1. (a) (10 points) Give the definition of Saccheri quadrilateral.

(b) (15 points) Prove that the summit angles of a Saccheri quadrilateral are always congruent.

2. (15 points) Non-Euclidean geometry was first invented by mathematicians who were trying to prove what about Euclidean geometry? Answer in a few sentences.

3. (20 points) Given a reflection \( r \) across a line \( l \) and a translation \( T \) in the same direction as \( l \), prove that

\[ r \circ T = T \circ r. \]

Hint: work in \((x,y)\)-coordinates, choosing coordinates in such a way as to make your computations simple.

4. (10 points) Describe the invariant lines of a glide reflection. (You do not need to give a proof, but describe clearly which lines are invariant.)

5. (30 points) For each of the following, answer true or false and give a brief explanation of your answer (just a sentence or two, not a formal proof, but some explanation why you answered true or false.)

(a) The composition of any two rotations (in Euclidean geometry) is a rotation.

(b) In hyperbolic geometry, any two lines which do not intersect are called “limiting parallels.”

(c) In Euclidean geometry, the set of all rotations and translations forms a group of symmetries.

(See definition below)

**Definition:** A group of symmetries is a set of Euclidean isometries that have the following properties:

1. Given any two elements of the set, the composition of the two elements is again a member of the set.

2. The composition of elements is an associative operation.

3. The identity is a member of the set.

4. Given any element of the set, its inverse exists and is an element of the set.