(1) **Fischer Projection:**

a) Fischer Projection can be rotated by 180° only!

b) If one group of the Fischer projection is held steady, the other groups can be rotated either clockwise or counter clockwise.
c) If the groups are oriented improperly in the original drawing, the Fischer can be “rearranged” using the following set of rules:

- Exchanging (one exchange!) any two groups around a Fischer projection generates the enantiomer of the original compound.
- Exchanging groups twice (two exchanges) regenerates the original stereochemistry. See the following example:

Is M1 same as M2?

\[\begin{array}{c}
\text{M1} \\
\text{H}_3\text{C} - \text{H}_2\text{C} & \text{CH}_3 \\
\text{H}_3\text{C} & \text{OH} & \text{OH} \\
1 & 2 & \text{M1}
\end{array}\]

\[\begin{array}{c}
\text{M2} \\
\text{H}_3\text{C} - \text{H}_2\text{C} & \text{CH}_2\text{-CH}_3 \\
\text{H}_3\text{C} - \text{OH} & \text{OH} & \text{OH} \\
1 & 2 & \text{M2}
\end{array}\]

\[\begin{array}{c}
\text{Exchange 1} \\
\text{On C # 1}
\end{array}\]

\[\begin{array}{c}
\text{M2} \\
\text{H}_3\text{C} - \text{H}_2\text{C} & \text{CH}_2\text{-CH}_3 \\
\text{H}_3\text{C} & \text{OH} & \text{OH} \\
1 & 2 & \text{M2}
\end{array}\]

\[\begin{array}{c}
\text{M2} \\
\text{H}_3\text{C} - \text{H}_2\text{C} & \text{CH}_2\text{-CH}_3 \\
\text{H}_3\text{C} - \text{OH} & \text{OH} & \text{OH} \\
1 & 2 & \text{M2}
\end{array}\]

\[\begin{array}{c}
\text{Exchange 2} \\
\text{On C # 1}
\end{array}\]

\[\begin{array}{c}
\text{M2} \\
\text{H}_3\text{C} - \text{H}_2\text{C} & \text{CH}_2\text{-CH}_3 \\
\text{H}_3\text{C} & \text{OH} & \text{OH} \\
1 & 2 & \text{M2}
\end{array}\]

\[\begin{array}{c}
\text{M2} \\
\text{H}_3\text{C} - \text{H}_2\text{C} & \text{CH}_2\text{-CH}_3 \\
\text{H}_3\text{C} - \text{OH} & \text{OH} & \text{OH} \\
1 & 2 & \text{M2}
\end{array}\]
Exchange 1

\[ \text{On C \# 2} \]

Exchange 2

\[ \text{On C \# 2} \]

Yes, \( M_2 = M_1 \)
A chiral molecule is a type of molecule that has a non-superposable mirror image. In chemistry, chirality usually refers to molecules. The chiral molecule and its mirror are called enantiomers or optical isomers. Pairs of enantiomers are often designated as "right" and "left" handed.

Notations:

I) An optically active substance (i.e., one pure enantiomer) will rotate the plane-polarized light:
   If the analyzer is rotated clockwise the rotation is (+) and the molecule is dextrorotary (D).
   If the analyzer is rotated counterclockwise the rotation is (-) and the molecule is laevorotatory (L).

II) R/S configurations:
   The Cahn-Ingold-Prelog R/S rules are used for naming enantiomers.
   a. The structural formula with two or more stereogenic carbons, each may assume an R or S configuration.
   b. Identify the stereogenic (chiral) centers (most commonly an sp\(^3\) C with 4 different groups attached).
   c. Assign the priority to each group (high priority = 1, low = 4) based on atomic number of the atom attached to the stereogenic center (Isotopes: If two groups differ only in isotopes, mass numbers are used at each step to break ties in atomic number.) For double and triple bonds:
      \[ A \rightarrow B \rightarrow \]
      \[ A \rightarrow B \rightarrow \]
      \[ B \] ghost atom
d. Position the lowest priority group away as if you were looking along the C-(4) sigma bond.
   e. For the other 3 groups, determine the direction of high to low priority (1 to 3).
   f. If this is clockwise, then the center is R (Latin: rectus = right).
   g. If this is counter clockwise, then it is S (Latin: sinister = left).
   h. As a general rule, a structure having \( n \) chiral centers will have \( 2^n \) possible combinations of these centers. Depending on the overall symmetry of the molecular structure, some of these combinations may be identical, but in the absence of such identity, we would expect to find \( 2^n \) stereoisomers.
In order to use a Fischer projection to determine R or S stereochemistry, you need to realize that the lowest priority group is oriented either up or down on your Fischer projection. In the following example, first adjust the orientation:

Exchange 1
On C # 2

Exchange 2
On C # 2

Use CIP Rules
On C # 2
Where, 2R means stereogenic carbons (#2) in the molecule has R configuration.

(4) Z/E assignments instead cis/trans:

By the CIP priority rules, find E-Z system (instead Cis & Trans):

Br
I
1
2
Cl
F
(Z)

On C #1: I > Br
On C #2: Cl > F
Therefore: I and Cl are together

Br
I
1
2
Cl
F
(E)

On C #1: I > Br
On C #2: Cl > F
Therefore: I and Cl are opposite