Triangles

1.0.1

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4.1 geom Namespace Reference

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- detail

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- class Line

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- class Triangle

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- using VectorD = Vector< double >
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Functions

- template<std::floating_point T>
  T distance (const Plane< T > &pl, const Vector< T > &pt)

  Calculates signed distance between point and plane.
- template<std::floating_point T>
  bool isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)

  Checks intersection of 2 triangles.
- template<std::floating_point T>
  std::variant< std::monostate, Line< T >, Plane< T > > intersect (const Plane< T > &pl1, const Plane< T > &pl2)

  Intersect 2 planes and return result of intersection.
- template<std::floating_point T>
  bool isIntersect (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Line< T > &line)

  Line print operator.
- template<std::floating_point T>
  bool operator== (const Line< T > &lhs, const Line< T > &rhs)

  Line equality operator.
- template<std::floating_point T>
  bool operator== (const Plane< T > &lhs, const Plane< T > &rhs)

  Plane equality operator.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Plane< T > &pl)

  Plane print operator.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Triangle< T > &tr)

  Triangle print operator.
- template<std::floating_point T>
  Vector< T > operator+ (const Vector< T > &lhs, const Vector< T > &rhs)

  Overloaded + operator.
- template<std::floating_point T>
  Vector< T > operator- (const Vector< T > &lhs, const Vector< T > &rhs)

  Overloaded - operator.
- template<Number nT, std::floating_point T>
  Vector< T > operator* (const nT &val, const Vector< T > &rhs)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vector< T > operator* (const Vector< T > &lhs, const nT &val)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vector< T > operator/ (const Vector< T > &lhs, const nT &val)

  Overloaded divide by value operator.
- template<std::floating_point T>
  T dot (const Vector< T > &lhs, const Vector< T > &rhs)

  Dot product function.
- template<std::floating_point T>
  Vector< T > cross (const Vector< T > &lhs, const Vector< T > &rhs)

  Cross product function.
- template<std::floating_point T>
  bool operator== (const Vector< T > &lhs, const Vector< T > &rhs)

  Vector equality operator.

- template<std::floating_point T>
  bool operator!= (const Vector< T > &lhs, const Vector< T > &rhs)
  Vector inequality operator.
- template<std::floating_point T>
  std::ostream & operator<< (std::ostream &ost, const Vector< T > &vec)
  Vector print operator.

Variables

- template<class T >
  concept Number = std::is_floating_point_v<T> || std::is_integral_v<T>
  Useful concept which represents floating point and integral types.

4.1.1 Detailed Description

line.hh Line class implementation

triangle.hh Triangle class implementation

Plane class implementation.

4.1.2 Typedef Documentation

4.1.2.1 VectorD

```
using geom::VectorD = typedef Vector<double>
```

Definition at line 391 of file vector.hh.

4.1.2.2 VectorF

```
using geom::VectorF = typedef Vector<float>
```

Definition at line 392 of file vector.hh.

4.1.3 Function Documentation

4.1.3.1 distance()

```
template<std::floating_point T>
T geom::distance (
            const Plane< T > & pl,
            const Vector< T > & pt )
```

Calculates signed distance between point and plane.

Template Parameters

T	- floating point type of coordinates

Parameters

pl	plane
pt	point

Returns

T signed distance between point and plane

Definition at line 26 of file distance.hh.

References geom::Plane< T >::dist(), dot(), and geom::Plane< T >::norm().

Referenced by geom::detail::helperMollerHaines(), and geom::detail::isOnOneSide().

4.1.3.2 isIntersect2D()

```
template<std::floating_point T>
bool geom::isIntersect2D (
             const Triangle< T > & tr1,
             const Triangle< T > & tr2 )
```

Checks intersection of 2 triangles.

Template Parameters

T	- floating point type of coordinates

Parameters

tr1	first triangle
tr2	second triangle

Returns

true if triangles are intersect

false if triangles are not intersect

Definition at line 183 of file intersection.hh.

Referenced by isIntersect().

4.1.3.3 intersect()

```
template<std::floating_point T>
std::variant< std::monostate, Line< T >, Plane< T > > geom::intersect (
            const Plane< T > & pl1,
            const Plane< T > & pl2 )
```

Intersect 2 planes and return result of intersection.

Common intersection case (parallel planes case is trivial):

Let $\overrightarrow{P}$ - point in space

pl_1 equation: $\overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1$

pl_2 equation: $\overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2$

Intersection line direction: $\overrightarrow{dir} = \overrightarrow{n}_1 \times \overrightarrow{n}_2$

Let origin of intersection line be a linear combination of $\overrightarrow{n}_1$ and $\overrightarrow{n}_2$:

$$\overrightarrow{P} = a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2$$

$\overrightarrow{P}$ must satisfy both pl_1 and pl_1 equations:

$$\overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1 \Leftrightarrow \overrightarrow{n}_1 \cdot (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) = d_1 \Leftrightarrow a + b \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 = d_1$$

$$\overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2 \Leftrightarrow \overrightarrow{n}_2 \cdot (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) = d_2 \Leftrightarrow a \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 + b = d_2$$

Let's find a and b:

$$a = \frac{d_2 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_1}{(\overrightarrow{n}_1 \cdot \overrightarrow{n}_2)^2 - 1}$$

$$b = \frac{d_1 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_2}{(\overrightarrow{n}_1 \cdot \overrightarrow{n}_2)^2 - 1}$$

Intersection line equation:

$$\overrightarrow{r}(t) = \overrightarrow{P} + t \cdot \overrightarrow{n}_1 \times \overrightarrow{n}_2 = (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) + t \cdot \overrightarrow{n}_1 \times \overrightarrow{n}_2$$

Template Parameters

T	- floating point type of coordinates

Parameters

pl1	first plane
pl2	second plane

Returns

std::variant<std::monostate, Line<T>, Plane<T>>

Definition at line 152 of file intersection.hh.

References cross(), geom::Plane< T >::dist(), dot(), and geom::Plane< T >::norm().

Referenced by geom::detail::isIntersectMollerHaines().

4.1.3.4 isIntersect()

```
template<std::floating_point T>
bool geom::isIntersect (
            const Triangle< T > & tr1,
            const Triangle< T > & tr2 )
```

Definition at line 128 of file intersection.hh.

References geom::Plane< T >::getBy3Points(), geom::detail::isIntersect2D(), geom::detail::isIntersectMollerHaines(), and geom::detail::isOnOneSide().

4.1.3.5 operator<<() [1/4]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Line< T > & line )
```

Line print operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in,out	*ost*	output stream
in	*line*	Line to print

Returns

std::ostream& modified ostream instance

Definition at line 89 of file line.hh.

References geom::Line< T >::dir(), and geom::Line< T >::org().

4.1.3.6 operator==() [1/3]

```
template<std::floating_point T>
bool geom::operator== (
            const Line< T > & lhs,
            const Line< T > & rhs )
```

Line equality operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in	*lhs*	1st line
in	*rhs*	2nd line

Returns

true if lines are equal

false if lines are not equal

Definition at line 105 of file line.hh.

References geom::Line< T >::isEqual().

4.1.3.7 operator==() [2/3]

```
template<std::floating_point T>
bool geom::operator== (
            const Plane< T > & lhs,
            const Plane< T > & rhs )
```

Plane equality operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in	*lhs*	1st plane
in	*rhs*	2nd plane

Returns

true if planes are equal

false if planes are not equal

Definition at line 147 of file plane.hh.

References geom::Plane< T >::isEqual().

4.1.3.8 operator<<() [2/4]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Plane< T > & pl )
```

Plane print operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in,out	*ost*	output stream
in	*pl*	plane to print

Returns

std::ostream& modified ostream instance

Definition at line 161 of file plane.hh.

References geom::Plane< T >::dist(), and geom::Plane< T >::norm().

4.1.3.9 operator<<() [3/4]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Triangle< T > & tr )
```

Triangle print operator.

Template Parameters

T	- floating point type of coordinates

Parameters

in,out	*ost*	output stream
in	*tr*	Triangle to print

Returns

std::ostream& modified ostream instance

Definition at line 60 of file triangle.hh.

4.1.3.10 operator+()

```
template<std::floating_point T>
Vector<T> geom::operator+ (
            const Vector< T > & lhs,
            const Vector< T > & rhs )
```

Overloaded + operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

Vector<T> sum of two vectors

Definition at line 244 of file vector.hh.

4.1.3.11 operator-()

```
template<std::floating_point T>
Vector<T> geom::operator- (
            const Vector< T > & lhs,
            const Vector< T > & rhs )
```

Overloaded - operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

Vector<T> res of two vectors

Definition at line 260 of file vector.hh.

4.1.3.12 operator*() [1/2]

```
template<Number nT, std::floating_point T>
Vector<T> geom::operator* (
            const nT & val,
            const Vector< T > & rhs )
```

Overloaded multiple by value operator.

Template Parameters

nT	type of value to multiply by
T	vector template parameter

Parameters

in	*val*	value to multiply by
in	*rhs*	vector to multiply by value

Returns

Vector<T> result vector

Definition at line 277 of file vector.hh.

4.1.3.13 operator*() [2/2]

```
template<Number nT, std::floating_point T>
Vector<T> geom::operator* (
```

```
const Vector< T > & lhs,
const nT & val )
```

Overloaded multiple by value operator.

Template Parameters

nT	type of value to multiply by
T	vector template parameter

Parameters

in	*val*	value to multiply by
in	*lhs*	vector to multiply by value

Returns

Vector<T> result vector

Definition at line 294 of file vector.hh.

4.1.3.14 operator/()

```
template<Number nT, std::floating_point T>
Vector<T> geom::operator/ (
            const Vector< T > & lhs,
            const nT & val )
```

Overloaded divide by value operator.

Template Parameters

nT	type of value to divide by
T	vector template parameter

Parameters

in	*val*	value to divide by
in	*lhs*	vector to divide by value

Returns

Vector<T> result vector

Definition at line 311 of file vector.hh.

4.1.3.15 dot()

```
template<std::floating_point T>
T geom::dot (
```

```
            const Vector< T > & lhs,
            const Vector< T > & rhs )
```

Dot product function.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

T dot production

Definition at line 327 of file vector.hh.

References geom::Vector< T >::dot().

Referenced by distance(), geom::detail::helperMollerHaines(), intersect(), geom::Vector< T >::isPerp(), and geom::Vector< T >::length2().

4.1.3.16 cross()

```
template<std::floating_point T>
Vector<T> geom::cross (
            const Vector< T > & lhs,
            const Vector< T > & rhs )
```

Cross product function.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

T cross production

Definition at line 341 of file vector.hh.

References geom::Vector< T >::cross().

Referenced by intersect(), and geom::Vector< T >::isPar().

4.1.3.17 operator==() [3/3]

```
template<std::floating_point T>
bool geom::operator== (
            const Vector< T > & lhs,
            const Vector< T > & rhs )
```

Vector equality operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

true if vectors are equal

false otherwise

Definition at line 356 of file vector.hh.

References geom::Vector< T >::isEqual().

4.1.3.18 operator"!=()

```
template<std::floating_point T>
bool geom::operator!= (
            const Vector< T > & lhs,
            const Vector< T > & rhs )
```

Vector inequality operator.

Template Parameters

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	second vector

Returns

true if vectors are not equal

false otherwise

Definition at line 371 of file vector.hh.

4.1.3.19 operator<<() [4/4]

```
template<std::floating_point T>
std::ostream& geom::operator<< (
            std::ostream & ost,
            const Vector< T > & vec )
```

Vector print operator.

Template Parameters

T	vector template parameter

Parameters

in,out	*ost*	output stream
in	*vec*	vector to print

Returns

std::ostream& modified stream instance

Definition at line 385 of file vector.hh.

References geom::Vector< T >::x, geom::Vector< T >::y, and geom::Vector< T >::z.

4.1.4 Variable Documentation

4.1.4.1 Number

```
template<class T >
concept geom::Number = std::is_floating_point_v<T> || std::is_integral_v<T>
```

Useful concept which represents floating point and integral types.

@concept Number

Template Parameters

T	

Definition at line 25 of file vector.hh.

4.2 geom::detail Namespace Reference

Functions

- template<std::floating_point T>
  bool isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)

  Checks intersection of 2 triangles.
- template<std::floating_point T>
  bool isIntersectMollerHaines (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  std::pair< T, T > helperMollerHaines (const Triangle< T > &tr, const Plane< T > &pl, const Line< T > &l)
- template<std::floating_point T>
  bool isOverlap (std::pair< T, T > &params1, std::pair< T, T > &params2)
- template<std::forward_iterator It>
  bool isSameSign (It begin, It end)
- template<std::floating_point T>
  bool isOnOneSide (const Plane< T > &pl, const Triangle< T > &tr)

4.2.1 Function Documentation

4.2.1.1 isIntersect2D()

```
template<std::floating_point T>
bool geom::detail::isIntersect2D (
            const Triangle< T > & tr1,
            const Triangle< T > & tr2 )
```

Checks intersection of 2 triangles.

Template Parameters

T	- floating point type of coordinates

Parameters

tr1	first triangle
tr2	second triangle

Returns

true if triangles are intersect

false if triangles are not intersect

Definition at line 183 of file intersection.hh.

Referenced by geom::isIntersect().

4.2.1.2 isIntersectMollerHaines()

```
template<std::floating_point T>
bool geom::detail::isIntersectMollerHaines (
            const Triangle< T > & tr1,
            const Triangle< T > & tr2 )
```

Definition at line 190 of file intersection.hh.

References geom::Plane< T >::getBy3Points(), helperMollerHaines(), geom::intersect(), and isOverlap().

Referenced by geom::isIntersect().

4.2.1.3 helperMollerHaines()

```
template<std::floating_point T>
std::pair< T, T > geom::detail::helperMollerHaines (
            const Triangle< T > & tr,
            const Plane< T > & pl,
            const Line< T > & l )
```

Definition at line 208 of file intersection.hh.

References geom::Line< T >::dir(), geom::distance(), geom::dot(), and geom::Line< T >::org().

Referenced by isIntersectMollerHaines().

4.2.1.4 isOverlap()

```
template<std::floating_point T>
bool geom::detail::isOverlap (
            std::pair< T, T > & params1,
            std::pair< T, T > & params2 )
```

Definition at line 244 of file intersection.hh.

Referenced by isIntersectMollerHaines().

4.2.1.5 isSameSign()

```
template<std::forward_iterator It>
bool geom::detail::isSameSign (
            It begin,
            It end )
```

Definition at line 250 of file intersection.hh.

Referenced by isOnOneSide().

4.2.1.6 isOnOneSide()

```
template<std::floating_point T>
bool geom::detail::isOnOneSide (
            const Plane< T > & pl,
            const Triangle< T > & tr )
```

Definition at line 263 of file intersection.hh.

References geom::distance(), and isSameSign().

Referenced by geom::isIntersect().

Chapter 5

Class Documentation

5.1 geom::Line< T > Class Template Reference

Line class implementation.

`#include <line.hh>`

Public Member Functions

- Line (const Vector< T > &org, const Vector< T > &dir)
  Construct a new Line object.
- const Vector< T > & org () const
  Getter for origin vector.
- const Vector< T > & dir () const
  Getter for direction vector.
- bool belongs (const Vector< T > &point) const
  Checks is point belongs to line.
- bool isEqual (const Line &line) const
  Checks is ∗this equals to another line.

Static Public Member Functions

- static Line getBy2Points (const Vector< T > &p1, const Vector< T > &p2)
  Get line by 2 points.

5.1.1 Detailed Description

template<std::floating_point T>
class geom::Line< T >

Line class implementation.

Template Parameters

T	- floating point type of coordinates

Definition at line 21 of file line.hh.

5.1.2 Constructor & Destructor Documentation

5.1.2.1 Line()

```
template<std::floating_point T>
geom::Line< T >::Line (
            const Vector< T > & org,
            const Vector< T > & dir )
```

Construct a new Line object.

Parameters

in	*org*	origin vector
in	*dir*	direction vector

Definition at line 111 of file line.hh.

References geom::Line< T >::org().

5.1.3 Member Function Documentation

5.1.3.1 org()

```
template<std::floating_point T>
const Vector< T > & geom::Line< T >::org
```

Getter for origin vector.

Returns

const Vector<T>& const reference to origin vector

Definition at line 118 of file line.hh.

Referenced by geom::Plane< T >::belongs(), geom::detail::helperMollerHaines(), geom::Line< T >::Line(), and geom::operator<<().

5.1.3.2 dir()

```
template<std::floating_point T>
const Vector< T > & geom::Line< T >::dir
```

Getter for direction vector.

Returns

const Vector<T>& const reference to direction vector

Definition at line 124 of file line.hh.

Referenced by geom::Plane< T >::belongs(), geom::detail::helperMollerHaines(), and geom::operator<<().

5.1.3.3 belongs()

```
template<std::floating_point T>
bool geom::Line< T >::belongs (
            const Vector< T > & point ) const
```

Checks is point belongs to line.

Parameters

in	*point*	const reference to point vector

Returns

true if point belongs to line

false if point doesn't belong to line

Definition at line 130 of file line.hh.

5.1.3.4 isEqual()

```
template<std::floating_point T>
bool geom::Line< T >::isEqual (
            const Line< T > & line ) const
```

Checks is *this equals to another line.

Parameters

in	*line*	const reference to another line

Returns

true if lines are equal

false if lines are not equal

Definition at line 136 of file line.hh.

Referenced by geom::operator==().

5.1.3.5 getBy2Points()

```
template<std::floating_point T>
Line< T > geom::Line< T >::getBy2Points (
            const Vector< T > & p1,
            const Vector< T > & p2 )  [static]
```

Get line by 2 points.

Parameters

in	*p1*	1st point
in	*p2*	2nd point

Returns

Line passing through two points

Definition at line 142 of file line.hh.

The documentation for this class was generated from the following file:

- include/primitives/line.hh

5.2 geom::Plane< T > Class Template Reference

Plane class realization.

`#include <plane.hh>`

Public Member Functions

- T dist () const
  Getter for distance.
- const Vector< T > & norm () const
  Getter for normal vector.
- bool belongs (const Vector< T > &point) const
  Checks if point belongs to plane.
- bool belongs (const Line< T > &line) const
  Checks if line belongs to plane.
- bool isEqual (const Plane &rhs) const
  *Checks is *this equals to another plane.*
- bool isPar (const Plane &rhs) const
  *Checks is *this is parallel to another plane.*

Static Public Member Functions

- static Plane getBy3Points (const Vector< T > &pt1, const Vector< T > &pt2, const Vector< T > &pt3)

  Get plane by 3 points.
- static Plane getParametric (const Vector< T > &org, const Vector< T > &dir1, const Vector< T > &dir2)

  Get plane from parametric plane equation.
- static Plane getNormalPoint (const Vector< T > &norm, const Vector< T > &point)

  Get plane from normal point plane equation.
- static Plane getNormalDist (const Vector< T > &norm, T constant)

  Get plane form normal const plane equation.

5.2.1 Detailed Description

template<std::floating_point T>
class geom::Plane< T >

Plane class realization.

Template Parameters

T	- floating point type of coordinates

Definition at line 24 of file plane.hh.

5.2.2 Member Function Documentation

5.2.2.1 dist()

```
template<std::floating_point T>
T geom::Plane< T >::dist
```

Getter for distance.

Returns

T value of distance

Definition at line 175 of file plane.hh.

Referenced by geom::distance(), geom::intersect(), and geom::operator<<().

5.2.2.2 norm()

```
template<std::floating_point T>
const Vector< T > & geom::Plane< T >::norm
```

Getter for normal vector.

Returns

const Vector<T>& const reference to normal vector

Definition at line 181 of file plane.hh.

Referenced by geom::distance(), geom::intersect(), and geom::operator<<().

5.2.2.3 belongs() [1/2]

```
template<std::floating_point T>
bool geom::Plane< T >::belongs (
            const Vector< T > & point ) const
```

Checks if point belongs to plane.

Parameters

in	*point*	const referene to point vector

Returns

true if point belongs to plane

false if point doesn't belong to plane

Definition at line 187 of file plane.hh.

5.2.2.4 belongs() [2/2]

```
template<std::floating_point T>
bool geom::Plane< T >::belongs (
            const Line< T > & line ) const
```

Checks if line belongs to plane.

Parameters

in	*line*	const referene to line

Returns

true if line belongs to plane

false if line doesn't belong to plane

Definition at line 193 of file plane.hh.

References geom::Line< T >::dir(), and geom::Line< T >::org().

5.2.2.5 isEqual()

```
template<std::floating_point T>
bool geom::Plane< T >::isEqual (
            const Plane< T > & rhs ) const
```

Checks is ∗this equals to another plane.

Parameters

in	*rhs*	const reference to another plane

Returns

true if planes are equal

false if planes are not equal

Definition at line 199 of file plane.hh.

Referenced by geom::operator==().

5.2.2.6 isPar()

```
template<std::floating_point T>
bool geom::Plane< T >::isPar (
            const Plane< T > & rhs ) const
```

Checks is ∗this is parallel to another plane.

Parameters

in	*rhs*	const reference to another plane

Returns

true if planes are parallel

false if planes are not parallel

Definition at line 205 of file plane.hh.

References geom::Plane< T >::isPar().

Referenced by geom::Plane< T >::isPar().

5.2.2.7 getBy3Points()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getBy3Points (
            const Vector< T > & pt1,
            const Vector< T > & pt2,
            const Vector< T > & pt3 )  [static]
```

Get plane by 3 points.

Parameters

in	*pt1*	1st point
in	*pt2*	2nd point
in	*pt3*	3rd point

Returns

Plane passing through three points

Definition at line 211 of file plane.hh.

Referenced by geom::isIntersect(), and geom::detail::isIntersectMollerHaines().

5.2.2.8 getParametric()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getParametric (
            const Vector< T > & org,
            const Vector< T > & dir1,
            const Vector< T > & dir2 )  [static]
```

Get plane from parametric plane equation.

Parameters

in	*org*	origin vector
in	*dir1*	1st direction vector
in	*dir2*	2nd direction vector

Returns

Plane

Definition at line 218 of file plane.hh.

References geom::Vector< T >::cross().

5.2.2.9 getNormalPoint()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getNormalPoint (
            const Vector< T > & norm,
            const Vector< T > & point )  [static]
```

Get plane from normal point plane equation.

Parameters

in	*norm*	normal vector
in	*point*	point lying on the plane

Returns

Plane

Definition at line 226 of file plane.hh.

References geom::Vector< T >::normalized().

5.2.2.10 getNormalDist()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getNormalDist (
            const Vector< T > & norm,
            T constant )  [static]
```

Get plane form normal const plane equation.

Parameters

in	*norm*	normal vector
in	*constant*	distance

Returns

Plane

Definition at line 233 of file plane.hh.

References geom::Vector< T >::normalized().

The documentation for this class was generated from the following file:

- include/primitives/plane.hh

5.3 geom::Triangle< T > Class Template Reference

Triangle class implementation.

`#include <triangle.hh>`

Public Member Functions

- Triangle (const Vector< T > &p1, const Vector< T > &p2, const Vector< T > &p3)
  Construct a new Triangle object from 3 points.
- const Vector< T > & operator[ ] (std::size_t idx) const
  Overloaded operator[] to get access to vertices.

5.3.1 Detailed Description

template<std::floating_point T>
class geom::Triangle< T >

Triangle class implementation.

Template Parameters

T	- floating point type of coordinates

Definition at line 24 of file triangle.hh.

5.3.2 Constructor & Destructor Documentation

5.3.2.1 Triangle()

```
template<std::floating_point T>
geom::Triangle< T >::Triangle (
```

```
            const Vector< T > & p1,
            const Vector< T > & p2,
            const Vector< T > & p3 )
```

Construct a new Triangle object from 3 points.

Parameters

in	*p1*	1st point
in	*p2*	2nd point
in	*p3*	3rd point

Definition at line 72 of file triangle.hh.

5.3.3 Member Function Documentation

5.3.3.1 operator[]()

```
template<std::floating_point T>
const Vector< T > & geom::Triangle< T >::operator[] (
            std::size_t idx ) const
```

Overloaded operator[] to get access to vertices.

Parameters

in	*idx*	index of vertex

Returns

const Vector<T>& const reference to vertex

Definition at line 77 of file triangle.hh.

The documentation for this class was generated from the following file:

- include/primitives/triangle.hh

5.4 geom::Vector< T > Class Template Reference

Vector class realization.

```
#include <vector.hh>
```

Public Member Functions

- Vector (T coordX, T coordY, T coordZ)

  Construct a new Vector object from 3 coordinates.
- Vector (T coordX={})

  Construct a new Vector object with equals coordinates.
- Vector & operator+= (const Vector &vec)

  Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.
- Vector & operator-= (const Vector &vec)

  Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.
- Vector operator- () const

  Unary - operator.
- template<Number nType>
  Vector & operator*= (nType val)

  *Overloaded *= by number operator.*
- template<Number nType>
  Vector & operator/= (nType val)

  Overloaded /= by number operator.
- T dot (const Vector &rhs) const

  Dot product function.
- Vector cross (const Vector &rhs) const

  Cross product function.
- T length2 () const

  Calculate squared length of a vector function.
- T length () const

  Calculate length of a vector function.
- Vector normalized () const

  Get normalized vector function.
- Vector & normalize ()

  Normalize vector function.
- T & operator[ ] (size_t i)

  Overloaded operator [] (non-const version) To get access to coordinates.
- T operator[ ] (size_t i) const

  Overloaded operator [] (const version) To get access to coordinates.
- bool isPar (const Vector &rhs) const

  Check if vector is parallel to another.
- bool isPerp (const Vector &rhs) const

  Check if vector is perpendicular to another.
- bool isEqual (const Vector &rhs) const

  Check if vector is equal to another.
- template<Number nType>
  Vector< T > & operator*= (nType val)
- template<Number nType>
  Vector< T > & operator/= (nType val)

Static Public Member Functions

- static bool isNumEq (T lhs, T rhs)

  Check equality (with threshold) of two floating point numbers function.
- static void setThreshold (T thres)

  Set new threshold value.
- static void getThreshold ()

  Get current threshold value.
- static void setDefThreshold ()

  Set threshold to default value.

Public Attributes

- T x {}

  Vector coordinates.
- T y {}
- T z {}

5.4.1 Detailed Description

template<std::floating_point T>
class geom::Vector< T >

Vector class realization.

Template Parameters

T	- floating point type of coordinates

Definition at line 34 of file vector.hh.

5.4.2 Constructor & Destructor Documentation

5.4.2.1 Vector() [1/2]

```
template<std::floating_point T>
geom::Vector< T >::Vector (
            T coordX,
            T coordY,
            T coordZ )  [inline]
```

Construct a new Vector object from 3 coordinates.

Parameters

in	*coordX*	x coordinate
in	*coordY*	y coordinate
in	*coordZ*	z coordinate

Definition at line 55 of file vector.hh.

5.4.2.2 Vector() [2/2]

```
template<std::floating_point T>
geom::Vector< T >::Vector (
            T coordX = {} )  [inline], [explicit]
```

Construct a new Vector object with equals coordinates.

Parameters

in	*coordX*	coordinate (default to {})

Definition at line 63 of file vector.hh.

5.4.3 Member Function Documentation

5.4.3.1 operator+=()

```
template<std::floating_point T>
Vector< T > & geom::Vector< T >::operator+= (
            const Vector< T > & vec )
```

Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.

Parameters

in	*vec*	vector to incremented with

Returns

Vector& reference to current instance

Definition at line 395 of file vector.hh.

References geom::Vector< T >::x, geom::Vector< T >::y, and geom::Vector< T >::z.

5.4.3.2 operator-=()

```
template<std::floating_point T>
Vector< T > & geom::Vector< T >::operator-= (
            const Vector< T > & vec )
```

Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.

Parameters

in	*vec*	vector to decremented with

Returns

Vector& reference to current instance

Definition at line 405 of file vector.hh.

References geom::Vector< T >::x, geom::Vector< T >::y, and geom::Vector< T >::z.

5.4.3.3 operator-()

```
template<std::floating_point T>
Vector< T > geom::Vector< T >::operator-
```

Unary - operator.

Returns

Vector negated Vector instance

Definition at line 415 of file vector.hh.

5.4.3.4 operator*=() [1/2]

```
template<std::floating_point T>
template<Number nType>
Vector& geom::Vector< T >::operator*= (
            nType val )
```

Overloaded *= by number operator.

Template Parameters

nType	numeric type of value to multiply by

Parameters

in	*val*	value to multiply by

Returns

Vector& reference to vector instance

5.4.3.5 operator/=() [1/2]

```
template<std::floating_point T>
template<Number nType>
Vector& geom::Vector< T >::operator/= (
            nType val )
```

Overloaded /= by number operator.

Template Parameters

nType	numeric type of value to divide by

Parameters

in	*val*	value to divide by

Returns

Vector& reference to vector instance

Warning

Does not check if val equals 0

5.4.3.6 dot()

```
template<std::floating_point T>
T geom::Vector< T >::dot (
            const Vector< T > & rhs ) const
```

Dot product function.

Parameters

rhs	vector to dot product with

Returns

T dot product of two vectors

Definition at line 443 of file vector.hh.

References geom::Vector< T >::x, geom::Vector< T >::y, and geom::Vector< T >::z.

Referenced by geom::dot().

5.4.3.7 cross()

```
template<std::floating_point T>
Vector< T > geom::Vector< T >::cross (
            const Vector< T > & rhs ) const
```

Cross product function.

Parameters

rhs	vector to cross product with

Returns

Vector cross product of two vectors

Definition at line 449 of file vector.hh.

References geom::Vector< T >::x, geom::Vector< T >::y, and geom::Vector< T >::z.

Referenced by geom::cross(), and geom::Plane< T >::getParametric().

5.4.3.8 length2()

```
template<std::floating_point T>
T geom::Vector< T >::length2
```

Calculate squared length of a vector function.

Returns

T length^2

Definition at line 455 of file vector.hh.

References geom::dot().

5.4.3.9 length()

```
template<std::floating_point T>
T geom::Vector< T >::length
```

Calculate length of a vector function.

Returns

T length

Definition at line 461 of file vector.hh.

5.4.3.10 normalized()

```
template<std::floating_point T>
Vector< T > geom::Vector< T >::normalized
```

Get normalized vector function.

Returns

Vector normalized vector

Definition at line 467 of file vector.hh.

References geom::Vector< T >::normalize().

Referenced by geom::Plane< T >::getNormalDist(), and geom::Plane< T >::getNormalPoint().

5.4.3.11 normalize()

```
template<std::floating_point T>
Vector< T > & geom::Vector< T >::normalize
```

Normalize vector function.

Returns

Vector& reference to instance

Definition at line 475 of file vector.hh.

Referenced by geom::Vector< T >::normalized().

5.4.3.12 operator[]() [1/2]

```
template<std::floating_point T>
T & geom::Vector< T >::operator[] (
            size_t i )
```

Overloaded operator [] (non-const version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y, 2 - z)

Returns

T& reference to coordinate value

Note

Coordinates calculated by mod 3

Definition at line 484 of file vector.hh.

5.4.3.13 operator[]() [2/2]

```
template<std::floating_point T>
T geom::Vector< T >::operator[] (
            size_t i ) const
```

Overloaded operator [] (const version) To get access to coordinates.

Parameters

i	index of coordinate (0 - x, 1 - y, 2 - z)

Returns

T coordinate value

Note

Coordinates calculated by mod 3

Definition at line 500 of file vector.hh.

5.4.3.14 isPar()

```
template<std::floating_point T>
bool geom::Vector< T >::isPar (
            const Vector< T > & rhs ) const
```

Check if vector is parallel to another.

Parameters

in	*rhs*	vector to check parallelism with

Returns

true if vector is parallel

false otherwise

Definition at line 516 of file vector.hh.

References geom::cross().

5.4.3.15 isPerp()

```
template<std::floating_point T>
bool geom::Vector< T >::isPerp (
            const Vector< T > & rhs ) const
```

Check if vector is perpendicular to another.

Parameters

in	*rhs*	vector to check perpendicularity with

Returns

true if vector is perpendicular

false otherwise

Definition at line 522 of file vector.hh.

References geom::dot().

5.4.3.16 isEqual()

```
template<std::floating_point T>
bool geom::Vector< T >::isEqual (
            const Vector< T > & rhs ) const
```

Check if vector is equal to another.

Parameters

in	*rhs*	vector to check equality with

Returns

true if vector is equal

false otherwise

Note

Equality check performs using isNumEq(T lhs, T rhs) function

Definition at line 528 of file vector.hh.

References geom::Vector< T >::x, geom::Vector< T >::y, and geom::Vector< T >::z.

Referenced by geom::operator==().

5.4.3.17 isNumEq()

```
template<std::floating_point T>
bool geom::Vector< T >::isNumEq (
            T lhs,
            T rhs )  [static]
```

Check equality (with threshold) of two floating point numbers function.

Parameters

in	*lhs*	first number
in	*rhs*	second number

Returns

true if numbers equals with threshold (|lhs - rhs| < threshold)

false otherwise

Note

Threshold defined by threshold_ static member

Definition at line 534 of file vector.hh.

5.4.3.18 setThreshold()

```
template<std::floating_point T>
void geom::Vector< T >::setThreshold (
            T thres )  [static]
```

Set new threshold value.

Parameters

in	*thres*	value to set

Definition at line 540 of file vector.hh.

5.4.3.19 getThreshold()

```
template<std::floating_point T>
void geom::Vector< T >::getThreshold  [static]
```

Get current threshold value.

Definition at line 546 of file vector.hh.

5.4.3.20 setDefThreshold()

```
template<std::floating_point T>
void geom::Vector< T >::setDefThreshold  [static]
```

Set threshold to default value.

Note

default value equals float point epsilon

Definition at line 552 of file vector.hh.

5.4.3.21 operator*=() [2/2]

```
template<std::floating_point T>
template<Number nType>
Vector<T>& geom::Vector< T >::operator*= (
            nType val )
```

Definition at line 422 of file vector.hh.

5.4.3.22 operator/=() [2/2]

```
template<std::floating_point T>
template<Number nType>
Vector<T>& geom::Vector< T >::operator/= (
            nType val )
```

Definition at line 433 of file vector.hh.

5.4.4 Member Data Documentation

5.4.4.1 x

```
template<std::floating_point T>
T geom::Vector< T >::x {}
```

Vector coordinates.

Definition at line 46 of file vector.hh.

Referenced by geom::Vector< T >::cross(), geom::Vector< T >::dot(), geom::Vector< T >::isEqual(), geom::Vector< T >::operator+
geom::Vector< T >::operator-=(), and geom::operator<<().

5.4.4.2 y

```
template<std::floating_point T>
T geom::Vector< T >::y {}
```

Definition at line 46 of file vector.hh.

Referenced by geom::Vector< T >::cross(), geom::Vector< T >::dot(), geom::Vector< T >::isEqual(), geom::Vector< T >::operator+
geom::Vector< T >::operator-=(), and geom::operator<<().

5.4.4.3 z

```
template<std::floating_point T>
T geom::Vector< T >::z {}
```

Definition at line 46 of file vector.hh.

Referenced by geom::Vector< T >::cross(), geom::Vector< T >::dot(), geom::Vector< T >::isEqual(), geom::Vector< T >::operator+
geom::Vector< T >::operator-=(), and geom::operator<<().

The documentation for this class was generated from the following file:

- include/primitives/vector.hh

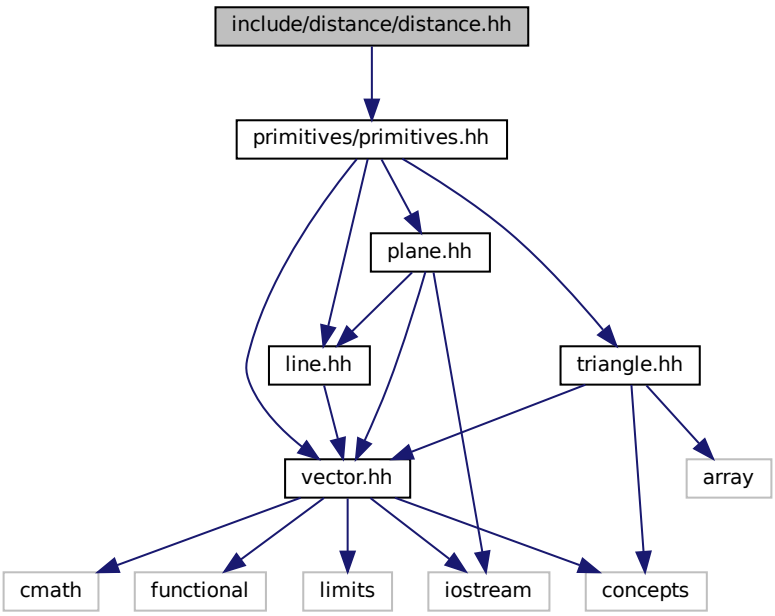
Chapter 6

File Documentation

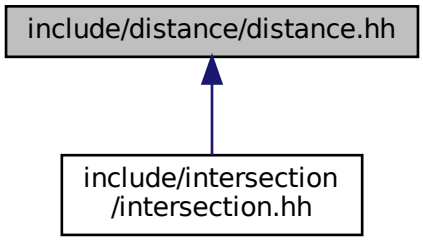
6.1 include/distance/distance.hh File Reference

```
#include "primitives/primitives.hh"
```

Include dependency graph for distance.hh:



This graph shows which files directly or indirectly include this file:



Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  T geom::distance (const Plane< T > &pl, const Vector< T > &pt)

  Calculates signed distance between point and plane.

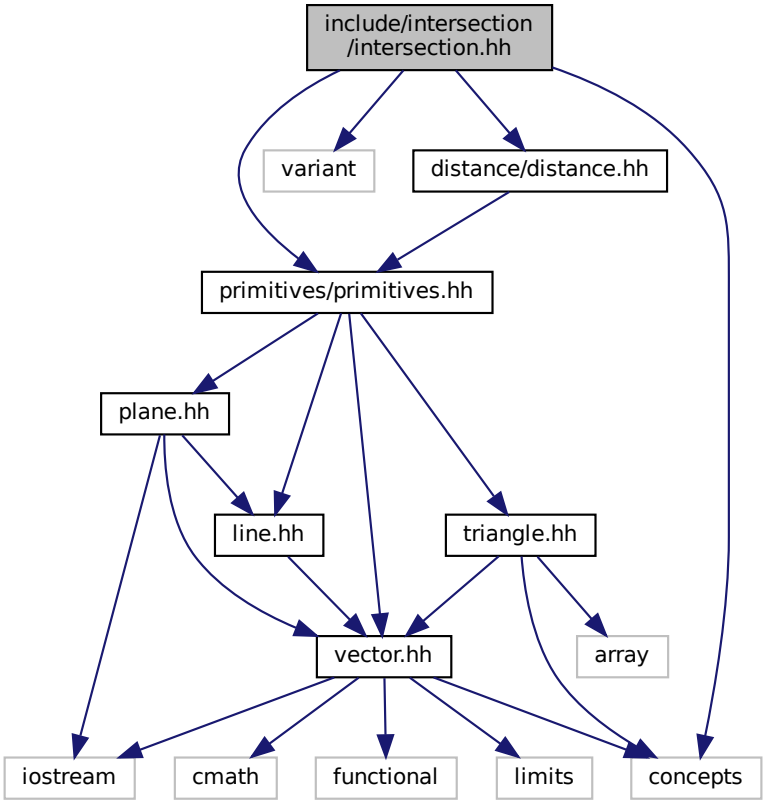
6.2 distance.hh

```
00001 #ifndef __INCLUDE_DISTANCE_DISTANCE_HH__
00002 #define __INCLUDE_DISTANCE_DISTANCE_HH__
00003
00004 #include "primitives/primitives.hh"
00005
00006 namespace geom
00007 {
00008
00009 /**
00010  * @brief Calculates signed distance between point and plane
00011  *
00012  * @tparam T - floating point type of coordinates
00013  * @param pl plane
00014  * @param pt point
00015  * @return T signed distance between point and plane
00016  */
00017 template <std::floating_point T>
00018 T distance(const Plane<T> &pl, const Vector<T> &pt);
00019
00020 } // namespace geom
00021
00022 namespace geom
00023 {
00024
00025 template <std::floating_point T>
00026 T distance(const Plane<T> &pl, const Vector<T> &pt)
00027 {
00028   return dot(pt, pl.norm()) - pl.dist();
00029 }
00030
00031 } // namespace geom
00032
00033 #endif // __INCLUDE_DISTANCE_DISTANCE_HH__
```

6.3 include/intersection/intersection.hh File Reference

```
#include <concepts>
#include <variant>
#include "distance/distance.hh"
#include "primitives/primitives.hh"
```

Include dependency graph for intersection.hh:



Namespaces

- geom

  line.hh Line class implementation
- geom::detail

Functions

- template<std::floating_point T>
  bool geom::isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)

  Checks intersection of 2 triangles.
- template<std::floating_point T>
  std::variant< std::monostate, Line< T >, Plane< T > > geom::intersect (const Plane< T > &pl1, const Plane< T > &pl2)

Intersect 2 planes and return result of intersection.

- template<std::floating_point T>
  bool geom::detail::isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)

  Checks intersection of 2 triangles.
- template<std::floating_point T>
  bool geom::detail::isIntersectMollerHaines (const Triangle< T > &tr1, const Triangle< T > &tr2)
- template<std::floating_point T>
  std::pair< T, T > geom::detail::helperMollerHaines (const Triangle< T > &tr, const Plane< T > &pl, const Line< T > &l)
- template<std::floating_point T>
  bool geom::detail::isOverlap (std::pair< T, T > &params1, std::pair< T, T > &params2)
- template<std::forward_iterator It>
  bool geom::detail::isSameSign (It begin, It end)
- template<std::floating_point T>
  bool geom::detail::isOnOneSide (const Plane< T > &pl, const Triangle< T > &tr)
- template<std::floating_point T>
  bool geom::isIntersect (const Triangle< T > &tr1, const Triangle< T > &tr2)

6.4 intersection.hh

```
00001 #ifndef __INCLUDE_INTERSECTION_INTERSECTION_HH__
00002 #define __INCLUDE_INTERSECTION_INTERSECTION_HH__
00003
00004 #include <concepts>
00005 #include <variant>
00006
00007 #include "distance/distance.hh"
00008 #include "primitives/primitives.hh"
00009
00010 namespace geom
00011 {
00012
00013 /**
00014  * @brief Checks intersection of 2 triangles
00015  *
00016  * @tparam T - floating point type of coordinates
00017  * @param tr1 first triangle
00018  * @param tr2 second triangle
00019  * @return true if triangles are intersect
00020  * @return false if triangles are not intersect
00021  */
00022 template <std::floating_point T>
00023 bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2);
00024
00025 /**
00026  * @brief Intersect 2 planes and return result of intersection
00027  * @details
00028  * Common intersection case (parallel planes case is trivial):
00029  *
00030  * Let \f$ \overrightarrow{P} \f$ - point in space
00031  *
00032  * \f$ pl_1 \f$ equation: \f$ \overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1 \f$
00033  *
00034  * \f$ pl_2 \f$ equation: \f$ \overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2 \f$
00035  *
00036  * Intersection line direction: \f$ \overrightarrow{dir} = \overrightarrow{n}_1 \times
00037  * \overrightarrow{n}_2 \f$
00038  *
00039  * Let origin of intersection line be a linear combination of \f$ \overrightarrow{n}_1 \f$
00040  * and \f$ \overrightarrow{n}_2 \f$: \f[ \overrightarrow{P} = a \cdot \overrightarrow{n}_1
00041  * + b \cdot \overrightarrow{n}_2 \f]
00042  *
00043  * \f$ \overrightarrow{P} \f$ must satisfy both \f$ pl_1 \f$ and \f$ pl_1 \f$ equations:
00044  * \f[
00045  * \overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1
00046  * \Leftrightarrow
00047  * \overrightarrow{n}_1
00048  * \cdot
00049  * \left(
00050  *  a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2
00051  *  \right)
00052  *  = d_1
00053  * \Leftrightarrow
00054  * a + b \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2  = d_1
```

```
00055  * \f]
00056  * \f[
00057  * \overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2
00058  * \Leftrightarrow
00059  * \overrightarrow{n}_2
00060  * \cdot
00061  * \left(
00062  *  a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2
00063  *  \right) = d_2
00064  * \Leftrightarrow
00065  * a \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 + b = d_2
00066  * \f]
00067  *
00068  * Let's find \f$a\f$ and \f$b\f$:
00069  * \f[
00070  * a = \frac{
00071  *  d_2 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_1
00072  * }{
00073  *  \left( \overrightarrow{n}_1 \cdot \overrightarrow{n}_2\right)^2 - 1
00074  * }
00075  * \f]
00076  * \f[
00077  * b = \frac{
00078  * d_1 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_2
00079  * }{
00080  *  \left( \overrightarrow{n}_1 \cdot \overrightarrow{n}_2\right)^2 - 1
00081  * }
00082  * \f]
00083  *
00084  * Intersection line equation:
00085  * \f[
00086  * \overrightarrow{r}(t) = \overrightarrow{P} + t \cdot \overrightarrow{n}_1 \times
00087  * \overrightarrow{n}_2 = (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) +
00088  * t \cdot \overrightarrow{n}_1 \times \overrightarrow{n}_2 \f]
00089  *
00090  * @tparam T - floating point type of coordinates
00091  * @param pl1 first plane
00092  * @param pl2 second plane
00093  * @return std::variant<std::monostate, Line<T>, Plane<T»
00094  */
00095 template <std::floating_point T>
00096 std::variant<std::monostate, Line<T>, Plane<T» intersect(const Plane<T> &pl1,
00097                                                          const Plane<T> &pl2);
00098
00099 namespace detail
00100 {
00101
00102 template <std::floating_point T>
00103 bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2);
00104
00105 template <std::floating_point T>
00106 bool isIntersectMollerHaines(const Triangle<T> &tr1, const Triangle<T> &tr2);
00107
00108 template <std::floating_point T>
00109 std::pair<T, T> helperMollerHaines(const Triangle<T> &tr, const Plane<T> &pl,
00110                                    const Line<T> &l);
00111
00112 template <std::floating_point T>
00113 bool isOverlap(std::pair<T, T> &params1, std::pair<T, T> &params2);
00114
00115 template <std::forward_iterator It>
00116 bool isSameSign(It begin, It end);
00117
00118 template <std::floating_point T>
00119 bool isOnOneSide(const Plane<T> &pl, const Triangle<T> &tr);
00120
00121 } // namespace detail
00122 } // namespace geom
00123
00124 namespace geom
00125 {
00126
00127 template <std::floating_point T>
00128 bool isIntersect(const Triangle<T> &tr1, const Triangle<T> &tr2)
00129 {
00130   /* TODO: handle invalid triangles case */
00131
00132   auto pl1 = Plane<T>::getBy3Points(tr1[0], tr1[1], tr1[2]);
00133
00134   if (!detail::isOnOneSide(pl1, tr2))
00135     return false;
00136
00137   auto pl2 = Plane<T>::getBy3Points(tr2[0], tr2[1], tr2[2]);
00138
00139   if (pl1 == pl2)
00140     return detail::isIntersect2D(tr1, tr2);
00141
```

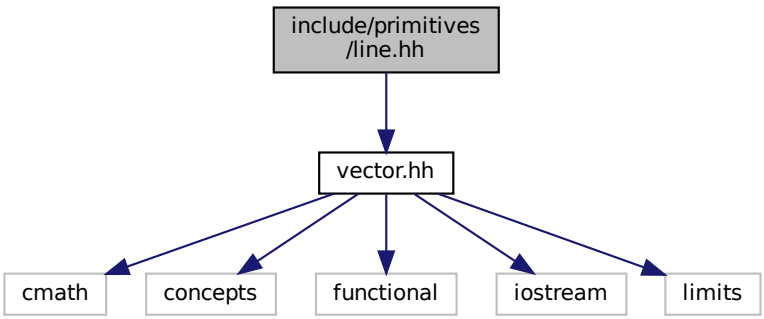
```
00142   if (pl1.isPar(pl2))
00143     return false;
00144
00145   if (!detail::isOnOneSide(pl2, tr1))
00146     return false;
00147
00148   return detail::isIntersectMollerHaines(tr1, tr2);
00149 }
00150
00151 template <std::floating_point T>
00152 std::variant<std::monostate, Line<T>, Plane<T>> intersect(const Plane<T> &pl1,
00153                                                           const Plane<T> &pl2)
00154 {
00155   const auto &n1 = pl1.norm();
00156   const auto &n2 = pl2.norm();
00157
00158   auto dir = cross(n1, n2);
00159
00160   /* if planes are parallel */
00161   if (Vector<T>{0} == dir)
00162   {
00163     if (pl1 == pl2)
00164       return pl1;
00165
00166     return std::monostate{};
00167   }
00168
00169   auto n1n2 = dot(n1, n2);
00170   auto d1 = pl1.dist();
00171   auto d2 = pl2.dist();
00172
00173   auto a = (d2 * n1n2 - d1) / (n1n2 * n1n2 - 1);
00174   auto b = (d1 * n1n2 - d2) / (n1n2 * n1n2 - 1);
00175
00176   return Line<T>{(a * n1) + (b * n2), dir};
00177 }
00178
00179 namespace detail
00180 {
00181
00182 template <std::floating_point T>
00183 bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2)
00184 {
00185   assert(false && "Not implemented yet");
00186   return false;
00187 }
00188
00189 template <std::floating_point T>
00190 bool isIntersectMollerHaines(const Triangle<T> &tr1, const Triangle<T> &tr2)
00191 {
00192   // All this function is HARDCODE
00193   // TODO:
00194   // 1) make it more beautiful
00195
00196   auto pl1 = Plane<T>::getBy3Points(tr1[0], tr1[1], tr1[2]);
00197   auto pl2 = Plane<T>::getBy3Points(tr2[0], tr2[1], tr2[2]);
00198
00199   auto l = std::get<Line<T>>(intersect(pl1, pl2));
00200
00201   auto params1 = helperMollerHaines(tr1, pl2, l);
00202   auto params2 = helperMollerHaines(tr2, pl1, l);
00203
00204   return isOverlap(params1, params2);
00205 }
00206
00207 template <std::floating_point T>
00208 std::pair<T, T> helperMollerHaines(const Triangle<T> &tr, const Plane<T> &pl,
00209                                    const Line<T> &l)
00210 {
00211   /* Project the triangle vertices onto line */
00212   std::array<T, 3> vert{};
00213   for (size_t i = 0; i < 3; ++i)
00214     vert[i] = dot(l.dir(), tr[i] - l.org());
00215
00216   std::array<T, 3> sdist{};
00217   for (size_t i = 0; i < 3; ++i)
00218     sdist[i] = distance(pl, tr[i]);
00219
00220   std::array<bool, 3> isOneSide{};
00221   for (size_t i = 0; i < 3; ++i)
00222     isOneSide[i] = (sdist[i] * sdist[(i + 1) % 3] > 0);
00223
00224   /* Looking for vertex which is alone on it's side */
00225   size_t rogue = 0;
00226   for (size_t i = 0; i < 3; ++i)
00227     if (isOneSide[i])
00228       rogue = (i + 2) % 3;
```

```
00229
00230   std::vector<T> params{};
00231   std::array<size_t, 2> arr{(rogue + 1) % 3, (rogue + 2) % 3};
00232
00233   for (size_t i : arr)
00234     params.push_back(vert[i] +
00235                      (vert[rogue] - vert[i]) * sdist[i] / (sdist[i] - sdist[rogue]));
00236
00237   if (params[0] > params[1])
00238     std::swap(params[0], params[1]);
00239
00240   return {params[0], params[1]};
00241 }
00242
00243 template <std::floating_point T>
00244 bool isOverlap(std::pair<T, T> &params1, std::pair<T, T> &params2)
00245 {
00246   return (params2.first <= params1.second) && (params2.second >= params1.first);
00247 }
00248
00249 template <std::forward_iterator It>
00250 bool isSameSign(It begin, It end)
00251 {
00252   auto cur = begin;
00253   auto prev = begin;
00254
00255   for (++cur; cur != end; ++cur)
00256     if ((*cur) * (*prev) < 0)
00257       return false;
00258
00259   return true;
00260 }
00261
00262 template <std::floating_point T>
00263 bool isOnOneSide(const Plane<T> &pl, const Triangle<T> &tr)
00264 {
00265   std::array<T, 3> sdist{};
00266   for (size_t i = 0; i < 3; ++i)
00267     sdist[i] = distance(pl, tr[i]);
00268
00269   if (detail::isSameSign(sdist.begin(), sdist.end()))
00270     return false;
00271
00272   return true;
00273 }
00274
00275 } // namespace detail
00276 } // namespace geom
00277
00278 #endif // __INCLUDE_INTERSECTION_INTERSECTION_HH__
```

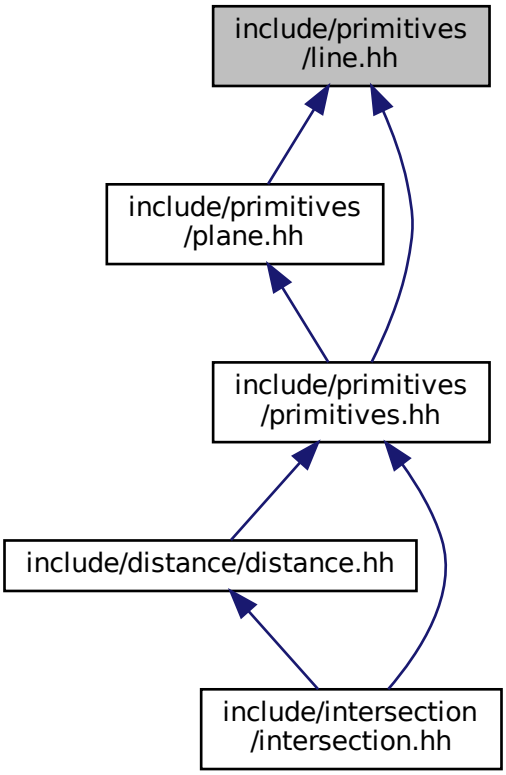
6.5 include/primitives/line.hh File Reference

`#include "vector.hh"`

Include dependency graph for line.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Line< T >

  Line class implementation.

Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Line< T > &line)

  Line print operator.
- template<std::floating_point T>
  bool geom::operator== (const Line< T > &lhs, const Line< T > &rhs)

  Line equality operator.

6.6 line.hh

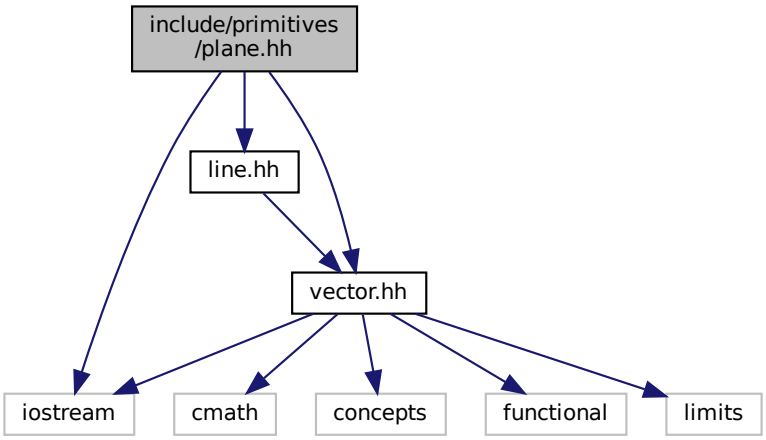
```
00001 #ifndef __INCLUDE_PRIMITIVES_LINE_HH__
00002 #define __INCLUDE_PRIMITIVES_LINE_HH__
00003
00004 #include "vector.hh"
00005
00006 /**
00007  * @brief line.hh
00008  * Line class implementation
00009  */
00010
00011 namespace geom
00012 {
00013
00014 /**
00015  * @class Line
00016  * @brief Line class implementation
00017  *
00018  * @tparam T - floating point type of coordinates
00019  */
00020 template <std::floating_point T>
00021 class Line final
00022 {
00023 private:
00024   /**
00025    * @brief Origin and direction vectors
00026    */
00027   Vector<T> org_{}, dir_{};
00028
00029 public:
00030   /**
00031    * @brief Construct a new Line object
00032    *
00033    * @param[in] org origin vector
00034    * @param[in] dir direction vector
00035    */
00036   Line(const Vector<T> &org, const Vector<T> &dir);
00037
00038   /**
00039    * @brief Getter for origin vector
00040    *
00041    * @return const Vector<T>& const reference to origin vector
00042    */
00043   const Vector<T> &org() const;
00044
00045   /**
00046    * @brief Getter for direction vector
00047    *
00048    * @return const Vector<T>& const reference to direction vector
00049    */
00050   const Vector<T> &dir() const;
00051
00052   /**
00053    * @brief Checks is point belongs to line
00054    *
00055    * @param[in] point const reference to point vector
00056    * @return true if point belongs to line
00057    * @return false if point doesn't belong to line
00058    */
00059   bool belongs(const Vector<T> &point) const;
00060
00061   /**
00062    * @brief Checks is *this equals to another line
00063    *
00064    * @param[in] line const reference to another line
00065    * @return true if lines are equal
00066    * @return false if lines are not equal
00067    */
00068   bool isEqual(const Line &line) const;
00069
00070   /**
00071    * @brief Get line by 2 points
00072    *
00073    * @param[in] p1 1st point
00074    * @param[in] p2 2nd point
00075    * @return Line passing through two points
00076    */
00077   static Line getBy2Points(const Vector<T> &p1, const Vector<T> &p2);
00078 };
00079
00080 /**
00081  * @brief Line print operator
00082  *
00083  * @tparam T - floating point type of coordinates
00084  * @param[in, out] ost output stream
00085  * @param[in] line Line to print
```

```
00086  * @return std::ostream& modified ostream instance
00087  */
00088 template <std::floating_point T>
00089 std::ostream &operator«(std::ostream &ost, const Line<T> &line)
00090 {
00091   ost « line.org() « " + " « line.dir() « " * t";
00092   return ost;
00093 }
00094
00095 /**
00096  * @brief Line equality operator
00097  *
00098  * @tparam T - floating point type of coordinates
00099  * @param[in] lhs 1st line
00100  * @param[in] rhs 2nd line
00101  * @return true if lines are equal
00102  * @return false if lines are not equal
00103  */
00104 template <std::floating_point T>
00105 bool operator==(const Line<T> &lhs, const Line<T> &rhs)
00106 {
00107   return lhs.isEqual(rhs);
00108 }
00109
00110 template <std::floating_point T>
00111 Line<T>::Line(const Vector<T> &org, const Vector<T> &dir) : org_{org}, dir_{dir}
00112 {
00113   if (dir_ == Vector<T>{0})
00114     throw std::logic_error{"Direction vector equals zero."};
00115 }
00116
00117 template <std::floating_point T>
00118 const Vector<T> &Line<T>::org() const
00119 {
00120   return org_;
00121 }
00122
00123 template <std::floating_point T>
00124 const Vector<T> &Line<T>::dir() const
00125 {
00126   return dir_;
00127 }
00128
00129 template <std::floating_point T>
00130 bool Line<T>::belongs(const Vector<T> &point) const
00131 {
00132   return dir_.cross(point - org_) == Vector<T>{0};
00133 }
00134
00135 template <std::floating_point T>
00136 bool Line<T>::isEqual(const Line<T> &line) const
00137 {
00138   return belongs(line.org_) && dir_.isPar(line.dir_);
00139 }
00140
00141 template <std::floating_point T>
00142 Line<T> Line<T>::getBy2Points(const Vector<T> &p1, const Vector<T> &p2)
00143 {
00144   return Line<T>{p1, p2 - p1};
00145 }
00146
00147 } // namespace geom
00148
00149 #endif // __INCLUDE_PRIMITIVES_LINE_HH__
```

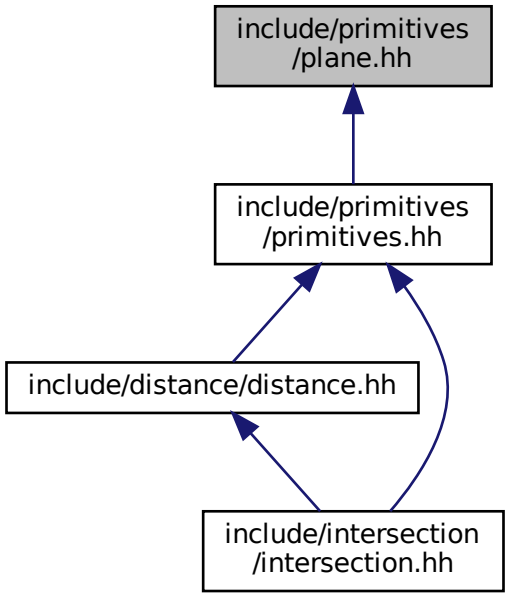
6.7 include/primitives/plane.hh File Reference

```
#include <iostream>
#include "line.hh"
#include "vector.hh"
```

Include dependency graph for plane.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Plane< T >

  Plane class realization.

Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  bool geom::operator== (const Plane< T > &lhs, const Plane< T > &rhs)

  Plane equality operator.
- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Plane< T > &pl)

  Plane print operator.

6.8 plane.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_PLANE_HH__
00002 #define __INCLUDE_PRIMITIVES_PLANE_HH__
00003
00004 #include <iostream>
00005
00006 #include "line.hh"
00007 #include "vector.hh"
00008
00009 /**
00010  * @brief
00011  * Plane class implementation
00012  */
00013
00014 namespace geom
00015 {
00016
00017 /**
00018  * @class Plane
00019  * @brief Plane class realization
00020  *
00021  * @tparam T - floating point type of coordinates
00022  */
00023 template <std::floating_point T>
00024 class Plane final
00025 {
00026 private:
00027   /**
00028    * @brief Normal vector, length equals to 1
00029    */
00030   Vector<T> norm_{};
00031
00032   /**
00033    * @brief Distance from zero to plane
00034    */
00035   T dist_{};
00036
00037   /**
00038    * @brief Construct a new Plane object from normal vector and distance
00039    *
00040    * @param[in] norm normal vector
00041    * @param[in] dist distance from plane to zero
00042    */
00043   Plane(const Vector<T> &norm, T dist);
00044
00045 public:
00046   /**
00047    * @brief Getter for distance
00048    *
00049    * @return T value of distance
00050    */
00051   T dist() const;
00052
00053   /**
00054    * @brief Getter for normal vector
00055    *
00056    * @return const Vector<T>& const reference to normal vector
00057    */
00058   const Vector<T> &norm() const;
```

```
00059
00060   /**
00061    * @brief Checks if point belongs to plane
00062    *
00063    * @param[in] point const referene to point vector
00064    * @return true if point belongs to plane
00065    * @return false if point doesn't belong to plane
00066    */
00067   bool belongs(const Vector<T> &point) const;
00068
00069   /**
00070    * @brief Checks if line belongs to plane
00071    *
00072    * @param[in] line const referene to line
00073    * @return true if line belongs to plane
00074    * @return false if line doesn't belong to plane
00075    */
00076   bool belongs(const Line<T> &line) const;
00077
00078   /**
00079    * @brief Checks is *this equals to another plane
00080    *
00081    * @param[in] rhs const reference to another plane
00082    * @return true if planes are equal
00083    * @return false if planes are not equal
00084    */
00085   bool isEqual(const Plane &rhs) const;
00086
00087   /**
00088    * @brief Checks is *this is parallel to another plane
00089    *
00090    * @param[in] rhs const reference to another plane
00091    * @return true if planes are parallel
00092    * @return false if planes are not parallel
00093    */
00094   bool isPar(const Plane &rhs) const;
00095
00096   /**
00097    * @brief Get plane by 3 points
00098    *
00099    * @param[in] pt1 1st point
00100    * @param[in] pt2 2nd point
00101    * @param[in] pt3 3rd point
00102    * @return Plane passing through three points
00103    */
00104   static Plane getBy3Points(const Vector<T> &pt1, const Vector<T> &pt2,
00105                             const Vector<T> &pt3);
00106
00107   /**
00108    * @brief Get plane from parametric plane equation
00109    *
00110    * @param[in] org origin vector
00111    * @param[in] dir1 1st direction vector
00112    * @param[in] dir2 2nd direction vector
00113    * @return Plane
00114    */
00115   static Plane getParametric(const Vector<T> &org, const Vector<T> &dir1,
00116                              const Vector<T> &dir2);
00117
00118   /**
00119    * @brief Get plane from normal point plane equation
00120    *
00121    * @param[in] norm normal vector
00122    * @param[in] point point lying on the plane
00123    * @return Plane
00124    */
00125   static Plane getNormalPoint(const Vector<T> &norm, const Vector<T> &point);
00126
00127   /**
00128    * @brief Get plane form normal const plane equation
00129    *
00130    * @param[in] norm normal vector
00131    * @param[in] constant distance
00132    * @return Plane
00133    */
00134   static Plane getNormalDist(const Vector<T> &norm, T constant);
00135 };
00136
00137 /**
00138  * @brief Plane equality operator
00139  *
00140  * @tparam T - floating point type of coordinates
00141  * @param[in] lhs 1st plane
00142  * @param[in] rhs 2nd plane
00143  * @return true if planes are equal
00144  * @return false if planes are not equal
00145  */
```

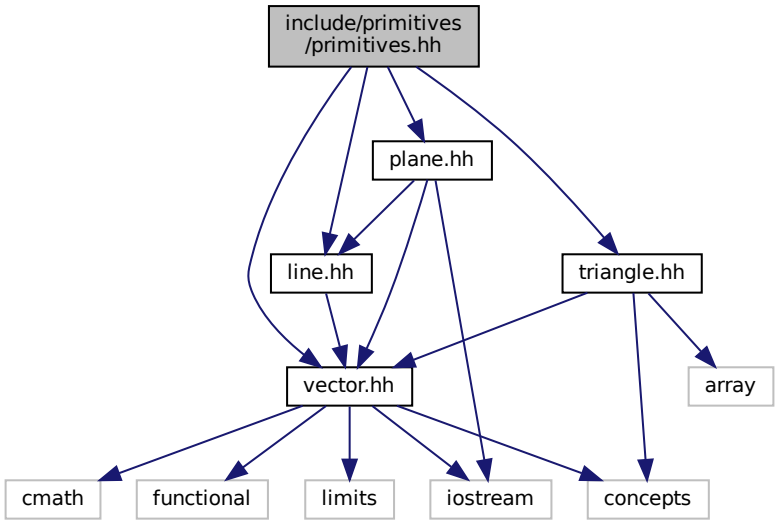
```
00146 template <std::floating_point T>
00147 bool operator==(const Plane<T> &lhs, const Plane<T> &rhs)
00148 {
00149   return lhs.isEqual(rhs);
00150 }
00151
00152 /**
00153  * @brief Plane print operator
00154  *
00155  * @tparam T - floating point type of coordinates
00156  * @param[in, out] ost output stream
00157  * @param[in] pl plane to print
00158  * @return std::ostream& modified ostream instance
00159  */
00160 template <std::floating_point T>
00161 std::ostream &operator«(std::ostream &ost, const Plane<T> &pl)
00162 {
00163   ost « pl.norm() « " * X = " « pl.dist();
00164   return ost;
00165 }
00166
00167 template <std::floating_point T>
00168 Plane<T>::Plane(const Vector<T> &norm, T dist) : norm_(norm), dist_(dist)
00169 {
00170   if (norm == Vector<T>{0})
00171     throw std::logic_error{"normal vector equals to zero"};
00172 }
00173
00174 template <std::floating_point T>
00175 T Plane<T>::dist() const
00176 {
00177   return dist_;
00178 }
00179
00180 template <std::floating_point T>
00181 const Vector<T> &Plane<T>::norm() const
00182 {
00183   return norm_;
00184 }
00185
00186 template <std::floating_point T>
00187 bool Plane<T>::belongs(const Vector<T> &pt) const
00188 {
00189   return Vector<T>::isNumEq(norm_.dot(pt), dist_);
00190 }
00191
00192 template <std::floating_point T>
00193 bool Plane<T>::belongs(const Line<T> &line) const
00194 {
00195   return norm_.isPerp(line.dir()) && belongs(line.org());
00196 }
00197
00198 template <std::floating_point T>
00199 bool Plane<T>::isEqual(const Plane &rhs) const
00200 {
00201   return (norm_ * dist_ == rhs.norm_ * rhs.dist_) && (norm_.isPar(rhs.norm_));
00202 }
00203
00204 template <std::floating_point T>
00205 bool Plane<T>::isPar(const Plane &rhs) const
00206 {
00207   return norm_.isPar(rhs.norm_);
00208 }
00209
00210 template <std::floating_point T>
00211 Plane<T> Plane<T>::getBy3Points(const Vector<T> &pt1, const Vector<T> &pt2,
00212                                 const Vector<T> &pt3)
00213 {
00214   return getParametric(pt1, pt2 - pt1, pt3 - pt1);
00215 }
00216
00217 template <std::floating_point T>
00218 Plane<T> Plane<T>::getParametric(const Vector<T> &org, const Vector<T> &dir1,
00219                                  const Vector<T> &dir2)
00220 {
00221   auto norm = dir1.cross(dir2);
00222   return getNormalPoint(norm, org);
00223 }
00224
00225 template <std::floating_point T>
00226 Plane<T> Plane<T>::getNormalPoint(const Vector<T> &norm, const Vector<T> &pt)
00227 {
00228   auto normalized = norm.normalized();
00229   return Plane{normalized, normalized.dot(pt)};
00230 }
00231
00232 template <std::floating_point T>
```

```
00233 Plane<T> Plane<T>::getNormalDist(const Vector<T> &norm, T dist)
00234 {
00235   auto normalized = norm.normalized();
00236   return Plane{normalized, dist};
00237 }
00238
00239 } // namespace geom
00240
00241 #endif // __INCLUDE_PRIMITIVES_PLANE_HH__
```

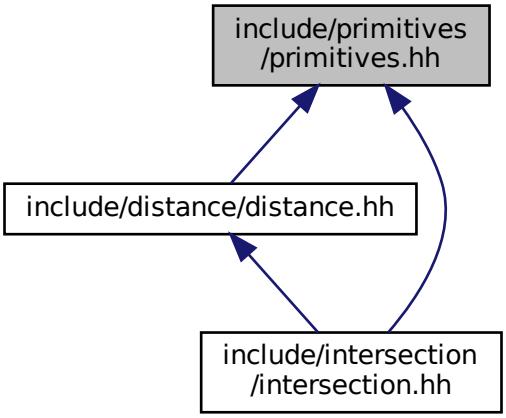
6.9 include/primitives/primitives.hh File Reference

```
#include "line.hh"
#include "plane.hh"
#include "triangle.hh"
#include "vector.hh"
```

Include dependency graph for primitives.hh:



This graph shows which files directly or indirectly include this file:



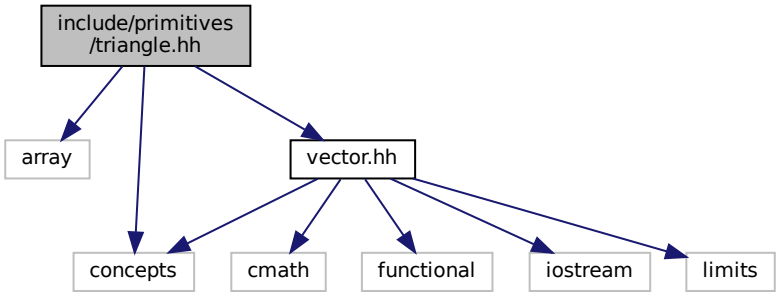
6.10 primitives.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_PRIMITIVES_HH__
00002 #define __INCLUDE_PRIMITIVES_PRIMITIVES_HH__
00003
00004 #include "line.hh"
00005 #include "plane.hh"
00006 #include "triangle.hh"
00007 #include "vector.hh"
00008
00009 #endif // __INCLUDE_PRIMITIVES_PRIMITIVES_HH__
```

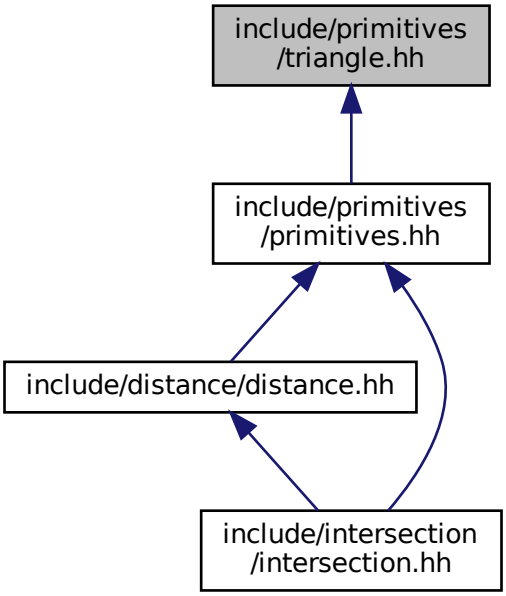
6.11 include/primitives/triangle.hh File Reference

```
#include <array>
#include <concepts>
#include "vector.hh"
```

Include dependency graph for triangle.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Triangle< T >

  Triangle class implementation.

Namespaces

- geom

  line.hh Line class implementation

Functions

- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Triangle< T > &tr)

  Triangle print operator.

6.12 triangle.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00002 #define __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00003
00004 #include <array>
00005 #include <concepts>
00006
00007 #include "vector.hh"
```

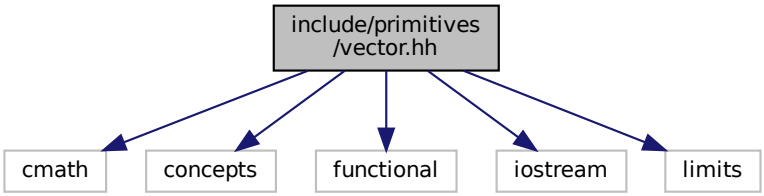
```
00008
00009 /**
00010  * @brief triangle.hh
00011  * Triangle class implementation
00012  */
00013
00014 namespace geom
00015 {
00016
00017 /**
00018  * @class Triangle
00019  * @brief Triangle class implementation
00020  *
00021  * @tparam T - floating point type of coordinates
00022  */
00023 template <std::floating_point T>
00024 class Triangle final
00025 {
00026 private:
00027   /**
00028    * @brief Vertices of triangle
00029    */
00030   std::array<Vector<T>, 3> vertices_;
00031
00032 public:
00033   /**
00034    * @brief Construct a new Triangle object from 3 points
00035    *
00036    * @param[in] p1 1st point
00037    * @param[in] p2 2nd point
00038    * @param[in] p3 3rd point
00039    */
00040   Triangle(const Vector<T> &p1, const Vector<T> &p2, const Vector<T> &p3);
00041
00042   /**
00043    * @brief Overloaded operator[] to get access to vertices
00044    *
00045    * @param[in] idx index of vertex
00046    * @return const Vector<T>& const reference to vertex
00047    */
00048   const Vector<T> &operator[](std::size_t idx) const;
00049 };
00050
00051 /**
00052  * @brief Triangle print operator
00053  *
00054  * @tparam T - floating point type of coordinates
00055  * @param[in, out] ost output stream
00056  * @param[in] tr Triangle to print
00057  * @return std::ostream& modified ostream instance
00058  */
00059 template <std::floating_point T>
00060 std::ostream &operator«(std::ostream &ost, const Triangle<T> &tr)
00061 {
00062   ost « "Triangle: {";
00063   for (size_t i : {0, 1, 2})
00064     ost « tr[i] « (i == 2 ? "" : ", ");
00065
00066   ost « "}";
00067
00068   return ost;
00069 }
00070
00071 template <std::floating_point T>
00072 Triangle<T>::Triangle(const Vector<T> &p1, const Vector<T> &p2, const Vector<T> &p3)
00073   : vertices_{p1, p2, p3}
00074 {}
00075
00076 template <std::floating_point T>
00077 const Vector<T> &Triangle<T>::operator[](std::size_t idx) const
00078 {
00079   return vertices_[idx % 3];
00080 }
00081
00082 } // namespace geom
00083
00084 #endif // __INCLUDE_PRIMITIVES_TRIANGLE_HH__
```

6.13 include/primitives/vector.hh File Reference

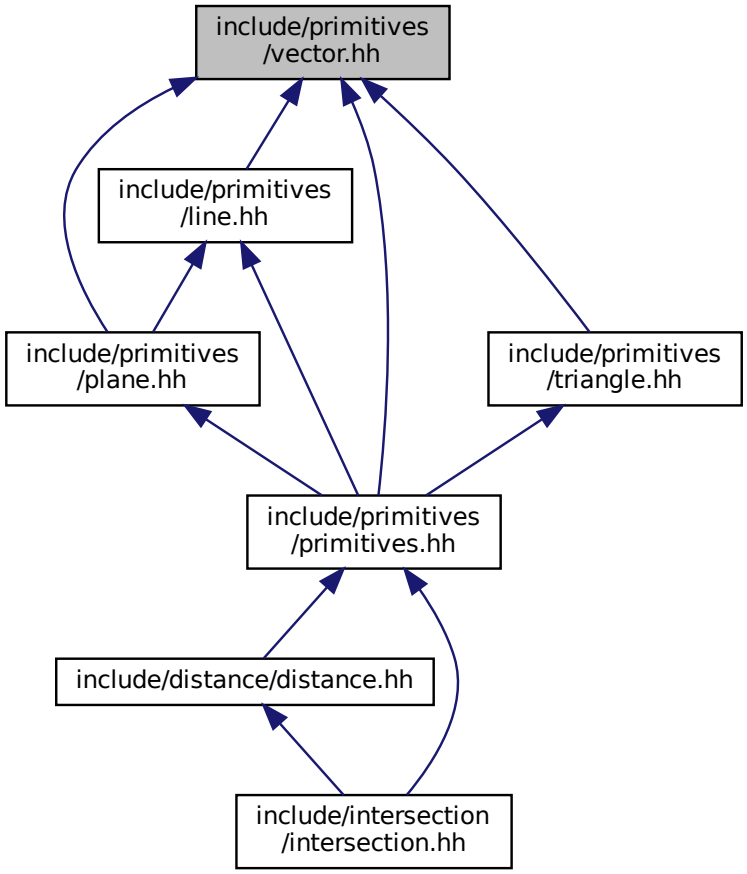
```
#include <cmath>
#include <concepts>
```

```
#include <functional>
#include <iostream>
#include <limits>
```

Include dependency graph for vector.hh:



This graph shows which files directly or indirectly include this file:



Classes

- class geom::Vector< T >

Vector class realization.

Namespaces

- geom

  line.hh Line class implementation

Typedefs

- using geom::VectorD = Vector< double >
- using geom::VectorF = Vector< float >

Functions

- template<std::floating_point T>
  Vector< T > geom::operator+ (const Vector< T > &lhs, const Vector< T > &rhs)

  Overloaded + operator.
- template<std::floating_point T>
  Vector< T > geom::operator- (const Vector< T > &lhs, const Vector< T > &rhs)

  Overloaded - operator.
- template<Number nT, std::floating_point T>
  Vector< T > geom::operator* (const nT &val, const Vector< T > &rhs)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vector< T > geom::operator* (const Vector< T > &lhs, const nT &val)

  Overloaded multiple by value operator.
- template<Number nT, std::floating_point T>
  Vector< T > geom::operator/ (const Vector< T > &lhs, const nT &val)

  Overloaded divide by value operator.
- template<std::floating_point T>
  T geom::dot (const Vector< T > &lhs, const Vector< T > &rhs)

  Dot product function.
- template<std::floating_point T>
  Vector< T > geom::cross (const Vector< T > &lhs, const Vector< T > &rhs)

  Cross product function.
- template<std::floating_point T>
  bool geom::operator== (const Vector< T > &lhs, const Vector< T > &rhs)

  Vector equality operator.
- template<std::floating_point T>
  bool geom::operator!= (const Vector< T > &lhs, const Vector< T > &rhs)

  Vector inequality operator.
- template<std::floating_point T>
  std::ostream & geom::operator<< (std::ostream &ost, const Vector< T > &vec)

  Vector print operator.

Variables

- template<class T >
  concept geom::Number = std::is_floating_point_v<T> || std::is_integral_v<T>

  Useful concept which represents floating point and integral types.

6.13.1 Detailed Description

Vector class implementation

Definition in file vector.hh.

6.14 vector.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_VECTOR_HH__
00002 #define __INCLUDE_PRIMITIVES_VECTOR_HH__
00003
00004 #include <cmath>
00005 #include <concepts>
00006 #include <functional>
00007 #include <iostream>
00008 #include <limits>
00009
00010 /**
00011  * @file vector.hh
00012  * Vector class implementation
00013  */
00014
00015 namespace geom
00016 {
00017
00018 /**
00019  * @concept Number
00020  * @brief Useful concept which represents floating point and integral types
00021  *
00022  * @tparam T
00023  */
00024 template <class T>
00025 concept Number = std::is_floating_point_v<T> || std::is_integral_v<T>;
00026
00027 /**
00028  * @class Vector
00029  * @brief Vector class realization
00030  *
00031  * @tparam T - floating point type of coordinates
00032  */
00033 template <std::floating_point T>
00034 struct Vector final
00035 {
00036 private:
00037   /**
00038    * @brief Threshold static variable for numbers comparision
00039    */
00040   static inline T threshold_ = 1e3 * std::numeric_limits<T>::epsilon();
00041
00042 public:
00043   /**
00044    * @brief Vector coordinates
00045    */
00046   T x{}, y{}, z{};
00047
00048   /**
00049    * @brief Construct a new Vector object from 3 coordinates
00050    *
00051    * @param[in] coordX x coordinate
00052    * @param[in] coordY y coordinate
00053    * @param[in] coordZ z coordinate
00054    */
00055   Vector(T coordX, T coordY, T coordZ) : x(coordX), y(coordY), z(coordZ)
00056   {}
00057
00058   /**
00059    * @brief Construct a new Vector object with equals coordinates
00060    *
00061    * @param[in] coordX coordinate (default to {})
00062    */
00063   explicit Vector(T coordX = {}) : Vector(coordX, coordX, coordX)
00064   {}
00065
00066   /**
00067    * @brief Overloaded += operator
00068    * Increments vector coordinates by corresponding coordinates of vec
00069    * @param[in] vec vector to incremented with
00070    * @return Vector& reference to current instance
00071    */
00072   Vector &operator+=(const Vector &vec);
```

```
00073
00074   /**
00075    * @brief Overloaded -= operator
00076    * Decrements vector coordinates by corresponding coordinates of vec
00077    * @param[in] vec vector to decremented with
00078    * @return Vector& reference to current instance
00079    */
00080   Vector &operator-=(const Vector &vec);
00081
00082   /**
00083    * @brief Unary - operator
00084    *
00085    * @return Vector negated Vector instance
00086    */
00087   Vector operator-() const;
00088
00089   /**
00090    * @brief Overloaded *= by number operator
00091    *
00092    * @tparam nType numeric type of value to multiply by
00093    * @param[in] val value to multiply by
00094    * @return Vector& reference to vector instance
00095    */
00096   template <Number nType>
00097   Vector &operator*=(nType val);
00098
00099   /**
00100    * @brief Overloaded /= by number operator
00101    *
00102    * @tparam nType numeric type of value to divide by
00103    * @param[in] val value to divide by
00104    * @return Vector& reference to vector instance
00105    *
00106    * @warning Does not check if val equals 0
00107    */
00108   template <Number nType>
00109   Vector &operator/=(nType val);
00110
00111   /**
00112    * @brief Dot product function
00113    *
00114    * @param rhs vector to dot product with
00115    * @return T dot product of two vectors
00116    */
00117   T dot(const Vector &rhs) const;
00118
00119   /**
00120    * @brief Cross product function
00121    *
00122    * @param rhs vector to cross product with
00123    * @return Vector cross product of two vectors
00124    */
00125   Vector cross(const Vector &rhs) const;
00126
00127   /**
00128    * @brief Calculate squared length of a vector function
00129    *
00130    * @return T length^2
00131    */
00132   T length2() const;
00133
00134   /**
00135    * @brief Calculate length of a vector function
00136    *
00137    * @return T length
00138    */
00139   T length() const;
00140
00141   /**
00142    * @brief Get normalized vector function
00143    *
00144    * @return Vector normalized vector
00145    */
00146   Vector normalized() const;
00147
00148   /**
00149    * @brief Normalize vector function
00150    *
00151    * @return Vector& reference to instance
00152    */
00153   Vector &normalize();
00154
00155   /**
00156    * @brief Overloaded operator [] (non-const version)
00157    * To get access to coordinates
00158    * @param i index of coordinate (0 - x, 1 - y, 2 - z)
00159    * @return T& reference to coordinate value
```

```
00160     *
00161     * @note Coordinates calculated by mod 3
00162     */
00163    T &operator[](size_t i);
00164
00165    /**
00166     * @brief Overloaded operator [] (const version)
00167     * To get access to coordinates
00168     * @param i index of coordinate (0 - x, 1 - y, 2 - z)
00169     * @return T coordinate value
00170     *
00171     * @note Coordinates calculated by mod 3
00172     */
00173    T operator[](size_t i) const;
00174
00175    /**
00176     * @brief Check if vector is parallel to another
00177     *
00178     * @param[in] rhs vector to check parallelism with
00179     * @return true if vector is parallel
00180     * @return false otherwise
00181     */
00182    bool isPar(const Vector &rhs) const;
00183
00184    /**
00185     * @brief Check if vector is perpendicular to another
00186     *
00187     * @param[in] rhs vector to check perpendicularity with
00188     * @return true if vector is perpendicular
00189     * @return false otherwise
00190     */
00191    bool isPerp(const Vector &rhs) const;
00192
00193    /**
00194     * @brief Check if vector is equal to another
00195     *
00196     * @param[in] rhs vector to check equality with
00197     * @return true if vector is equal
00198     * @return false otherwise
00199     *
00200     * @note Equality check performs using isNumEq(T lhs, T rhs) function
00201     */
00202    bool isEqual(const Vector &rhs) const;
00203
00204    /**
00205     * @brief Check equality (with threshold) of two floating point numbers function
00206     *
00207     * @param[in] lhs first number
00208     * @param[in] rhs second number
00209     * @return true if numbers equals with threshold (|lhs - rhs| < threshold)
00210     * @return false otherwise
00211     *
00212     * @note Threshold defined by threshold_ static member
00213     */
00214    static bool isNumEq(T lhs, T rhs);
00215
00216    /**
00217     * @brief Set new threshold value
00218     *
00219     * @param[in] thres value to set
00220     */
00221    static void setThreshold(T thres);
00222
00223    /**
00224     * @brief Get current threshold value
00225     */
00226    static void getThreshold();
00227
00228    /**
00229     * @brief Set threshold to default value
00230     * @note default value equals float point epsilon
00231     */
00232    static void setDefThreshold();
00233 };
00234
00235 /**
00236  * @brief Overloaded + operator
00237  *
00238  * @tparam T vector template parameter
00239  * @param[in] lhs first vector
00240  * @param[in] rhs second vector
00241  * @return Vector<T> sum of two vectors
00242  */
00243 template <std::floating_point T>
00244 Vector<T> operator+(const Vector<T> &lhs, const Vector<T> &rhs)
00245 {
00246    Vector<T> res{lhs};
```

```
00247   res += rhs;
00248   return res;
00249 }
00250
00251 /**
00252  * @brief Overloaded - operator
00253  *
00254  * @tparam T vector template parameter
00255  * @param[in] lhs first vector
00256  * @param[in] rhs second vector
00257  * @return Vector<T> res of two vectors
00258  */
00259 template <std::floating_point T>
00260 Vector<T> operator-(const Vector<T> &lhs, const Vector<T> &rhs)
00261 {
00262   Vector<T> res{lhs};
00263   res -= rhs;
00264   return res;
00265 }
00266
00267 /**
00268  * @brief Overloaded multiple by value operator
00269  *
00270  * @tparam nT type of value to multiply by
00271  * @tparam T vector template parameter
00272  * @param[in] val value to multiply by
00273  * @param[in] rhs vector to multiply by value
00274  * @return Vector<T> result vector
00275  */
00276 template <Number nT, std::floating_point T>
00277 Vector<T> operator*(const nT &val, const Vector<T> &rhs)
00278 {
00279   Vector<T> res{rhs};
00280   res *= val;
00281   return res;
00282 }
00283
00284 /**
00285  * @brief Overloaded multiple by value operator
00286  *
00287  * @tparam nT type of value to multiply by
00288  * @tparam T vector template parameter
00289  * @param[in] val value to multiply by
00290  * @param[in] lhs vector to multiply by value
00291  * @return Vector<T> result vector
00292  */
00293 template <Number nT, std::floating_point T>
00294 Vector<T> operator*(const Vector<T> &lhs, const nT &val)
00295 {
00296   Vector<T> res{lhs};
00297   res *= val;
00298   return res;
00299 }
00300
00301 /**
00302  * @brief Overloaded divide by value operator
00303  *
00304  * @tparam nT type of value to divide by
00305  * @tparam T vector template parameter
00306  * @param[in] val value to divide by
00307  * @param[in] lhs vector to divide by value
00308  * @return Vector<T> result vector
00309  */
00310 template <Number nT, std::floating_point T>
00311 Vector<T> operator/(const Vector<T> &lhs, const nT &val)
00312 {
00313   Vector<T> res{lhs};
00314   res /= val;
00315   return res;
00316 }
00317
00318 /**
00319  * @brief Dot product function
00320  *
00321  * @tparam T vector template parameter
00322  * @param[in] lhs first vector
00323  * @param[in] rhs second vector
00324  * @return T dot production
00325  */
00326 template <std::floating_point T>
00327 T dot(const Vector<T> &lhs, const Vector<T> &rhs)
00328 {
00329   return lhs.dot(rhs);
00330 }
00331
00332 /**
00333  * @brief Cross product function
```

```
00334  *
00335  * @tparam T vector template parameter
00336  * @param[in] lhs first vector
00337  * @param[in] rhs second vector
00338  * @return T cross production
00339  */
00340 template <std::floating_point T>
00341 Vector<T> cross(const Vector<T> &lhs, const Vector<T> &rhs)
00342 {
00343   return lhs.cross(rhs);
00344 }
00345
00346 /**
00347  * @brief Vector equality operator
00348  *
00349  * @tparam T vector template parameter
00350  * @param[in] lhs first vector
00351  * @param[in] rhs second vector
00352  * @return true if vectors are equal
00353  * @return false otherwise
00354  */
00355 template <std::floating_point T>
00356 bool operator==(const Vector<T> &lhs, const Vector<T> &rhs)
00357 {
00358   return lhs.isEqual(rhs);
00359 }
00360
00361 /**
00362  * @brief Vector inequality operator
00363  *
00364  * @tparam T vector template parameter
00365  * @param[in] lhs first vector
00366  * @param[in] rhs second vector
00367  * @return true if vectors are not equal
00368  * @return false otherwise
00369  */
00370 template <std::floating_point T>
00371 bool operator!=(const Vector<T> &lhs, const Vector<T> &rhs)
00372 {
00373   return !(lhs == rhs);
00374 }
00375
00376 /**
00377  * @brief Vector print operator
00378  *
00379  * @tparam T vector template parameter
00380  * @param[in, out] ost output stream
00381  * @param[in] vec vector to print
00382  * @return std::ostream& modified stream instance
00383  */
00384 template <std::floating_point T>
00385 std::ostream &operator«(std::ostream &ost, const Vector<T> &vec)
00386 {
00387   ost « "(" « vec.x « ", " « vec.y « ", " « vec.z « ")";
00388   return ost;
00389 }
00390
00391 using VectorD = Vector<double>;
00392 using VectorF = Vector<float>;
00393
00394 template <std::floating_point T>
00395 Vector<T> &Vector<T>::operator+=(const Vector &vec)
00396 {
00397   x += vec.x;
00398   y += vec.y;
00399   z += vec.z;
00400
00401   return *this;
00402 }
00403
00404 template <std::floating_point T>
00405 Vector<T> &Vector<T>::operator-=(const Vector &vec)
00406 {
00407   x -= vec.x;
00408   y -= vec.y;
00409   z -= vec.z;
00410
00411   return *this;
00412 }
00413
00414 template <std::floating_point T>
00415 Vector<T> Vector<T>::operator-() const
00416 {
00417   return Vector{-x, -y, -z};
00418 }
00419
00420 template <std::floating_point T>
```

```
00421 template <Number nType>
00422 Vector<T> &Vector<T>::operator*=(nType val)
00423 {
00424   x *= val;
00425   y *= val;
00426   z *= val;
00427
00428   return *this;
00429 }
00430
00431 template <std::floating_point T>
00432 template <Number nType>
00433 Vector<T> &Vector<T>::operator/=(nType val)
00434 {
00435   x /= static_cast<T>(val);
00436   y /= static_cast<T>(val);
00437   z /= static_cast<T>(val);
00438
00439   return *this;
00440 }
00441
00442 template <std::floating_point T>
00443 T Vector<T>::dot(const Vector &rhs) const
00444 {
00445   return x * rhs.x + y * rhs.y + z * rhs.z;
00446 }
00447
00448 template <std::floating_point T>
00449 Vector<T> Vector<T>::cross(const Vector &rhs) const
00450 {
00451   return Vector{y * rhs.z - z * rhs.y, z * rhs.x - x * rhs.z, x * rhs.y - y * rhs.x};
00452 }
00453
00454 template <std::floating_point T>
00455 T Vector<T>::length2() const
00456 {
00457   return dot(*this);
00458 }
00459
00460 template <std::floating_point T>
00461 T Vector<T>::length() const
00462 {
00463   return std::sqrt(length2());
00464 }
00465
00466 template <std::floating_point T>
00467 Vector<T> Vector<T>::normalized() const
00468 {
00469   Vector res{*this};
00470   res.normalize();
00471   return res;
00472 }
00473
00474 template <std::floating_point T>
00475 Vector<T> &Vector<T>::normalize()
00476 {
00477   T len2 = length2();
00478   if (isNumEq(len2, 0) || isNumEq(len2, 1))
00479     return *this;
00480   return *this /= std::sqrt(len2);
00481 }
00482
00483 template <std::floating_point T>
00484 T &Vector<T>::operator[](size_t i)
00485 {
00486   switch (i % 3)
00487   {
00488   case 0:
00489     return x;
00490   case 1:
00491     return y;
00492   case 2:
00493     return z;
00494   default:
00495     throw std::logic_error{"Impossible case in operator[]\n"};
00496   }
00497 }
00498
00499 template <std::floating_point T>
00500 T Vector<T>::operator[](size_t i) const
00501 {
00502   switch (i % 3)
00503   {
00504   case 0:
00505     return x;
00506   case 1:
00507     return y;
```

```
00508   case 2:
00509     return z;
00510   default:
00511     throw std::logic_error{"Impossible case in operator[]\n"};
00512   }
00513 }
00514
00515 template <std::floating_point T>
00516 bool Vector<T>::isPar(const Vector &rhs) const
00517 {
00518   return cross(rhs).isEqual(Vector<T>{0});
00519 }
00520
00521 template <std::floating_point T>
00522 bool Vector<T>::isPerp(const Vector &rhs) const
00523 {
00524   return isNumEq(dot(rhs), 0);
00525 }
00526
00527 template <std::floating_point T>
00528 bool Vector<T>::isEqual(const Vector &rhs) const
00529 {
00530   return isNumEq(x, rhs.x) && isNumEq(y, rhs.y) && isNumEq(z, rhs.z);
00531 }
00532
00533 template <std::floating_point T>
00534 bool Vector<T>::isNumEq(T lhs, T rhs)
00535 {
00536   return std::abs(rhs - lhs) < threshold_;
00537 }
00538
00539 template <std::floating_point T>
00540 void Vector<T>::setThreshold(T thres)
00541 {
00542   threshold_ = thres;
00543 }
00544
00545 template <std::floating_point T>
00546 void Vector<T>::getThreshold()
00547 {
00548   return threshold_;
00549 }
00550
00551 template <std::floating_point T>
00552 void Vector<T>::setDefThreshold()
00553 {
00554   threshold_ = std::numeric_limits<T>::epsilon();
00555 }
00556
00557 } // namespace geom
00558
00559 #endif // __INCLUDE_PRIMITIVES_VECTOR_HH__
```