

MLL 100

Introduction to Materials Science and Engineering

Lecture-3

Dr. Sangeeta Santra (ssantra@mse.iitd.ac.in)



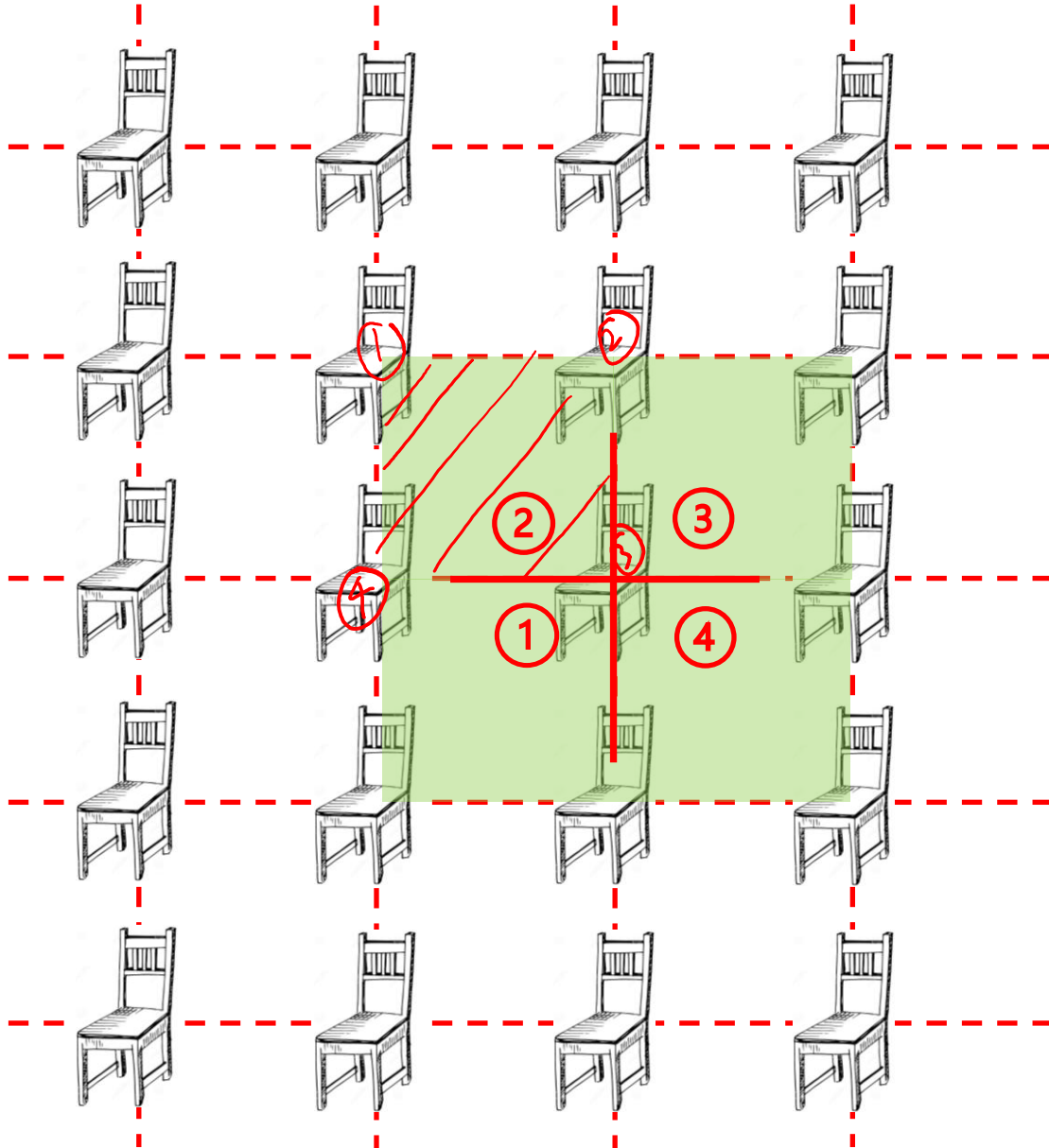
IIT Delhi
Department of Materials Science and Engineering

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What we learnt in Lecture-2?

- Symmetry operations: Inversion, Glide
- Lattice, Motif
- Classification of materials: atomic order

Primitive and non-primitive cell



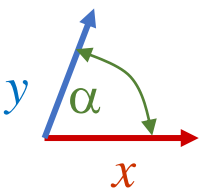
Lattice: Translationally periodic arrangement of points in space such that every point has identical surroundings

- Dotted grid is a **2-D Square lattice** and the intersection points are called the **lattice points**

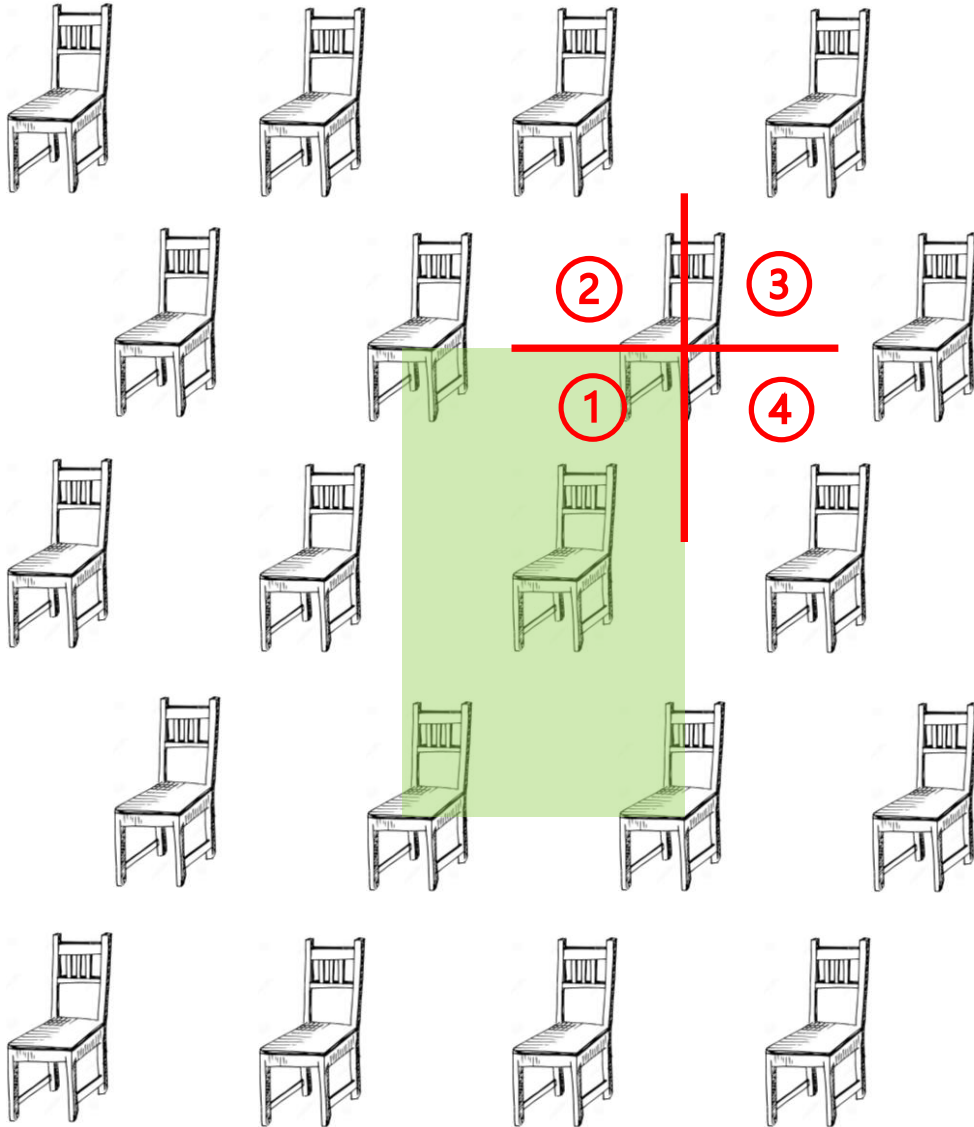
Entity associated with the lattice point is called a **motif**

- How many chairs per unit cell?

One $\left(\frac{1}{4}\right)^{\text{th}}$ → Each chair
Total chairs = 4
 $(4 \times \frac{1}{4}) = 1$

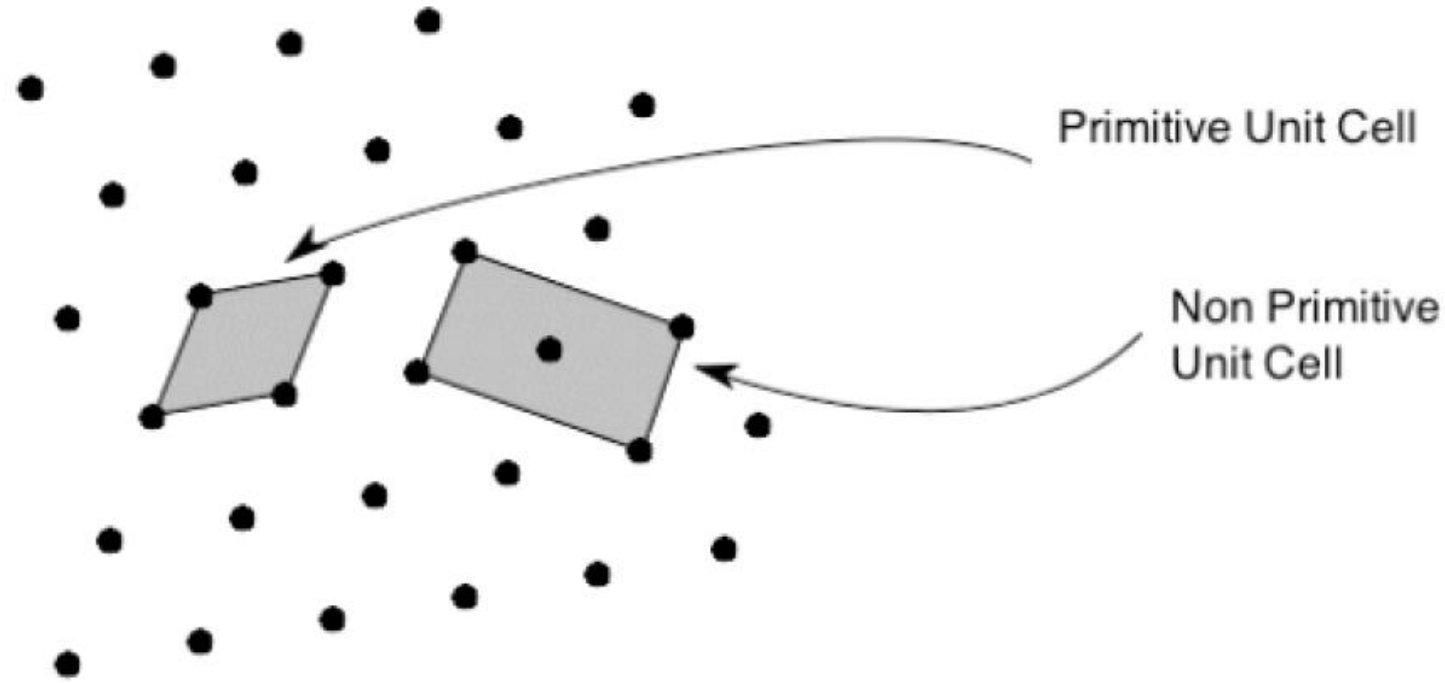


Primitive and non-primitive cell



- How many chairs per unit cell?

Two



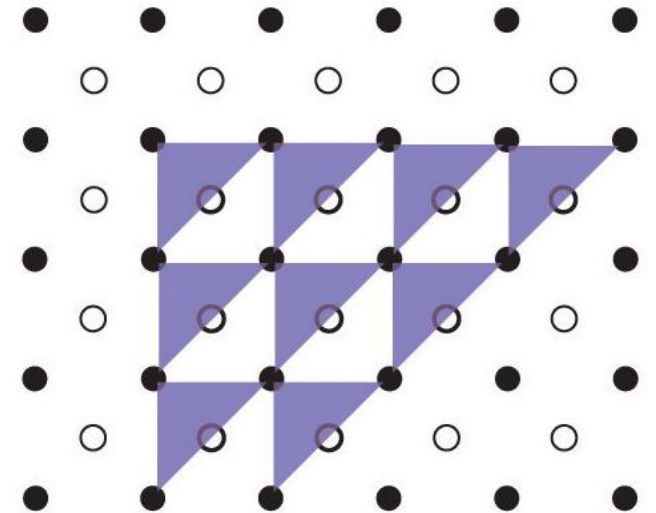
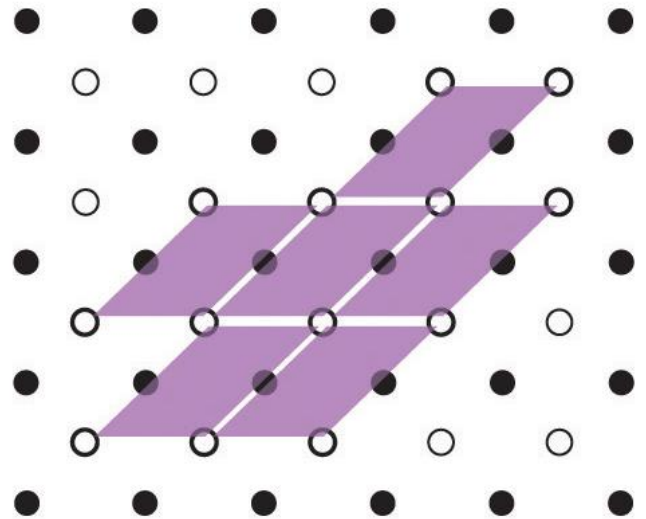
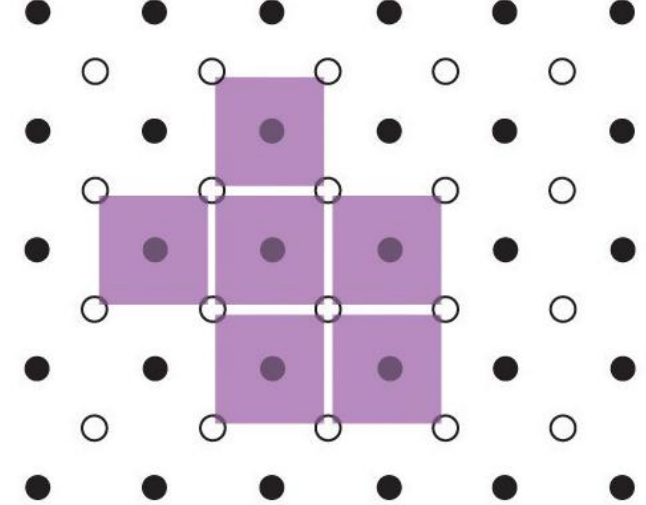
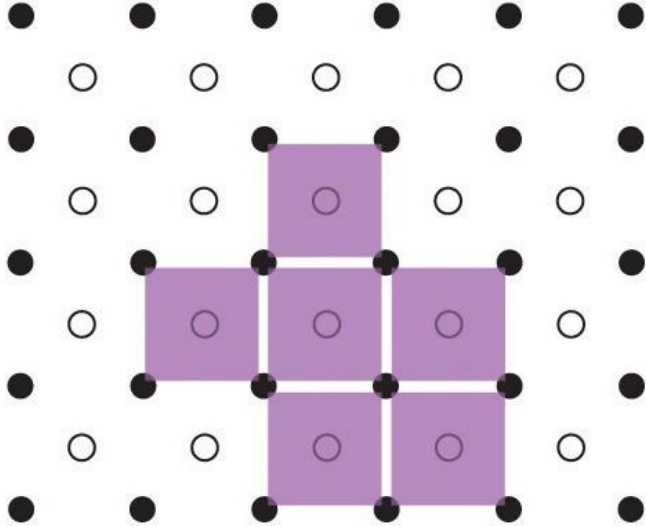
Primitive unit cell:

Only one lattice point, made up from the lattice points at each of the corners.

Non-primitive unit cell:

Additional lattice points, either on a face or edge or within, and therefore, have more than one lattice point per unit cell.

Number of lattice points per unit cell



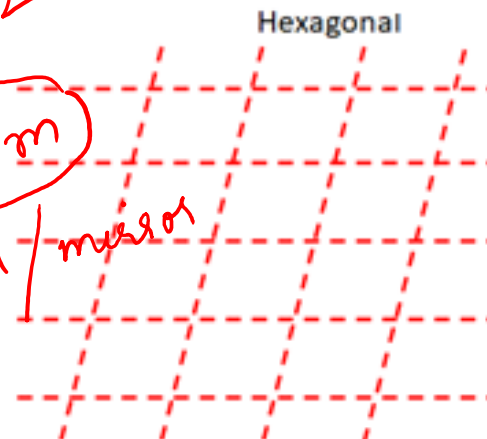
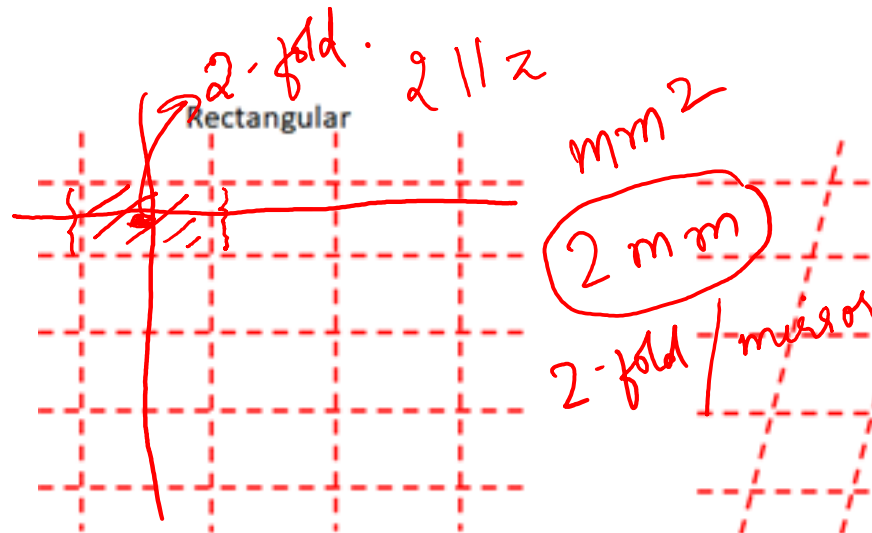
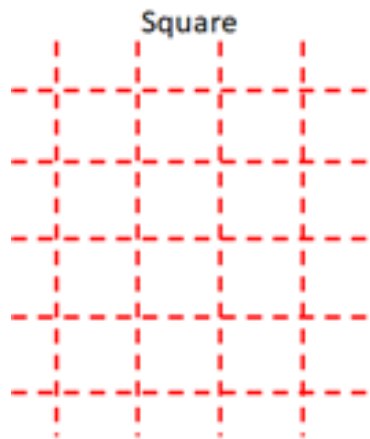
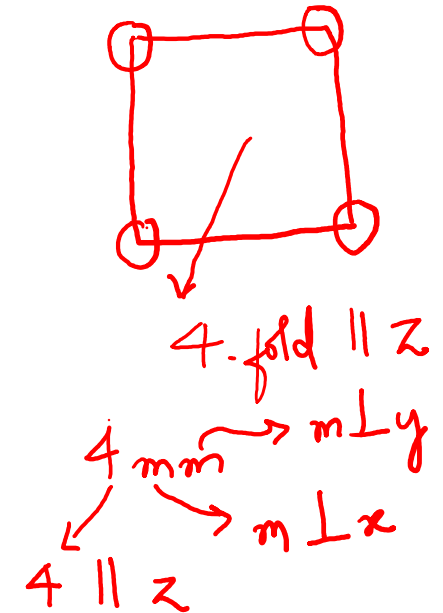
What are the factors governing the selection of my lattice?

- Should enclose smallest possible area
- Symmetry of the lattice should be higher

Centered square lattice = Simple square lattice

2-D lattices

Lattice	Symmetry	Shape of UC	Lattice Parameters
Square	4mm	Square	($a = b$, $\alpha = 90^\circ$)
Rectangle	mm2	Rectangle	($a \neq b$, $\alpha = 90^\circ$)
Centered Rectangle	mm2	Rectangle	($a \neq b$, $\alpha = 90^\circ$)
Hexagonal	6mm	120° Rhombus	($a = b$, $\alpha = 120^\circ$)
Rectangular Oblique	2	Parallelogram	($a \neq b$, α general value)



10 point groups

+

5 2-D lattice

= 17 plane groups



1

m



2

2 mm



3

3 m



4

4 mm



6

6 mm

Square

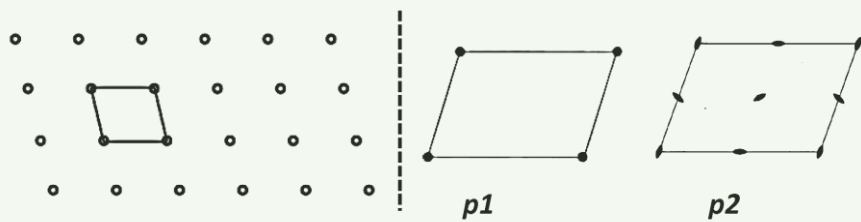
Rectangle

Centered Rectangle

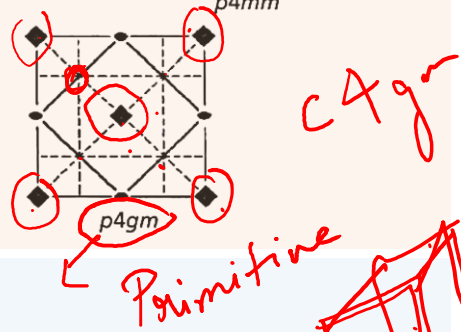
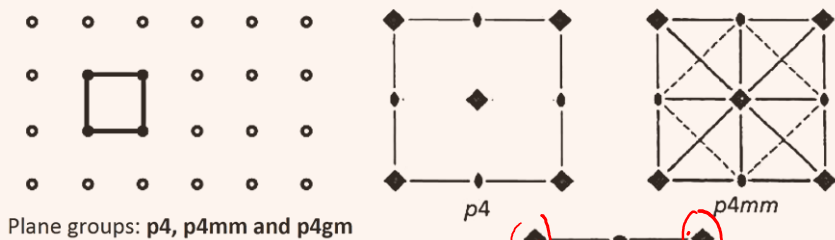
Hexagonal

Rectangular Oblique

Oblique (parallelogram) ($a \neq b, \neq 90^\circ$)



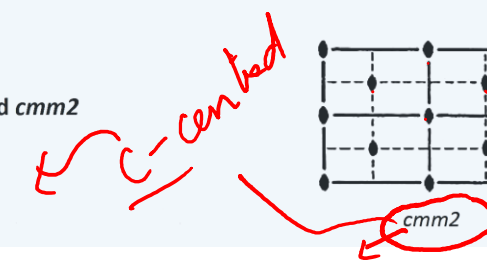
Square ($a = b, 90^\circ$)



Centered rectangular ($a \neq b, 90^\circ$)



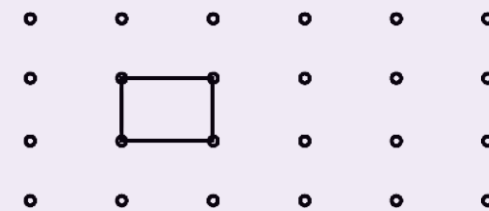
Plane groups: cm and $cmm2$



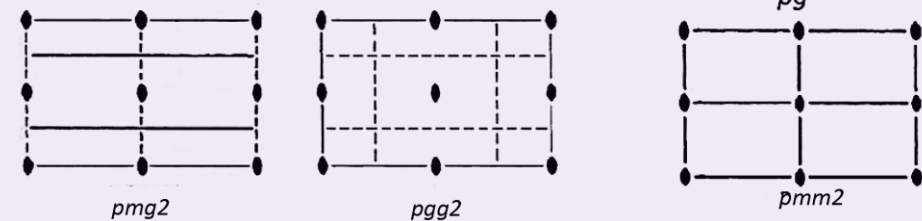
17 Plane groups

What does the 'g' stand for?

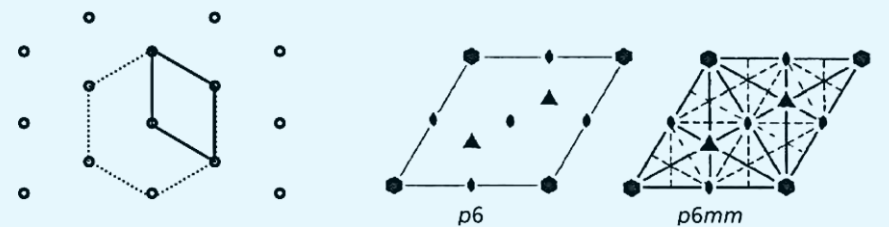
Rectangular ($a \neq b, 90^\circ$)



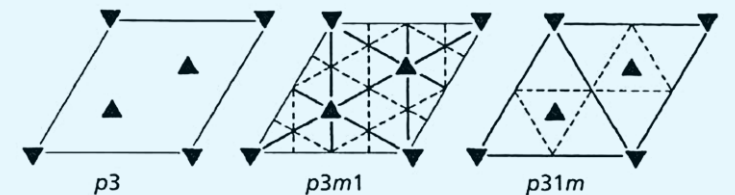
Plane groups: pm , pg , $pmm2$ and $pgg2$

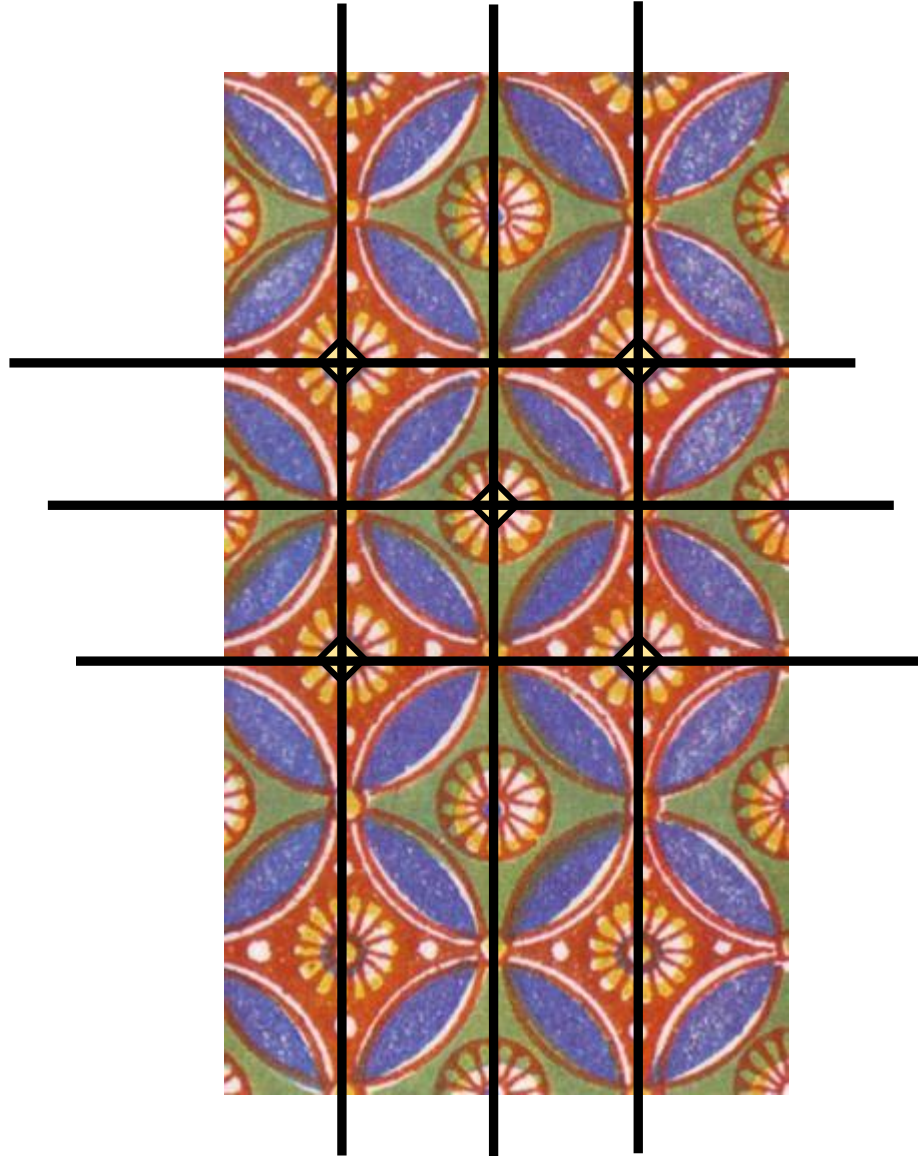


Rhombic or hexagonal ($a = b, 120^\circ$)



Plane groups: $p3$, $p3m1$, $p31m$, $p6$ and $p6mm$

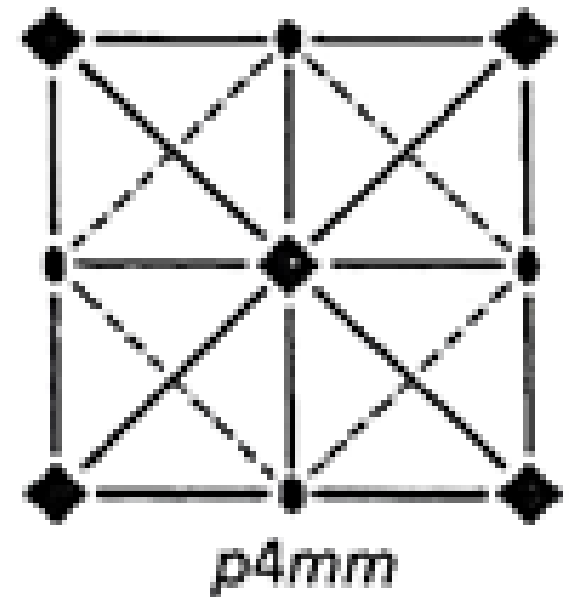


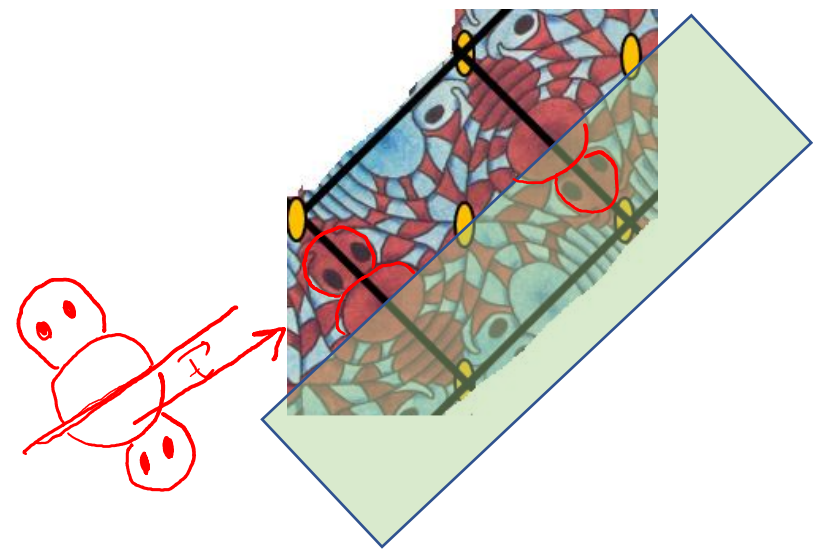
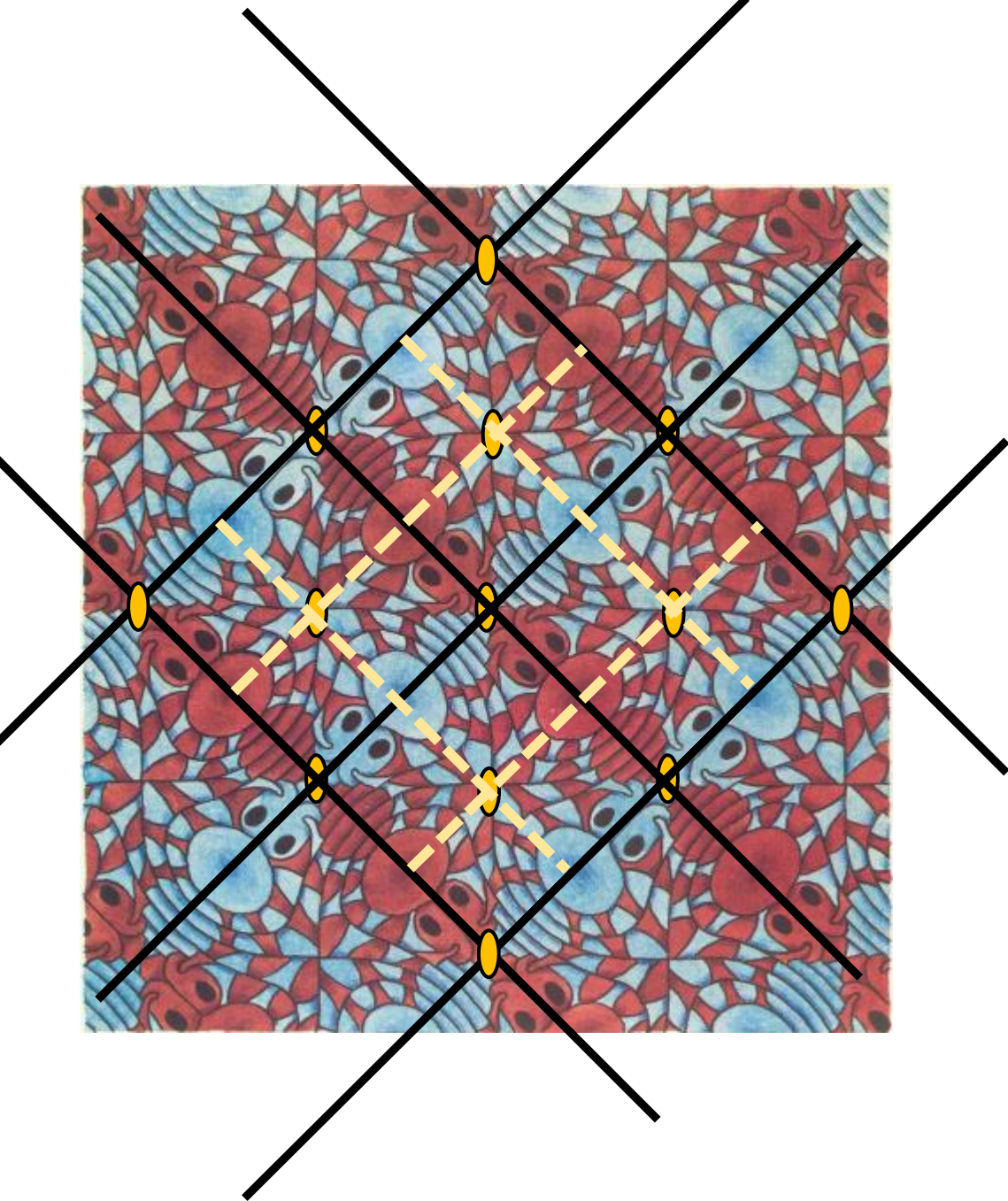


- What is the highest symmetry of rotation?
- Is mirror (m) present perpendicular to any of the axes?

4-fold $\parallel z$

Yes, m





- What is the highest symmetry of rotation?

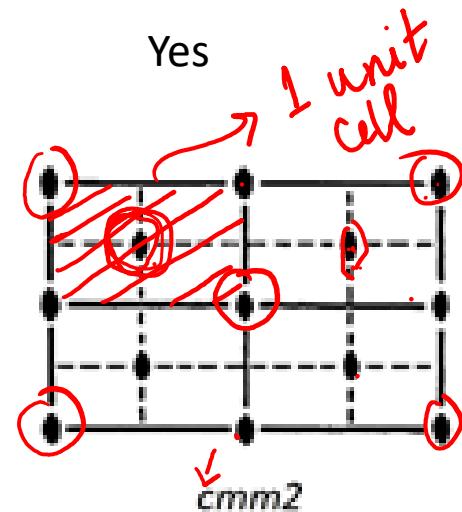
2-fold C_2 z

- Is mirror (m) present perpendicular to any of the axes?

Yes, m

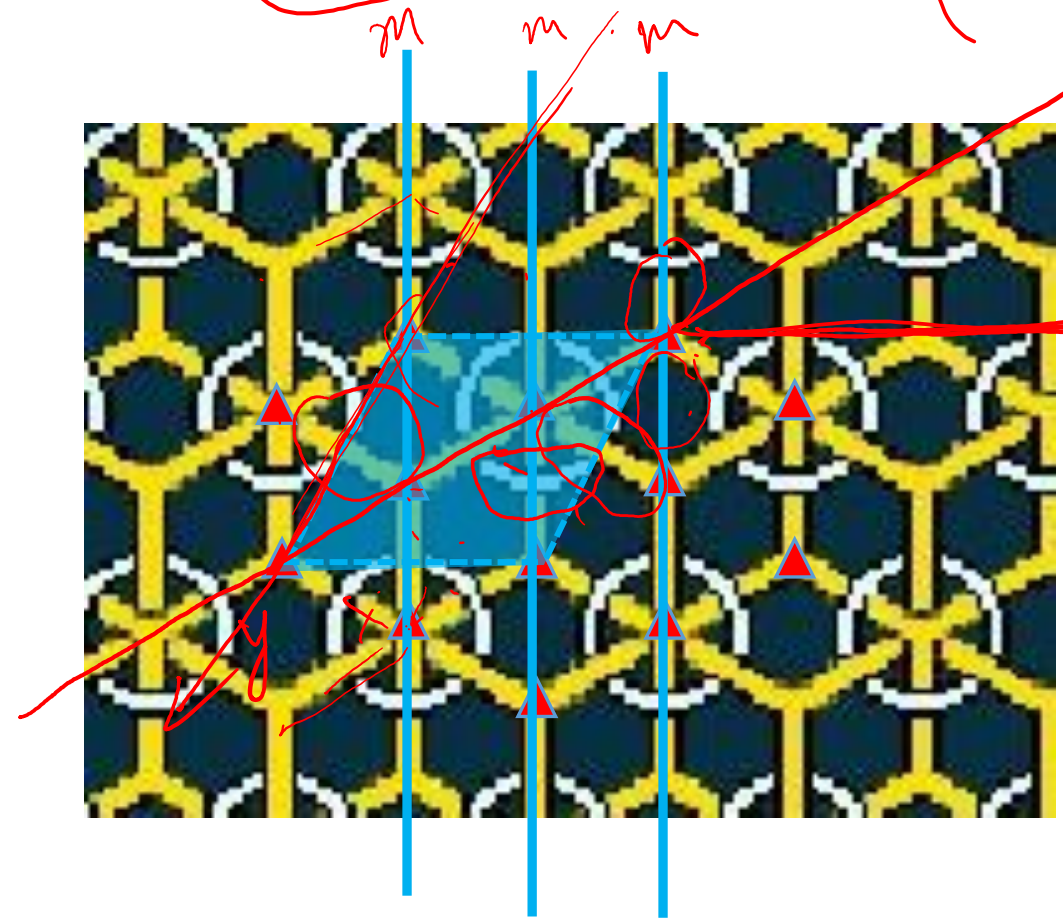
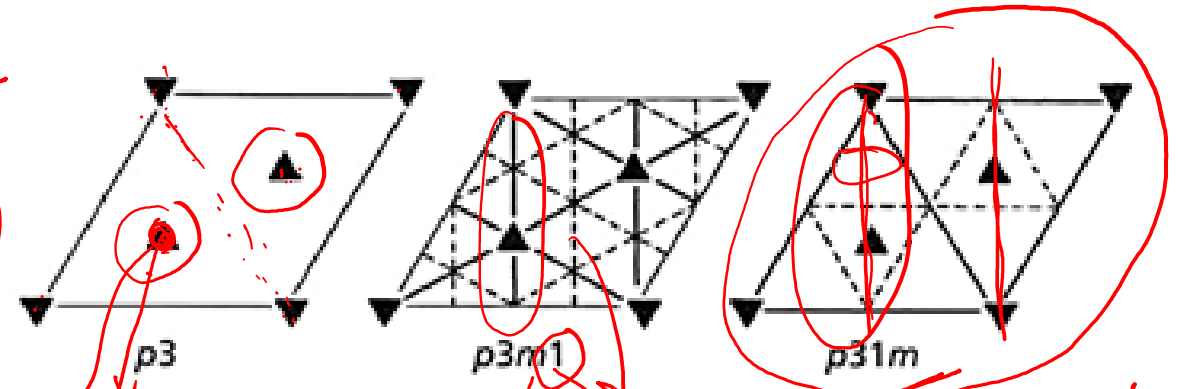
- Are the mirrors perpendicular to each other?

Yes



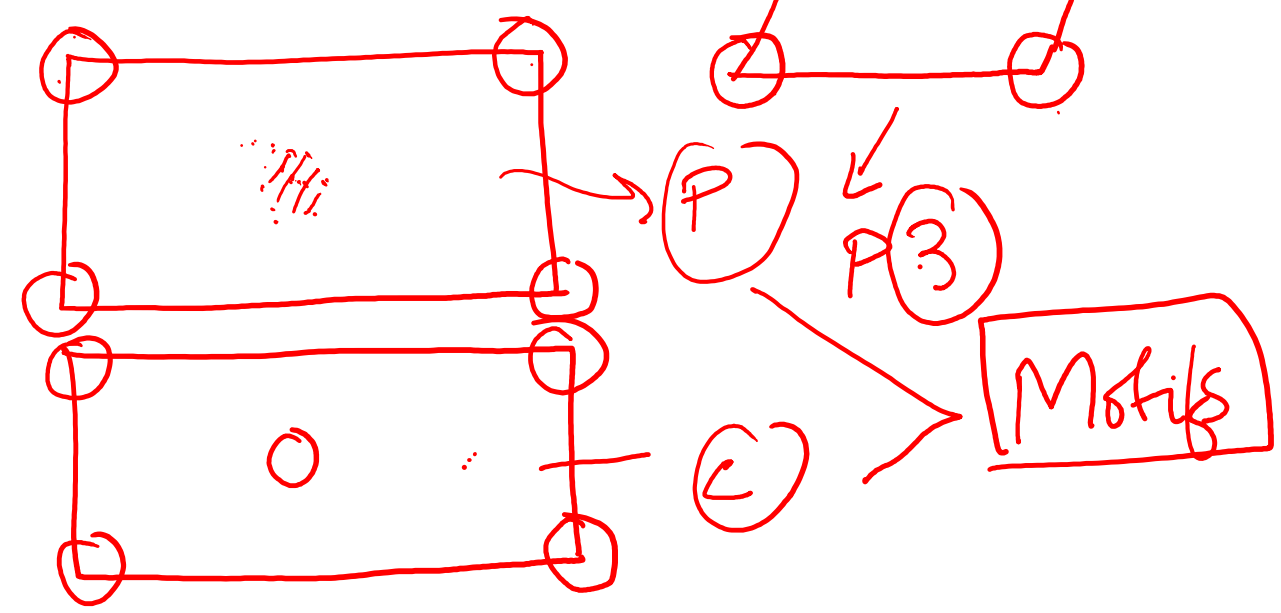
~~17 P6~~ $P3m2$
 $P3m2$

Bold solid
 (Mirror)



Symmetry elements

glide planes
 Motifs/atoms



Crystal Hierarchy

□ Unique ways to arrange the lattice points in:

2-D : 5

3-D: 14

