

2. **Axis of symmetry ( $C_n$ )** – rotation gives identical appearance. The axis of symmetry, also called the rotation axis and denoted by  $C_n$ , is one of the most fundamental symmetry elements in molecular symmetry and crystallography. An axis of symmetry is an imaginary line passing through a molecule or crystal such that rotation by a specific angle about this line leaves the object appearing unchanged. An object is said to possess an n-fold axis of symmetry ( $C_n$ ) if rotation of the object through an angle of  $360^\circ/n$  about the axis brings it into an indistinguishable configuration. In simple words, after rotation, the object looks exactly the same as before. Meaning of the Symbol  $C_n$

$C$  → rotation operation

$n$  → number of identical positions obtained in one full rotation

Examples:

$C_2$  → rotation by  $180^\circ$

$C_3$  → rotation by  $120^\circ$

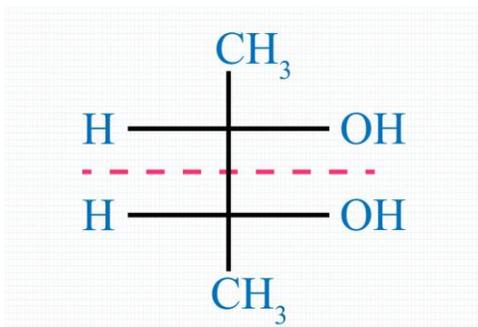
$C_4$  → rotation by  $90^\circ$

$C_6$  → rotation by  $60^\circ$

**Rotation Operation:** When an object has a  $C_n$  axis: It can be rotated  $n - 1$  times within  $360^\circ$  and still appear unchanged. Including the original position, there are  $n$  indistinguishable orientations.

### Common Types of Rotational Axes

1. **Two-fold Axis ( $C_2$ ):** Object repeats itself after rotation by  $180^\circ$ . Example: Hydrogen peroxide molecule, rectangular objects.



#### Typical examples:

Hydrogen peroxide molecule

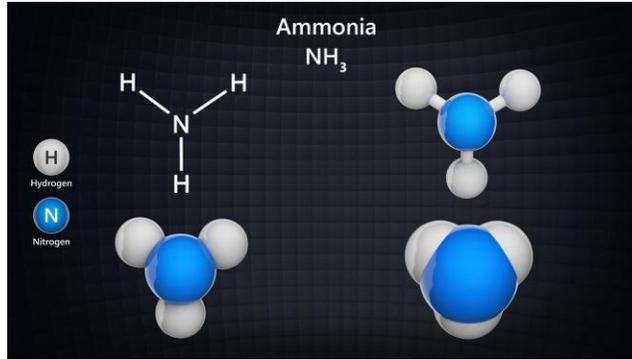
Rectangular objects

Many organic molecules with simple backbones

#### Key idea:

Object matches itself twice in one full rotation.

2. **Three-fold Axis ( $C_3$ ):** Repeats after  $120^\circ$  rotation. Example: Ammonia molecule.



**Typical examples:**

Ammonia molecule

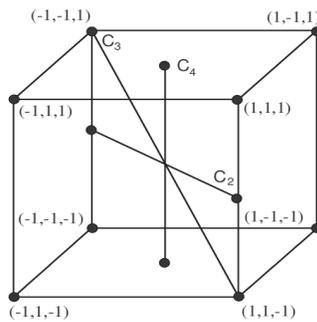
Equilateral triangle

Trigonal pyramidal structures

**Key idea:**

Object matches itself three times in one full rotation.

**3. Four-fold Axis (C<sub>4</sub>):** Repeats after 90° rotation. Example: Square planar molecules.



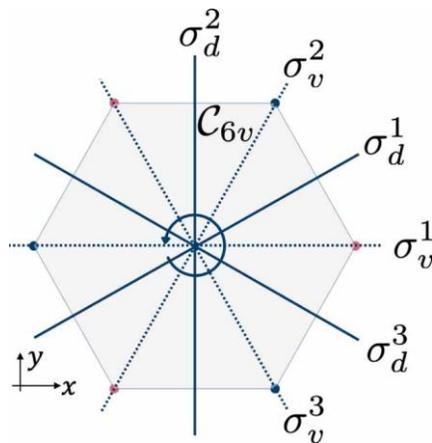
**Typical examples:**

- Square planar metal complexes
- Square objects

**Key idea:**

Object matches itself **four times** in one full rotation.

**4. Six-fold Axis ( $C_6$ ):** Repeats after  $60^\circ$  rotation. Common in hexagonal crystal systems.



**Typical examples:**

- Benzene ring
- Hexagonal crystal systems

- Snowflake-like structures

**Key idea:**

Object matches itself **six times** in one full rotation.

**Importance of Axis of Symmetry**

- Helps classify molecules into point groups.
- Determines optical activity.
- Influences spectroscopic selection rules.
- Important in understanding crystal structures and packing.