both notes have the same amplitude in the unfiltered sound, by how many dB is the piccolo sound attenuated relative to the tuba?

27. An electric guitar pickup has the following parameters: \( L \approx 2.5 \text{ Henry, } R \approx 30,000 \text{ Ohms} \) (this is the effective resistance at the pickup’s resonant frequency including
magnet losses) and $C \approx 150$ pF. What is the frequency where the output of the pickup is greatest, i.e., at what frequency is the resonance peak of the pickup?

28. Consider the same electric guitar pickup with parameters: $L \approx 2.5$ Henry, $R \approx 30,000$ Ohms, and $C \approx 150$ pF. By how much is the voltage output of the pickup boosted at the resonance peak compared to low frequency (near 0 Hz)?

29. If you could reduce the total capacitance of an electric guitar pickup by increasing the thickness of the insulation on the wire used to wind the pickup, what effects would this have on the resonant frequency of the pickup? Would the voltage output increase or decrease? Would high frequencies be amplified or attenuated?

30. In your own words describe what a wah pedal does and how it works.

31. In your own words describe how the gain/distortion stage in the guitar amplifier project works.

32. Sketch the circuit diagram for the simple guitar tone control circuit that we discussed in class and describe in your own words how it works.