Problem 1: Chemical Safety

1-1. For each of the compounds listed below that have a NFPA health rating of 3 or higher, summarize in a few sentences (e.g., 2 to 3) what the specific health issues / concerns are.

1-2. For each of the compounds listed below that have a NFPA flammability rating of 3 or higher, indicate the flash point and, if any additional flammability issues / concerns are mentioned, summarize them in a few sentences (e.g., 2 to 3).

- Acetone
- HF
- H₂SO₄
- H₂O₂
- KOH
- Methanol
- Silane (SiH₄)
- Phosphine (PH₃)
- Carbon Tetrafluoride (CF₄)

Problem 2: Spin Curves

With a particular resist you find that when you spin it on a 100-mm-diameter wafer at 500 RPM, you obtain a 10-µm-thick film.

2-1. Using the above information, plot “spin curve” (i.e., thickness as a function of spin rate in RPM) for the 100-mm-diameter wafer.

2-2. Using the above information again, plot the “spin curve” for a 150-mm-diameter wafer.

NOTE: Show the math you used to solve this problem and plot both curves on the same graph.

Problem 3: Imperfect Contact Lithography

When performing contact lithography using 436 nm light, you regularly obtain a minimum linewidth of 2 µm. One day you perform the exact same photolithography process (i.e., used the same tool, materials, chemicals, step sequence, temperature), but yet you find that only features greater than or equal to 6 µm is size are correctly resolved. State why this happened and provide a quantitative measure for how this “contact” lithography is imperfect.
**Problem 4: Cheap Masks**

You want to make some masks, but do not have enough money. While printing out transparencies for a talk you are about to give, you come up with the idea of making masks with a laser printer.

4-1. Theoretically, what is the smallest feature (in micrometers) you could print with a common high-resolution laser printer (1200 dpi)?

4-2. To print 5 µm dots & spaces, what printer resolution is needed? Do such printers exist? If so, indicate and examples (i.e., provide the make, model number, and cost).

4-3. Since laser printer toner and transparencies were not designed to be used as masks, what might be some problems that you could encounter that would make the use of a transparency mask difficult?

**Problem 5: Photoresist Contrast and Image Modulation**

![Graph](attachment:image.png)

5-1. Calculate the contrast of photoresist A.

5-2. Calculate the CMTF of photoresist D.

5-3. If you determine that the minimum exposure time for photoresist D at the CMTF limit is 20 seconds, what is the brightness (intensity) of your exposure tool?

**Problem 6: Design Rules**

A foundry has the following minimum design rules:

- ANCH size: 4.0 µm
- ANCH gap: 6.0 µm
- M1 size: 4.0 µm
- M1 gap: 4.0 µm
- M2 size: 2.0 µm
- M2 gap: 4.0 µm
- ANCH enclosed by M1: 3.0 µm
- M2 cut outside M1: 3.0 µm
- M2 cut inside M1: 3.0 µm
6-1. Please circle the areas that violate design rules.