

Write your name here: \_\_\_\_\_

Instructions:

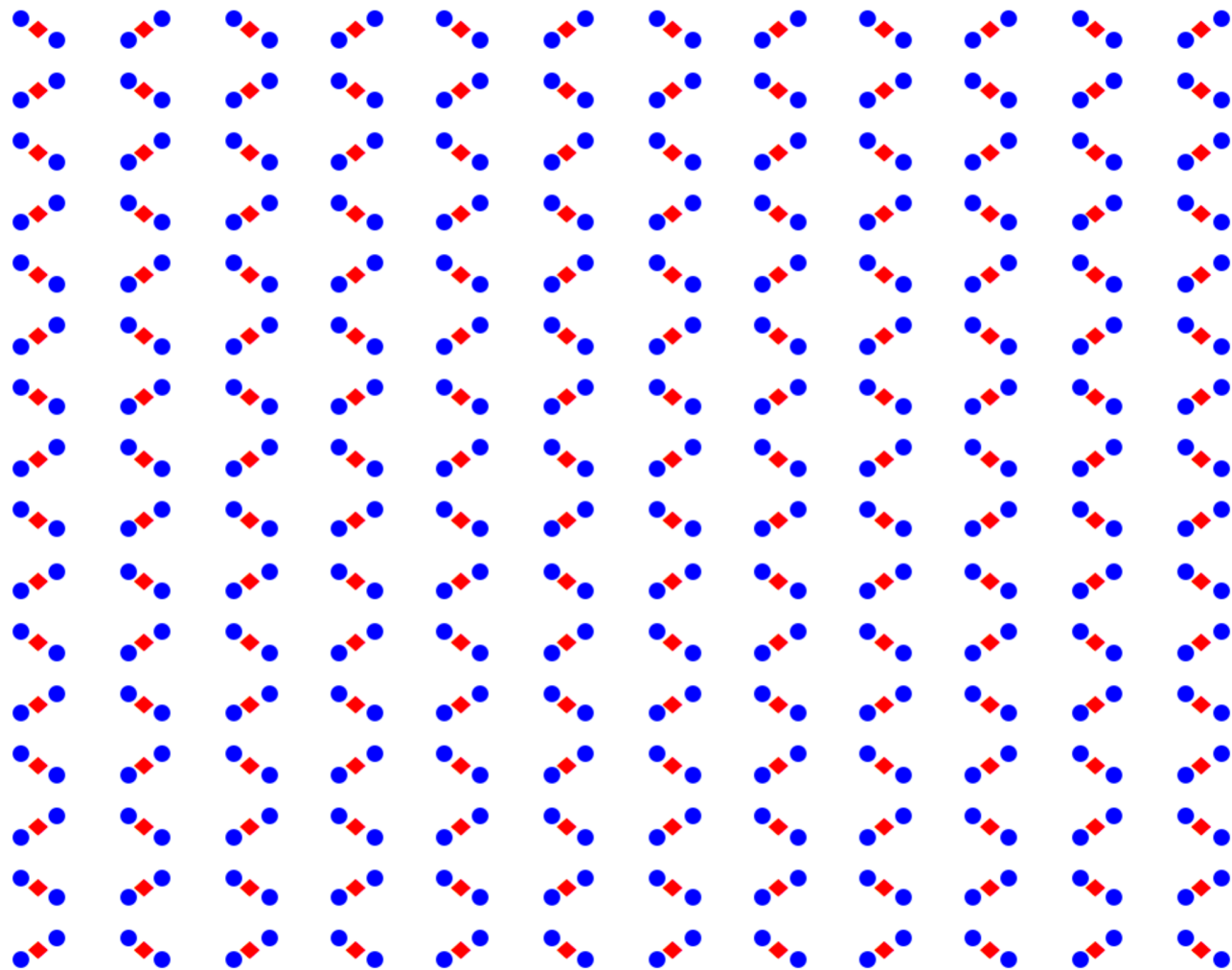
- Answer all questions to the best of your abilities. Be sure to write legibly and state your answers clearly.
- The point values for each question are indicated.
- You are not allowed to use notes, friends, phones, consultants, employees, etc.
- You may (and should) use a straight edge.
- You should complete this exam using both pen and pencil. Plots and stereograms should be in pencil, and will be graded only once (very carefully).
- You will not need a calculator, so put all calculators away.
- There are a total of 105 points. 100 points will be considered a perfect score for grading purposes. Points above 100 will count as extra credit for the midterm contribution to your grade.
- Feel free to ask questions, but only for clarification purposes.

I sincerely hope you all do really well.

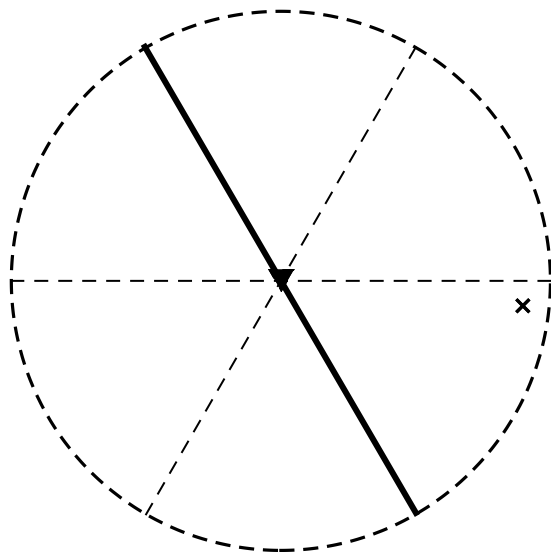
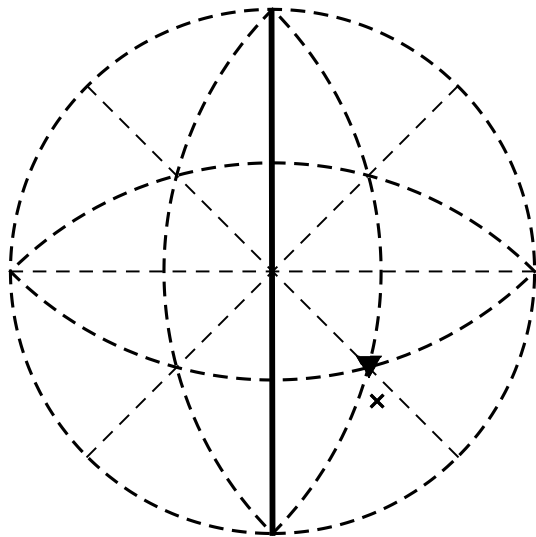
-Prof. Chrzan

Problem 1. [Total of 55 points] The structure below is a 2D crystal. It includes two types of atoms, indicated by circles and diamonds. On the figure:

- a. [5 points] Place an  $\times$  at the positions of the lattice points.
- b. [5 points] Identify a set of primitive lattice vectors for the crystal.
- c. [5 points] Identify a primitive unit cell.
- d. [5 points] How many atoms are in the primitive unit cell?
- e. [5 points] Which plane group describes the symmetry of this crystal?
- f. [5 points] Identify the asymmetric unit for this crystal.
- g. [5 points] Give the Wyckoff letter for the positions of the atoms indicated by circles.
- h. [5 points] Give the Wyckoff letter for the positions of the atoms indicated by diamonds.
- i. [5 points] Sketch the lattice vectors used to describe this group in the plane group tables.
- j. [5 points] Using your answer for part (i), sketch the reciprocal lattice vectors using the same origin you used for the part (i). Which of these reciprocal lattices vectors,  $\mathbf{a}^*$  or  $\mathbf{b}^*$  has the larger magnitude? (Note that you do not need the absolute lengths of the lattice vectors to do this problem. Focus on the physical meaning of the definition of the reciprocal lattice vectors.
- k. [5 points] At which reciprocal lattice points  $hk$  will the atoms indicated by diamonds give contributions to the x-ray diffraction pattern?

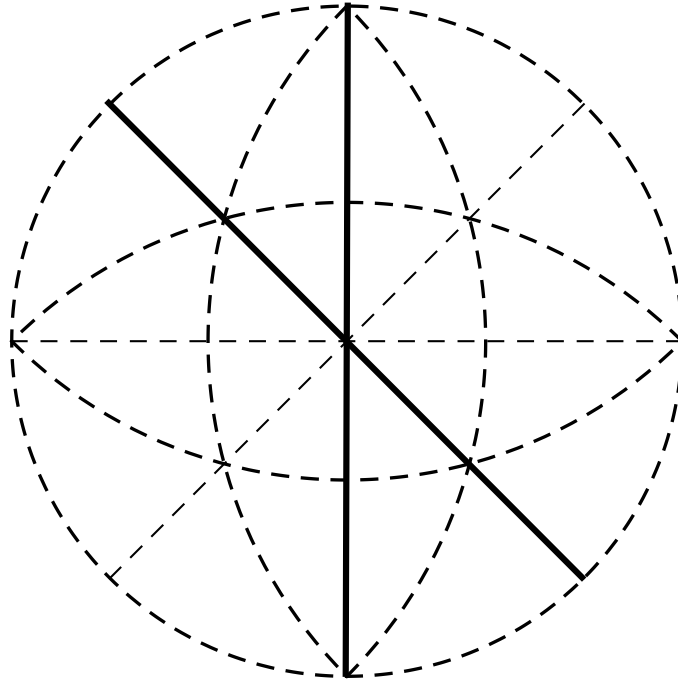


2. [10 points each] Complete the stereographic projections for the point groups shown below. Enumerate all the symmetry elements of the point group.



Problem 3. A crystal is known to have the point symmetries shown below.

- a. [10 points] Complete the stereogram to identify all the point symmetry elements of this crystal.
- b. [20 points] What is the structure of the conductivity tensor for this material? (For example, a cubic material needs only one number to describe its conductivity tensor, and the tensor is diagonal.) Prove that you have the correct answer with a clear mathematical argument indicating all of your reasoning.



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