Problem 1:

Explain in your own words why a higher Analog to Digital Converter resolution (in bits) results in lower noise due to quantization.
Problem 2:

In class and in the notes, you saw how sensors transform variation in real-world parameters into changes in measurable electronic quantities such as potential difference, current, resistance, etc. using simple circuits (see the electret microphone). For each of the following parameters, describe a simple electronics circuit or scheme (please do not tell us you will measure pressure with a “pressure sensor”) that would allow you to measure it. Essentially, design a sensor! Remember Occam’s razor: Keep it simple!

Most of these are commercially available and fully detailed on Wikipedia. Remember this isn’t graded for correctness, so if you don’t know how each of these might work, do yourself a favor and be creative!

A. Pressure on the ocean floor.

B. Frequency of a guitar string (guitar pickup).

C. Rotational speed of a bicycle wheel.

D. Frequency of breathing at night.

E. Imperfections on a knife blade not visible to the naked eye.
Problem 3:

A. Pick 3 FUNdaMENTAL principles from chapter 3 of FUNdaMENTALS. Sketch a design that violates all three of them.

B. Explain why your design violates these principles. Be specific.

C. Describe and sketch design changes that ensure these principles are satisfied.
Problem 4:

A. For each of the following objects, count and name the degrees of freedom of the object or system in space. Stay high-level (for the helicopter, we only want the motions of the whole helicopter in flight, not the opening/closing of doors, etc.). Except in part b, give two answers for each, one with friction as a constraint, and the other with no friction.

   a. A basic rolling office chair sitting on a tile floor.

   b. A passenger car driving on a flat plane (count friction as a constraint).

   c. A ball sitting on a flat plane.

   d. A ball sitting in a v-groove.

   e. A passenger airplane.

B. Consider the office chair mentioned above. It probably has 5 or 6 “legs” with caster wheels. If the chair is of decent quality, all of the wheels are probably touching the flat tile floor. How is this possible?! (It might be best to first answer the question: why shouldn't it be possible?).
Problem 5:

You have proposed the assembly below (shown disassembled) in which two plates will sit against each other with a set of 4 pegs to hold them in place. The holes in the top plate are all sized and drilled to exactly fit the pegs.

During your presentation, your co-worker stops you and asserts that there is no possible way that the two plates will fit together on the assembly line.

A. Is your co-worker right? (Hint: Yes he is). If so, why? What fundamental principle are you violating?

B. What simple design changes could you implement to fix this problem?