

# Triangles

1.0.1

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<b>1 Namespace Index</b>	<b>1</b>
1.1 Namespace List	1
<b>2 Class Index</b>	<b>3</b>
2.1 Class List	3
<b>3 File Index</b>	<b>5</b>
3.1 File List	5
<b>4 Namespace Documentation</b>	<b>7</b>
4.1 geom Namespace Reference	7
4.1.1 Detailed Description	10
4.1.2 Typedef Documentation	10
4.1.2.1 Vec2D	10
4.1.2.2 Vec2F	10
4.1.2.3 Vec3D	10
4.1.2.4 Vec3F	10
4.1.3 Function Documentation	10
4.1.3.1 distance()	10
4.1.3.2 isIntersect()	11
4.1.3.3 intersect() [1/2]	12
4.1.3.4 intersect() [2/2]	13
4.1.3.5 operator<<() [1/5]	14
4.1.3.6 operator==( ) [1/4]	14
4.1.3.7 operator==( ) [2/4]	15
4.1.3.8 operator<<() [2/5]	16
4.1.3.9 operator<<() [3/5]	16
4.1.3.10 operator>>() [1/2]	17
4.1.3.11 operator+() [1/2]	17
4.1.3.12 operator-() [1/2]	17
4.1.3.13 operator*() [1/4]	18
4.1.3.14 operator*() [2/4]	18
4.1.3.15 operator/() [1/2]	20
4.1.3.16 dot() [1/2]	20
4.1.3.17 operator==( ) [3/4]	21
4.1.3.18 operator!=( ) [1/2]	22
4.1.3.19 operator<<() [4/5]	22
4.1.3.20 operator+() [2/2]	23
4.1.3.21 operator-() [2/2]	23
4.1.3.22 operator*() [3/4]	24
4.1.3.23 operator*() [4/4]	24
4.1.3.24 operator/() [2/2]	26
4.1.3.25 dot() [2/2]	26

4.1.3.26 cross()	27
4.1.3.27 triple()	28
4.1.3.28 operator==( ) [ 4 / 4 ]	28
4.1.3.29 operator!=( ) [ 2 / 2 ]	29
4.1.3.30 operator<<( ) [ 5 / 5 ]	29
4.1.3.31 operator>>( ) [ 2 / 2 ]	30
4.1.4 Variable Documentation	30
4.1.4.1 Number	31
4.2 geom::detail Namespace Reference	32
4.2.1 Typedef Documentation	33
4.2.1.1 Segment2D	33
4.2.1.2 Trian2	33
4.2.1.3 Segment3D	33
4.2.2 Function Documentation	33
4.2.2.1 isIntersect2D()	33
4.2.2.2 isIntersectMollerHaines()	34
4.2.2.3 helperMollerHaines()	34
4.2.2.4 isIntersectBothInvalid()	34
4.2.2.5 isIntersectValidInvalid()	34
4.2.2.6 isIntersectPointTriangle()	35
4.2.2.7 isIntersectPointSegment()	35
4.2.2.8 isIntersectSegmentSegment()	35
4.2.2.9 isPoint()	35
4.2.2.10 isOverlap()	36
4.2.2.11 isSameSign() [ 1 / 2 ]	36
4.2.2.12 isSameSign() [ 2 / 2 ]	36
4.2.2.13 isOnOneSide()	36
4.2.2.14 getTrian2()	37
4.2.2.15 isCounterClockwise()	37
4.2.2.16 computeInterval()	37
4.2.2.17 getSegment()	37
<b>5 Class Documentation</b>	<b>39</b>
5.1 geom::Line< T > Class Template Reference	39
5.1.1 Detailed Description	39
5.1.2 Constructor & Destructor Documentation	40
5.1.2.1 Line()	40
5.1.3 Member Function Documentation	40
5.1.3.1 org()	40
5.1.3.2 dir()	41
5.1.3.3 getPoint()	41
5.1.3.4 belongs()	41

5.1.3.5 isEqual()	42
5.1.3.6 isPar()	42
5.1.3.7 isSkew()	43
5.1.3.8 getBy2Points()	43
5.2 geom::Plane< T > Class Template Reference	44
5.2.1 Detailed Description	44
5.2.2 Member Function Documentation	45
5.2.2.1 dist()	45
5.2.2.2 norm()	45
5.2.2.3 belongs() [1/2]	45
5.2.2.4 belongs() [2/2]	46
5.2.2.5 isEqual()	46
5.2.2.6 isPar()	47
5.2.2.7 getBy3Points()	47
5.2.2.8 getParametric()	48
5.2.2.9 getNormalPoint()	48
5.2.2.10 getNormalDist()	49
5.3 geom::Triangle< T > Class Template Reference	49
5.3.1 Detailed Description	50
5.3.2 Constructor & Destructor Documentation	50
5.3.2.1 Triangle() [1/2]	50
5.3.2.2 Triangle() [2/2]	50
5.3.3 Member Function Documentation	51
5.3.3.1 operator[]() [1/2]	51
5.3.3.2 operator[]() [2/2]	51
5.3.3.3 getPlane()	51
5.3.3.4 isValid()	52
5.4 geom::Vec2< T > Class Template Reference	52
5.4.1 Detailed Description	54
5.4.2 Constructor & Destructor Documentation	54
5.4.2.1 Vec2() [1/2]	54
5.4.2.2 Vec2() [2/2]	54
5.4.3 Member Function Documentation	55
5.4.3.1 operator+=( )	55
5.4.3.2 operator-=( )	55
5.4.3.3 operator-( )	56
5.4.3.4 operator*=( ) [1/2]	56
5.4.3.5 operator/=( ) [1/2]	56
5.4.3.6 dot()	58
5.4.3.7 length2()	58
5.4.3.8 length()	59
5.4.3.9 getPerp()	59

5.4.3.10 normalized()	59
5.4.3.11 normalize()	60
5.4.3.12 operator[]() [1/2]	60
5.4.3.13 operator[]() [2/2]	60
5.4.3.14 isPar()	61
5.4.3.15 isPerp()	61
5.4.3.16 isEqual()	62
5.4.3.17 isNumEq()	62
5.4.3.18 setThreshold()	63
5.4.3.19 getThreshold()	63
5.4.3.20 setDefThreshold()	64
5.4.3.21 operator*=( ) [2/2]	64
5.4.3.22 operator/=( ) [2/2]	64
5.4.4 Member Data Documentation	64
5.4.4.1 x	64
5.4.4.2 y	65
5.5 geom::Vec3< T > Class Template Reference	65
5.5.1 Detailed Description	66
5.5.2 Constructor & Destructor Documentation	67
5.5.2.1 Vec3() [1/2]	67
5.5.2.2 Vec3() [2/2]	67
5.5.3 Member Function Documentation	67
5.5.3.1 operator+=( )	67
5.5.3.2 operator-=( )	68
5.5.3.3 operator-( )	68
5.5.3.4 operator*=( ) [1/2]	69
5.5.3.5 operator/=( ) [1/2]	69
5.5.3.6 dot()	70
5.5.3.7 cross()	70
5.5.3.8 length2()	71
5.5.3.9 length()	71
5.5.3.10 normalized()	71
5.5.3.11 normalize()	72
5.5.3.12 operator[]() [1/2]	72
5.5.3.13 operator[]() [2/2]	72
5.5.3.14 isPar()	73
5.5.3.15 isPerp()	73
5.5.3.16 isEqual()	74
5.5.3.17 isNumEq()	74
5.5.3.18 setThreshold()	75
5.5.3.19 getThreshold()	75
5.5.3.20 setDefThreshold()	76

5.5.3.21 operator*=( ) [ 2 / 2 ]	76
5.5.3.22 operator/=( ) [ 2 / 2 ]	76
5.5.4 Member Data Documentation	76
5.5.4.1 x	76
5.5.4.2 y	77
5.5.4.3 z	77
<b>6 File Documentation</b>	<b>79</b>
6.1 include/distance/distance.hh File Reference	79
6.2 distance.hh	80
6.3 include/intersection/intersection.hh File Reference	81
6.4 intersection.hh	82
6.5 include/primitives/common.hh File Reference	90
6.6 common.hh	92
6.7 include/primitives/line.hh File Reference	92
6.8 line.hh	94
6.9 include/primitives/plane.hh File Reference	96
6.10 plane.hh	98
6.11 include/primitives/primitives.hh File Reference	100
6.12 primitives.hh	102
6.13 include/primitives/triangle.hh File Reference	102
6.14 triangle.hh	104
6.15 include/primitives/vec2.hh File Reference	105
6.15.1 Detailed Description	107
6.16 vec2.hh	107
6.17 include/primitives/vec3.hh File Reference	113
6.17.1 Detailed Description	116
6.18 vec3.hh	117





# Chapter 1

## Namespace Index

### 1.1 Namespace List

Here is a list of all namespaces with brief descriptions:

<a href="#">geom</a>	<a href="#">Line.hh</a> <a href="#">Line</a> class implementation . . . . .	<a href="#">7</a>
<a href="#">geom::detail</a>	. . . . .	<a href="#">32</a>



## Chapter 2

# Class Index

### 2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

<a href="#">geom::Line&lt; T &gt;</a>	
<a href="#">Line</a> class implementation . . . . .	<a href="#">39</a>
<a href="#">geom::Plane&lt; T &gt;</a>	
<a href="#">Plane</a> class realization . . . . .	<a href="#">44</a>
<a href="#">geom::Triangle&lt; T &gt;</a>	
<a href="#">Triangle</a> class implementation . . . . .	<a href="#">49</a>
<a href="#">geom::Vec2&lt; T &gt;</a>	
<a href="#">Vec2</a> class realization . . . . .	<a href="#">52</a>
<a href="#">geom::Vec3&lt; T &gt;</a>	
<a href="#">Vec3</a> class realization . . . . .	<a href="#">65</a>



## Chapter 3

# File Index

### 3.1 File List

Here is a list of all files with brief descriptions:

include/distance/ <a href="#">distance.hh</a>	79
include/intersection/ <a href="#">intersection.hh</a>	81
include/primitives/ <a href="#">common.hh</a>	90
include/primitives/ <a href="#">line.hh</a>	92
include/primitives/ <a href="#">plane.hh</a>	96
include/primitives/ <a href="#">primitives.hh</a>	100
include/primitives/ <a href="#">triangle.hh</a>	102
include/primitives/ <a href="#">vec2.hh</a>	105
include/primitives/ <a href="#">vec3.hh</a>	113



## Chapter 4

# Namespace Documentation

### 4.1 geom Namespace Reference

[line.hh](#) [Line](#) class implementation

#### Namespaces

- [detail](#)

#### Classes

- class [Line](#)  
*[Line](#) class implementation.*
- class [Plane](#)  
*[Plane](#) class realization.*
- class [Triangle](#)  
*[Triangle](#) class implementation.*
- class [Vec2](#)  
*[Vec2](#) class realization.*
- class [Vec3](#)  
*[Vec3](#) class realization.*

#### Typedefs

- using [Vec2D](#) = [Vec2](#)< double >
- using [Vec2F](#) = [Vec2](#)< float >
- using [Vec3D](#) = [Vec3](#)< double >
- using [Vec3F](#) = [Vec3](#)< float >

## Functions

- `template<std::floating_point T>`  
`T distance (const Plane< T > &pl, const Vec3< T > &pt)`  
*Calculates signed distance between point and plane.*
- `template<std::floating_point T>`  
`bool intersect (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>`  
`std::variant< std::monostate, Vec3< T >, Line< T > > intersect (const Line< T > &l1, const Line< T > &l2)`  
*Intersect 2 lines and return result of intersection.*
- `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>`  
`std::istream & operator>> (std::istream &ist, Triangle< T > &tr)`
- `template<std::floating_point T>`  
`Vec2< T > operator+ (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Overloaded + operator.*
- `template<std::floating_point T>`  
`Vec2< T > operator- (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Overloaded - operator.*
- `template<Number nT, std::floating_point T>`  
`Vec2< T > operator* (const nT &val, const Vec2< T > &rhs)`  
*Overloaded multiple by value operator.*
- `template<Number nT, std::floating_point T>`  
`Vec2< T > operator* (const Vec2< T > &lhs, const nT &val)`  
*Overloaded multiple by value operator.*
- `template<Number nT, std::floating_point T>`  
`Vec2< T > operator/ (const Vec2< T > &lhs, const nT &val)`  
*Overloaded divide by value operator.*
- `template<std::floating_point T>`  
`T dot (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Dot product function.*
- `template<std::floating_point T>`  
`bool operator== (const Vec2< T > &lhs, const Vec2< T > &rhs)`



*Vec2 equality operator.*

- `template<std::floating_point T>`  
`bool operator!= (const Vec2< T > &lhs, const Vec2< T > &rhs)`

*Vec2 inequality operator.*

- `template<std::floating_point T>`  
`std::ostream & operator<< (std::ostream &ost, const Vec2< T > &vec)`

*Vec2 print operator.*

- `template<std::floating_point T>`  
`Vec3< T > operator+ (const Vec3< T > &lhs, const Vec3< T > &rhs)`

*Overloaded + operator.*

- `template<std::floating_point T>`  
`Vec3< T > operator- (const Vec3< T > &lhs, const Vec3< T > &rhs)`

*Overloaded - operator.*

- `template<Number nT, std::floating_point T>`  
`Vec3< T > operator* (const nT &val, const Vec3< T > &rhs)`

*Overloaded multiple by value operator.*

- `template<Number nT, std::floating_point T>`  
`Vec3< T > operator* (const Vec3< T > &lhs, const nT &val)`

*Overloaded multiple by value operator.*

- `template<Number nT, std::floating_point T>`  
`Vec3< T > operator/ (const Vec3< T > &lhs, const nT &val)`

*Overloaded divide by value operator.*

- `template<std::floating_point T>`  
`T dot (const Vec3< T > &lhs, const Vec3< T > &rhs)`

*Dot product function.*

- `template<std::floating_point T>`  
`Vec3< T > cross (const Vec3< T > &lhs, const Vec3< T > &rhs)`

*Cross product function.*

- `template<std::floating_point T>`  
`T triple (const Vec3< T > &v1, const Vec3< T > &v2, const Vec3< T > &v3)`

*Triple product function.*

- `template<std::floating_point T>`  
`bool operator== (const Vec3< T > &lhs, const Vec3< T > &rhs)`

*Vec3 equality operator.*

- `template<std::floating_point T>`  
`bool operator!= (const Vec3< T > &lhs, const Vec3< T > &rhs)`

*Vec3 inequality operator.*

- `template<std::floating_point T>`  
`std::ostream & operator<< (std::ostream &ost, const Vec3< T > &vec)`

*Vec3 print operator.*

- `template<std::floating_point T>`  
`std::istream & operator>> (std::istream &ist, Vec3< T > &vec)`

*Vec3 scan 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 Vec2D

```
using geom::Vec2D = typedef Vec2<double>
```

Definition at line 367 of file [vec2.hh](#).

#### 4.1.2.2 Vec2F

```
using geom::Vec2F = typedef Vec2<float>
```

Definition at line 368 of file [vec2.hh](#).

#### 4.1.2.3 Vec3D

```
using geom::Vec3D = typedef Vec3<double>
```

Definition at line 413 of file [vec3.hh](#).

#### 4.1.2.4 Vec3F

```
using geom::Vec3F = typedef Vec3<float>
```

Definition at line 414 of file [vec3.hh](#).

### 4.1.3 Function Documentation

#### 4.1.3.1 distance()

```
template<std::floating_point T>
T geom::distance (
    const Plane< T > & pl,
    const Vec3< T > & pt )
```

Calculates signed distance between point and plane.

## Template Parameters

<i>T</i>	- floating point type of coordinates
----------	--------------------------------------

## Parameters

<i>pl</i>	plane
<i>pt</i>	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\(\)](#), [geom::detail::isIntersectValidInvalid\(\)](#), and [geom::detail::isOnOneSide\(\)](#).

## 4.1.3.2 isIntersect()

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

Checks intersection of 2 triangles.

## Template Parameters

<i>T</i>	- floating point type of coordinates
----------	--------------------------------------

## Parameters

<i>tr1</i>	first triangle
<i>tr2</i>	second triangle

## Returns

true if triangles are intersect  
false if triangles are not intersect

Definition at line 223 of file [intersection.hh](#).

References [geom::Triangle< T >::getPlane\(\)](#), [geom::detail::isIntersect2D\(\)](#), [geom::detail::isIntersectBothInvalid\(\)](#), [geom::detail::isIntersectMollerHaines\(\)](#), [geom::detail::isIntersectValidInvalid\(\)](#), [geom::detail::isOnOneSide\(\)](#), and [geom::Triangle< T >::isValid\(\)](#).

#### 4.1.3.3 intersect() [1/2]

```
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  $\vec{P}$  - point in space

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

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

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

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

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

$\vec{P}$  must satisfy both  $pl_1$  and  $pl_2$  equations:

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

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

Let's find  $a$  and  $b$ :

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

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

Intersection line equation:

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

##### Template Parameters

$T$	- floating point type of coordinates
-----	--------------------------------------

##### Parameters

in	$pl1$	first plane
in	$pl2$	second plane

##### Returns

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

Definition at line 255 of file [intersection.hh](#).

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

Referenced by [geom::detail::isIntersectMollerHaines\(\)](#), and [geom::detail::isIntersectSegmentSegment\(\)](#).

#### 4.1.3.4 intersect() [2/2]

```
template<std::floating_point T>
std::variant< std::monostate, Vec3< T >, Line< T > > geom::intersect (
    const Line< T > & l1,
    const Line< T > & l2 )
```

Intersect 2 lines and return result of intersection.

Common intersection case (parallel & skew lines cases are trivial): Let  $\vec{P}$  - point in space, intersection point of two lines.

$$l_1 \text{ equation: } \vec{or\dot{g}}_1 + \vec{dir_1} \cdot t_1 = \vec{P}$$

$$l_2 \text{ equation: } \vec{or\dot{g}}_2 + \vec{dir_2} \cdot t_2 = \vec{P}$$

Let's equate left sides:

$$\vec{or\dot{g}}_1 + \vec{dir_1} \cdot t_1 = \vec{or\dot{g}}_2 + \vec{dir_2} \cdot t_2$$

Cross multiply both sides from right by  $\vec{dir_2}$ :

$$t_1 \cdot (\vec{dir_1} \times \vec{dir_2}) = (\vec{or\dot{g}}_2 - \vec{or\dot{g}}_1) \times \vec{dir_2}$$

Dot multiply both sides by  $\frac{\vec{dir_1} \times \vec{dir_2}}{|\vec{dir_1} \times \vec{dir_2}|^2}$ :

$$t_1 = \frac{((\vec{or\dot{g}}_2 - \vec{or\dot{g}}_1) \times \vec{dir_2}) \cdot (\vec{dir_1} \times \vec{dir_2})}{|\vec{dir_1} \times \vec{dir_2}|^2}$$

Thus we get intersection point parameter  $t_1$  on  $l_1$ , let's substitute it to  $l_1$  equation:

$$\vec{P} = \vec{or\dot{g}}_1 + \frac{((\vec{or\dot{g}}_2 - \vec{or\dot{g}}_1) \times \vec{dir_2}) \cdot (\vec{dir_1} \times \vec{dir_2})}{|\vec{dir_1} \times \vec{dir_2}|^2} \cdot \vec{dir_1}$$

#### Template Parameters

$T$	- floating point type of coordinates
-----	--------------------------------------

#### Parameters

in	$l1$	first line
----	------	------------

## Parameters

<code>in</code>	<code>/2</code>	second line
-----------------	-----------------	-------------

## Returns

`std::variant<std::monostate, Vec3<T>, Line<T>>`

Definition at line 282 of file [intersection.hh](#).

References [cross\(\)](#), [geom::Line< T >::dir\(\)](#), [dot\(\)](#), [geom::Line< T >::getPoint\(\)](#), [geom::Line< T >::isEqual\(\)](#), [geom::Line< T >::isPar\(\)](#), [geom::Line< T >::isSkew\(\)](#), and [geom::Line< T >::org\(\)](#).

4.1.3.5 `operator<<()` [1/5]

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

[Line](#) print operator.

## Template Parameters

<code>T</code>	- floating point type of coordinates
----------------	--------------------------------------

## Parameters

<code>in, out</code>	<code>ost</code>	output stream
<code>in</code>	<code>line</code>	<a href="#">Line</a> to print

## Returns

`std::ostream&` modified ostream instance

Definition at line 117 of file [line.hh](#).

References [geom::Line< T >::dir\(\)](#), and [geom::Line< T >::org\(\)](#).

4.1.3.6 `operator==()` [1/4]

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

[Line](#) equality operator.

## Template Parameters

<i>T</i>	- floating point type of coordinates
----------	--------------------------------------

## Parameters

in	<i>lhs</i>	1st line
in	<i>rhs</i>	2nd line

## Returns

true if lines are equal  
false if lines are not equal

Definition at line 133 of file [line.hh](#).

References [geom::Line< T >::isEqual\(\)](#).

## 4.1.3.7 operator==( ) [2/4]

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

[Plane](#) equality operator.

## Template Parameters

<i>T</i>	- floating point type of coordinates
----------	--------------------------------------

## Parameters

in	<i>lhs</i>	1st plane
in	<i>rhs</i>	2nd plane

## Returns

true if planes are equal  
false if planes are not equal

Definition at line 143 of file [plane.hh](#).

References [geom::Plane< T >::isEqual\(\)](#).

**4.1.3.8 operator<<() [2/5]**

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

Plane print operator.

**Template Parameters**

<i>T</i>	- floating point type of coordinates
----------	--------------------------------------

**Parameters**

<i>in, out</i>	<i>ost</i>	output stream
<i>in</i>	<i>pl</i>	plane to print

**Returns**

std::ostream& modified ostream instance

Definition at line 157 of file [plane.hh](#).

References [geom::Plane< T >::dist\(\)](#), and [geom::Plane< T >::norm\(\)](#).

**4.1.3.9 operator<<() [3/5]**

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

Triangle print operator.

**Template Parameters**

<i>T</i>	- floating point type of coordinates
----------	--------------------------------------

**Parameters**

<i>in, out</i>	<i>ost</i>	output stream
<i>in</i>	<i>tr</i>	<a href="#">Triangle</a> to print

**Returns**

std::ostream& modified ostream instance



Definition at line 88 of file [triangle.hh](#).

#### 4.1.3.10 operator>>() [1/2]

```
template<std::floating_point T>
std::istream& geom::operator>> (
    std::istream & ist,
    Triangle< T > & tr )
```

Definition at line 100 of file [triangle.hh](#).

#### 4.1.3.11 operator+() [1/2]

```
template<std::floating_point T>
Vec2<T> geom::operator+ (
    const Vec2< T > & lhs,
    const Vec2< T > & rhs )
```

Overloaded + operator.

##### Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

##### Parameters

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

##### Returns

Vec2<T> sum of two vectors

Definition at line 234 of file [vec2.hh](#).

#### 4.1.3.12 operator-() [1/2]

```
template<std::floating_point T>
Vec2<T> geom::operator- (
    const Vec2< T > & lhs,
    const Vec2< T > & rhs )
```

Overloaded - operator.

**Template Parameters**

<i>T</i>	vector template parameter
----------	---------------------------

**Parameters**

<i>in</i>	<i>lhs</i>	first vector
<i>in</i>	<i>rhs</i>	second vector

**Returns**

`Vec2<T>` res of two vectors

Definition at line 250 of file [vec2.hh](#).

**4.1.3.13 operator\*() [1/4]**

```
template<Number nT, std::floating_point T>
Vec2<T> geom::operator* (
    const nT & val,
    const Vec2< T > & rhs )
```

Overloaded multiple by value operator.

**Template Parameters**

<i>nT</i>	type of value to multiply by
<i>T</i>	vector template parameter

**Parameters**

<i>in</i>	<i>val</i>	value to multiply by
<i>in</i>	<i>rhs</i>	vector to multiply by value

**Returns**

`Vec2<T>` result vector

Definition at line 267 of file [vec2.hh](#).

**4.1.3.14 operator\*() [2/4]**

```
template<Number nT, std::floating_point T>
Vec2<T> geom::operator* (
```

```
const Vec2< T > & lhs,  
const nT & val )
```

Overloaded multiple by value operator.

**Template Parameters**

<i>nT</i>	type of value to multiply by
<i>T</i>	vector template parameter

**Parameters**

in	<i>val</i>	value to multiply by
in	<i>lhs</i>	vector to multiply by value

**Returns**

Vec2<T> result vector

Definition at line 284 of file [vec2.hh](#).

**4.1.3.15 operator/() [1/2]**

```
template<Number nT, std::floating_point T>
Vec2<T> geom::operator/ (
    const Vec2< T > & lhs,
    const nT & val )
```

Overloaded divide by value operator.

**Template Parameters**

<i>nT</i>	type of value to divide by
<i>T</i>	vector template parameter

**Parameters**

in	<i>val</i>	value to divide by
in	<i>lhs</i>	vector to divide by value

**Returns**

Vec2<T> result vector

Definition at line 301 of file [vec2.hh](#).

**4.1.3.16 dot() [1/2]**

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

```
const Vec2< T > & lhs,
const Vec2< T > & rhs )
```

Dot product function.

#### Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

#### Parameters

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

#### Returns

T dot production

Definition at line 317 of file [vec2.hh](#).

References [geom::Vec2< T >::dot\(\)](#).

Referenced by [geom::detail::computeInterval\(\)](#), [distance\(\)](#), [geom::detail::helperMollerHaines\(\)](#), [intersect\(\)](#), [geom::detail::isIntersectPointSegment\(\)](#), [geom::detail::isIntersectPointTriangle\(\)](#), [geom::detail::isIntersectSegmentSegment\(\)](#), [geom::Vec2< T >::isPerp\(\)](#), [geom::Vec3< T >::isPerp\(\)](#), [geom::Vec2< T >::length2\(\)](#), [geom::Vec3< T >::length2\(\)](#), and [triple\(\)](#).

#### 4.1.3.17 operator==( ) [3/4]

```
template<std::floating_point T>
bool geom::operator== (
    const Vec2< T > & lhs,
    const Vec2< T > & rhs )
```

[Vec2](#) equality operator.

#### Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

#### Parameters

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

**Returns**

true if vectors are equal  
false otherwise

Definition at line 332 of file [vec2.hh](#).

References [geom::Vec2< T >::isEqual\(\)](#).

**4.1.3.18 operator!=() [1/2]**

```
template<std::floating_point T>
bool geom::operator!= (
    const Vec2< T > & lhs,
    const Vec2< T > & rhs )
```

[Vec2](#) inequality operator.

**Template Parameters**

<i>T</i>	vector template parameter
----------	---------------------------

**Parameters**

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

**Returns**

true if vectors are not equal  
false otherwise

Definition at line 347 of file [vec2.hh](#).

**4.1.3.19 operator<<() [4/5]**

```
template<std::floating_point T>
std::ostream& geom::operator<< (
    std::ostream & ost,
    const Vec2< T > & vec )
```

[Vec2](#) print operator.

**Template Parameters**

<i>T</i>	vector template parameter
----------	---------------------------

## Parameters

<i>in, out</i>	<i>ost</i>	output stream
<i>in</i>	<i>vec</i>	vector to print

## Returns

`std::ostream&` modified stream instance

Definition at line 361 of file [vec2.hh](#).

References [geom::Vec2< T >::x](#), and [geom::Vec2< T >::y](#).

4.1.3.20 `operator+()` [2/2]

```
template<std::floating_point T>
Vec3<T> geom::operator+ (
    const Vec3< T > & lhs,
    const Vec3< T > & rhs )
```

Overloaded + operator.

## Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

## Parameters

<i>in</i>	<i>lhs</i>	first vector
<i>in</i>	<i>rhs</i>	second vector

## Returns

`Vec3<T>` sum of two vectors

Definition at line 236 of file [vec3.hh](#).

4.1.3.21 `operator-()` [2/2]

```
template<std::floating_point T>
Vec3<T> geom::operator- (
    const Vec3< T > & lhs,
    const Vec3< T > & rhs )
```

Overloaded - operator.

## Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

## Parameters

<i>in</i>	<i>lhs</i>	first vector
<i>in</i>	<i>rhs</i>	second vector

## Returns

`Vec3<T>` res of two vectors

Definition at line 252 of file [vec3.hh](#).

4.1.3.22 `operator*()` [3/4]

```
template<Number nT, std::floating_point T>
Vec3<T> geom::operator* (
    const nT & val,
    const Vec3< T > & rhs )
```

Overloaded multiple by value operator.

## Template Parameters

<i>nT</i>	type of value to multiply by
<i>T</i>	vector template parameter

## Parameters

<i>in</i>	<i>val</i>	value to multiply by
<i>in</i>	<i>rhs</i>	vector to multiply by value

## Returns

`Vec3<T>` result vector

Definition at line 269 of file [vec3.hh](#).

4.1.3.23 `operator*()` [4/4]

```
template<Number nT, std::floating_point T>
Vec3<T> geom::operator* (
```



```
const Vec3< T > & lhs,  
const nT & val )
```

Overloaded multiple by value operator.

**Template Parameters**

<i>nT</i>	type of value to multiply by
<i>T</i>	vector template parameter

**Parameters**

in	<i>val</i>	value to multiply by
in	<i>lhs</i>	vector to multiply by value

**Returns**

Vec3<T> result vector

Definition at line 286 of file [vec3.hh](#).

**4.1.3.24 operator/() [2/2]**

```
template<Number nT, std::floating_point T>
Vec3<T> geom::operator/ (
    const Vec3< T > & lhs,
    const nT & val )
```

Overloaded divide by value operator.

**Template Parameters**

<i>nT</i>	type of value to divide by
<i>T</i>	vector template parameter

**Parameters**

in	<i>val</i>	value to divide by
in	<i>lhs</i>	vector to divide by value

**Returns**

Vec3<T> result vector

Definition at line 303 of file [vec3.hh](#).

**4.1.3.25 dot() [2/2]**

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

```
const Vec3< T > & lhs,
const Vec3< T > & rhs )
```

Dot product function.

#### Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

#### Parameters

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

#### Returns

T dot production

Definition at line 319 of file [vec3.hh](#).

References [geom::Vec3< T >::dot\(\)](#).

#### 4.1.3.26 cross()

```
template<std::floating_point T>
Vec3<T> geom::cross (
    const Vec3< T > & lhs,
    const Vec3< T > & rhs )
```

Cross product function.

#### Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

#### Parameters

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

#### Returns

T cross production

Definition at line 333 of file [vec3.hh](#).

References [geom::Vec3< T >::cross\(\)](#).

Referenced by [intersect\(\)](#), [geom::Vec3< T >::isPar\(\)](#), [geom::Triangle< T >::isValid\(\)](#), and [triple\(\)](#).

#### 4.1.3.27 triple()

```
template<std::floating_point T>
T geom::triple (
    const Vec3< T > & v1,
    const Vec3< T > & v2,
    const Vec3< T > & v3 )
```

Triple product function.

##### Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

##### Parameters

in	<i>v1</i>	first vector
in	<i>v2</i>	second vector
in	<i>v3</i>	third vector

##### Returns

T triple production

Definition at line 348 of file [vec3.hh](#).

References [cross\(\)](#), and [dot\(\)](#).

Referenced by [geom::Line< T >::isSkew\(\)](#).

#### 4.1.3.28 operator==( ) [4/4]

```
template<std::floating_point T>
bool geom::operator==(
    const Vec3< T > & lhs,
    const Vec3< T > & rhs )
```

[Vec3](#) equality operator.

##### Template Parameters

<i>T</i>	vector template parameter
----------	---------------------------

##### Parameters

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

**Returns**

true if vectors are equal  
false otherwise

Definition at line 363 of file [vec3.hh](#).

References [geom::Vec3< T >::isEqual\(\)](#).

**4.1.3.29 operator"!="() [2/2]**

```
template<std::floating_point T>
bool geom::operator!= (
    const Vec3< T > & lhs,
    const Vec3< T > & rhs )
```

[Vec3](#) inequality operator.

**Template Parameters**

<i>T</i>	vector template parameter
----------	---------------------------

**Parameters**

in	<i>lhs</i>	first vector
in	<i>rhs</i>	second vector

**Returns**

true if vectors are not equal  
false otherwise

Definition at line 378 of file [vec3.hh](#).

**4.1.3.30 operator<<() [5/5]**

```
template<std::floating_point T>
std::ostream& geom::operator<< (
    std::ostream & ost,
    const Vec3< T > & vec )
```

[Vec3](#) print operator.

**Template Parameters**

<i>T</i>	vector template parameter
----------	---------------------------

**Parameters**

<i>in, out</i>	<i>ost</i>	output stream
<i>in</i>	<i>vec</i>	vector to print

**Returns**

`std::ostream&` modified stream instance

Definition at line 392 of file [vec3.hh](#).

References [geom::Vec3< T >::x](#), [geom::Vec3< T >::y](#), and [geom::Vec3< T >::z](#).

**4.1.3.31 operator>>() [2/2]**

```
template<std::floating_point T>
std::istream& geom::operator>> (
    std::istream & ist,
    Vec3< T > & vec )
```

[Vec3](#) scan operator.

**Template Parameters**

<i>T</i>	vector template parameter
----------	---------------------------

**Parameters**

<i>in, out</i>	<i>ist</i>	input stram
<i>in, out</i>	<i>vec</i>	vector to scan

**Returns**

`std::istream&` modified stream instance

Definition at line 407 of file [vec3.hh](#).

References [geom::Vec3< T >::x](#), [geom::Vec3< T >::y](#), and [geom::Vec3< 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

<i>T</i>	
----------	--

Definition at line 15 of file [common.hh](#).

## 4.2 geom::detail Namespace Reference

### Typedefs

- `template<typename T >`  
using [Segment2D](#) = `std::pair< T, T >`
- `template<std::floating_point T>`  
using [Trian2](#) = `std::array< Vec2< T >, 3 >`
- `template<std::floating_point T>`  
using [Segment3D](#) = `std::pair< Vec3< T >, Vec3< T > >`

### Functions

- `template<std::floating_point T>`  
`bool isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)`
- `template<std::floating_point T>`  
`bool isIntersectMollerHaines (const Triangle< T > &tr1, const Triangle< T > &tr2)`
- `template<std::floating_point T>`  
`Segment2D< T > helperMollerHaines (const Triangle< T > &tr, const Plane< T > &pl, const Line< T > &l)`
- `template<std::floating_point T>`  
`bool isIntersectBothInvalid (const Triangle< T > &tr1, const Triangle< T > &tr2)`
- `template<std::floating_point T>`  
`bool isIntersectValidInvalid (const Triangle< T > &valid, const Triangle< T > &invalid)`
- `template<std::floating_point T>`  
`bool isIntersectPointTriangle (const Vec3< T > &pt, const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`bool isIntersectPointSegment (const Vec3< T > &pt, const Segment3D< T > &segm)`
- `template<std::floating_point T>`  
`bool isIntersectSegmentSegment (const Segment3D< T > &segm1, const Segment3D< T > &segm2)`
- `template<std::floating_point T>`  
`bool isPoint (const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`bool isOverlap (Segment2D< T > &segm1, Segment2D< T > &segm2)`
- `template<std::forward_iterator It>`  
`bool isSameSign (It begin, It end)`
- `template<Number T>`  
`bool isSameSign (T num1, T num2)`
- `template<std::floating_point T>`  
`bool isOnOneSide (const Plane< T > &pl, const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`Trian2< T > getTrian2 (const Plane< T > &pl, const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`bool isCounterClockwise (Trian2< T > &tr)`
- `template<std::floating_point T>`  
`Segment2D< T > computeInterval (const Trian2< T > &tr, const Vec2< T > &d)`
- `template<std::floating_point T>`  
`Segment3D< T > getSegment (const Triangle< T > &tr)`



## 4.2.1 Typedef Documentation

### 4.2.1.1 Segment2D

```
template<typename T >
using geom::detail::Segment2D = typedef std::pair<T, T>
```

Definition at line 157 of file [intersection.hh](#).

### 4.2.1.2 Trian2

```
template<std::floating_point T>
using geom::detail::Trian2 = typedef std::array<Vec2<T>, 3>
```

Definition at line 160 of file [intersection.hh](#).

### 4.2.1.3 Segment3D

```
template<std::floating_point T>
using geom::detail::Segment3D = typedef std::pair<Vec3<T>, Vec3<T> >
```

Definition at line 163 of file [intersection.hh](#).

## 4.2.2 Function Documentation

### 4.2.2.1 isIntersect2D()

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

Definition at line 309 of file [intersection.hh](#).

References [computeInterval\(\)](#), [geom::Triangle< T >::getPlane\(\)](#), and [getTrian2\(\)](#).

Referenced by [geom::isIntersect\(\)](#), and [isIntersectValidInvalid\(\)](#).

#### 4.2.2.2 isIntersectMollerHaines()

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

Definition at line 334 of file [intersection.hh](#).

References [geom::Triangle< T >::getPlane\(\)](#), [helperMollerHaines\(\)](#), [geom::intersect\(\)](#), and [isOverlap\(\)](#).

Referenced by [geom::isIntersect\(\)](#).

#### 4.2.2.3 helperMollerHaines()

```
template<std::floating_point T>
Segment2D< T > geom::detail::helperMollerHaines (
    const Triangle< T > & tr,
    const Plane< T > & pl,
    const Line< T > & l )
```

Definition at line 348 of file [intersection.hh](#).

References [geom::Line< T >::dir\(\)](#), [geom::distance\(\)](#), [geom::dot\(\)](#), [isSameSign\(\)](#), and [geom::Line< T >::org\(\)](#).

Referenced by [isIntersectMollerHaines\(\)](#).

#### 4.2.2.4 isIntersectBothInvalid()

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

Definition at line 392 of file [intersection.hh](#).

References [getSegment\(\)](#), [isIntersectPointSegment\(\)](#), [isIntersectSegmentSegment\(\)](#), and [isPoint\(\)](#).

Referenced by [geom::isIntersect\(\)](#).

#### 4.2.2.5 isIntersectValidInvalid()

```
template<std::floating_point T>
bool geom::detail::isIntersectValidInvalid (
    const Triangle< T > & valid,
    const Triangle< T > & invalid )
```

Definition at line 410 of file [intersection.hh](#).

References [geom::distance\(\)](#), [geom::Triangle< T >::getPlane\(\)](#), [getSegment\(\)](#), [isIntersect2D\(\)](#), [isIntersectPointTriangle\(\)](#), and [isPoint\(\)](#).

Referenced by [geom::isIntersect\(\)](#).

#### 4.2.2.6 isIntersectPointTriangle()

```
template<std::floating_point T>
bool geom::detail::isIntersectPointTriangle (
    const Vec3< T > & pt,
    const Triangle< T > & tr )
```

Definition at line 435 of file [intersection.hh](#).

References [geom::dot\(\)](#), [geom::Triangle< T >::getPlane\(\)](#), and [geom::Vec3< T >::getThreshold\(\)](#).

Referenced by [isIntersectValidInvalid\(\)](#).

#### 4.2.2.7 isIntersectPointSegment()

```
template<std::floating_point T>
bool geom::detail::isIntersectPointSegment (
    const Vec3< T > & pt,
    const Segment3D< T > & segm )
```

Definition at line 463 of file [intersection.hh](#).

References [geom::dot\(\)](#), and [isSameSign\(\)](#).

Referenced by [isIntersectBothInvalid\(\)](#), and [isIntersectSegmentSegment\(\)](#).

#### 4.2.2.8 isIntersectSegmentSegment()

```
template<std::floating_point T>
bool geom::detail::isIntersectSegmentSegment (
    const Segment3D< T > & segm1,
    const Segment3D< T > & segm2 )
```

Definition at line 476 of file [intersection.hh](#).

References [geom::dot\(\)](#), [geom::intersect\(\)](#), [isIntersectPointSegment\(\)](#), and [isOverlap\(\)](#).

Referenced by [isIntersectBothInvalid\(\)](#).

#### 4.2.2.9 isPoint()

```
template<std::floating_point T>
bool geom::detail::isPoint (
    const Triangle< T > & tr )
```

Definition at line 500 of file [intersection.hh](#).

Referenced by [isIntersectBothInvalid\(\)](#), and [isIntersectValidInvalid\(\)](#).

#### 4.2.2.10 isOverlap()

```
template<std::floating_point T>
bool geom::detail::isOverlap (
    Segment2D< T > & segm1,
    Segment2D< T > & segm2 )
```

Definition at line 506 of file [intersection.hh](#).

Referenced by [isIntersectMollerHaines\(\)](#), and [isIntersectSegmentSegment\(\)](#).

#### 4.2.2.11 isSameSign() [1/2]

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

Definition at line 512 of file [intersection.hh](#).

Referenced by [helperMollerHaines\(\)](#), [isIntersectPointSegment\(\)](#), and [isOnOneSide\(\)](#).

#### 4.2.2.12 isSameSign() [2/2]

```
template<Number T>
bool geom::detail::isSameSign (
    T num1,
    T num2 )
```

Definition at line 525 of file [intersection.hh](#).

References [geom::Vec3< T >::isNumEq\(\)](#).

#### 4.2.2.13 isOnOneSide()

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

Definition at line 533 of file [intersection.hh](#).

References [geom::distance\(\)](#), and [isSameSign\(\)](#).

Referenced by [geom::isIntersect\(\)](#).

#### 4.2.2.14 getTrian2()

```
template<std::floating_point T>
Trian2< T > geom::detail::getTrian2 (
    const Plane< T > & pl,
    const Triangle< T > & tr )
```

Definition at line 546 of file [intersection.hh](#).

References [isCounterClockwise\(\)](#), and [geom::Plane< T >::norm\(\)](#).

Referenced by [isIntersect2D\(\)](#).

#### 4.2.2.15 isCounterClockwise()

```
template<std::floating_point T>
bool geom::detail::isCounterClockwise (
    Trian2< T > & tr )
```

Definition at line 580 of file [intersection.hh](#).

Referenced by [getTrian2\(\)](#).

#### 4.2.2.16 computeInterval()

```
template<std::floating_point T>
Segment2D< T > geom::detail::computeInterval (
    const Trian2< T > & tr,
    const Vec2< T > & d )
```

Definition at line 600 of file [intersection.hh](#).

References [geom::dot\(\)](#).

Referenced by [isIntersect2D\(\)](#).

#### 4.2.2.17 getSegment()

```
template<std::floating_point T>
Segment3D< T > geom::detail::getSegment (
    const Triangle< T > & tr )
```

Definition at line 616 of file [intersection.hh](#).

Referenced by [isIntersectBothInvalid\(\)](#), and [isIntersectValidInvalid\(\)](#).



## Chapter 5

# Class Documentation

### 5.1 geom::Line< T > Class Template Reference

Line class implementation.

```
#include <line.hh>
```

#### Public Member Functions

- [Line](#) (const [Vec3](#)< T > &org, const [Vec3](#)< T > &dir)  
*Construct a new [Line](#) object.*
- const [Vec3](#)< T > & org () const  
*Getter for origin vector.*
- const [Vec3](#)< T > & dir () const  
*Getter for direction vector.*
- template<Number nType>  
[Vec3](#)< T > [getPoint](#) (nType t) const  
*Get point on line by parameter t.*
- bool [belongs](#) (const [Vec3](#)< T > &point) const  
*Checks is point belongs to line.*
- bool [isEqual](#) (const [Line](#) &line) const  
*Checks is \*this equals to another line.*
- bool [isPar](#) (const [Line](#) &line) const  
*Checks is \*this parallel to another line.*
- bool [isSkew](#) (const [Line](#)< T > &line) const  
*Checks is \*this is skew with another line.*

#### Static Public Member Functions

- static [Line](#) [getBy2Points](#) (const [Vec3](#)< T > &p1, const [Vec3](#)< 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

<i>T</i>	- 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 Vec3< T > & org,
    const Vec3< T > & dir )
```

Construct a new [Line](#) object.

#### Parameters

in	<i>org</i>	origin vector
in	<i>dir</i>	direction vector

Definition at line 139 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 Vec3< T > & geom::Line< T >::org
```

Getter for origin vector.

#### Returns

const Vec3<T>& const reference to origin vector

Definition at line 146 of file [line.hh](#).

Referenced by [geom::Plane< T >::belongs\(\)](#), [geom::detail::helperMollerHaines\(\)](#), [geom::intersect\(\)](#), [geom::Line< T >::Line\(\)](#), and [geom::operator<<\(\)](#).



## 5.1.3.2 dir()

```
template<std::floating_point T>
const Vec3< T > & geom::Line< T >::dir
```

Getter for direction vector.

## Returns

const Vec3<T>& const reference to direction vector

Definition at line 152 of file [line.hh](#).

Referenced by [geom::Plane< T >::belongs\(\)](#), [geom::detail::helperMollerHaines\(\)](#), [geom::intersect\(\)](#), and [geom::operator<<\(\)](#).

## 5.1.3.3 getPoint()

```
template<std::floating_point T>
template<Number nType>
Vec3< T > geom::Line< T >::getPoint (
    nType t ) const
```

Get point on line by parameter t.

## Template Parameters

<i>nType</i>	numeric type
--------------	--------------

## Parameters

in	<i>t</i>	point paramater from line's equation
----	----------	--------------------------------------

## Returns

Vec3<T> Point related to parameter

Definition at line 159 of file [line.hh](#).

Referenced by [geom::intersect\(\)](#).

## 5.1.3.4 belongs()

```
template<std::floating_point T>
bool geom::Line< T >::belongs (
    const Vec3< T > & point ) const
```

Checks is point belongs to line.

**Parameters**

in	<i>point</i>	const reference to point vector
----	--------------	---------------------------------

**Returns**

true if point belongs to line  
false if point doesn't belong to line

Definition at line 165 of file [line.hh](#).

**5.1.3.5 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	<i>line</i>	const reference to another line
----	-------------	---------------------------------

**Returns**

true if lines are equal  
false if lines are not equal

Definition at line 171 of file [line.hh](#).

Referenced by [geom::intersect\(\)](#), and [geom::operator==\(\)](#).

**5.1.3.6 isPar()**

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

Checks is \*this parallel to another line.

**Note**

Assumes equal lines as parallel

## Parameters

<code>in</code>	<code>line</code>	const reference to another line
-----------------	-------------------	---------------------------------

## Returns

true if lines are parallel  
false if lines are not parallel

Definition at line 177 of file [line.hh](#).

Referenced by [geom::intersect\(\)](#).

**5.1.3.7 isSkew()**

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

Checks is \*this is skew with another line.

## Parameters

<code>in</code>	<code>line</code>	const reference to another line
-----------------	-------------------	---------------------------------

## Returns

true if lines are skew  
false if lines are not skew

Definition at line 183 of file [line.hh](#).

References [geom::Vec3< T >::isNumEq\(\)](#), and [geom::triple\(\)](#).

Referenced by [geom::intersect\(\)](#).

**5.1.3.8 getBy2Points()**

```
template<std::floating_point T>
Line< T > geom::Line< T >::getBy2Points (
    const Vec3< T > & p1,
    const Vec3< T > & p2 ) [static]
```

Get line by 2 points.

## Parameters

in	<i>p1</i>	1st point
in	<i>p2</i>	2nd point

## Returns

[Line](#) passing through two points

Definition at line 190 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 [Vec3](#)< T > & [norm](#) () const  
*Getter for normal vector.*
- bool [belongs](#) (const [Vec3](#)< 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 [Vec3](#)< T > &pt1, const [Vec3](#)< T > &pt2, const [Vec3](#)< T > &pt3)  
*Get plane by 3 points.*
- static [Plane](#) [getParametric](#) (const [Vec3](#)< T > &org, const [Vec3](#)< T > &dir1, const [Vec3](#)< T > &dir2)  
*Get plane from parametric plane equation.*
- static [Plane](#) [getNormalPoint](#) (const [Vec3](#)< T > &norm, const [Vec3](#)< T > &point)  
*Get plane from normal point plane equation.*
- static [Plane](#) [getNormalDist](#) (const [Vec3](#)< 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

<code>T</code>	- floating point type of coordinates
----------------	--------------------------------------

Definition at line 22 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 171 of file [plane.hh](#).

Referenced by [geom::distance\(\)](#), [geom::intersect\(\)](#), and [geom::operator<<\(\)](#).

### 5.2.2.2 norm()

```
template<std::floating_point T>
const Vec3< T > & geom::Plane< T >::norm
```

Getter for normal vector.

**Returns**

const Vec3<T>& const reference to normal vector

Definition at line 177 of file [plane.hh](#).

Referenced by [geom::distance\(\)](#), [geom::detail::getTrian2\(\)](#), [geom::intersect\(\)](#), and [geom::operator<<\(\)](#).

### 5.2.2.3 belongs() [1/2]

```
template<std::floating_point T>
bool geom::Plane< T >::belongs (
    const Vec3< T > & point ) const
```

Checks if point belongs to plane.

**Parameters**

in	<i>point</i>	const referene to point vector
----	--------------	--------------------------------

**Returns**

true if point belongs to plane  
false if point doesn't belong to plane

Definition at line 183 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	<i>line</i>	const referene to line
----	-------------	------------------------

**Returns**

true if line belongs to plane  
false if line doesn't belong to plane

Definition at line 189 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	<i>rhs</i>	const reference to another plane
----	------------	----------------------------------

**Returns**

true if planes are equal  
false if planes are not equal

Definition at line 195 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 201 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 Vec3< T > & pt1,
    const Vec3< T > & pt2,
    const Vec3< 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 207 of file [plane.hh](#).

Referenced by [geom::Triangle< T >::getPlane\(\)](#).

**5.2.2.8 getParametric()**

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getParametric (
    const Vec3< T > & org,
    const Vec3< T > & dir1,
    const Vec3< T > & dir2 ) [static]
```

Get plane from parametric plane equation.

**Parameters**

in	<i>org</i>	origin vector
in	<i>dir1</i>	1st direction vector
in	<i>dir2</i>	2nd direction vector

**Returns**

[Plane](#)

Definition at line 213 of file [plane.hh](#).

References [geom::Vec3< T >::cross\(\)](#).

**5.2.2.9 getNormalPoint()**

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getNormalPoint (
    const Vec3< T > & norm,
    const Vec3< T > & point ) [static]
```

Get plane from normal point plane equation.

**Parameters**

in	<i>norm</i>	normal vector
in	<i>point</i>	point lying on the plane



## Returns

[Plane](#)Definition at line 220 of file [plane.hh](#).References [geom::Vec3< T >::normalized\(\)](#).

## 5.2.2.10 getNormalDist()

```
template<std::floating_point T>
Plane< T > geom::Plane< T >::getNormalDist (
    const Vec3< T > & norm,
    T constant ) [static]
```

Get plane form normal const plane equation.

## Parameters

in	<i>norm</i>	normal vector
in	<i>constant</i>	distance

## Returns

[Plane](#)Definition at line 227 of file [plane.hh](#).References [geom::Vec3< T >::normalized\(\)](#).

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

- include/primitives/[plane.hh](#)

## 5.3 geom::Triangle&lt; T &gt; Class Template Reference

[Triangle](#) class implementation.

#include &lt;triangle.hh&gt;

## Public Member Functions

- [Triangle](#) ()  
*Construct a new [Triangle](#) object.*
- [Triangle](#) (const [Vec3](#)< T > &p1, const [Vec3](#)< T > &p2, const [Vec3](#)< T > &p3)  
*Construct a new [Triangle](#) object from 3 points.*
- const [Vec3](#)< T > & [operator\[\]](#) (std::size\_t idx) const  
*Overloaded operator[] to get access to vertices.*
- [Vec3](#)< T > & [operator\[\]](#) (std::size\_t idx)  
*Overloaded operator[] to get access to vertices.*
- [Plane](#)< T > [getPlane](#) () const  
*Get triangle's plane.*
- bool [isValid](#) () const  
*Check is triangle valid.*

### 5.3.1 Detailed Description

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

[Triangle](#) class implementation.

#### Template Parameters

<i>T</i>	- floating point type of coordinates
----------	--------------------------------------

Definition at line 24 of file [triangle.hh](#).

### 5.3.2 Constructor & Destructor Documentation

#### 5.3.2.1 Triangle() [1/2]

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

Construct a new [Triangle](#) object.

Definition at line 107 of file [triangle.hh](#).

#### 5.3.2.2 Triangle() [2/2]

```
template<std::floating_point T>
geom::Triangle< T >::Triangle (
    const Vec3< T > & p1,
    const Vec3< T > & p2,
    const Vec3< T > & p3 )
```

Construct a new [Triangle](#) object from 3 points.

#### Parameters

in	<i>p1</i>	1st point
in	<i>p2</i>	2nd point
in	<i>p3</i>	3rd point

Definition at line 111 of file [triangle.hh](#).

### 5.3.3 Member Function Documentation

#### 5.3.3.1 operator[]() [1/2]

```
template<std::floating_point T>
const Vec3< T > & geom::Triangle< T >::operator[] (
    std::size_t idx ) const
```

Overloaded operator[] to get access to vertices.

##### Parameters

in	<i>idx</i>	index of vertex
----	------------	-----------------

##### Returns

const Vec3<T>& const reference to vertex

Definition at line 116 of file [triangle.hh](#).

#### 5.3.3.2 operator[]() [2/2]

```
template<std::floating_point T>
Vec3< T > & geom::Triangle< T >::operator[] (
    std::size_t idx )
```

Overloaded operator[] to get access to vertices.

##### Parameters

in	<i>idx</i>	index of vertex
----	------------	-----------------

##### Returns

Vec3<T>& reference to vertex

Definition at line 122 of file [triangle.hh](#).

#### 5.3.3.3 getPlane()

```
template<std::floating_point T>
Plane< T > geom::Triangle< T >::getPlane
```

Get triangle's plane.

**Returns**

Plane<T>

Definition at line 128 of file [triangle.hh](#).

References [geom::Plane< T >::getBy3Points\(\)](#).

Referenced by [geom::isIntersect\(\)](#), [geom::detail::isIntersect2D\(\)](#), [geom::detail::isIntersectMollerHaines\(\)](#), [geom::detail::isIntersectPointTriangle\(\)](#), and [geom::detail::isIntersectValidInvalid\(\)](#).

**5.3.3.4 isValid()**

```
template<std::floating_point T>
bool geom::Triangle< T >::isValid
```

Check is triangle valid.

**Returns**

true if triangle is valid  
false if triangle is invalid

Definition at line 134 of file [triangle.hh](#).

References [geom::cross\(\)](#).

Referenced by [geom::isIntersect\(\)](#).

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

- [include/primitives/triangle.hh](#)

**5.4 geom::Vec2< T > Class Template Reference**

[Vec2](#) class realization.

```
#include <vec2.hh>
```

## Public Member Functions

- [Vec2](#) (T coordX, T coordY)  
*Construct a new [Vec2](#) object from 3 coordinates.*
- [Vec2](#) (T coordX={})  
*Construct a new [Vec2](#) object with equals coordinates.*
- [Vec2](#) & [operator+=](#) (const [Vec2](#) &vec)  
*Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.*
- [Vec2](#) & [operator-=](#) (const [Vec2](#) &vec)  
*Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.*
- [Vec2](#) [operator-](#) () const  
*Unary - operator.*
- template<Number nType>  
[Vec2](#) & [operator\\*=](#) (nType val)  
*Overloaded \*= by number operator.*
- template<Number nType>  
[Vec2](#) & [operator/=](#) (nType val)  
*Overloaded /= by number operator.*
- T [dot](#) (const [Vec2](#) &rhs) const  
*Dot product function.*
- T [length2](#) () const  
*Calculate squared length of a vector function.*
- T [length](#) () const  
*Calculate length of a vector function.*
- [Vec2](#) [getPerp](#) () const  
*Get the perpendicular to this vector.*
- [Vec2](#) [normalized](#) () const  
*Get normalized vector function.*
- [Vec2](#) & [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 [Vec2](#) &rhs) const  
*Check if vector is parallel to another.*
- bool [isPerp](#) (const [Vec2](#) &rhs) const  
*Check if vector is perpendicular to another.*
- bool [isEqual](#) (const [Vec2](#) &rhs) const  
*Check if vector is equal to another.*
- template<Number nType>  
[Vec2](#)< T > & [operator\\*=](#) (nType val)
- template<Number nType>  
[Vec2](#)< 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 T [getThreshold](#) ()  
*Get current threshold value.*
- static void [setDefThreshold](#) ()  
*Set threshold to default value.*

## Public Attributes

- `T x {}`  
*Vec2 coordinates.*
- `T y {}`

### 5.4.1 Detailed Description

```
template<std::floating_point T>
class geom::Vec2< T >
```

[Vec2](#) class realization.

Template Parameters

<code>T</code>	- floating point type of coordinates
----------------	--------------------------------------

Definition at line 26 of file [vec2.hh](#).

### 5.4.2 Constructor & Destructor Documentation

#### 5.4.2.1 `Vec2()` [1/2]

```
template<std::floating_point T>
geom::Vec2< T >::Vec2 (
    T coordX,
    T coordY ) [inline]
```

Construct a new [Vec2](#) object from 3 coordinates.

Parameters

in	<code>coordX</code>	x coordinate
in	<code>coordY</code>	y coordinate

Definition at line 46 of file [vec2.hh](#).

#### 5.4.2.2 `Vec2()` [2/2]

```
template<std::floating_point T>
geom::Vec2< T >::Vec2 (
    T coordX = {} ) [inline], [explicit]
```

Construct a new [Vec2](#) object with equals coordinates.

## Parameters

in	<i>coordX</i>	coordinate (default to {})
----	---------------	----------------------------

Definition at line 54 of file [vec2.hh](#).

### 5.4.3 Member Function Documentation

#### 5.4.3.1 operator+=()

```
template<std::floating_point T>
Vec2< T > & geom::Vec2< T >::operator+= (
    const Vec2< T > & vec )
```

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

## Parameters

in	<i>vec</i>	vector to incremented with
----	------------	----------------------------

## Returns

[Vec2](#)& reference to current instance

Definition at line 371 of file [vec2.hh](#).

References [geom::Vec2< T >::x](#), and [geom::Vec2< T >::y](#).

#### 5.4.3.2 operator-=()

```
template<std::floating_point T>
Vec2< T > & geom::Vec2< T >::operator-= (
    const Vec2< T > & vec )
```

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

## Parameters

in	<i>vec</i>	vector to decremented with
----	------------	----------------------------

## Returns

[Vec2](#)& reference to current instance

Definition at line 380 of file [vec2.hh](#).

References [geom::Vec2< T >::x](#), and [geom::Vec2< T >::y](#).

#### 5.4.3.3 operator-()

```
template<std::floating_point T>
Vec2< T > geom::Vec2< T >::operator-
```

Unary - operator.

##### Returns

[Vec2](#) negated [Vec2](#) instance

Definition at line 389 of file [vec2.hh](#).

#### 5.4.3.4 operator\*=( ) [1/2]

```
template<std::floating_point T>
template<Number nType>
Vec2& geom::Vec2< T >::operator*= (
    nType val )
```

Overloaded \*= by number operator.

##### Template Parameters

<i>nType</i>	numeric type of value to multiply by
--------------	--------------------------------------

##### Parameters

in	<i>val</i>	value to multiply by
----	------------	----------------------

##### Returns

[Vec2&](#) reference to vector instance

#### 5.4.3.5 operator/=( ) [1/2]

```
template<std::floating_point T>
template<Number nType>
```



```
Vec2& geom::Vec2< T >::operator/= (
    nType val )
```

Overloaded /= by number operator.

**Template Parameters**

<i>nType</i>	numeric type of value to divide by
--------------	------------------------------------

**Parameters**

<i>in</i>	<i>val</i>	value to divide by
-----------	------------	--------------------

**Returns**

[Vec2](#)& reference to vector instance

**Warning**

Does not check if *val* equals 0

**5.4.3.6 dot()**

```
template<std::floating_point T>
T geom::Vec2< T >::dot (
    const Vec2< T > & rhs ) const
```

Dot product function.

**Parameters**

<i>rhs</i>	vector to dot product with
------------	----------------------------

**Returns**

T dot product of two vectors

Definition at line 415 of file [vec2.hh](#).

References [geom::Vec2< T >::x](#), and [geom::Vec2< T >::y](#).

Referenced by [geom::dot\(\)](#).

**5.4.3.7 length2()**

```
template<std::floating_point T>
T geom::Vec2< T >::length2
```

Calculate squared length of a vector function.

**Returns**

$T \text{ length}^2$

Definition at line 421 of file [vec2.hh](#).

References [geom::dot\(\)](#).

**5.4.3.8 length()**

```
template<std::floating_point T>
T geom::Vec2< T >::length
```

Calculate length of a vector function.

**Returns**

$T \text{ length}$

Definition at line 427 of file [vec2.hh](#).

**5.4.3.9 getPerp()**

```
template<std::floating_point T>
Vec2< T > geom::Vec2< T >::getPerp
```

Get the perpendicular to this vector.

**Returns**

[Vec2](#) perpendicular vector

Definition at line 433 of file [vec2.hh](#).

**5.4.3.10 normalized()**

```
template<std::floating_point T>
Vec2< T > geom::Vec2< T >::normalized
```

Get normalized vector function.

**Returns**

[Vec2](#) normalized vector

Definition at line 439 of file [vec2.hh](#).

References [geom::Vec2< T >::normalize\(\)](#).

#### 5.4.3.11 normalize()

```
template<std::floating_point T>
Vec2< T > & geom::Vec2< T >::normalize
```

Normalize vector function.

##### Returns

Vec2& reference to instance

Definition at line 447 of file [vec2.hh](#).

Referenced by [geom::Vec2< T >::normalized\(\)](#).

#### 5.4.3.12 operator[]() [1/2]

```
template<std::floating_point T>
T & geom::Vec2< T >::operator[] (
    size_t i )
```

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

##### Parameters

<i>i</i>	index of coordinate (0 - x, 1 - y)
----------	------------------------------------

##### Returns

T& reference to coordinate value

##### Note

Coordinates calculated by mod 2

Definition at line 456 of file [vec2.hh](#).

#### 5.4.3.13 operator[]() [2/2]

```
template<std::floating_point T>
T geom::Vec2< T >::operator[] (
    size_t i ) const
```

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

## Parameters

<i>i</i>	index of coordinate (0 - x, 1 - y)
----------	------------------------------------

## Returns

T coordinate value

## Note

Coordinates calculated by mod 2

Definition at line 470 of file [vec2.hh](#).

## 5.4.3.14 isPar()

```
template<std::floating_point T>
bool geom::Vec2< T >::isPar (
    const Vec2< T > & rhs ) const
```

Check if vector is parallel to another.

## Parameters

<i>in</i>	<i>rhs</i>	vector to check parallelism with
-----------	------------	----------------------------------

## Returns

true if vector is parallel  
false otherwise

Definition at line 484 of file [vec2.hh](#).

References [geom::Vec2< T >::x](#), and [geom::Vec2< T >::y](#).

## 5.4.3.15 isPerp()

```
template<std::floating_point T>
bool geom::Vec2< T >::isPerp (
    const Vec2< T > & rhs ) const
```

Check if vector is perpendicular to another.

**Parameters**

<i>in</i>	<i>rhs</i>	vector to check perpendicularity with
-----------	------------	---------------------------------------

**Returns**

true if vector is perpendicular  
false otherwise

Definition at line 491 of file [vec2.hh](#).

References [geom::dot\(\)](#).

**5.4.3.16 isEqual()**

```
template<std::floating_point T>
bool geom::Vec2< T >::isEqual (
    const Vec2< T > & rhs ) const
```

Check if vector is equal to another.

**Parameters**

<i>in</i>	<i>rhs</i>	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 497 of file [vec2.hh](#).

References [geom::Vec2< T >::x](#), and [geom::Vec2< T >::y](#).

Referenced by [geom::operator==\(\)](#).

**5.4.3.17 isNumEq()**

```
template<std::floating_point T>
bool geom::Vec2< T >::isNumEq (
    T lhs,
    T rhs ) [static]
```

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

## Parameters

in	<i>lhs</i>	first number
in	<i>rhs</i>	second number

## Returns

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

## Note

Threshold defined by `threshold_ static` member

Definition at line 503 of file [vec2.hh](#).

**5.4.3.18 setThreshold()**

```
template<std::floating_point T>
void geom::Vec2< T >::setThreshold (
    T thres ) [static]
```

Set new threshold value.

## Parameters

in	<i>thres</i>	value to set
----	--------------	--------------

Definition at line 509 of file [vec2.hh](#).

**5.4.3.19 getThreshold()**

```
template<std::floating_point T>
T geom::Vec2< T >::getThreshold [static]
```

Get current threshold value.

Definition at line 515 of file [vec2.hh](#).

#### 5.4.3.20 setDefThreshold()

```
template<std::floating_point T>
void geom::Vec2< T >::setDefThreshold [static]
```

Set threshold to default value.

##### Note

default value equals float point epsilon

Definition at line 521 of file [vec2.hh](#).

#### 5.4.3.21 operator\*=( ) [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec2<T>& geom::Vec2< T >::operator*= (
    nType val )
```

Definition at line 396 of file [vec2.hh](#).

#### 5.4.3.22 operator/=( ) [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec2<T>& geom::Vec2< T >::operator/= (
    nType val )
```

Definition at line 406 of file [vec2.hh](#).

### 5.4.4 Member Data Documentation

#### 5.4.4.1 x

```
template<std::floating_point T>
T geom::Vec2< T >::x {}
```

[Vec2](#) coordinates.

Definition at line 38 of file [vec2.hh](#).

Referenced by [geom::Vec2< T >::dot\(\)](#), [geom::Vec2< T >::isEqual\(\)](#), [geom::Vec2< T >::isPar\(\)](#), [geom::Vec2< T >::operator+=\( \)](#), [geom::Vec2< T >::operator-=\( \)](#), and [geom::operator<<\(\)](#).



## 5.4.4.2 y

```
template<std::floating_point T>
T geom::Vec2< T >::y {}
```

Definition at line 38 of file [vec2.hh](#).

Referenced by [geom::Vec2< T >::dot\(\)](#), [geom::Vec2< T >::isEqual\(\)](#), [geom::Vec2< T >::isPar\(\)](#), [geom::Vec2< T >::operator+=\(\)](#), [geom::Vec2< T >::operator-=\(\)](#), and [geom::operator<<\(\)](#).

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

- include/primitives/[vec2.hh](#)

## 5.5 geom::Vec3&lt; T &gt; Class Template Reference

[Vec3](#) class realization.

```
#include <vec3.hh>
```

## Public Member Functions

- [Vec3](#) (T coordX, T coordY, T coordZ)  
*Construct a new [Vec3](#) object from 3 coordinates.*
- [Vec3](#) (T coordX={})  
*Construct a new [Vec3](#) object with equals coordinates.*
- [Vec3](#) & [operator+=](#) (const [Vec3](#) &vec)  
*Overloaded += operator Increments vector coordinates by corresponding coordinates of vec.*
- [Vec3](#) & [operator-=](#) (const [Vec3](#) &vec)  
*Overloaded -= operator Decrements vector coordinates by corresponding coordinates of vec.*
- [Vec3](#) [operator-](#) () const  
*Unary - operator.*
- template<Number nType>  
[Vec3](#) & [operator\\*=](#) (nType val)  
*Overloaded \*= by number operator.*
- template<Number nType>  
[Vec3](#) & [operator/=](#) (nType val)  
*Overloaded /= by number operator.*
- T [dot](#) (const [Vec3](#) &rhs) const  
*Dot product function.*
- [Vec3](#) [cross](#) (const [Vec3](#) &rhs) const  
*Cross product function.*
- T [length2](#) () const  
*Calculate squared length of a vector function.*
- T [length](#) () const  
*Calculate length of a vector function.*
- [Vec3](#) [normalized](#) () const  
*Get normalized vector function.*
- [Vec3](#) & [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 `Vec3` &rhs) const  
*Check if vector is parallel to another.*
- bool `isPerp` (const `Vec3` &rhs) const  
*Check if vector is perpendicular to another.*
- bool `isEqual` (const `Vec3` &rhs) const  
*Check if vector is equal to another.*
- template<Number nType>  
`Vec3< T > & operator*=` (nType val)
- template<Number nType>  
`Vec3< 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 T `getThreshold` ()  
*Get current threshold value.*
- static void `setDefThreshold` ()  
*Set threshold to default value.*

## Public Attributes

- T x {}  
*`Vec3` coordinates.*
- T y {}
- T z {}

### 5.5.1 Detailed Description

```
template<std::floating_point T>
class geom::Vec3< T >
```

`Vec3` class realization.

#### Template Parameters

<code>T</code>	- floating point type of coordinates
----------------	--------------------------------------

Definition at line 26 of file `vec3.hh`.

## 5.5.2 Constructor & Destructor Documentation

### 5.5.2.1 Vec3() [1/2]

```
template<std::floating_point T>
geom::Vec3< T >::Vec3 (
    T coordX,
    T coordY,
    T coordZ ) [inline]
```

Construct a new [Vec3](#) object from 3 coordinates.

#### Parameters

in	<i>coordX</i>	x coordinate
in	<i>coordY</i>	y coordinate
in	<i>coordZ</i>	z coordinate

Definition at line 47 of file [vec3.hh](#).

### 5.5.2.2 Vec3() [2/2]

```
template<std::floating_point T>
geom::Vec3< T >::Vec3 (
    T coordX = {} ) [inline], [explicit]
```

Construct a new [Vec3](#) object with equals coordinates.

#### Parameters

in	<i>coordX</i>	coordinate (default to {})
----	---------------	----------------------------

Definition at line 55 of file [vec3.hh](#).

## 5.5.3 Member Function Documentation

### 5.5.3.1 operator+=()

```
template<std::floating_point T>
Vec3< T > & geom::Vec3< T >::operator+= (
    const Vec3< T > & vec )
```

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

## Parameters

in	vec	vector to incremented with
----	-----	----------------------------

## Returns

[Vec3](#)& reference to current instance

Definition at line 417 of file [vec3.hh](#).

References [geom::Vec3< T >::x](#), [geom::Vec3< T >::y](#), and [geom::Vec3< T >::z](#).

### 5.5.3.2 operator-=()

```
template<std::floating_point T>
Vec3< T > & geom::Vec3< T >::operator-= (
    const Vec3< T > & vec )
```

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

## Parameters

in	vec	vector to decremented with
----	-----	----------------------------

## Returns

[Vec3](#)& reference to current instance

Definition at line 427 of file [vec3.hh](#).

References [geom::Vec3< T >::x](#), [geom::Vec3< T >::y](#), and [geom::Vec3< T >::z](#).

### 5.5.3.3 operator-()

```
template<std::floating_point T>
Vec3< T > geom::Vec3< T >::operator-
```

Unary - operator.

## Returns

[Vec3](#) negated [Vec3](#) instance

Definition at line 437 of file [vec3.hh](#).

**5.5.3.4 operator\*=( ) [1/2]**

```
template<std::floating_point T>
template<Number nType>
Vec3& geom::Vec3< T >::operator*= (
    nType val )
```

Overloaded \*= by number operator.

**Template Parameters**

<i>nType</i>	numeric type of value to multiply by
--------------	--------------------------------------

**Parameters**

in	<i>val</i>	value to multiply by
----	------------	----------------------

**Returns**

Vec3& reference to vector instance

**5.5.3.5 operator/=( ) [1/2]**

```
template<std::floating_point T>
template<Number nType>
Vec3& geom::Vec3< T >::operator/= (
    nType val )
```

Overloaded /= by number operator.

**Template Parameters**

<i>nType</i>	numeric type of value to divide by
--------------	------------------------------------

**Parameters**

in	<i>val</i>	value to divide by
----	------------	--------------------

**Returns**

Vec3& reference to vector instance

**Warning**

Does not check if val equals 0

### 5.5.3.6 dot()

```
template<std::floating_point T>
T geom::Vec3< T >::dot (
    const Vec3< T > & rhs ) const
```

Dot product function.

#### Parameters

<i>rhs</i>	vector to dot product with
------------	----------------------------

#### Returns

T dot product of two vectors

Definition at line 465 of file [vec3.hh](#).

References [geom::Vec3< T >::x](#), [geom::Vec3< T >::y](#), and [geom::Vec3< T >::z](#).

Referenced by [geom::dot\(\)](#).

### 5.5.3.7 cross()

```
template<std::floating_point T>
Vec3< T > geom::Vec3< T >::cross (
    const Vec3< T > & rhs ) const
```

Cross product function.

#### Parameters

<i>rhs</i>	vector to cross product with
------------	------------------------------

#### Returns

[Vec3](#) cross product of two vectors

Definition at line 471 of file [vec3.hh](#).

References [geom::Vec3< T >::x](#), [geom::Vec3< T >::y](#), and [geom::Vec3< T >::z](#).

Referenced by [geom::cross\(\)](#), and [geom::Plane< T >::getParametric\(\)](#).

### 5.5.3.8 length2()

```
template<std::floating_point T>
T geom::Vec3< T >::length2
```

Calculate squared length of a vector function.

#### Returns

$T \text{ length}^2$

Definition at line 477 of file [vec3.hh](#).

References [geom::dot\(\)](#).

### 5.5.3.9 length()

```
template<std::floating_point T>
T geom::Vec3< T >::length
```

Calculate length of a vector function.

#### Returns

$T \text{ length}$

Definition at line 483 of file [vec3.hh](#).

### 5.5.3.10 normalized()

```
template<std::floating_point T>
Vec3< T > geom::Vec3< T >::normalized
```

Get normalized vector function.

#### Returns

[Vec3](#) normalized vector

Definition at line 489 of file [vec3.hh](#).

References [geom::Vec3< T >::normalize\(\)](#).

Referenced by [geom::Plane< T >::getNormalDist\(\)](#), and [geom::Plane< T >::getNormalPoint\(\)](#).

**5.5.3.11 normalize()**

```
template<std::floating_point T>
Vec3< T > & geom::Vec3< T >::normalize
```

Normalize vector function.

**Returns**

[Vec3](#)& reference to instance

Definition at line [497](#) of file [vec3.hh](#).

Referenced by [geom::Vec3< T >::normalized\(\)](#).

**5.5.3.12 operator[]() [1/2]**

```
template<std::floating_point T>
T & geom::Vec3< T >::operator[] (
    size_t i )
```

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

**Parameters**

<i>i</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 [506](#) of file [vec3.hh](#).

**5.5.3.13 operator[]() [2/2]**

```
template<std::floating_point T>
T geom::Vec3< T >::operator[] (
    size_t i ) const
```

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



## Parameters

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

## Returns

T coordinate value

## Note

Coordinates calculated by mod 3

Definition at line 522 of file [vec3.hh](#).

## 5.5.3.14 isPar()

```
template<std::floating_point T>
bool geom::Vec3< T >::isPar (
    const Vec3< T > & rhs ) const
```

Check if vector is parallel to another.

## Parameters

<i>in</i>	<i>rhs</i>	vector to check parallelism with
-----------	------------	----------------------------------

## Returns

true if vector is parallel  
false otherwise

Definition at line 538 of file [vec3.hh](#).

References [geom::cross\(\)](#).

## 5.5.3.15 isPerp()

```
template<std::floating_point T>
bool geom::Vec3< T >::isPerp (
    const Vec3< T > & rhs ) const
```

Check if vector is perpendicular to another.

**Parameters**

<i>in</i>	<i>rhs</i>	vector to check perpendicularity with
-----------	------------	---------------------------------------

**Returns**

true if vector is perpendicular  
false otherwise

Definition at line 544 of file [vec3.hh](#).

References [geom::dot\(\)](#).

**5.5.3.16 isEqual()**

```
template<std::floating_point T>
bool geom::Vec3< T >::isEqual (
    const Vec3< T > & rhs ) const
```

Check if vector is equal to another.

**Parameters**

<i>in</i>	<i>rhs</i>	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 550 of file [vec3.hh](#).

References [geom::Vec3< T >::x](#), [geom::Vec3< T >::y](#), and [geom::Vec3< T >::z](#).

Referenced by [geom::operator==\(\)](#).

**5.5.3.17 isNumEq()**

```
template<std::floating_point T>
bool geom::Vec3< T >::isNumEq (
    T lhs,
    T rhs ) [static]
```

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

## Parameters

in	<i>lhs</i>	first number
in	<i>rhs</i>	second number

## Returns

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

## Note

Threshold defined by `threshold_` static member

Definition at line 556 of file [vec3.hh](#).

Referenced by [geom::detail::isSameSign\(\)](#), and [geom::Line< T >::isSkew\(\)](#).

**5.5.3.18 setThreshold()**

```
template<std::floating_point T>
void geom::Vec3< T >::setThreshold (
    T thres ) [static]
```

Set new threshold value.

## Parameters

in	<i>thres</i>	value to set
----	--------------	--------------

Definition at line 562 of file [vec3.hh](#).

**5.5.3.19 getThreshold()**

```
template<std::floating_point T>
T geom::Vec3< T >::getThreshold [static]
```

Get current threshold value.

Definition at line 568 of file [vec3.hh](#).

Referenced by [geom::detail::isIntersectPointTriangle\(\)](#).

### 5.5.3.20 setDefThreshold()

```
template<std::floating_point T>
void geom::Vec3< T >::setDefThreshold [static]
```

Set threshold to default value.

#### Note

default value equals float point epsilon

Definition at line 574 of file [vec3.hh](#).

### 5.5.3.21 operator\*=( ) [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec3<T>& geom::Vec3< T >::operator*= (
    nType val )
```

Definition at line 444 of file [vec3.hh](#).

### 5.5.3.22 operator/=( ) [2/2]

```
template<std::floating_point T>
template<Number nType>
Vec3<T>& geom::Vec3< T >::operator/= (
    nType val )
```

Definition at line 455 of file [vec3.hh](#).

## 5.5.4 Member Data Documentation

### 5.5.4.1 x

```
template<std::floating_point T>
T geom::Vec3< T >::x {}
```

[Vec3](#) coordinates.

Definition at line 38 of file [vec3.hh](#).

Referenced by [geom::Vec3< T >::cross\(\)](#), [geom::Vec3< T >::dot\(\)](#), [geom::Vec3< T >::isEqual\(\)](#), [geom::Vec3< T >::operator+=\( \)](#), [geom::Vec3< T >::operator-=\( \)](#), [geom::operator<<\(\)](#), and [geom::operator>>\(\)](#).

### 5.5.4.2 y

```
template<std::floating_point T>
T geom::Vec3< T >::y {}
```

Definition at line 38 of file [vec3.hh](#).

Referenced by [geom::Vec3< T >::cross\(\)](#), [geom::Vec3< T >::dot\(\)](#), [geom::Vec3< T >::isEqual\(\)](#), [geom::Vec3< T >::operator+=\(\)](#), [geom::Vec3< T >::operator-=\(\)](#), [geom::operator<<\(\)](#), and [geom::operator>>\(\)](#).

### 5.5.4.3 z

```
template<std::floating_point T>
T geom::Vec3< T >::z {}
```

Definition at line 38 of file [vec3.hh](#).

Referenced by [geom::Vec3< T >::cross\(\)](#), [geom::Vec3< T >::dot\(\)](#), [geom::Vec3< T >::isEqual\(\)](#), [geom::Vec3< T >::operator+=\(\)](#), [geom::Vec3< T >::operator-=\(\)](#), [geom::operator<<\(\)](#), and [geom::operator>>\(\)](#).

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

- [include/primitives/vec3.hh](#)



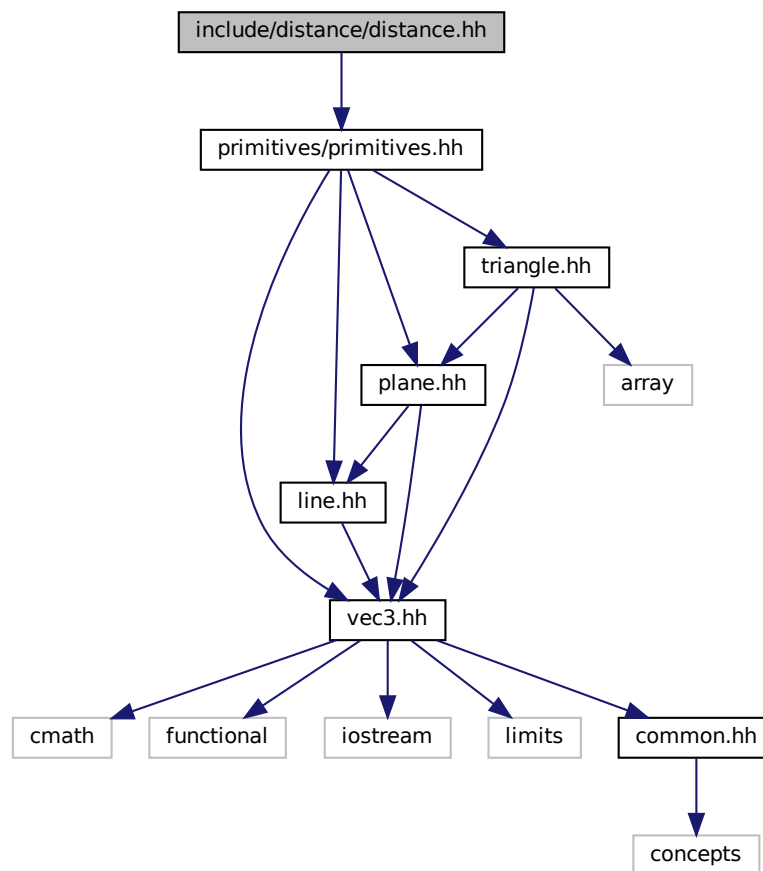
## Chapter 6

# File Documentation

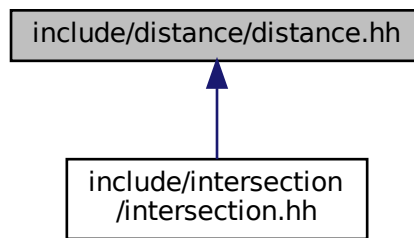
### 6.1 include/distance/distance.hh File Reference

```
#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 Vec3< T > &pt)`  
*Calculates signed distance between point and plane.*

## 6.2 distance.hh

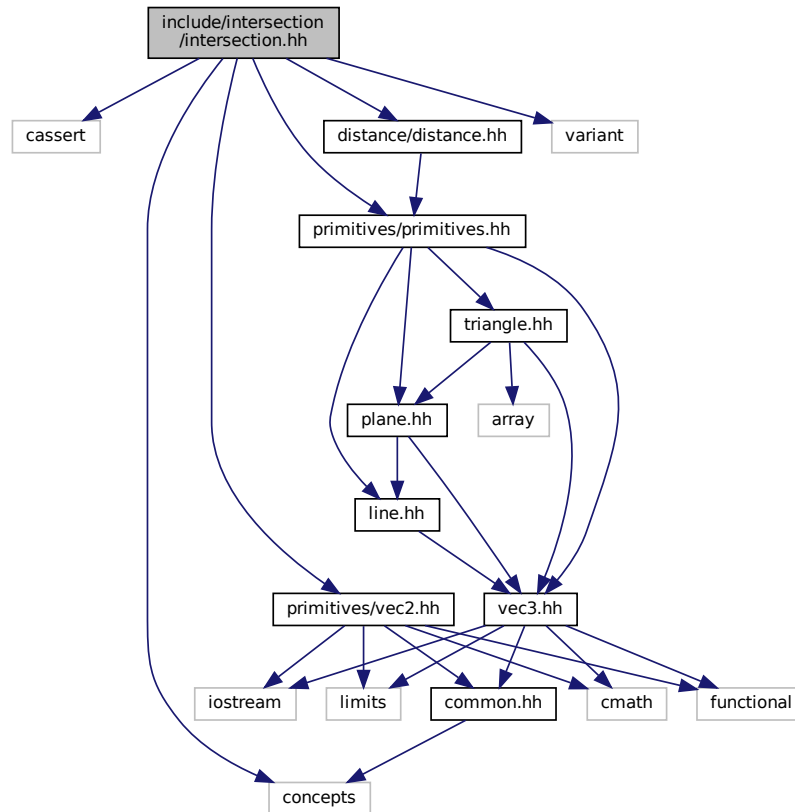
```

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 Vec3<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 Vec3<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 <cassert>
#include <concepts>
#include <variant>
#include "distance/distance.hh"
#include "primitives/primitives.hh"
#include "primitives/vec2.hh"
Include dependency graph for intersection.hh:
```



### Namespaces

- [geom](#)  
     [line.hh](#) *Line* class implementation
- [geom::detail](#)

### Typedefs

- `template<typename T>`  
   using [geom::detail::Segment2D](#) = `std::pair< T, T >`
- `template<std::floating_point T>`  
   using [geom::detail::Trian2](#) = `std::array< Vec2< T >, 3 >`
- `template<std::floating_point T>`  
   using [geom::detail::Segment3D](#) = `std::pair< Vec3< T >, Vec3< T > >`

## Functions

- `template<std::floating_point T>`  
`bool geom::isIntersect (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>`  
`std::variant< std::monostate, Vec3< T >, Line< T > > geom::intersect (const Line< T > &l1, const Line< T > &l2)`  
*Intersect 2 lines and return result of intersection.*
- `template<std::floating_point T>`  
`bool geom::detail::isIntersect2D (const Triangle< T > &tr1, const Triangle< T > &tr2)`
- `template<std::floating_point T>`  
`bool geom::detail::isIntersectMollerHaines (const Triangle< T > &tr1, const Triangle< T > &tr2)`
- `template<std::floating_point T>`  
`Segment2D< T > geom::detail::helperMollerHaines (const Triangle< T > &tr, const Plane< T > &pl, const Line< T > &l)`
- `template<std::floating_point T>`  
`bool geom::detail::isIntersectBothInvalid (const Triangle< T > &tr1, const Triangle< T > &tr2)`
- `template<std::floating_point T>`  
`bool geom::detail::isIntersectValidInvalid (const Triangle< T > &valid, const Triangle< T > &invalid)`
- `template<std::floating_point T>`  
`bool geom::detail::isIntersectPointTriangle (const Vec3< T > &pt, const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`bool geom::detail::isIntersectPointSegment (const Vec3< T > &pt, const Segment3D< T > &segm)`
- `template<std::floating_point T>`  
`bool geom::detail::isIntersectSegmentSegment (const Segment3D< T > &segm1, const Segment3D< T > &segm2)`
- `template<std::floating_point T>`  
`bool geom::detail::isPoint (const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`bool geom::detail::isOverlap (Segment2D< T > &segm1, Segment2D< T > &segm2)`
- `template<std::forward_iterator It>`  
`bool geom::detail::isSameSign (It begin, It end)`
- `template<Number T>`  
`bool geom::detail::isSameSign (T num1, T num2)`
- `template<std::floating_point T>`  
`bool geom::detail::isOnOneSide (const Plane< T > &pl, const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`Trian2< T > geom::detail::getTrian2 (const Plane< T > &pl, const Triangle< T > &tr)`
- `template<std::floating_point T>`  
`bool geom::detail::isCounterClockwise (Trian2< T > &tr)`
- `template<std::floating_point T>`  
`Segment2D< T > geom::detail::computeInterval (const Trian2< T > &tr, const Vec2< T > &d)`
- `template<std::floating_point T>`  
`Segment3D< T > geom::detail::getSegment (const Triangle< T > &tr)`

## 6.4 intersection.hh

```
00001 #ifndef __INCLUDE_INTERSECTION_INTERSECTION_HH__
00002 #define __INCLUDE_INTERSECTION_INTERSECTION_HH__
00003
00004 #include <cassert>
```

```

00005 #include <concepts>
00006 #include <variant>
00007
00008 #include "distance/distance.hh"
00009 #include "primitives/primitives.hh"
00010 #include "primitives/vec2.hh"
00011
00012 namespace geom
00013 {
00014
00015 /**
00016  * @brief Checks intersection of 2 triangles
00017  *
00018  * @tparam T - floating point type of coordinates
00019  * @param tr1 first triangle
00020  * @param tr2 second triangle
00021  * @return true if triangles are intersect
00022  * @return false if triangles are not intersect
00023  */
00024 template <std::floating_point T>
00025 bool isIntersect(const Triangle<T> &tr1, const Triangle<T> &tr2);
00026
00027 /**
00028  * @brief Intersect 2 planes and return result of intersection
00029  * @details
00030  * Common intersection case (parallel planes case is trivial):
00031  *
00032  * Let  $\vec{P}$  - point in space
00033  *
00034  *  $\vec{pl}_1$  equation:  $\vec{n}_1 \cdot \vec{P} = d_1$ 
00035  *
00036  *  $\vec{pl}_2$  equation:  $\vec{n}_2 \cdot \vec{P} = d_2$ 
00037  *
00038  * Intersection line direction:  $\vec{dir} = \vec{n}_1 \times \vec{n}_2$ 
00039  *
00040  *
00041  * Let origin of intersection line be a linear combination of  $\vec{n}_1$  and  $\vec{n}_2$ 
00042  * and  $\vec{P}$ :  $\vec{P} = a \cdot \vec{n}_1 + b \cdot \vec{n}_2$ 
00043  *
00044  *
00045  *  $\vec{P}$  must satisfy both  $\vec{pl}_1$  and  $\vec{pl}_2$  equations:
00046  *
00047  *  $\vec{n}_1 \cdot \vec{P} = d_1$ 
00048  *
00049  *  $\vec{n}_1 \cdot (a \cdot \vec{n}_1 + b \cdot \vec{n}_2) = d_1$ 
00050  *
00051  *  $a + b \cdot \vec{n}_1 \cdot \vec{n}_2 = d_1$ 
00052  *
00053  *  $a = d_1 - b \cdot \vec{n}_1 \cdot \vec{n}_2$ 
00054  *
00055  *  $\vec{n}_2 \cdot \vec{P} = d_2$ 
00056  *
00057  *  $\vec{n}_2 \cdot (a \cdot \vec{n}_1 + b \cdot \vec{n}_2) = d_2$ 
00058  *
00059  *  $a \cdot \vec{n}_1 \cdot \vec{n}_2 + b = d_2$ 
00060  *
00061  *  $a \cdot \vec{n}_1 \cdot \vec{n}_2 + (d_1 - a \cdot \vec{n}_1 \cdot \vec{n}_2) = d_2$ 
00062  *
00063  *  $d_1 = d_2$ 
00064  *
00065  * Let's find  $a$  and  $b$ :
00066  *
00067  *  $a = \frac{d_2 - d_1}{\vec{n}_1 \cdot \vec{n}_2 - 1}$ 
00068  *
00069  *  $b = \frac{d_1 - a \cdot \vec{n}_1 \cdot \vec{n}_2}{1}$ 
00070  *
00071  *
00072  * Intersection line equation:
00073  *
00074  *  $\vec{r}(t) = \vec{P} + t \cdot \vec{dir}$ 
00075  *
00076  *  $\vec{r}(t) = (a \cdot \vec{n}_1 + b \cdot \vec{n}_2) + t \cdot \vec{dir}$ 
00077  *
00078  *
00079  *
00080  *
00081  *
00082  *
00083  *
00084  *
00085  *
00086  *
00087  *
00088  *
00089  *
00090  *
00091  *

```

```

00092 * @tparam T - floating point type of coordinates
00093 * @param[in] pl1 first plane
00094 * @param[in] pl2 second plane
00095 * @return std::variant<std::monostate, Line<T>, Plane<T>
00096 */
00097 template <std::floating_point T>
00098 std::variant<std::monostate, Line<T>, Plane<T> intersect(const Plane<T> &pl1, const Plane<T> &pl2);
00099
00100 /**
00101 * @brief Intersect 2 lines and return result of intersection
00102 * @details
00103 * Common intersection case (parallel & skew lines cases are trivial):
00104 * Let  $\vec{P}$  - point in space, intersection point of two lines.
00105 *
00106 *  $\vec{l}_1$  equation:  $\vec{org}_1 + \vec{dir}_1 \cdot t_1 = \vec{P}$ 
00107 *
00108 *  $\vec{l}_2$  equation:  $\vec{org}_2 + \vec{dir}_2 \cdot t_2 = \vec{P}$ 
00109 *
00110 * Let's equate left sides:
00111 *  $\vec{org}_1 + \vec{dir}_1 \cdot t_1 = \vec{org}_2 + \vec{dir}_2 \cdot t_2$ 
00112 *
00113 * Cross multiply both sides from right by  $\vec{dir}_2$ :
00114 *  $\vec{org}_1 \cdot \vec{dir}_2 + \vec{dir}_1 \cdot \vec{dir}_2 \cdot t_1 = \vec{org}_2 \cdot \vec{dir}_2 + \vec{dir}_2 \cdot \vec{dir}_2 \cdot t_2$ 
00115 *
00116 * Dot multiply both sides by  $\frac{\vec{dir}_1 \cdot \vec{dir}_2}{|\vec{dir}_1|^2}$ :
00117 *  $\vec{org}_1 \cdot \vec{dir}_2 + |\vec{dir}_2|^2 \cdot t_1 = \vec{org}_2 \cdot \vec{dir}_2 + |\vec{dir}_2|^2 \cdot t_2$ 
00118 *
00119 * Thus we get intersection point parameter  $t_1$  on  $\vec{l}_1$ , let's substitute it to  $\vec{l}_1$  equation:
00120 *  $\vec{P} = \vec{org}_1 + \frac{\vec{org}_2 - \vec{org}_1 \cdot \vec{dir}_2}{|\vec{dir}_2|^2} + \frac{\vec{org}_1 \cdot \vec{dir}_2 - \vec{org}_2 \cdot \vec{dir}_2}{|\vec{dir}_2|^2} \cdot \vec{dir}_1$ 
00121 *
00122 * @tparam T - floating point type of coordinates
00123 * @param[in] l1 first line
00124 * @param[in] l2 second line
00125 * @return std::variant<std::monostate, Vec3<T>, Line<T>
00126 */
00127 template <std::floating_point T>
00128 std::variant<std::monostate, Vec3<T>, Line<T> intersect(const Line<T> &l1, const Line<T> &l2);
00129
00130 namespace detail
00131 {
00132     template <typename T>
00133     using Segment2D = std::pair<T, T>;
00134
00135     template <std::floating_point T>
00136     using Trian2 = std::array<Vec2<T>, 3>;
00137
00138     template <std::floating_point T>
00139     using Segment3D = std::pair<Vec3<T>, Vec3<T>>;
00140
00141     template <std::floating_point T>
00142     bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2);
00143
00144     template <std::floating_point T>
00145     bool isIntersectMollerHaines(const Triangle<T> &tr1, const Triangle<T> &tr2);
00146
00147     template <std::floating_point T>
00148     Segment2D<T> helperMollerHaines(const Triangle<T> &tr, const Plane<T> &pl, const Line<T> &l);
00149
00150     template <std::floating_point T>
00151     bool isIntersectBothInvalid(const Triangle<T> &tr1, const Triangle<T> &tr2);
00152
00153     template <std::floating_point T>
00154     bool isIntersectValidInvalid(const Triangle<T> &valid, const Triangle<T> &invalid);

```

```

00179
00180 template <std::floating_point T>
00181 bool isIntersectPointTriangle(const Vec3<T> &pt, const Triangle<T> &tr);
00182
00183 template <std::floating_point T>
00184 bool isIntersectPointSegment(const Vec3<T> &pt, const Segment3D<T> &segm);
00185
00186 template <std::floating_point T>
00187 bool isIntersectSegmentSegment(const Segment3D<T> &segm1, const Segment3D<T> &segm2);
00188
00189 template <std::floating_point T>
00190 bool isPoint(const Triangle<T> &tr);
00191
00192 template <std::floating_point T>
00193 bool isOverlap(Segment2D<T> &segm1, Segment2D<T> &segm2);
00194
00195 template <std::forward_iterator It>
00196 bool isSameSign(It begin, It end);
00197
00198 template <Number T>
00199 bool isSameSign(T num1, T num2);
00200
00201 template <std::floating_point T>
00202 bool isOnOneSide(const Plane<T> &pl, const Triangle<T> &tr);
00203
00204 template <std::floating_point T>
00205 Trian2<T> getTrian2(const Plane<T> &pl, const Triangle<T> &tr);
00206
00207 template <std::floating_point T>
00208 bool isCounterClockwise(Trian2<T> &tr);
00209
00210 template <std::floating_point T>
00211 Segment2D<T> computeInterval(const Trian2<T> &tr, const Vec2<T> &d);
00212
00213 template <std::floating_point T>
00214 Segment3D<T> getSegment(const Triangle<T> &tr);
00215
00216 } // namespace detail
00217 } // namespace geom
00218
00219 namespace geom
00220 {
00221
00222 template <std::floating_point T>
00223 bool isIntersect(const Triangle<T> &tr1, const Triangle<T> &tr2)
00224 {
00225     auto isInv1 = !tr1.isValid();
00226     auto isInv2 = !tr2.isValid();
00227
00228     if (isInv1 && isInv2)
00229         return detail::isIntersectBothInvalid(tr1, tr2);
00230
00231     if (isInv1)
00232         return detail::isIntersectValidInvalid(tr2, tr1);
00233
00234     if (isInv2)
00235         return detail::isIntersectValidInvalid(tr1, tr2);
00236
00237     auto pl1 = tr1.getPlane();
00238     if (detail::isOnOneSide(pl1, tr2))
00239         return false;
00240
00241     auto pl2 = tr2.getPlane();
00242     if (pl1 == pl2)
00243         return detail::isIntersect2D(tr1, tr2);
00244
00245     if (pl1.isPar(pl2))
00246         return false;
00247
00248     if (detail::isOnOneSide(pl2, tr1))
00249         return false;
00250
00251     return detail::isIntersectMollerHaines(tr1, tr2);
00252 }
00253
00254 template <std::floating_point T>
00255 std::variant<std::monostate, Line<T>, Plane<T>> intersect(const Plane<T> &p1, const Plane<T> &p2)
00256 {
00257     const auto &n1 = p1.norm();
00258     const auto &n2 = p2.norm();
00259
00260     auto dir = cross(n1, n2);
00261
00262     /* if planes are parallel */
00263     if (Vec3<T>{0} == dir)
00264     {
00265         if (p1 == p2)

```

```

00266         return p11;
00267
00268     return std::monostate{};
00269 }
00270
00271 auto nln2 = dot(n1, n2);
00272 auto d1 = p11.dist();
00273 auto d2 = p12.dist();
00274
00275 auto a = (d2 * nln2 - d1) / (nln2 * nln2 - 1);
00276 auto b = (d1 * nln2 - d2) / (nln2 * nln2 - 1);
00277
00278 return Line<T>{(a * n1) + (b * n2), dir};
00279 }
00280
00281 template <std::floating_point T>
00282 std::variant<std::monostate, Vec3<T>, Line<T>> intersect(const Line<T> &l1, const Line<T> &l2)
00283 {
00284     if (l1.isPar(l2))
00285     {
00286         if (l1.isEqual(l2))
00287             return l1;
00288
00289         return std::monostate{};
00290     }
00291
00292     if (l1.isSkew(l2))
00293         return std::monostate{};
00294
00295     auto dir1xdir2 = cross(l1.dir(), l2.dir());
00296     auto org2l1xdir2 = cross(l2.org() - l1.org(), l2.dir());
00297
00298     auto t1_intersect = dot(org2l1xdir2, dir1xdir2) / dir1xdir2.length2();
00299
00300     auto point = l1.getPoint(t1_intersect);
00301
00302     return point;
00303 }
00304
00305 namespace detail
00306 {
00307
00308 template <std::floating_point T>
00309 bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2)
00310 {
00311     auto p1 = tr1.getPlane();
00312
00313     auto trian1 = getTrian2(p1, tr1);
00314     auto trian2 = getTrian2(p1, tr2);
00315
00316     for (auto trian : {trian1, trian2})
00317     {
00318         for (size_t i0 = 0, i1 = 2; i0 < 3; i1 = i0, ++i0)
00319         {
00320             auto d = (trian[i0] - trian[i1]).getPerp();
00321
00322             auto s1 = computeInterval(trian1, d);
00323             auto s2 = computeInterval(trian2, d);
00324
00325             if (s2.second < s1.first || s1.second < s2.first)
00326                 return false;
00327         }
00328     }
00329
00330     return true;
00331 }
00332
00333 template <std::floating_point T>
00334 bool isIntersectMollerHaines(const Triangle<T> &tr1, const Triangle<T> &tr2)
00335 {
00336     auto p11 = tr1.getPlane();
00337     auto p12 = tr2.getPlane();
00338
00339     auto l = std::get<Line<T>>(intersect(p11, p12));
00340
00341     auto params1 = helperMollerHaines(tr1, p12, l);
00342     auto params2 = helperMollerHaines(tr2, p11, l);
00343
00344     return isOverlap(params1, params2);
00345 }
00346
00347 template <std::floating_point T>
00348 Segment2D<T> helperMollerHaines(const Triangle<T> &tr, const Plane<T> &p1, const Line<T> &l)
00349 {
00350     /* Project the triangle vertices onto line */
00351     std::array<T, 3> vert{};
00352     for (size_t i = 0; i < 3; ++i)

```

```

00353     vert[i] = dot(l.dir(), tr[i] - l.org());
00354
00355     std::array<T, 3> sdist{};
00356     for (size_t i = 0; i < 3; ++i)
00357         sdist[i] = distance(pl, tr[i]);
00358
00359     std::array<bool, 3> isOneSide{};
00360     for (size_t i = 0; i < 3; ++i)
00361         isOneSide[i] = isSameSign(sdist[i], sdist[(i + 1) % 3]);
00362
00363     /* Looking for vertex which is alone on it's side */
00364     size_t rogue = 0;
00365     if (std::all_of(isOneSide.begin(), isOneSide.end(), [](const auto &elem) { return !elem; }))
00366     {
00367         for (size_t i = 0; i < 3; ++i)
00368             if (!Vec3<T>::isNumEq(0, sdist[i]))
00369                 rogue = i;
00370     }
00371     else
00372     {
00373         for (size_t i = 0; i < 3; ++i)
00374             if (isOneSide[i])
00375                 rogue = (i + 2) % 3;
00376     }
00377
00378     std::vector<T> segm{};
00379     std::array<size_t, 2> arr{(rogue + 1) % 3, (rogue + 2) % 3};
00380
00381     for (size_t i : arr)
00382         segm.push_back(vert[i] + (vert[rogue] - vert[i]) * sdist[i] / (sdist[i] - sdist[rogue]));
00383
00384     /* Sort segment's ends */
00385     if (segm[0] > segm[1])
00386         std::swap(segm[0], segm[1]);
00387
00388     return {segm[0], segm[1]};
00389 }
00390
00391 template <std::floating_point T>
00392 bool isIntersectBothInvalid(const Triangle<T> &tr1, const Triangle<T> &tr2)
00393 {
00394     auto isPoint1 = isPoint(tr1);
00395     auto isPoint2 = isPoint(tr2);
00396
00397     if (isPoint1 && isPoint2)
00398         return tr1[0] == tr2[0];
00399
00400     if (isPoint1)
00401         return isIntersectPointSegment(tr1[0], getSegment(tr2));
00402
00403     if (isPoint2)
00404         return isIntersectPointSegment(tr2[0], getSegment(tr1));
00405
00406     return isIntersectSegmentSegment(getSegment(tr1), getSegment(tr2));
00407 }
00408
00409 template <std::floating_point T>
00410 bool isIntersectValidInvalid(const Triangle<T> &valid, const Triangle<T> &invalid)
00411 {
00412     if (isPoint(invalid))
00413         return isIntersectPointTriangle(invalid[0], valid);
00414
00415     auto segm = getSegment(invalid);
00416     auto pl = valid.getPlane();
00417
00418     auto dst1 = distance(pl, segm.first);
00419     auto dst2 = distance(pl, segm.second);
00420
00421     if (dst1 * dst2 > 0)
00422         return false;
00423
00424     if (Vec3<T>::isNumEq(dst1, 0) && Vec3<T>::isNumEq(dst2, 0))
00425         return isIntersect2D(valid, invalid);
00426
00427     dst1 = std::abs(dst1);
00428     dst2 = std::abs(dst2);
00429
00430     auto pt = segm.first + (segm.second - segm.first) * dst1 / (dst1 + dst2);
00431     return isIntersectPointTriangle(pt, valid);
00432 }
00433
00434 template <std::floating_point T>
00435 bool isIntersectPointTriangle(const Vec3<T> &pt, const Triangle<T> &tr)
00436 {
00437     if (!tr.getPlane().belongs(pt))
00438         return false;
00439 }

```

```

00440  /* TODO: comment better */
00441  /* pt = point + u * edge1 + v * edge2 */
00442  auto point = pt - tr[0];
00443  auto edge1 = tr[1] - tr[0];
00444  auto edge2 = tr[2] - tr[0];
00445
00446  auto dotE1E1 = dot(edge1, edge1);
00447  auto dotE1E2 = dot(edge1, edge2);
00448  auto dotE1PT = dot(edge1, point);
00449
00450  auto dotE2E2 = dot(edge2, edge2);
00451  auto dotE2PT = dot(edge2, point);
00452
00453  auto denom = dotE1E1 * dotE2E2 - dotE1E2 * dotE1E2;
00454  auto u = (dotE2E2 * dotE1PT - dotE1E2 * dotE2PT) / denom;
00455  auto v = (dotE1E1 * dotE2PT - dotE1E2 * dotE1PT) / denom;
00456
00457  /* Point belongs to triangle if: (u >= 0) && (v >= 0) && (u + v <= 1) */
00458  auto eps = Vec3<T>::getThreshold();
00459  return (u > -eps) && (v > -eps) && (u + v < 1 + eps);
00460 }
00461
00462 template <std::floating_point T>
00463 bool isIntersectPointSegment(const Vec3<T> &pt, const Segment3D<T> &segm)
00464 {
00465     Line<T> l{segm.first, segm.second - segm.first};
00466     if (!l.belongs(pt))
00467         return false;
00468
00469     auto beg = dot(l.dir(), segm.first - pt);
00470     auto end = dot(l.dir(), segm.second - pt);
00471
00472     return !isSameSign(beg, end);
00473 }
00474
00475 template <std::floating_point T>
00476 bool isIntersectSegmentSegment(const Segment3D<T> &segm1, const Segment3D<T> &segm2)
00477 {
00478     Line<T> l1{segm1.first, segm1.second - segm1.first};
00479     Line<T> l2{segm2.first, segm2.second - segm2.first};
00480     auto intersectionResult = intersect(l1, l2);
00481
00482     if (std::holds_alternative<Line<T>>(intersectionResult))
00483     {
00484         const auto &dir = l1.dir();
00485         Segment2D<T> s1{dot(dir, segm1.first), dot(dir, segm1.second)};
00486         Segment2D<T> s2{dot(dir, segm2.first), dot(dir, segm2.second)};
00487         return isOverlap(s1, s2);
00488     }
00489
00490     if (std::holds_alternative<Vec3<T>>(intersectionResult))
00491     {
00492         auto pt = std::get<Vec3<T>>(intersectionResult);
00493         return isIntersectPointSegment(pt, segm1) && isIntersectPointSegment(pt, segm2);
00494     }
00495
00496     return false;
00497 }
00498
00499 template <std::floating_point T>
00500 bool isPoint(const Triangle<T> &tr)
00501 {
00502     return (tr[0] == tr[1]) && (tr[0] == tr[2]);
00503 }
00504
00505 template <std::floating_point T>
00506 bool isOverlap(Segment2D<T> &segm1, Segment2D<T> &segm2)
00507 {
00508     return (segm2.first <= segm1.second) && (segm2.second >= segm1.first);
00509 }
00510
00511 template <std::forward_iterator It>
00512 bool isSameSign(It begin, It end)
00513 {
00514     auto cur = begin;
00515     auto prev = begin;
00516
00517     for (++cur; cur != end; ++cur)
00518         if ((*cur) * (*prev) <= 0)
00519             return false;
00520
00521     return true;
00522 }
00523
00524 template <Number T>
00525 bool isSameSign(T num1, T num2)
00526 {

```



```

00527     if (num1 * num2 > Vec3<T>::getThreshold())
00528         return true;
00529     return Vec3<T>::isNumEq(num1, 0) && Vec3<T>::isNumEq(num2, 0);
00530 }
00531
00532 template <std::floating_point T>
00533 bool isOnOneSide(const Plane<T> &pl, const Triangle<T> &tr)
00534 {
00535     std::array<T, 3> sdist{};
00536     for (size_t i = 0; i < 3; ++i)
00537         sdist[i] = distance(pl, tr[i]);
00538
00539     if (detail::isSameSign(sdist.begin(), sdist.end()))
00540         return true;
00541
00542     return false;
00543 }
00544
00545 template <std::floating_point T>
00546 Trian2<T> getTrian2(const Plane<T> &pl, const Triangle<T> &tr)
00547 {
00548     auto norm = pl.norm();
00549
00550     const Vec3<T> x{1, 0, 0};
00551     const Vec3<T> y{0, 1, 0};
00552     const Vec3<T> z{0, 0, 1};
00553
00554     std::array<Vec3<T>, 3> xyz{x, y, z};
00555     std::array<T, 3> xyzDot;
00556
00557     std::transform(xyz.begin(), xyz.end(), xyzDot.begin(),
00558         [&norm](const auto &axis) { return std::abs(dot(axis, norm)); });
00559
00560     auto maxIt = std::max_element(xyzDot.begin(), xyzDot.end());
00561     auto maxIdx = static_cast<size_t>(maxIt - xyzDot.begin());
00562
00563     Trian2<T> res;
00564     for (size_t i = 0; i < 3; ++i)
00565         for (size_t j = 0, k = 0; j < 2; ++j, ++k)
00566             {
00567                 if (k == maxIdx)
00568                     ++k;
00569
00570                 res[i][j] = tr[i][k];
00571             }
00572
00573     if (!isCounterClockwise(res))
00574         std::swap(res[0], res[1]);
00575
00576     return res;
00577 }
00578
00579 template <std::floating_point T>
00580 bool isCounterClockwise(Trian2<T> &tr)
00581 {
00582     /**
00583      * The triangle is counterclockwise ordered if \delta > 0
00584      * and clockwise ordered if \delta < 0.
00585      *
00586      *      + 1 1 1 +
00587      * \delta = det | x0 x1 x2 | = (x1 * y2 - x2 * y1) - (x0 * y2 - x2 * y0)
00588      *               + y0 y1 y2 +               + (x0 * y1 - x1 * y0)
00589      *
00590      */
00591
00592     auto x0 = tr[0][0], x1 = tr[1][0], x2 = tr[2][0];
00593     auto y0 = tr[0][1], y1 = tr[1][1], y2 = tr[2][1];
00594
00595     auto delta = (x1 * y2 - x2 * y1) - (x0 * y2 - x2 * y0) + (x0 * y1 - x1 * y0);
00596     return (delta > 0);
00597 }
00598
00599 template <std::floating_point T>
00600 Segment2D<T> computeInterval(const Trian2<T> &tr, const Vec2<T> &d)
00601 {
00602     auto init = dot(d, tr[0]);
00603     auto min = init;
00604     auto max = init;
00605
00606     for (size_t i = 1; i < 3; ++i)
00607         if (auto val = dot(d, tr[i]); val < min)
00608             min = val;
00609         else if (val > max)
00610             max = val;
00611
00612     return {min, max};
00613 }

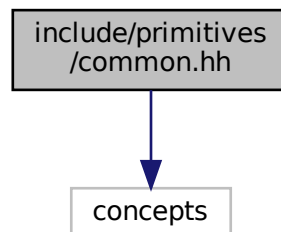
```

```
00614
00615 template <std::floating_point T>
00616 Segment3D<T> getSegment(const Triangle<T> &tr)
00617 {
00618     std::array<T, 3> lenArr{};
00619     for (size_t i = 0; i < 3; ++i)
00620         lenArr[i] = (tr[i] - tr[i + 1]).length2();
00621
00622     auto maxIt = std::max_element(lenArr.begin(), lenArr.end());
00623     auto maxIdx = static_cast<size_t>(maxIt - lenArr.begin());
00624
00625     return {tr[maxIdx], tr[maxIdx + 1]};
00626 }
00627
00628 } // namespace detail
00629 } // namespace geom
00630
00631 #endif // __INCLUDE_INTERSECTION_INTERSECTION_HH__
```

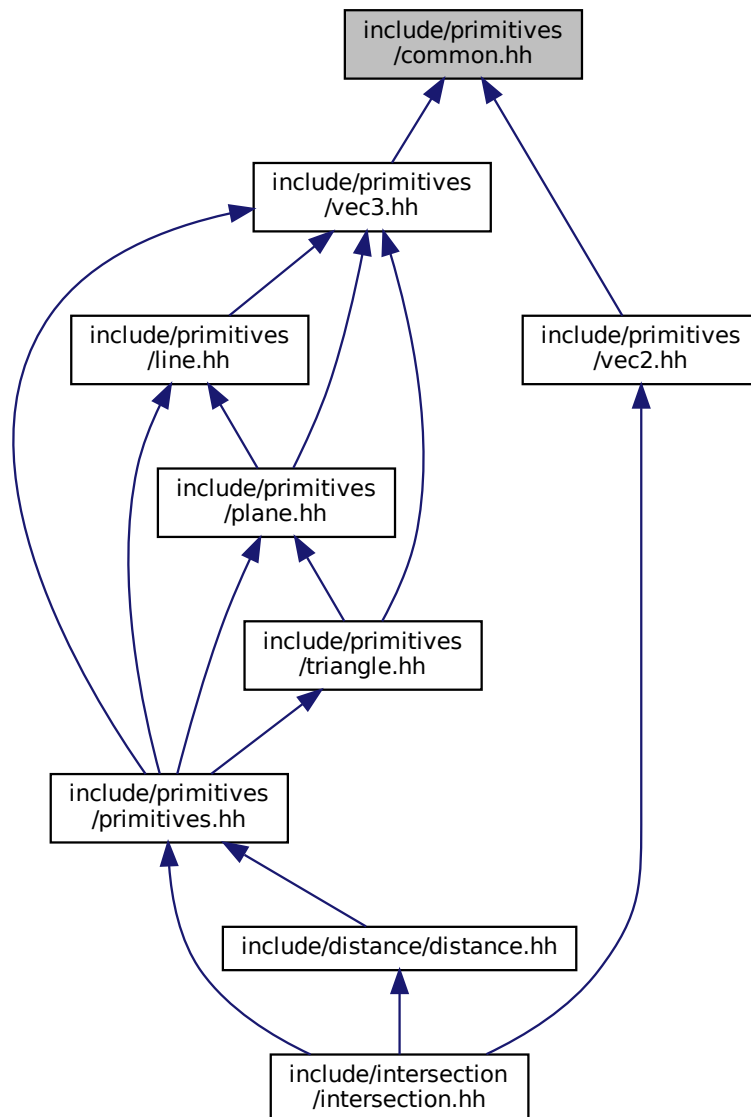
## 6.5 include/primitives/common.hh File Reference

```
#include <concepts>
```

Include dependency graph for common.hh:



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



## Namespaces

- [geom](#)  
*line.hh Line class implementation*

## 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.*

## 6.6 common.hh

```

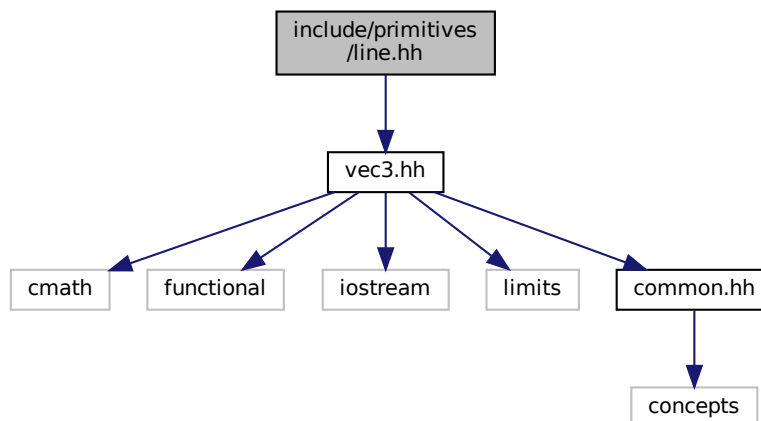
00001 #ifndef __INCLUDE_PRIMITIVES_COMMON_HH__
00002 #define __INCLUDE_PRIMITIVES_COMMON_HH__
00003
00004 #include <concepts>
00005
00006 namespace geom
00007 {
00008 /**
00009  * @concept Number
00010  * @brief Useful concept which represents floating point and integral types
00011  *
00012  * @tparam T
00013  */
00014 template <class T>
00015 concept Number = std::is_floating_point_v<T> || std::is_integral_v<T>;
00016
00017 } // namespace geom
00018
00019 #endif // __INCLUDE_PRIMITIVES_COMMON_HH__

```

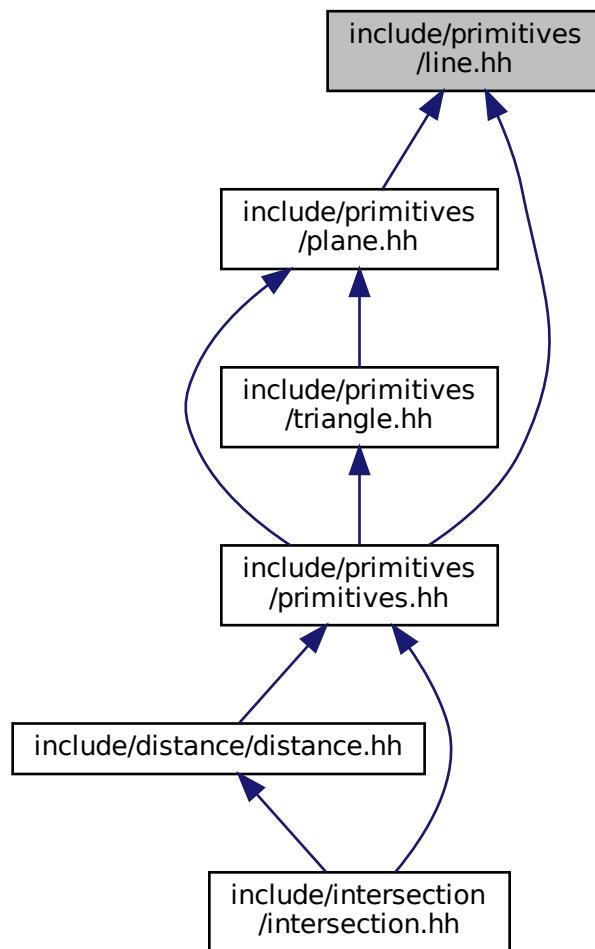
## 6.7 include/primitives/line.hh File Reference

```
#include "vec3.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.*

## 6.8 line.hh

```

00001 #ifndef __INCLUDE_PRIMITIVES_LINE_HH__
00002 #define __INCLUDE_PRIMITIVES_LINE_HH__
00003
00004 #include "vec3.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 Vec3<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 Vec3<T> &org, const Vec3<T> &dir);
00037
00038 /**
00039  * @brief Getter for origin vector
00040  *
00041  * @return const Vec3<T>& const reference to origin vector
00042  */
00043 const Vec3<T> &org() const;
00044
00045 /**
00046  * @brief Getter for direction vector
00047  *
00048  * @return const Vec3<T>& const reference to direction vector
00049  */
00050 const Vec3<T> &dir() const;
00051
00052 /**
00053  * @brief Get point on line by parameter t
00054  *
00055  * @tparam nType numeric type
00056  * @param[in] t point paramater from line's equation
00057  * @return Vec3<T> Point related to parameter
00058  */
00059 template <Number nType>
00060 Vec3<T> getPoint(nType t) const;
00061
00062 /**
00063  * @brief Checks is point belongs to line
00064  *
00065  * @param[in] point const reference to point vector
00066  * @return true if point belongs to line
00067  * @return false if point doesn't belong to line
00068  */
00069 bool belongs(const Vec3<T> &point) const;
00070
00071 /**
00072  * @brief Checks is *this equals to another line
00073  *
00074  * @param[in] line const reference to another line

```

```

00075     * @return true if lines are equal
00076     * @return false if lines are not equal
00077     */
00078     bool isEqual(const Line &line) const;
00079
00080     /**
00081     * @brief Checks is *this parallel to another line
00082     * @note Assumes equal lines as parallel
00083     * @param[in] line const reference to another line
00084     * @return true if lines are parallel
00085     * @return false if lines are not parallel
00086     */
00087     bool isPar(const Line &line) const;
00088
00089     /**
00090     * @brief Checks is *this is skew with another line
00091     *
00092     * @param[in] line const reference to another line
00093     * @return true if lines are skew
00094     * @return false if lines are not skew
00095     */
00096     bool isSkew(const Line<T> &line) const;
00097
00098     /**
00099     * @brief Get line by 2 points
00100     *
00101     * @param[in] p1 1st point
00102     * @param[in] p2 2nd point
00103     * @return Line passing through two points
00104     */
00105     static Line getBy2Points(const Vec3<T> &p1, const Vec3<T> &p2);
00106 };
00107
00108 /**
00109 * @brief Line print operator
00110 *
00111 * @tparam T - floating point type of coordinates
00112 * @param[in, out] ost output stream
00113 * @param[in] line Line to print
00114 * @return std::ostream& modified ostream instance
00115 */
00116 template <std::floating_point T>
00117 std::ostream &operator<<(std::ostream &ost, const Line<T> &line)
00118 {
00119     ost << line.org() << " + " << line.dir() << " * t";
00120     return ost;
00121 }
00122
00123 /**
00124 * @brief Line equality operator
00125 *
00126 * @tparam T - floating point type of coordinates
00127 * @param[in] lhs 1st line
00128 * @param[in] rhs 2nd line
00129 * @return true if lines are equal
00130 * @return false if lines are not equal
00131 */
00132 template <std::floating_point T>
00133 bool operator==(const Line<T> &lhs, const Line<T> &rhs)
00134 {
00135     return lhs.isEqual(rhs);
00136 }
00137
00138 template <std::floating_point T>
00139 Line<T>::Line(const Vec3<T> &org, const Vec3<T> &dir) : org_{org}, dir_{dir}
00140 {
00141     if (dir_ == Vec3<T>{0})
00142         throw std::logic_error{"Direction vector equals zero."};
00143 }
00144
00145 template <std::floating_point T>
00146 const Vec3<T> &Line<T>::org() const
00147 {
00148     return org_;
00149 }
00150
00151 template <std::floating_point T>
00152 const Vec3<T> &Line<T>::dir() const
00153 {
00154     return dir_;
00155 }
00156
00157 template <std::floating_point T>
00158 template <Number nType>
00159 Vec3<T> Line<T>::getPoint(nType t) const
00160 {
00161     return org_ + dir_ * t;

```

```

00162 }
00163
00164 template <std::floating_point T>
00165 bool Line<T>::belongs(const Vec3<T> &point) const
00166 {
00167     return dir_.cross(point - org_) == Vec3<T>{0};
00168 }
00169
00170 template <std::floating_point T>
00171 bool Line<T>::isEqual(const Line<T> &line) const
00172 {
00173     return belongs(line.org_) && dir_.isPar(line.dir_);
00174 }
00175
00176 template <std::floating_point T>
00177 bool Line<T>::isPar(const Line<T> &line) const
00178 {
00179     return dir_.isPar(line.dir_);
00180 }
00181
00182 template <std::floating_point T>
00183 bool Line<T>::isSkew(const Line<T> &line) const
00184 {
00185     auto res = triple(line.org_ - org_, dir_, line.dir_);
00186     return !Vec3<T>::isNumEq(res, T{0});
00187 }
00188
00189 template <std::floating_point T>
00190 Line<T> Line<T>::getBy2Points(const Vec3<T> &p1, const Vec3<T> &p2)
00191 {
00192     return Line<T>{p1, p2 - p1};
00193 }
00194
00195 } // namespace geom
00196
00197 #endif // __INCLUDE_PRIMITIVES_LINE_HH__

```

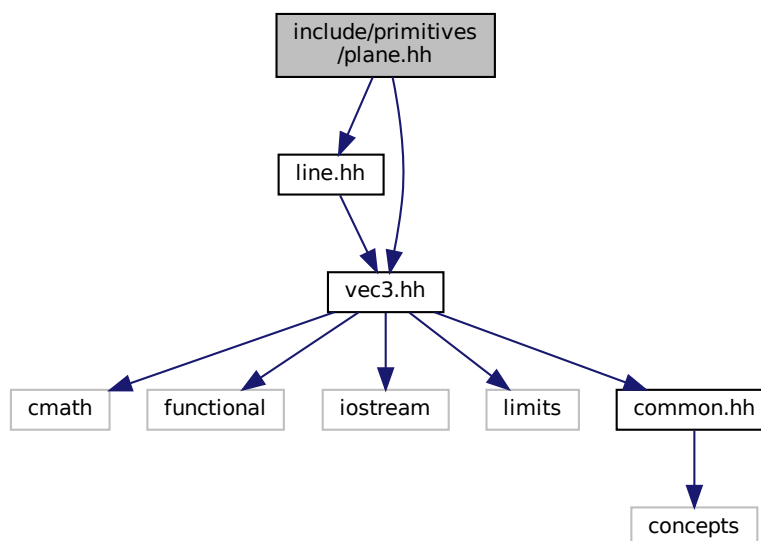
## 6.9 include/primitives/plane.hh File Reference

```

#include "line.hh"
#include "vec3.hh"

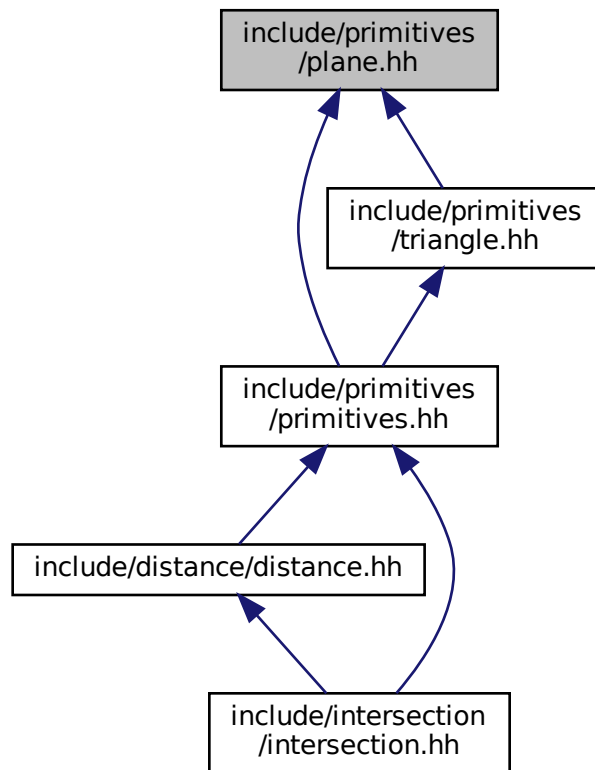
```

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.

## 6.10 plane.hh

```

00001 #ifndef __INCLUDE_PRIMITIVES_PLANE_HH__
00002 #define __INCLUDE_PRIMITIVES_PLANE_HH__
00003
00004 #include "line.hh"
00005 #include "vec3.hh"
00006
00007 /**
00008  * @brief
00009  * Plane class implementation
00010  */
00011
00012 namespace geom
00013 {
00014
00015 /**
00016  * @class Plane
00017  * @brief Plane class realization
00018  *
00019  * @tparam T - floating point type of coordinates
00020  */
00021 template <std::floating_point T>
00022 class Plane final
00023 {
00024 private:
00025     /**
00026      * @brief Normal vector, length equals to 1
00027      */
00028     Vec3<T> norm_{};
00029
00030     /**
00031      * @brief Distance from zero to plane
00032      */
00033     T dist_{};
00034
00035     /**
00036      * @brief Construct a new Plane object from normal vector and distance
00037      *
00038      * @param[in] norm normal vector
00039      * @param[in] dist distance from plane to zero
00040      */
00041     Plane(const Vec3<T> &norm, T dist);
00042
00043 public:
00044     /**
00045      * @brief Getter for distance
00046      *
00047      * @return T value of distance
00048      */
00049     T dist() const;
00050
00051     /**
00052      * @brief Getter for normal vector
00053      *
00054      * @return const Vec3<T>& const reference to normal vector
00055      */
00056     const Vec3<T> &norm() const;
00057
00058     /**
00059      * @brief Checks if point belongs to plane
00060      *
00061      * @param[in] point const referene to point vector
00062      * @return true if point belongs to plane
00063      * @return false if point doesn't belong to plane
00064      */
00065     bool belongs(const Vec3<T> &point) const;
00066
00067     /**
00068      * @brief Checks if line belongs to plane
00069      *
00070      * @param[in] line const referene to line
00071      * @return true if line belongs to plane
00072      * @return false if line doesn't belong to plane
00073      */
00074     bool belongs(const Line<T> &line) const;
00075
00076     /**
00077      * @brief Checks is *this equals to another plane
00078      *
00079      * @param[in] rhs const reference to another plane
00080      * @return true if planes are equal
00081      * @return false if planes are not equal
00082      */
00083     bool isEqual(const Plane &rhs) const;
00084
00085     /**

```

```

00086     * @brief Checks is *this is parallel to another plane
00087     *
00088     * @param[in] rhs const reference to another plane
00089     * @return true if planes are parallel
00090     * @return false if planes are not parallel
00091     */
00092     bool isPar(const Plane &rhs) const;
00093
00094     /**
00095     * @brief Get plane by 3 points
00096     *
00097     * @param[in] pt1 1st point
00098     * @param[in] pt2 2nd point
00099     * @param[in] pt3 3rd point
00100     * @return Plane passing through three points
00101     */
00102     static Plane getBy3Points(const Vec3<T> &pt1, const Vec3<T> &pt2, const Vec3<T> &pt3);
00103
00104     /**
00105     * @brief Get plane from parametric plane equation
00106     *
00107     * @param[in] org origin vector
00108     * @param[in] dir1 1st direction vector
00109     * @param[in] dir2 2nd direction vector
00110     * @return Plane
00111     */
00112     static Plane getParametric(const Vec3<T> &org, const Vec3<T> &dir1, const Vec3<T> &dir2);
00113
00114     /**
00115     * @brief Get plane from normal point plane equation
00116     *
00117     * @param[in] norm normal vector
00118     * @param[in] point point lying on the plane
00119     * @return Plane
00120     */
00121     static Plane getNormalPoint(const Vec3<T> &norm, const Vec3<T> &point);
00122
00123     /**
00124     * @brief Get plane form normal const plane equation
00125     *
00126     * @param[in] norm normal vector
00127     * @param[in] constant distance
00128     * @return Plane
00129     */
00130     static Plane getNormalDist(const Vec3<T> &norm, T constant);
00131 };
00132
00133 /**
00134 * @brief Plane equality operator
00135 *
00136 * @tparam T - floating point type of coordinates
00137 * @param[in] lhs 1st plane
00138 * @param[in] rhs 2nd plane
00139 * @return true if planes are equal
00140 * @return false if planes are not equal
00141 */
00142 template <std::floating_point T>
00143 bool operator==(const Plane<T> &lhs, const Plane<T> &rhs)
00144 {
00145     return lhs.isEqual(rhs);
00146 }
00147
00148 /**
00149 * @brief Plane print operator
00150 *
00151 * @tparam T - floating point type of coordinates
00152 * @param[in, out] ost output stream
00153 * @param[in] pl plane to print
00154 * @return std::ostream& modified ostream instance
00155 */
00156 template <std::floating_point T>
00157 std::ostream &operator<<(std::ostream &ost, const Plane<T> &pl)
00158 {
00159     ost << pl.norm() << " * X = " << pl.dist();
00160     return ost;
00161 }
00162
00163 template <std::floating_point T>
00164 Plane<T>::Plane(const Vec3<T> &norm, T dist) : norm_(norm), dist_(dist)
00165 {
00166     if (norm == Vec3<T>{0})
00167         throw std::logic_error{"normal vector equals to zero"};
00168 }
00169
00170 template <std::floating_point T>
00171 T Plane<T>::dist() const
00172 {

```

```

00173     return dist_;
00174 }
00175
00176 template <std::floating_point T>
00177 const Vec3<T> &Plane<T>::norm() const
00178 {
00179     return norm_;
00180 }
00181
00182 template <std::floating_point T>
00183 bool Plane<T>::belongs(const Vec3<T> &pt) const
00184 {
00185     return Vec3<T>::isNumEq(norm_.dot(pt), dist_);
00186 }
00187
00188 template <std::floating_point T>
00189 bool Plane<T>::belongs(const Line<T> &line) const
00190 {
00191     return norm_.isPerp(line.dir()) && belongs(line.org());
00192 }
00193
00194 template <std::floating_point T>
00195 bool Plane<T>::isEqual(const Plane &rhs) const
00196 {
00197     return (norm_ * dist_ == rhs.norm_ * rhs.dist_) && (norm_.isPar(rhs.norm_));
00198 }
00199
00200 template <std::floating_point T>
00201 bool Plane<T>::isPar(const Plane &rhs) const
00202 {
00203     return norm_.isPar(rhs.norm_);
00204 }
00205
00206 template <std::floating_point T>
00207 Plane<T> Plane<T>::getBy3Points(const Vec3<T> &pt1, const Vec3<T> &pt2, const Vec3<T> &pt3)
00208 {
00209     return getParametric(pt1, pt2 - pt1, pt3 - pt1);
00210 }
00211
00212 template <std::floating_point T>
00213 Plane<T> Plane<T>::getParametric(const Vec3<T> &org, const Vec3<T> &dir1, const Vec3<T> &dir2)
00214 {
00215     auto norm = dir1.cross(dir2);
00216     return getNormalPoint(norm, org);
00217 }
00218
00219 template <std::floating_point T>
00220 Plane<T> Plane<T>::getNormalPoint(const Vec3<T> &norm, const Vec3<T> &pt)
00221 {
00222     auto normalized = norm.normalized();
00223     return Plane{normalized, normalized.dot(pt)};
00224 }
00225
00226 template <std::floating_point T>
00227 Plane<T> Plane<T>::getNormalDist(const Vec3<T> &norm, T dist)
00228 {
00229     auto normalized = norm.normalized();
00230     return Plane{normalized, dist};
00231 }
00232
00233 } // namespace geom
00234
00235 #endif // __INCLUDE_PRIMITIVES_PLANE_HH__

```

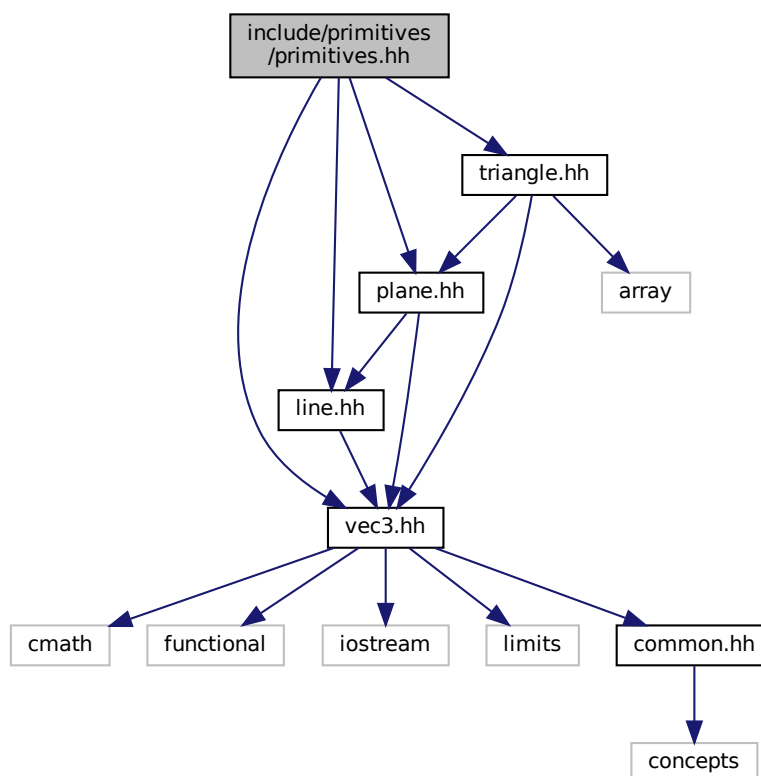
## 6.11 include/primitives/primitives.hh File Reference

```

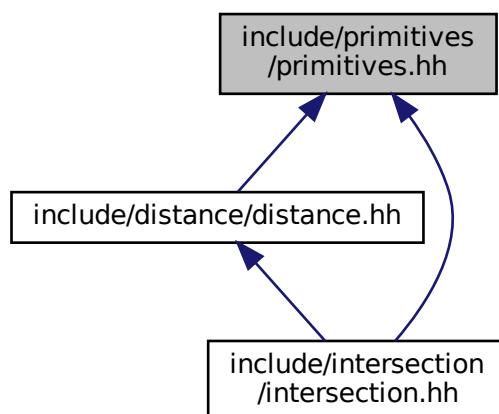
#include "line.hh"
#include "plane.hh"
#include "triangle.hh"
#include "vec3.hh"

```

Include dependency graph for primitives.hh:



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



## 6.12 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 "vec3.hh"
00008
00009 #endif // __INCLUDE_PRIMITIVES_PRIMITIVES_HH__

```

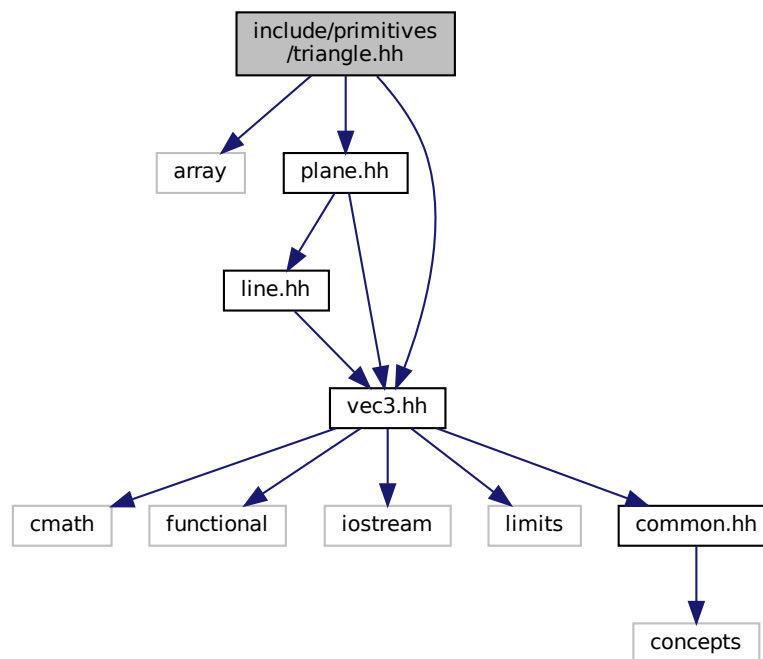
## 6.13 include/primitives/triangle.hh File Reference

```

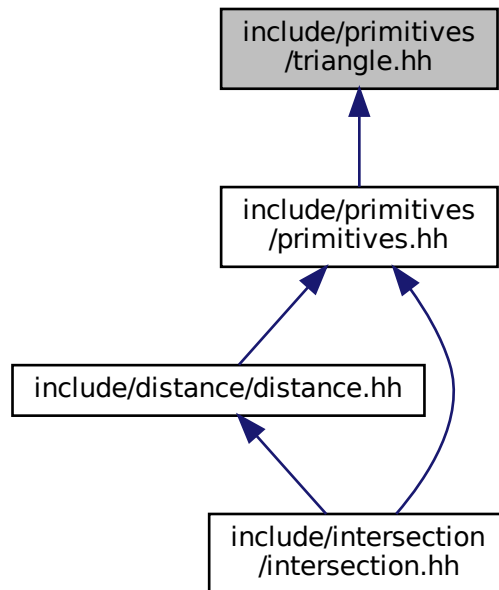
#include <array>
#include "plane.hh"
#include "vec3.hh"

```

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.
- template<std::floating\_point T>  
std::istream & [geom::operator>>](#) (std::istream &ist, Triangle< T > &tr)

## 6.14 triangle.hh

```

00001 #ifndef __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00002 #define __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00003
00004 #include <array>
00005
00006 #include "plane.hh"
00007 #include "vec3.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<Vec3<T>, 3> vertices_;
00031
00032 public:
00033     /**
00034      * @brief Construct a new Triangle object
00035      */
00036     Triangle();
00037
00038     /**
00039      * @brief Construct a new Triangle object from 3 points
00040      *
00041      * @param[in] p1 1st point
00042      * @param[in] p2 2nd point
00043      * @param[in] p3 3rd point
00044      */
00045     Triangle(const Vec3<T> &p1, const Vec3<T> &p2, const Vec3<T> &p3);
00046
00047     /**
00048      * @brief Overloaded operator[] to get access to vertices
00049      *
00050      * @param[in] idx index of vertex
00051      * @return const Vec3<T>& const reference to vertex
00052      */
00053     const Vec3<T> &operator[](std::size_t idx) const;
00054
00055     /**
00056      * @brief Overloaded operator[] to get access to vertices
00057      *
00058      * @param[in] idx index of vertex
00059      * @return Vec3<T>& reference to vertex
00060      */
00061     Vec3<T> &operator[](std::size_t idx);
00062
00063     /**
00064      * @brief Get triangle's plane
00065      *
00066      * @return Plane<T>
00067      */
00068     Plane<T> getPlane() const;
00069
00070     /**
00071      * @brief Check is triangle valid
00072      *
00073      * @return true if triangle is valid
00074      * @return false if triangle is invalid
00075      */
00076     bool isValid() const;
00077 };
00078
00079 /**
00080  * @brief Triangle print operator
00081  *
00082  * @tparam T - floating point type of coordinates
00083  * @param[in, out] ost output stream
00084  * @param[in] tr Triangle to print
00085  * @return std::ostream& modified ostream instance

```



```

00086  */
00087  template <std::floating_point T>
00088  std::ostream &operator<<(std::ostream &ost, const Triangle<T> &tr)
00089  {
00090      ost << "Triangle: {";
00091      for (size_t i = 0; i < 3; ++i)
00092          ost << tr[i] << (i == 2 ? " " : ", ");
00093
00094      ost << "}";
00095
00096      return ost;
00097  }
00098
00099  template <std::floating_point T>
00100  std::istream &operator>>(std::istream &ist, Triangle<T> &tr)
00101  {
00102      ist >> tr[0] >> tr[1] >> tr[2];
00103      return ist;
00104  }
00105
00106  template <std::floating_point T>
00107  Triangle<T>::Triangle() : vertices_()
00108  {}
00109
00110  template <std::floating_point T>
00111  Triangle<T>::Triangle(const Vec3<T> &p1, const Vec3<T> &p2, const Vec3<T> &p3)
00112      : vertices_{p1, p2, p3}
00113  {}
00114
00115  template <std::floating_point T>
00116  const Vec3<T> &Triangle<T>::operator[](std::size_t idx) const
00117  {
00118      return vertices_[idx % 3];
00119  }
00120
00121  template <std::floating_point T>
00122  Vec3<T> &Triangle<T>::operator[](std::size_t idx)
00123  {
00124      return vertices_[idx % 3];
00125  }
00126
00127  template <std::floating_point T>
00128  Plane<T> Triangle<T>::getPlane() const
00129  {
00130      return Plane<T>::getBy3Points(vertices_[0], vertices_[1], vertices_[2]);
00131  }
00132
00133  template <std::floating_point T>
00134  bool Triangle<T>::isValid() const
00135  {
00136      auto edge1 = vertices_[1] - vertices_[0];
00137      auto edge2 = vertices_[2] - vertices_[0];
00138
00139      auto cross12 = cross(edge1, edge2);
00140      return (cross12 != Vec3<T>{});
00141  }
00142
00143 } // namespace geom
00144
00145 #endif // __INCLUDE_PRIMITIVES_TRIANGLE_HH__

```

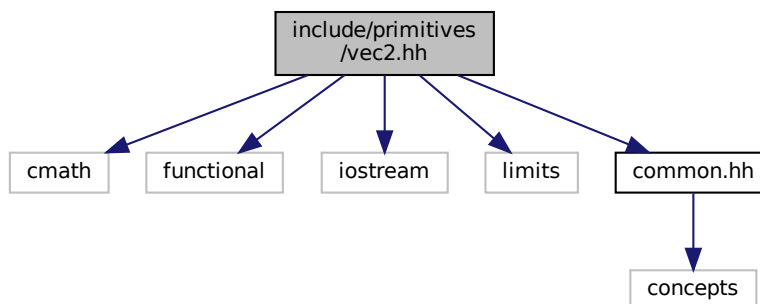
## 6.15 include/primitives/vec2.hh File Reference

```

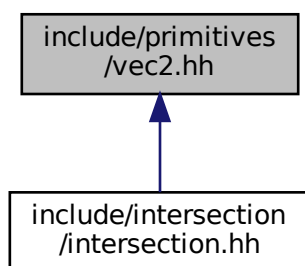
#include <cmath>
#include <functional>
#include <iostream>
#include <limits>
#include "common.hh"

```

Include dependency graph for `vec2.hh`:



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



## Classes

- class `geom::Vec2< T >`  
*Vec2 class realization.*

## Namespaces

- `geom`  
*line.hh Line class implementation*

## Typedefs

- using `geom::Vec2D` = `Vec2< double >`
- using `geom::Vec2F` = `Vec2< float >`

## Functions

- `template<std::floating_point T>`  
`Vec2< T > geom::operator+ (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Overloaded + operator.*
- `template<std::floating_point T>`  
`Vec2< T > geom::operator- (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Overloaded - operator.*
- `template<Number nT, std::floating_point T>`  
`Vec2< T > geom::operator* (const nT &val, const Vec2< T > &rhs)`  
*Overloaded multiple by value operator.*
- `template<Number nT, std::floating_point T>`  
`Vec2< T > geom::operator* (const Vec2< T > &lhs, const nT &val)`  
*Overloaded multiple by value operator.*
- `template<Number nT, std::floating_point T>`  
`Vec2< T > geom::operator/ (const Vec2< T > &lhs, const nT &val)`  
*Overloaded divide by value operator.*
- `template<std::floating_point T>`  
`T geom::dot (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Dot product function.*
- `template<std::floating_point T>`  
`bool geom::operator== (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Vec2 equality operator.*
- `template<std::floating_point T>`  
`bool geom::operator!= (const Vec2< T > &lhs, const Vec2< T > &rhs)`  
*Vec2 inequality operator.*
- `template<std::floating_point T>`  
`std::ostream & geom::operator<< (std::ostream &ost, const Vec2< T > &vec)`  
*Vec2 print operator.*

### 6.15.1 Detailed Description

Vec2 class implementation

Definition in file [vec2.hh](#).

## 6.16 vec2.hh

```
00001 #ifndef __INCLUDE_PRIMITIVES_VEC2_HH__
00002 #define __INCLUDE_PRIMITIVES_VEC2_HH__
00003
00004 #include <cmath>
00005 #include <functional>
00006 #include <iostream>
00007 #include <limits>
00008
00009 #include "common.hh"
00010
00011 /**
00012  * @file vec2.hh
00013  * Vec2 class implementation
00014  */
00015
00016 namespace geom
00017 {
00018
00019 /**
00020  * @class Vec2
00021  * @brief Vec2 class realization
```

```

00022  *
00023  * @tparam T - floating point type of coordinates
00024  */
00025  template <std::floating_point T>
00026  struct Vec2 final
00027  {
00028  private:
00029      /**
00030       * @brief Threshold static variable for numbers comparision
00031       */
00032       static inline T threshold_ = 1e3 * std::numeric_limits<T>::epsilon();
00033
00034  public:
00035      /**
00036       * @brief Vec2 coordinates
00037       */
00038       T x{}, y{};
00039
00040      /**
00041       * @brief Construct a new Vec2 object from 3 coordinates
00042       *
00043       * @param[in] coordX x coordinate
00044       * @param[in] coordY y coordinate
00045       */
00046       Vec2(T coordX, T coordY) : x(coordX), y(coordY)
00047       {}
00048
00049      /**
00050       * @brief Construct a new Vec2 object with equals coordinates
00051       *
00052       * @param[in] coordX coordinate (default to {})
00053       */
00054       explicit Vec2(T coordX = {}) : Vec2(coordX, coordX)
00055       {}
00056
00057      /**
00058       * @brief Overloaded += operator
00059       * Increments vector coordinates by corresponding coordinates of vec
00060       * @param[in] vec vector to incremented with
00061       * @return Vec2& reference to current instance
00062       */
00063       Vec2 &operator+=(const Vec2 &vec);
00064
00065      /**
00066       * @brief Overloaded -= operator
00067       * Decrements vector coordinates by corresponding coordinates of vec
00068       * @param[in] vec vector to decremented with
00069       * @return Vec2& reference to current instance
00070       */
00071       Vec2 &operator-=(const Vec2 &vec);
00072
00073      /**
00074       * @brief Unary - operator
00075       *
00076       * @return Vec2 negated Vec2 instance
00077       */
00078       Vec2 operator-() const;
00079
00080      /**
00081       * @brief Overloaded *= by number operator
00082       *
00083       * @tparam nType numeric type of value to multiply by
00084       * @param[in] val value to multiply by
00085       * @return Vec2& reference to vector instance
00086       */
00087       template <Number nType>
00088       Vec2 &operator*=(nType val);
00089
00090      /**
00091       * @brief Overloaded /= by number operator
00092       *
00093       * @tparam nType numeric type of value to divide by
00094       * @param[in] val value to divide by
00095       * @return Vec2& reference to vector instance
00096       *
00097       * @warning Does not check if val equals 0
00098       */
00099       template <Number nType>
00100       Vec2 &operator/=(nType val);
00101
00102      /**
00103       * @brief Dot product function
00104       *
00105       * @param rhs vector to dot product with
00106       * @return T dot product of two vectors
00107       */
00108       T dot(const Vec2 &rhs) const;

```

```

00109
00110 /**
00111  * @brief Calculate squared length of a vector function
00112  *
00113  * @return T length^2
00114  */
00115 T length2() const;
00116
00117 /**
00118  * @brief Calculate length of a vector function
00119  *
00120  * @return T length
00121  */
00122 T length() const;
00123
00124 /**
00125  * @brief Get the perpendicular to this vector
00126  *
00127  * @return Vec2 perpendicular vector
00128  */
00129 Vec2 getPerp() const;
00130
00131 /**
00132  * @brief Get normalized vector function
00133  *
00134  * @return Vec2 normalized vector
00135  */
00136 Vec2 normalized() const;
00137
00138 /**
00139  * @brief Normalize vector function
00140  *
00141  * @return Vec2& reference to instance
00142  */
00143 Vec2 &normalize();
00144
00145 /**
00146  * @brief Overloaded operator [] (non-const version)
00147  * To get access to coordinates
00148  * @param i index of coordinate (0 - x, 1 - y)
00149  * @return T& reference to coordinate value
00150  *
00151  * @note Coordinates calculated by mod 2
00152  */
00153 T &operator[](size_t i);
00154
00155 /**
00156  * @brief Overloaded operator [] (const version)
00157  * To get access to coordinates
00158  * @param i index of coordinate (0 - x, 1 - y)
00159  * @return T coordinate value
00160  *
00161  * @note Coordinates calculated by mod 2
00162  */
00163 T operator[](size_t i) const;
00164
00165 /**
00166  * @brief Check if vector is parallel to another
00167  *
00168  * @param[in] rhs vector to check parallelism with
00169  * @return true if vector is parallel
00170  * @return false otherwise
00171  */
00172 bool isPar(const Vec2 &rhs) const;
00173
00174 /**
00175  * @brief Check if vector is perpendicular to another
00176  *
00177  * @param[in] rhs vector to check perpendicularity with
00178  * @return true if vector is perpendicular
00179  * @return false otherwise
00180  */
00181 bool isPerp(const Vec2 &rhs) const;
00182
00183 /**
00184  * @brief Check if vector is equal to another
00185  *
00186  * @param[in] rhs vector to check equality with
00187  * @return true if vector is equal
00188  * @return false otherwise
00189  *
00190  * @note Equality check performs using isNumEq(T lhs, T rhs) function
00191  */
00192 bool isEqual(const Vec2 &rhs) const;
00193
00194 /**
00195  * @brief Check equality (with threshold) of two floating point numbers function

```

```

00196     *
00197     * @param[in] lhs first number
00198     * @param[in] rhs second number
00199     * @return true if numbers equals with threshold ( $|lhs - rhs| < threshold$ )
00200     * @return false otherwise
00201     *
00202     * @note Threshold defined by threshold_ static member
00203     */
00204     static bool isNumEq(T lhs, T rhs);
00205
00206     /**
00207     * @brief Set new threshold value
00208     *
00209     * @param[in] thres value to set
00210     */
00211     static void setThreshold(T thres);
00212
00213     /**
00214     * @brief Get current threshold value
00215     */
00216     static T getThreshold();
00217
00218     /**
00219     * @brief Set threshold to default value
00220     * @note default value equals float point epsilon
00221     */
00222     static void setDefThreshold();
00223 };
00224
00225 /**
00226 * @brief Overloaded + operator
00227 *
00228 * @tparam T vector template parameter
00229 * @param[in] lhs first vector
00230 * @param[in] rhs second vector
00231 * @return Vec2<T> sum of two vectors
00232 */
00233 template <std::floating_point T>
00234 Vec2<T> operator+(const Vec2<T> &lhs, const Vec2<T> &rhs)
00235 {
00236     Vec2<T> res{lhs};
00237     res += rhs;
00238     return res;
00239 }
00240
00241 /**
00242 * @brief Overloaded - operator
00243 *
00244 * @tparam T vector template parameter
00245 * @param[in] lhs first vector
00246 * @param[in] rhs second vector
00247 * @return Vec2<T> res of two vectors
00248 */
00249 template <std::floating_point T>
00250 Vec2<T> operator-(const Vec2<T> &lhs, const Vec2<T> &rhs)
00251 {
00252     Vec2<T> res{lhs};
00253     res -= rhs;
00254     return res;
00255 }
00256
00257 /**
00258 * @brief Overloaded multiple by value operator
00259 *
00260 * @tparam nT type of value to multiply by
00261 * @tparam T vector template parameter
00262 * @param[in] val value to multiply by
00263 * @param[in] rhs vector to multiply by value
00264 * @return Vec2<T> result vector
00265 */
00266 template <Number nT, std::floating_point T>
00267 Vec2<T> operator*(const nT &val, const Vec2<T> &rhs)
00268 {
00269     Vec2<T> res{rhs};
00270     res *= val;
00271     return res;
00272 }
00273
00274 /**
00275 * @brief Overloaded multiple by value operator
00276 *
00277 * @tparam nT type of value to multiply by
00278 * @tparam T vector template parameter
00279 * @param[in] val value to multiply by
00280 * @param[in] lhs vector to multiply by value
00281 * @return Vec2<T> result vector
00282 */

```

```

00283 template <Number nT, std::floating_point T>
00284 Vec2<T> operator*(const Vec2<T> &lhs, const nT &val)
00285 {
00286     Vec2<T> res{lhs};
00287     res *= val;
00288     return res;
00289 }
00290
00291 /**
00292  * @brief Overloaded divide by value operator
00293  *
00294  * @tparam nT type of value to divide by
00295  * @tparam T vector template parameter
00296  * @param[in] val value to divide by
00297  * @param[in] lhs vector to divide by value
00298  * @return Vec2<T> result vector
00299  */
00300 template <Number nT, std::floating_point T>
00301 Vec2<T> operator/(const Vec2<T> &lhs, const nT &val)
00302 {
00303     Vec2<T> res{lhs};
00304     res /= val;
00305     return res;
00306 }
00307
00308 /**
00309  * @brief Dot product function
00310  *
00311  * @tparam T vector template parameter
00312  * @param[in] lhs first vector
00313  * @param[in] rhs second vector
00314  * @return T dot production
00315  */
00316 template <std::floating_point T>
00317 T dot(const Vec2<T> &lhs, const Vec2<T> &rhs)
00318 {
00319     return lhs.dot(rhs);
00320 }
00321
00322 /**
00323  * @brief Vec2 equality operator
00324  *
00325  * @tparam T vector template parameter
00326  * @param[in] lhs first vector
00327  * @param[in] rhs second vector
00328  * @return true if vectors are equal
00329  * @return false otherwise
00330  */
00331 template <std::floating_point T>
00332 bool operator==(const Vec2<T> &lhs, const Vec2<T> &rhs)
00333 {
00334     return lhs.isEqual(rhs);
00335 }
00336
00337 /**
00338  * @brief Vec2 inequality operator
00339  *
00340  * @tparam T vector template parameter
00341  * @param[in] lhs first vector
00342  * @param[in] rhs second vector
00343  * @return true if vectors are not equal
00344  * @return false otherwise
00345  */
00346 template <std::floating_point T>
00347 bool operator!=(const Vec2<T> &lhs, const Vec2<T> &rhs)
00348 {
00349     return !(lhs == rhs);
00350 }
00351
00352 /**
00353  * @brief Vec2 print operator
00354  *
00355  * @tparam T vector template parameter
00356  * @param[in, out] ost output stream
00357  * @param[in] vec vector to print
00358  * @return std::ostream& modified stream instance
00359  */
00360 template <std::floating_point T>
00361 std::ostream &operator<<(std::ostream &ost, const Vec2<T> &vec)
00362 {
00363     ost << "(" << vec.x << ", " << vec.y << ")";
00364     return ost;
00365 }
00366
00367 using Vec2D = Vec2<double>;
00368 using Vec2F = Vec2<float>;
00369

```

```

00370 template <std::floating_point T>
00371 Vec2<T> &Vec2<T>::operator+=(const Vec2 &vec)
00372 {
00373     x += vec.x;
00374     y += vec.y;
00375     return *this;
00376 }
00377
00378 template <std::floating_point T>
00379 Vec2<T> &Vec2<T>::operator-=(const Vec2 &vec)
00380 {
00381     x -= vec.x;
00382     y -= vec.y;
00383     return *this;
00384 }
00385
00386 template <std::floating_point T>
00387 Vec2<T> Vec2<T>::operator-() const
00388 {
00389     return Vec2{-x, -y};
00390 }
00391
00392 template <std::floating_point T>
00393 template <Number nType>
00394 Vec2<T> &Vec2<T>::operator*=(nType val)
00395 {
00396     x *= val;
00397     y *= val;
00398     return *this;
00399 }
00400
00401 template <std::floating_point T>
00402 template <Number nType>
00403 Vec2<T> &Vec2<T>::operator/=(nType val)
00404 {
00405     x /= static_cast<T>(val);
00406     y /= static_cast<T>(val);
00407     return *this;
00408 }
00409
00410 template <std::floating_point T>
00411 T Vec2<T>::dot(const Vec2 &rhs) const
00412 {
00413     return x * rhs.x + y * rhs.y;
00414 }
00415
00416 template <std::floating_point T>
00417 T Vec2<T>::length2() const
00418 {
00419     return dot(*this);
00420 }
00421
00422 template <std::floating_point T>
00423 T Vec2<T>::length() const
00424 {
00425     return std::sqrt(length2());
00426 }
00427
00428 template <std::floating_point T>
00429 Vec2<T> Vec2<T>::getPerp() const
00430 {
00431     return {y, -x};
00432 }
00433
00434 template <std::floating_point T>
00435 Vec2<T> Vec2<T>::normalized() const
00436 {
00437     Vec2 res{*this};
00438     res.normalize();
00439     return res;
00440 }
00441
00442 template <std::floating_point T>
00443 Vec2<T> &Vec2<T>::normalize()
00444 {
00445     T len2 = length2();
00446     if (isNumEq(len2, 0) || isNumEq(len2, 1))
00447         return *this;
00448     return *this /= std::sqrt(len2);
00449 }
00450
00451 template <std::floating_point T>
00452 T &Vec2<T>::operator[](size_t i)

```



```

00457 {
00458     switch (i % 2)
00459     {
00460     case 0:
00461         return x;
00462     case 1:
00463         return y;
00464     default:
00465         throw std::logic_error{"Impossible case in operator[]\n"};
00466     }
00467 }
00468
00469 template <std::floating_point T>
00470 T Vec2<T>::operator[](size_t i) const
00471 {
00472     switch (i % 2)
00473     {
00474     case 0:
00475         return x;
00476     case 1:
00477         return y;
00478     default:
00479         throw std::logic_error{"Impossible case in operator[]\n"};
00480     }
00481 }
00482
00483 template <std::floating_point T>
00484 bool Vec2<T>::isPar(const Vec2 &rhs) const
00485 {
00486     auto det = x * rhs.y - rhs.x * y;
00487     return isNumEq(det, 0);
00488 }
00489
00490 template <std::floating_point T>
00491 bool Vec2<T>::isPerp(const Vec2 &rhs) const
00492 {
00493     return isNumEq(dot(rhs), 0);
00494 }
00495
00496 template <std::floating_point T>
00497 bool Vec2<T>::isEqual(const Vec2 &rhs) const
00498 {
00499     return isNumEq(x, rhs.x) && isNumEq(y, rhs.y);
00500 }
00501
00502 template <std::floating_point T>
00503 bool Vec2<T>::isNumEq(T lhs, T rhs)
00504 {
00505     return std::abs(rhs - lhs) < threshold_;
00506 }
00507
00508 template <std::floating_point T>
00509 void Vec2<T>::setThreshold(T thres)
00510 {
00511     threshold_ = thres;
00512 }
00513
00514 template <std::floating_point T>
00515 T Vec2<T>::getThreshold()
00516 {
00517     return threshold_;
00518 }
00519
00520 template <std::floating_point T>
00521 void Vec2<T>::setDefThreshold()
00522 {
00523     threshold_ = std::numeric_limits<T>::epsilon();
00524 }
00525
00526 } // namespace geom
00527
00528 #endif // __INCLUDE_PRIMITIVES_VEC2_HH__

```

## 6.17 include/primitives/vec3.hh File Reference

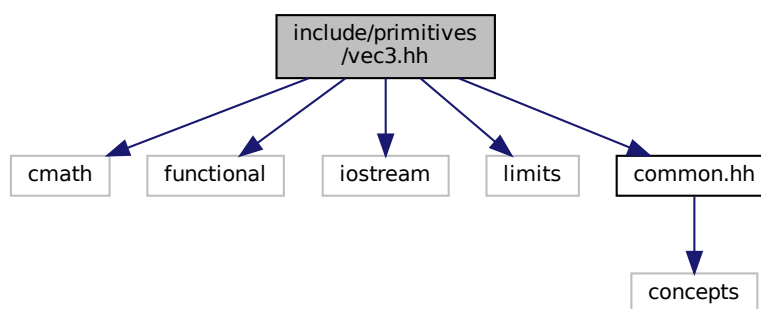
```

#include <cmath>
#include <functional>
#include <iostream>
#include <limits>

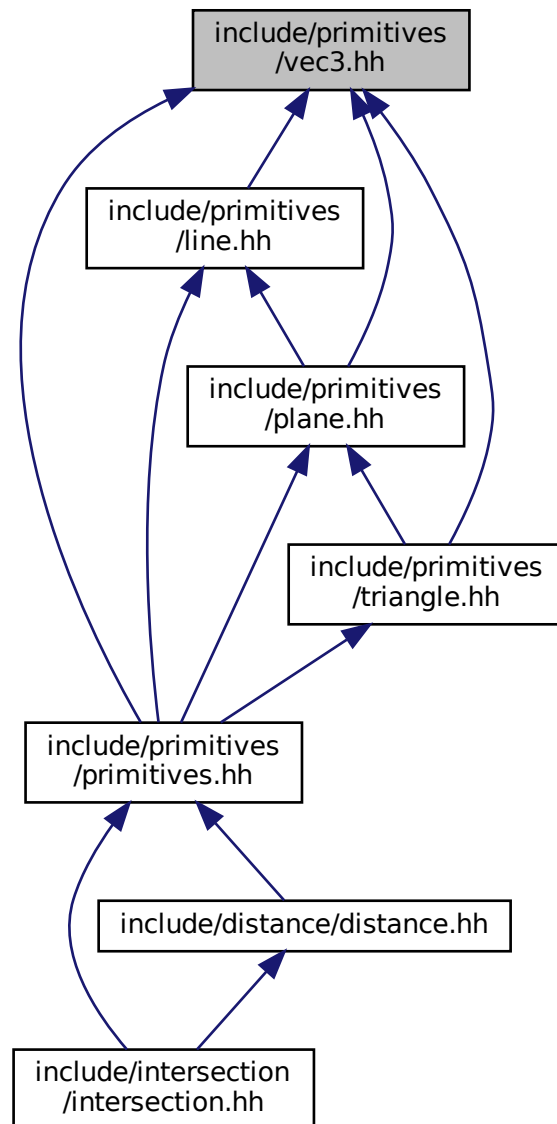
```

```
#include "common.hh"
```

Include dependency graph for vec3.hh:



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



## Classes

- class [geom::Vec3< T >](#)  
*Vec3 class realization.*

## Namespaces

- [geom](#)  
*line.hh Line class implementation*

## Typedefs

- using [geom::Vec3D](#) = Vec3< double >
- using [geom::Vec3F](#) = Vec3< float >

## Functions

- template<std::floating\_point T>  
Vec3< T > [geom::operator+](#) (const Vec3< T > &lhs, const Vec3< T > &rhs)  
*Overloaded + operator.*
- template<std::floating\_point T>  
Vec3< T > [geom::operator-](#) (const Vec3< T > &lhs, const Vec3< T > &rhs)  
*Overloaded - operator.*
- template<Number nT, std::floating\_point T>  
Vec3< T > [geom::operator\\*](#) (const nT &val, const Vec3< T > &rhs)  
*Overloaded multiple by value operator.*
- template<Number nT, std::floating\_point T>  
Vec3< T > [geom::operator\\*](#) (const Vec3< T > &lhs, const nT &val)  
*Overloaded multiple by value operator.*
- template<Number nT, std::floating\_point T>  
Vec3< T > [geom::operator/](#) (const Vec3< T > &lhs, const nT &val)  
*Overloaded divide by value operator.*
- template<std::floating\_point T>  
T [geom::dot](#) (const Vec3< T > &lhs, const Vec3< T > &rhs)  
*Dot product function.*
- template<std::floating\_point T>  
Vec3< T > [geom::cross](#) (const Vec3< T > &lhs, const Vec3< T > &rhs)  
*Cross product function.*
- template<std::floating\_point T>  
T [geom::triple](#) (const Vec3< T > &v1, const Vec3< T > &v2, const Vec3< T > &v3)  
*Triple product function.*
- template<std::floating\_point T>  
bool [geom::operator==](#) (const Vec3< T > &lhs, const Vec3< T > &rhs)  
*Vec3 equality operator.*
- template<std::floating\_point T>  
bool [geom::operator!=](#) (const Vec3< T > &lhs, const Vec3< T > &rhs)  
*Vec3 inequality operator.*
- template<std::floating\_point T>  
std::ostream & [geom::operator<<](#) (std::ostream &ost, const Vec3< T > &vec)  
*Vec3 print operator.*
- template<std::floating\_point T>  
std::istream & [geom::operator>>](#) (std::istream &ist, Vec3< T > &vec)  
*Vec3 scan operator.*

### 6.17.1 Detailed Description

Vec3 class implementation

Definition in file [vec3.hh](#).

## 6.18 vec3.hh

```

00001 #ifndef __INCLUDE_PRIMITIVES_VEC3_HH__
00002 #define __INCLUDE_PRIMITIVES_VEC3_HH__
00003
00004 #include <cmath>
00005 #include <functional>
00006 #include <iostream>
00007 #include <limits>
00008
00009 #include "common.hh"
00010
00011 /**
00012  * @file vec3.hh
00013  * Vec3 class implementation
00014  */
00015
00016 namespace geom
00017 {
00018
00019 /**
00020  * @class Vec3
00021  * @brief Vec3 class realization
00022  *
00023  * @tparam T - floating point type of coordinates
00024  */
00025 template <std::floating_point T>
00026 struct Vec3 final
00027 {
00028 private:
00029     /**
00030      * @brief Threshold static variable for numbers comparision
00031      */
00032     static inline T threshold_ = 1e3 * std::numeric_limits<T>::epsilon();
00033
00034 public:
00035     /**
00036      * @brief Vec3 coordinates
00037      */
00038     T x{}, y{}, z{};
00039
00040     /**
00041      * @brief Construct a new Vec3 object from 3 coordinates
00042      *
00043      * @param[in] coordX x coordinate
00044      * @param[in] coordY y coordinate
00045      * @param[in] coordZ z coordinate
00046      */
00047     Vec3(T coordX, T coordY, T coordZ) : x(coordX), y(coordY), z(coordZ)
00048     {}
00049
00050     /**
00051      * @brief Construct a new Vec3 object with equals coordinates
00052      *
00053      * @param[in] coordX coordinate (default to {})
00054      */
00055     explicit Vec3(T coordX = {}) : Vec3(coordX, coordX, coordX)
00056     {}
00057
00058     /**
00059      * @brief Overloaded += operator
00060      * Increments vector coordinates by corresponding coordinates of vec
00061      * @param[in] vec vector to incremented with
00062      * @return Vec3& reference to current instance
00063      */
00064     Vec3 &operator+=(const Vec3 &vec);
00065
00066     /**
00067      * @brief Overloaded -= operator
00068      * Decrements vector coordinates by corresponding coordinates of vec
00069      * @param[in] vec vector to decremented with
00070      * @return Vec3& reference to current instance
00071      */
00072     Vec3 &operator-=(const Vec3 &vec);
00073
00074     /**
00075      * @brief Unary - operator
00076      *
00077      * @return Vec3 negated Vec3 instance
00078      */
00079     Vec3 operator-() const;
00080
00081     /**
00082      * @brief Overloaded *= by number operator
00083      *
00084      * @tparam nType numeric type of value to multiply by
00085      * @param[in] val value to multiply by

```

```

00086     * @return Vec3& reference to vector instance
00087     */
00088     template <Number nType>
00089     Vec3 &operator*=(nType val);
00090
00091     /**
00092     * @brief Overloaded /= by number operator
00093     *
00094     * @tparam nType numeric type of value to divide by
00095     * @param[in] val value to divide by
00096     * @return Vec3& reference to vector instance
00097     *
00098     * @warning Does not check if val equals 0
00099     */
00100     template <Number nType>
00101     Vec3 &operator/=(nType val);
00102
00103     /**
00104     * @brief Dot product function
00105     *
00106     * @param rhs vector to dot product with
00107     * @return T dot product of two vectors
00108     */
00109     T dot(const Vec3 &rhs) const;
00110
00111     /**
00112     * @brief Cross product function
00113     *
00114     * @param rhs vector to cross product with
00115     * @return Vec3 cross product of two vectors
00116     */
00117     Vec3 cross(const Vec3 &rhs) const;
00118
00119     /**
00120     * @brief Calculate squared length of a vector function
00121     *
00122     * @return T length^2
00123     */
00124     T length2() const;
00125
00126     /**
00127     * @brief Calculate length of a vector function
00128     *
00129     * @return T length
00130     */
00131     T length() const;
00132
00133     /**
00134     * @brief Get normalized vector function
00135     *
00136     * @return Vec3 normalized vector
00137     */
00138     Vec3 normalized() const;
00139
00140     /**
00141     * @brief Normalize vector function
00142     *
00143     * @return Vec3& reference to instance
00144     */
00145     Vec3 &normalize();
00146
00147     /**
00148     * @brief Overloaded operator [] (non-const version)
00149     * To get access to coordinates
00150     * @param i index of coordinate (0 - x, 1 - y, 2 - z)
00151     * @return T& reference to coordinate value
00152     *
00153     * @note Coordinates calculated by mod 3
00154     */
00155     T &operator[](size_t i);
00156
00157     /**
00158     * @brief Overloaded operator [] (const version)
00159     * To get access to coordinates
00160     * @param i index of coordinate (0 - x, 1 - y, 2 - z)
00161     * @return T coordinate value
00162     *
00163     * @note Coordinates calculated by mod 3
00164     */
00165     T operator[](size_t i) const;
00166
00167     /**
00168     * @brief Check if vector is parallel to another
00169     *
00170     * @param[in] rhs vector to check parallelism with
00171     * @return true if vector is parallel
00172     * @return false otherwise

```

```

00173     */
00174     bool isPar(const Vec3 &rhs) const;
00175
00176     /**
00177      * @brief Check if vector is perpendicular to another
00178      *
00179      * @param[in] rhs vector to check perpendicularity with
00180      * @return true if vector is perpendicular
00181      * @return false otherwise
00182     */
00183     bool isPerp(const Vec3 &rhs) const;
00184
00185     /**
00186      * @brief Check if vector is equal to another
00187      *
00188      * @param[in] rhs vector to check equality with
00189      * @return true if vector is equal
00190      * @return false otherwise
00191     */
00192     * @note Equality check performs using isNumEq(T lhs, T rhs) function
00193     */
00194     bool isEqual(const Vec3 &rhs) const;
00195
00196     /**
00197      * @brief Check equality (with threshold) of two floating point numbers function
00198      *
00199      * @param[in] lhs first number
00200      * @param[in] rhs second number
00201      * @return true if numbers equals with threshold (|lhs - rhs| < threshold)
00202      * @return false otherwise
00203     */
00204     * @note Threshold defined by threshold_ static member
00205     */
00206     static bool isNumEq(T lhs, T rhs);
00207
00208     /**
00209      * @brief Set new threshold value
00210      *
00211      * @param[in] thres value to set
00212     */
00213     static void setThreshold(T thres);
00214
00215     /**
00216      * @brief Get current threshold value
00217     */
00218     static T getThreshold();
00219
00220     /**
00221      * @brief Set threshold to default value
00222      * @note default value equals float point epsilon
00223     */
00224     static void setDefThreshold();
00225 };
00226
00227 /**
00228  * @brief Overloaded + operator
00229  *
00230  * @tparam T vector template parameter
00231  * @param[in] lhs first vector
00232  * @param[in] rhs second vector
00233  * @return Vec3<T> sum of two vectors
00234  */
00235 template <std::floating_point T>
00236 Vec3<T> operator+(const Vec3<T> &lhs, const Vec3<T> &rhs)
00237 {
00238     Vec3<T> res{lhs};
00239     res += rhs;
00240     return res;
00241 }
00242
00243 /**
00244  * @brief Overloaded - operator
00245  *
00246  * @tparam T vector template parameter
00247  * @param[in] lhs first vector
00248  * @param[in] rhs second vector
00249  * @return Vec3<T> res of two vectors
00250  */
00251 template <std::floating_point T>
00252 Vec3<T> operator-(const Vec3<T> &lhs, const Vec3<T> &rhs)
00253 {
00254     Vec3<T> res{lhs};
00255     res -= rhs;
00256     return res;
00257 }
00258
00259 /**

```

```

00260 * @brief Overloaded multiple by value operator
00261 *
00262 * @tparam nT type of value to multiply by
00263 * @tparam T vector template parameter
00264 * @param[in] val value to multiply by
00265 * @param[in] rhs vector to multiply by value
00266 * @return Vec3<T> result vector
00267 */
00268 template <Number nT, std::floating_point T>
00269 Vec3<T> operator*(const nT &val, const Vec3<T> &rhs)
00270 {
00271     Vec3<T> res{rhs};
00272     res *= val;
00273     return res;
00274 }
00275
00276 /**
00277 * @brief Overloaded multiple by value operator
00278 *
00279 * @tparam nT type of value to multiply by
00280 * @tparam T vector template parameter
00281 * @param[in] val value to multiply by
00282 * @param[in] lhs vector to multiply by value
00283 * @return Vec3<T> result vector
00284 */
00285 template <Number nT, std::floating_point T>
00286 Vec3<T> operator*(const Vec3<T> &lhs, const nT &val)
00287 {
00288     Vec3<T> res{lhs};
00289     res *= val;
00290     return res;
00291 }
00292
00293 /**
00294 * @brief Overloaded divide by value operator
00295 *
00296 * @tparam nT type of value to divide by
00297 * @tparam T vector template parameter
00298 * @param[in] val value to divide by
00299 * @param[in] lhs vector to divide by value
00300 * @return Vec3<T> result vector
00301 */
00302 template <Number nT, std::floating_point T>
00303 Vec3<T> operator/(const Vec3<T> &lhs, const nT &val)
00304 {
00305     Vec3<T> res{lhs};
00306     res /= val;
00307     return res;
00308 }
00309
00310 /**
00311 * @brief Dot product function
00312 *
00313 * @tparam T vector template parameter
00314 * @param[in] lhs first vector
00315 * @param[in] rhs second vector
00316 * @return T dot production
00317 */
00318 template <std::floating_point T>
00319 T dot(const Vec3<T> &lhs, const Vec3<T> &rhs)
00320 {
00321     return lhs.dot(rhs);
00322 }
00323
00324 /**
00325 * @brief Cross product function
00326 *
00327 * @tparam T vector template parameter
00328 * @param[in] lhs first vector
00329 * @param[in] rhs second vector
00330 * @return T cross production
00331 */
00332 template <std::floating_point T>
00333 Vec3<T> cross(const Vec3<T> &lhs, const Vec3<T> &rhs)
00334 {
00335     return lhs.cross(rhs);
00336 }
00337
00338 /**
00339 * @brief Triple product function
00340 *
00341 * @tparam T vector template parameter
00342 * @param[in] v1 first vector
00343 * @param[in] v2 second vector
00344 * @param[in] v3 third vector
00345 * @return T triple production
00346 */

```



```

00347 template <std::floating_point T>
00348 T triple(const Vec3<T> &v1, const Vec3<T> &v2, const Vec3<T> &v3)
00349 {
00350     return dot(v1, cross(v2, v3));
00351 }
00352
00353 /**
00354  * @brief Vec3 equality operator
00355  *
00356  * @tparam T vector template parameter
00357  * @param[in] lhs first vector
00358  * @param[in] rhs second vector
00359  * @return true if vectors are equal
00360  * @return false otherwise
00361  */
00362 template <std::floating_point T>
00363 bool operator==(const Vec3<T> &lhs, const Vec3<T> &rhs)
00364 {
00365     return lhs.isEqual(rhs);
00366 }
00367
00368 /**
00369  * @brief Vec3 inequality operator
00370  *
00371  * @tparam T vector template parameter
00372  * @param[in] lhs first vector
00373  * @param[in] rhs second vector
00374  * @return true if vectors are not equal
00375  * @return false otherwise
00376  */
00377 template <std::floating_point T>
00378 bool operator!=(const Vec3<T> &lhs, const Vec3<T> &rhs)
00379 {
00380     return !(lhs == rhs);
00381 }
00382
00383 /**
00384  * @brief Vec3 print operator
00385  *
00386  * @tparam T vector template parameter
00387  * @param[in, out] ost output stream
00388  * @param[in] vec vector to print
00389  * @return std::ostream& modified stream instance
00390  */
00391 template <std::floating_point T>
00392 std::ostream &operator<<(std::ostream &ost, const Vec3<T> &vec)
00393 {
00394     ost << "(" << vec.x << ", " << vec.y << ", " << vec.z << ")";
00395     return ost;
00396 }
00397
00398 /**
00399  * @brief Vec3 scan operator
00400  *
00401  * @tparam T vector template parameter
00402  * @param[in, out] ist input stream
00403  * @param[in, out] vec vector to scan
00404  * @return std::istream& modified stream instance
00405  */
00406 template <std::floating_point T>
00407 std::istream &operator>>(std::istream &ist, Vec3<T> &vec)
00408 {
00409     ist >> vec.x >> vec.y >> vec.z;
00410     return ist;
00411 }
00412
00413 using Vec3D = Vec3<double>;
00414 using Vec3F = Vec3<float>;
00415
00416 template <std::floating_point T>
00417 Vec3<T> &Vec3<T>::operator+=(const Vec3 &vec)
00418 {
00419     x += vec.x;
00420     y += vec.y;
00421     z += vec.z;
00422     return *this;
00423 }
00424
00425 template <std::floating_point T>
00426 Vec3<T> &Vec3<T>::operator-=(const Vec3 &vec)
00427 {
00428     x -= vec.x;
00429     y -= vec.y;
00430     z -= vec.z;
00431     return *this;
00432 }
00433

```

```

00434 }
00435
00436 template <std::floating_point T>
00437 Vec3<T> Vec3<T>::operator-() const
00438 {
00439     return Vec3{-x, -y, -z};
00440 }
00441
00442 template <std::floating_point T>
00443 template <Number nType>
00444 Vec3<T> &Vec3<T>::operator*=(nType val)
00445 {
00446     x *= val;
00447     y *= val;
00448     z *= val;
00449     return *this;
00450 }
00451
00452
00453 template <std::floating_point T>
00454 template <Number nType>
00455 Vec3<T> &Vec3<T>::operator/=(nType val)
00456 {
00457     x /= static_cast<T>(val);
00458     y /= static_cast<T>(val);
00459     z /= static_cast<T>(val);
00460     return *this;
00461 }
00462
00463
00464 template <std::floating_point T>
00465 T Vec3<T>::dot(const Vec3 &rhs) const
00466 {
00467     return x * rhs.x + y * rhs.y + z * rhs.z;
00468 }
00469
00470 template <std::floating_point T>
00471 Vec3<T> Vec3<T>::cross(const Vec3 &rhs) const
00472 {
00473     return Vec3{y * rhs.z - z * rhs.y, z * rhs.x - x * rhs.z, x * rhs.y - y * rhs.x};
00474 }
00475
00476 template <std::floating_point T>
00477 T Vec3<T>::length2() const
00478 {
00479     return dot(*this);
00480 }
00481
00482 template <std::floating_point T>
00483 T Vec3<T>::length() const
00484 {
00485     return std::sqrt(length2());
00486 }
00487
00488 template <std::floating_point T>
00489 Vec3<T> Vec3<T>::normalized() const
00490 {
00491     Vec3 res{*this};
00492     res.normalize();
00493     return res;
00494 }
00495
00496 template <std::floating_point T>
00497 Vec3<T> &Vec3<T>::normalize()
00498 {
00499     T len2 = length2();
00500     if (isNumEq(len2, 0) || isNumEq(len2, 1))
00501         return *this;
00502     return *this /= std::sqrt(len2);
00503 }
00504
00505 template <std::floating_point T>
00506 T &Vec3<T>::operator[](size_t i)
00507 {
00508     switch (i % 3)
00509     {
00510     case 0:
00511         return x;
00512     case 1:
00513         return y;
00514     case 2:
00515         return z;
00516     default:
00517         throw std::logic_error{"Impossible case in operator[]\n"};
00518     }
00519 }
00520

```

```

00521 template <std::floating_point T>
00522 T Vec3<T>::operator[](size_t i) const
00523 {
00524     switch (i % 3)
00525     {
00526     case 0:
00527         return x;
00528     case 1:
00529         return y;
00530     case 2:
00531         return z;
00532     default:
00533         throw std::logic_error{"Impossible case in operator[]\n"};
00534     }
00535 }
00536
00537 template <std::floating_point T>
00538 bool Vec3<T>::isPar(const Vec3 &rhs) const
00539 {
00540     return cross(rhs).isEqual(Vec3<T>{0});
00541 }
00542
00543 template <std::floating_point T>
00544 bool Vec3<T>::isPerp(const Vec3 &rhs) const
00545 {
00546     return isNumEq(dot(rhs), 0);
00547 }
00548
00549 template <std::floating_point T>
00550 bool Vec3<T>::isEqual(const Vec3 &rhs) const
00551 {
00552     return isNumEq(x, rhs.x) && isNumEq(y, rhs.y) && isNumEq(z, rhs.z);
00553 }
00554
00555 template <std::floating_point T>
00556 bool Vec3<T>::isNumEq(T lhs, T rhs)
00557 {
00558     return std::abs(rhs - lhs) < threshold_;
00559 }
00560
00561 template <std::floating_point T>
00562 void Vec3<T>::setThreshold(T thres)
00563 {
00564     threshold_ = thres;
00565 }
00566
00567 template <std::floating_point T>
00568 T Vec3<T>::getThreshold()
00569 {
00570     return threshold_;
00571 }
00572
00573 template <std::floating_point T>
00574 void Vec3<T>::setDefThreshold()
00575 {
00576     threshold_ = std::numeric_limits<T>::epsilon();
00577 }
00578
00579 } // namespace geom
00580
00581 #endif // __INCLUDE_PRIMITIVES_VEC3_HH__

```

