



# Computer Graphics

LECTURE 10

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# Last Class

- ▶ Viewing
  - ▶ Perspectives
  - ▶ Projections

# Today's Agenda

- ▶ Geometric Objects
  - ▶ Vector Space
  - ▶ Affine Space

# Scalars, Points and Vectors

- ▶ Geometry is a subject that relates objects in  $n$  – dimensional space (In computer graphics we deal with 3 dimensional space)
- ▶ Scalars, vectors and points form minimum set of primitives and are used to build sophisticated objects.
- ▶ A point is a location in space that neither has size nor shape.
- ▶ Real numbers (magnitudes) such as distance between two points are a scalars
- ▶ Vectors are also required to work with directions.

# Scalars



- ▶ Scalars are members of sets which can be combined by addition and multiplication and obey associativity, commutivity and inverses axioms
- ▶ Scalars don't possess any geometric properties
- ▶ Real and Complex numbers

# Vectors

- ▶ A quantity defined by magnitude and direction
- ▶ Velocity, Force etc.
- ▶ For computer graphics, a directed line segment (can be used for any vector) is most significant example

# Vector Operations

- ▶ Vectors have following properties
- ▶ Inverses: Equal in magnitude but opposite in direction
- ▶ Scalar Multiplication: A vector can be multiplied by a scalar (magnitude changes only not the direction)
- ▶ Zero vector is also defined with zero magnitude and undefined direction
- ▶ Head to Tail Rule is used to add vectors

# Head to Tail Rule





# Linear Vector Space Extensions

- ▶ Linear Vector Space may not have ways to measure a scalar quantity.
- ▶ A **Euclidean space** is an extension of a vector space that adds a measure of size or distance and allows us to define such things as the length of a line segment.
- ▶ An **affine space** is an extension of the vector space that includes an additional type of object: the point.
  - ▶ Operations between vectors and points are allowed

# Affine Space

- ▶ Combines point and vector space
- ▶ Allows following operations
  - ▶ Vector-vector addition
  - ▶ Scalar-vector multiplication
  - ▶ Point-vector addition
  - ▶ Scalar-scalar operations

# Summary

- ▶ Geometric Objects
  - ▶ Vector Space
  - ▶ Affine Space

# References

- ▶ Fundamentals of Computer Graphics Third Edition by Peter Shirley and Steve Marschner
- ▶ Interactive Computer Graphics, A Top-down Approach with OpenGL (Sixth Edition) by Edward Angel.