Triangles

1.0.1

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Chapter 1

Namespace Index

1.1 Namespace List

Here is a list of all namespaces with brief descriptions:

Chapter 2

Class Index

2.1 Class List

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

Chapter 3

File Index

3.1 File List

Here is a list of all files with brief descriptions:

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 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 > > 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

T	- floating point type of coordinates

Parameters

pl	plane
pt	point

Returns

T signed distance between point and plane

Definition at line 26 of file distance.hh.

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

Referenced by geom::detail::helperMollerHaines(), 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

T	- floating point type of coordinates

Parameters

tr1	first triangle
tr2	second triangle

Returns

true if triangles are intersect

false if triangles are not intersect

Definition at line 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 $\overrightarrow{P}$ - point in space

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

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

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

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

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

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

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

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

Let's find a and b:

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

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

Intersection line equation:

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

Template Parameters

T	- floating point type of coordinates

Parameters

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 $\overrightarrow{P}$ - point in space, intersection point of two lines.

l_1 equation: $\overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 = \overrightarrow{P}$

l_2 equation: $\overrightarrow{org}_2 + \overrightarrow{dir}_2 \cdot t_2 = \overrightarrow{P}$

Let's equate left sides:

$$\overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 = \overrightarrow{org}_2 + \overrightarrow{dir}_2 \cdot t_2$$

Cross multiply both sides from right by $\overrightarrow{dir}_2$:

$$t_1 \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right) = (\overrightarrow{org}_2 - \overrightarrow{org}_1) \times \overrightarrow{dir}_2$$

Dot multiply both sides by $\frac{\overrightarrow{dir}_1 \times \overrightarrow{dir}_2}{\left|\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right|^2}$:

$$t_1 = \frac{\left((\overrightarrow{org}_2 - \overrightarrow{org}_1) \times \overrightarrow{dir}_2\right) \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right)}{\left|\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right|^2}$$

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

$$\overrightarrow{P} = \overrightarrow{org}_1 + \frac{\left((\overrightarrow{org}_2 - \overrightarrow{org}_1) \times \overrightarrow{dir}_2\right) \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right)}{\left|\overrightarrow{dir}_1 \times \overrightarrow{dir}_2\right|^2} \cdot \overrightarrow{dir}_1$$

Template Parameters

T	- floating point type of coordinates

Parameters

in	*l1*	first line

Parameters

in	*l2*	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

T	- floating point type of coordinates

Parameters

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

Returns

std::ostream& modified ostream instance

Definition at line 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

T	- floating point type of coordinates

Parameters

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

Returns

true if lines are equal

false if lines are not equal

Definition at line 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

T	- floating point type of coordinates

Parameters

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

Returns

true if planes are equal

false if planes are not equal

Definition at line 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

T	- floating point type of coordinates

Parameters

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

Returns

std::ostream& modified ostream instance

Definition at line 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

T	- floating point type of coordinates

Parameters

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

Returns

std::ostream& modified ostream instance

Definition at line 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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

nT	type of value to multiply by
T	vector template parameter

Parameters

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

Returns

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

nT	type of value to multiply by
T	vector template parameter

Parameters

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

Returns

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

nT	type of value to divide by
T	vector template parameter

Parameters

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

Returns

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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

T	vector template parameter

Parameters

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

Returns

true if vectors are not equal

false otherwise

Definition at line 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

T	vector template parameter

Parameters

in,out	*ost*	output stream
in	*vec*	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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

nT	type of value to multiply by
T	vector template parameter

Parameters

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

Returns

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

nT	type of value to multiply by
T	vector template parameter

Parameters

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

Returns

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

nT	type of value to divide by
T	vector template parameter

Parameters

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

Returns

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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

T	vector template parameter

Parameters

in	*v1*	first vector
in	*v2*	second vector
in	*v3*	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

T	vector template parameter

Parameters

in	*lhs*	first vector
in	*rhs*	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

T	vector template parameter

Parameters

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

Returns

true if vectors are not equal

false otherwise

Definition at line 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

T	vector template parameter

Parameters

in,out	*ost*	output stream
in	*vec*	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

T	vector template parameter

Parameters

in,out	*ist*	input stram
in,out	*vec*	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

T	

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 482 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 506 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 512 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 518 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 531 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 539 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 552 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 586 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 606 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 622 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

T	- floating point type of coordinates

Definition at line 21 of file line.hh.

5.1.2 Constructor & Destructor Documentation

5.1.2.1 Line()

```
template<std::floating_point T>
geom::Line< T >::Line (
            const Vec3< T > & org,
            const Vec3< T > & dir )
```

Construct a new Line object.

Parameters

in	*org*	origin vector
in	*dir*	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

nType	numeric type

Parameters

in	*t*	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	*point*	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	*line*	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

in	*line*	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

in	*line*	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	*p1*	1st point
in	*p2*	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

T	- 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	*point*	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	*line*	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	*rhs*	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	*org*	origin vector
in	*dir1*	1st direction vector
in	*dir2*	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	*norm*	normal vector
in	*point*	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	*norm*	normal vector
in	*constant*	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< T > Class Template Reference

Triangle class implementation.

`#include <triangle.hh>`

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

T	- floating point type of coordinates

Definition at line 24 of file triangle.hh.

5.3.2 Constructor & Destructor Documentation

5.3.2.1 Triangle() [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	*p1*	1st point
in	*p2*	2nd point
in	*p3*	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	*idx*	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	*idx*	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

T	- 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	*coordX*	x coordinate
in	*coordY*	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	*coordX*	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	*vec*	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	*vec*	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

nType	numeric type of value to multiply by

Parameters

in	*val*	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

nType	numeric type of value to divide by

Parameters

in	*val*	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

rhs	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 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 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	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	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

in	*rhs*	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

in	*rhs*	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

in	*rhs*	vector to check equality with

Returns

true if vector is equal

false otherwise

Note

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

Definition at line 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	*lhs*	first number
in	*rhs*	second number

Returns

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

false otherwise

Note

Threshold defined by threshold_ static member

Definition at line 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	*thres*	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< T > 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

T	- 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	*coordX*	x coordinate
in	*coordY*	y coordinate
in	*coordZ*	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	*coordX*	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

nType	numeric type of value to multiply by

Parameters

in	*val*	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

nType	numeric type of value to divide by

Parameters

in	*val*	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

rhs	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

rhs	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 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 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	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	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

in	*rhs*	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

in	*rhs*	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

in	*rhs*	vector to check equality with

Returns

true if vector is equal

false otherwise

Note

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

Definition at line 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	*lhs*	first number
in	*rhs*	second number

Returns

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

false otherwise

Note

Threshold defined by threshold_ static member

Definition at line 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	*thres*	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

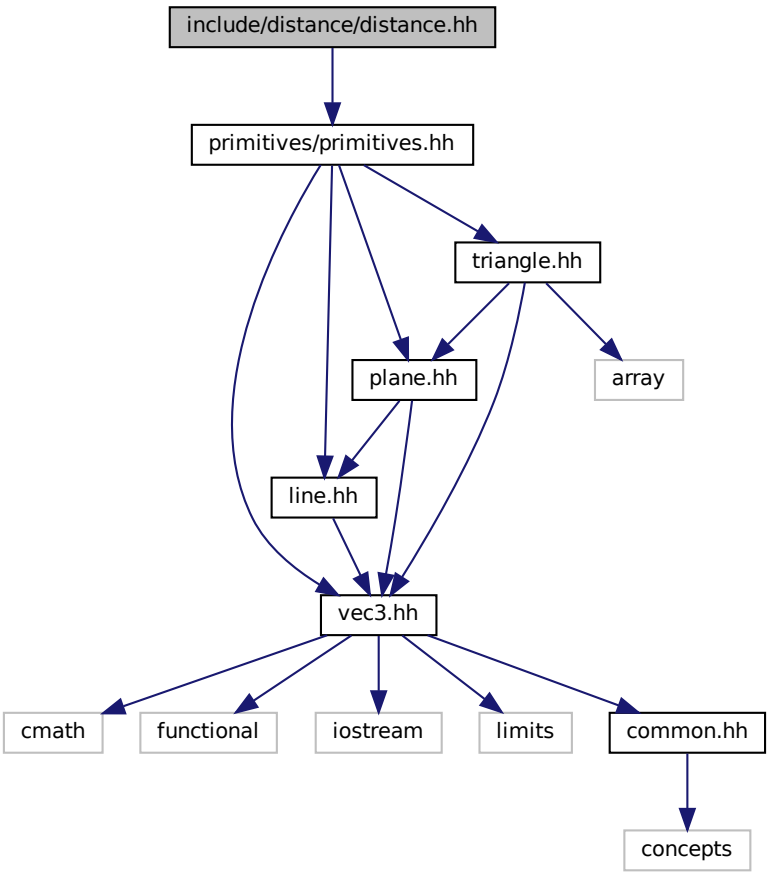
Chapter 6

File Documentation

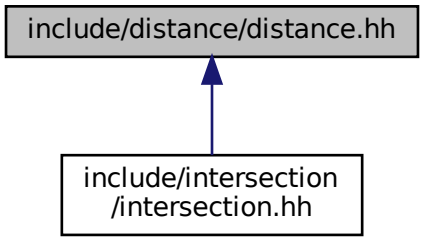
6.1 include/distance/distance.hh File Reference

```
#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.

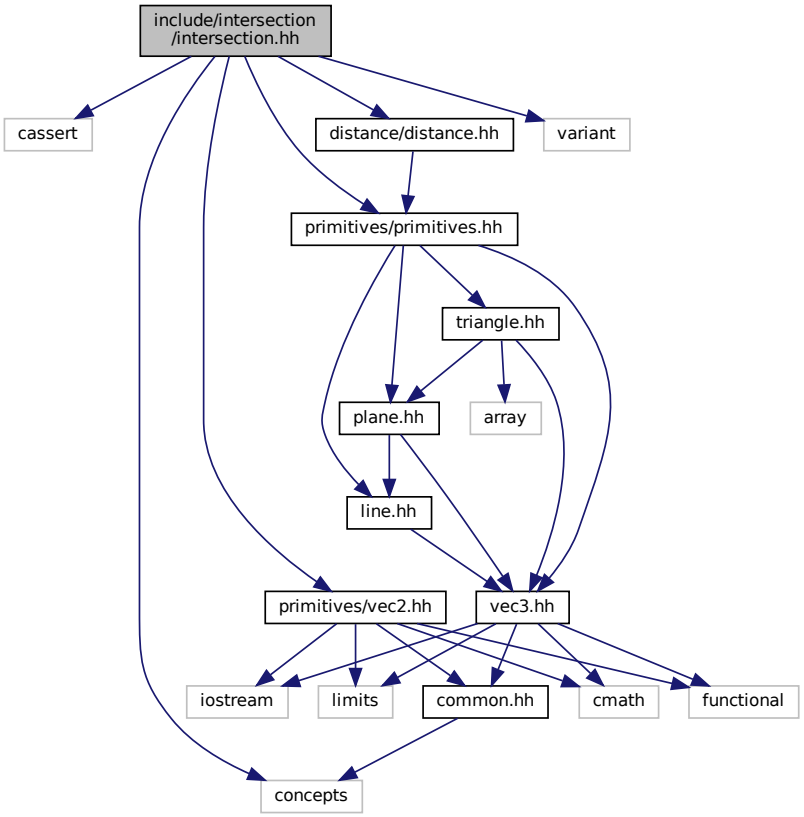
6.2 distance.hh

```
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 \f$ \overrightarrow{P} \f$ - point in space
00033  *
00034  * \f$ pl_1 \f$ equation: \f$ \overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1 \f$
00035  *
00036  * \f$ pl_2 \f$ equation: \f$ \overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2 \f$
00037  *
00038  * Intersection line direction: \f$ \overrightarrow{dir} = \overrightarrow{n}_1 \times
00039  * \overrightarrow{n}_2 \f$
00040  *
00041  * Let origin of intersection line be a linear combination of \f$ \overrightarrow{n}_1 \f$
00042  * and \f$ \overrightarrow{n}_2 \f$: \f[ \overrightarrow{P} = a \cdot \overrightarrow{n}_1
00043  * + b \cdot \overrightarrow{n}_2 \f]
00044  *
00045  * \f$ \overrightarrow{P} \f$ must satisfy both \f$ pl_1 \f$ and \f$ pl_1 \f$ equations:
00046  * \f[
00047  * \overrightarrow{n}_1 \cdot \overrightarrow{P} = d_1
00048  * \Leftrightarrow
00049  * \overrightarrow{n}_1
00050  * \cdot
00051  * \left(
00052  *  a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2
00053  *  \right)
00054  *  = d_1
00055  * \Leftrightarrow
00056  * a + b \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2  = d_1
00057  * \f]
00058  * \f[
00059  * \overrightarrow{n}_2 \cdot \overrightarrow{P} = d_2
00060  * \Leftrightarrow
00061  * \overrightarrow{n}_2
00062  * \cdot
00063  * \left(
00064  *  a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2
00065  *  \right) = d_2
00066  * \Leftrightarrow
00067  * a \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 + b = d_2
00068  * \f]
00069  *
00070  * Let's find \f$a\f$ and \f$b\f$:
00071  * \f[
00072  * a = \frac{
00073  *  d_2 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_1
00074  * }{
00075  *  \left( \overrightarrow{n}_1 \cdot \overrightarrow{n}_2\right)^2 - 1
00076  * }
00077  * \f]
00078  * \f[
00079  * b = \frac{
00080  * d_1 \cdot \overrightarrow{n}_1 \cdot \overrightarrow{n}_2 - d_2
00081  * }{
00082  *  \left( \overrightarrow{n}_1 \cdot \overrightarrow{n}_2\right)^2 - 1
00083  * }
00084  * \f]
00085  *
00086  * Intersection line equation:
00087  * \f[
00088  * \overrightarrow{r}(t) = \overrightarrow{P} + t \cdot \overrightarrow{n}_1 \times
00089  * \overrightarrow{n}_2 = (a \cdot \overrightarrow{n}_1 + b \cdot \overrightarrow{n}_2) +
00090  * t \cdot \overrightarrow{n}_1 \times \overrightarrow{n}_2 \f]
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 \f$ \overrightarrow{P} \f$ - point in space, intersection point of two lines.
00105  *
00106  * \f$ l_1 \f$ equation: \f$ \overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 =
00107  * \overrightarrow{P} \f$
00108  *
00109  * \f$ l_2 \f$ equation: \f$ \overrightarrow{org}_2 + \overrightarrow{dir}_2
00110  * \cdot t_2 = \overrightarrow{P} \f$
00111  *
00112  * Let's equate left sides:
00113  * \f[
00114  * \overrightarrow{org}_1 + \overrightarrow{dir}_1 \cdot t_1 =
00115  * \overrightarrow{org}_2 + \overrightarrow{dir}_2 \cdot t_2
00116  * \f]
00117  * Cross multiply both sides from right by \f$ \overrightarrow{dir}_2 \f$:
00118  * \f[
00119  * t_1 \cdot \left(\overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right) =
00120  * \left(\overrightarrow{org}_2 - \overrightarrow{org}_1 \right) \times \overrightarrow{dir}_2
00121  * \f]
00122  * Dot multiply both sides by \f$ \frac{\overrightarrow{dir}_1 \times \overrightarrow{dir}_2}{\left|
00123  * \overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right|^2} \f$:
00124  *
00125  * \f[
00126  * t_1 = \frac{
00127  *  \left(\left(\overrightarrow{org}_2 - \overrightarrow{org}_1 \right) \times
00128  * \overrightarrow{dir}_2\right) \cdot \left( \overrightarrow{dir}_1 \times \overrightarrow{dir}_2
00129  * \right)
00130  * }{
00131  * \left| \overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right|^2
00132  * }
00133  * \f]
00134  *
00135  * Thus we get intersection point parameter \f$ t_1 \f$ on \f$ l_1 \f$, let's substitute it to \f$
00136  * l_1 \f$ equation: \f[ \overrightarrow{P} = \overrightarrow{org}_1 + \frac{
00137  *  \left(\left(\overrightarrow{org}_2 - \overrightarrow{org}_1 \right) \times
00138  * \overrightarrow{dir}_2\right) \cdot \left( \overrightarrow{dir}_1 \times \overrightarrow{dir}_2
00139  * \right)
00140  * }{
00141  * \left| \overrightarrow{dir}_1 \times \overrightarrow{dir}_2 \right|^2
00142  * } \cdot \overrightarrow{dir}_1
00143  * \f]
00144  *
00145  * @tparam T - floating point type of coordinates
00146  * @param[in] l1 first line
00147  * @param[in] l2 second line
00148  * @return std::variant<std::monostate, Vec3<T>, Line<T>»
00149  */
00150 template <std::floating_point T>
00151 std::variant<std::monostate, Vec3<T>, Line<T>» intersect(const Line<T> &l1, const Line<T> &l2);
00152
00153 namespace detail
00154 {
00155
00156 template <typename T>
00157 using Segment2D = std::pair<T, T>;
00158
00159 template <std::floating_point T>
00160 using Trian2 = std::array<Vec2<T>, 3>;
00161
00162 template <std::floating_point T>
00163 using Segment3D = std::pair<Vec3<T>, Vec3<T>>;
00164
00165 template <std::floating_point T>
00166 bool isIntersect2D(const Triangle<T> &tr1, const Triangle<T> &tr2);
00167
00168 template <std::floating_point T>
00169 bool isIntersectMollerHaines(const Triangle<T> &tr1, const Triangle<T> &tr2);
00170
00171 template <std::floating_point T>
00172 Segment2D<T> helperMollerHaines(const Triangle<T> &tr, const Plane<T> &pl, const Line<T> &l);
00173
00174 template <std::floating_point T>
00175 bool isIntersectBothInvalid(const Triangle<T> &tr1, const Triangle<T> &tr2);
00176
00177 template <std::floating_point T>
00178 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> &pl1, const Plane<T> &pl2)
00256 {
00257   const auto &n1 = pl1.norm();
00258   const auto &n2 = pl2.norm();
00259
00260   auto dir = cross(n1, n2);
00261
00262   /* if planes are parallel */
00263   if (Vec3<T>{0} == dir)
00264   {
00265     if (pl1 == pl2)
```

```
00266       return pl1;
00267
00268     return std::monostate{};
00269   }
00270
00271   auto n1n2 = dot(n1, n2);
00272   auto d1 = pl1.dist();
00273   auto d2 = pl2.dist();
00274
00275   auto a = (d2 * n1n2 - d1) / (n1n2 * n1n2 - 1);
00276   auto b = (d1 * n1n2 - d2) / (n1n2 * n1n2 - 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 org21xdir2 = cross(l2.org() - l1.org(), l2.dir());
00297
00298   auto t1_intersect = dot(org21xdir2, 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 pl = tr1.getPlane();
00312
00313   auto trian1 = getTrian2(pl, tr1);
00314   auto trian2 = getTrian2(pl, 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 pl1 = tr1.getPlane();
00337   auto pl2 = tr2.getPlane();
00338
00339   auto l = std::get<Line<T>>(intersect(pl1, pl2));
00340
00341   auto params1 = helperMollerHaines(tr1, pl2, l);
00342   auto params2 = helperMollerHaines(tr2, pl1, 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> &pl, 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   // auto beg = dot(l.dir(), segm.first);
00475   // auto end = dot(l.dir(), segm.second);
00476   // auto proj = dot(l.dir(), pt);
00477
00478   // return !((proj > end) || (proj < beg));
00479 }
00480
00481 template <std::floating_point T>
00482 bool isIntersectSegmentSegment(const Segment3D<T> &segm1, const Segment3D<T> &segm2)
00483 {
00484   Line<T> l1{segm1.first, segm1.second - segm1.first};
00485   Line<T> l2{segm2.first, segm2.second - segm2.first};
00486   auto intersectionResult = intersect(l1, l2);
00487
00488   if (std::holds_alternative<Line<T>>(intersectionResult))
00489   {
00490     const auto &dir = l1.dir();
00491     Segment2D<T> s1{dot(dir, segm1.first), dot(dir, segm1.second)};
00492     Segment2D<T> s2{dot(dir, segm2.first), dot(dir, segm2.second)};
00493     return isOverlap(s1, s2);
00494   }
00495
00496   if (std::holds_alternative<Vec3<T>>(intersectionResult))
00497   {
00498     auto pt = std::get<Vec3<T»(intersectionResult);
00499     return isIntersectPointSegment(pt, segm1) && isIntersectPointSegment(pt, segm2);
00500   }
00501
00502   return false;
00503 }
00504
00505 template <std::floating_point T>
00506 bool isPoint(const Triangle<T> &tr)
00507 {
00508   return (tr[0] == tr[1]) && (tr[0] == tr[2]);
00509 }
00510
00511 template <std::floating_point T>
00512 bool isOverlap(Segment2D<T> &segm1, Segment2D<T> &segm2)
00513 {
00514   return (segm2.first <= segm1.second) && (segm2.second >= segm1.first);
00515 }
00516
00517 template <std::forward_iterator It>
00518 bool isSameSign(It begin, It end)
00519 {
00520   auto cur = begin;
00521   auto prev = begin;
00522
00523   for (++cur; cur != end; ++cur)
00524     if ((*cur) * (*prev) <= 0)
00525       return false;
00526
```

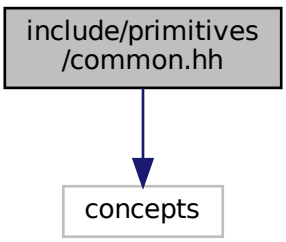
```
00527   return true;
00528 }
00529
00530 template <Number T>
00531 bool isSameSign(T num1, T num2)
00532 {
00533   if (num1 * num2 > Vec3<T>::getThreshold())
00534     return true;
00535   return Vec3<T>::isNumEq(num1, 0) && Vec3<T>::isNumEq(num2, 0);
00536 }
00537
00538 template <std::floating_point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

```
00614       min = val;
00615     else if (val > max)
00616       max = val;
00617
00618   return {min, max};
00619 }
00620
00621 template <std::floating_point T>
00622 Segment3D<T> getSegment(const Triangle<T> &tr)
00623 {
00624   std::array<T, 3> lenArr{};
00625   for (size_t i = 0; i < 3; ++i)
00626     lenArr[i] = (tr[i] - tr[i + 1]).length2();
00627
00628   auto maxIt = std::max_element(lenArr.begin(), lenArr.end());
00629   auto maxIdx = static_cast<size_t>(maxIt - lenArr.begin());
00630
00631   return {tr[maxIdx], tr[maxIdx + 1]};
00632 }
00633
00634 } // namespace detail
00635 } // namespace geom
00636
00637 #endif // __INCLUDE_INTERSECTION_INTERSECTION_HH__
```

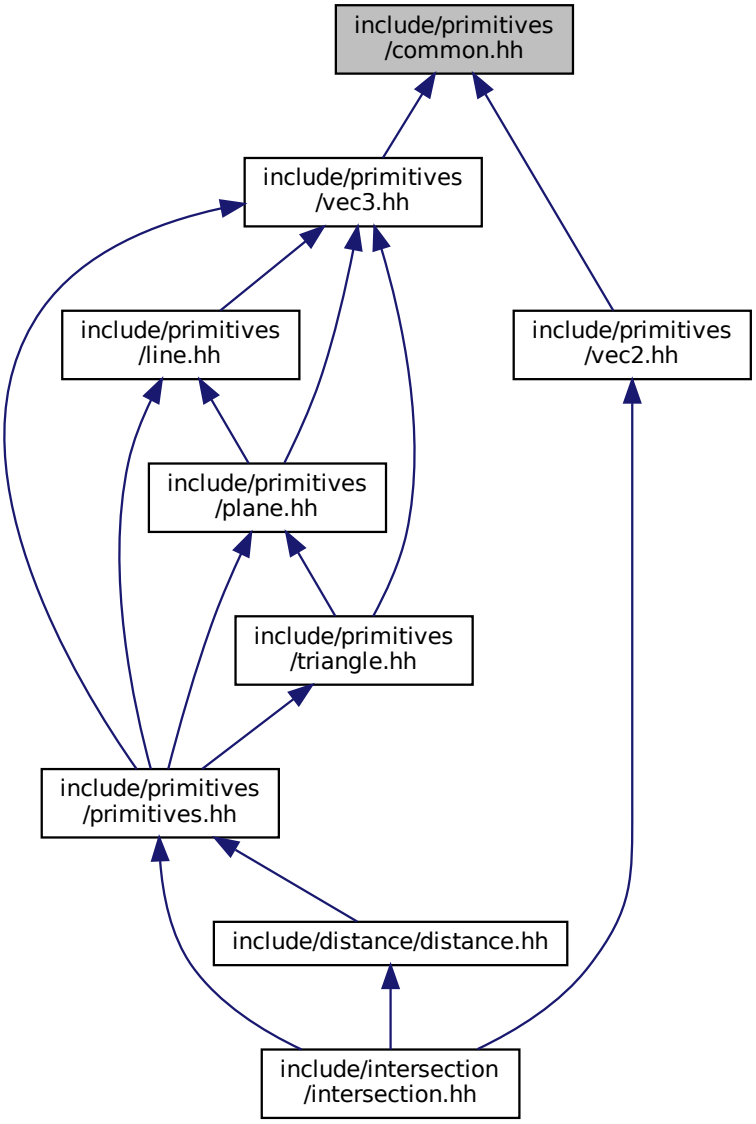
6.5 include/primitives/common.hh File Reference

`#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.

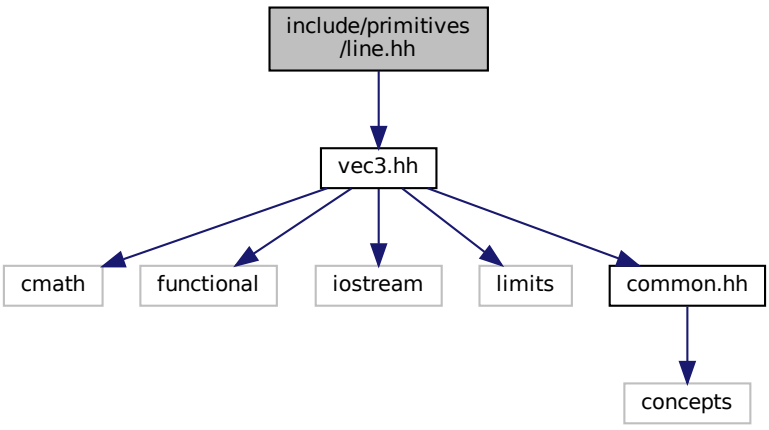
6.6 common.hh

```
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__
```

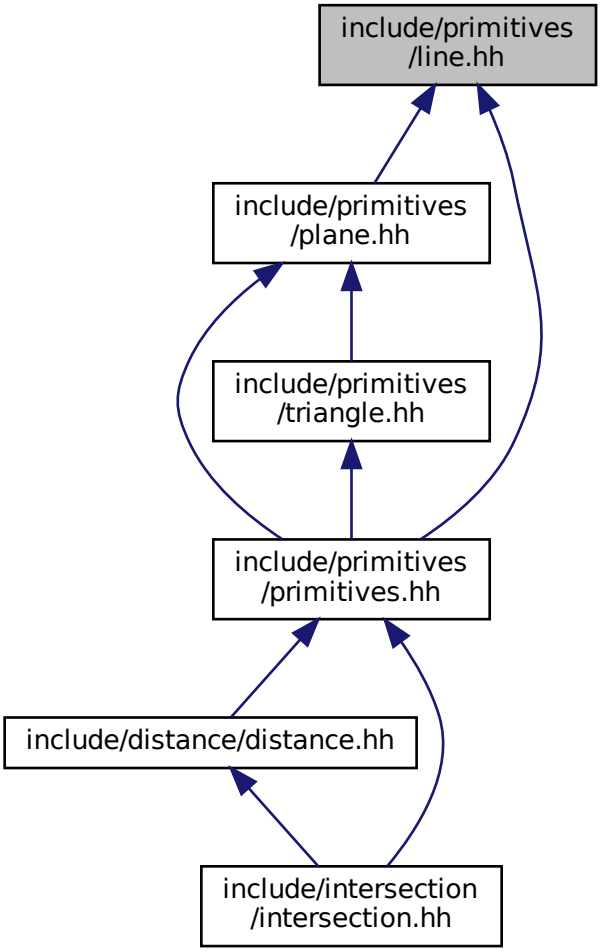
6.7 include/primitives/line.hh File Reference

`#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
```

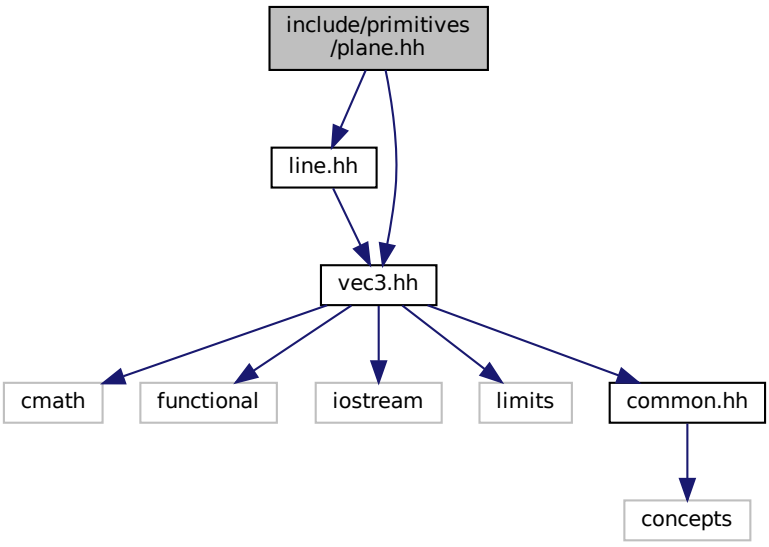
```
00075     * @return true if lines are equal
00076     * @return false if lines are not equal
00077     */
00078    bool isEqual(const Line &line) const;
00079
00080    /**
00081     * @brief Checks is *this parallel to another line
00082     * @note Assumes equal lines as parallel
00083     * @param[in] 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__
```

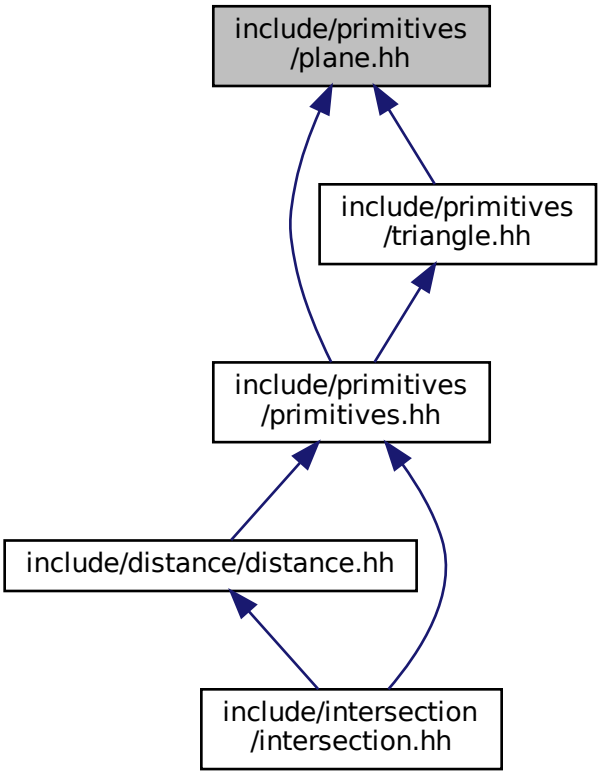
6.9 include/primitives/plane.hh File Reference

```
#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   /**
```

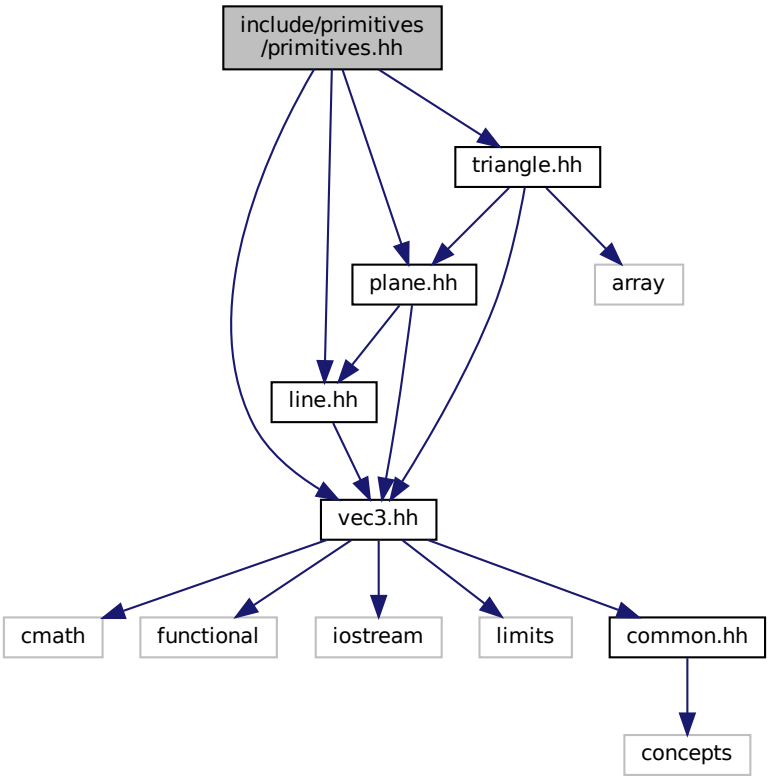
```
00086     * @brief Checks is *this is parallel to another plane
00087     *
00088     * @param[in] rhs const reference to another plane
00089     * @return true if planes are parallel
00090     * @return false if planes are not parallel
00091     */
00092    bool isPar(const Plane &rhs) const;
00093
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__
```

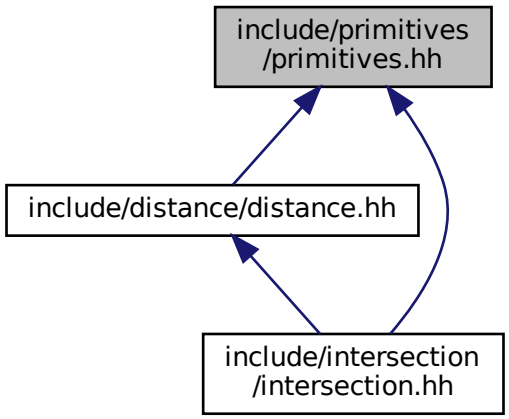
6.11 include/primitives/primitives.hh File Reference

```
#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:



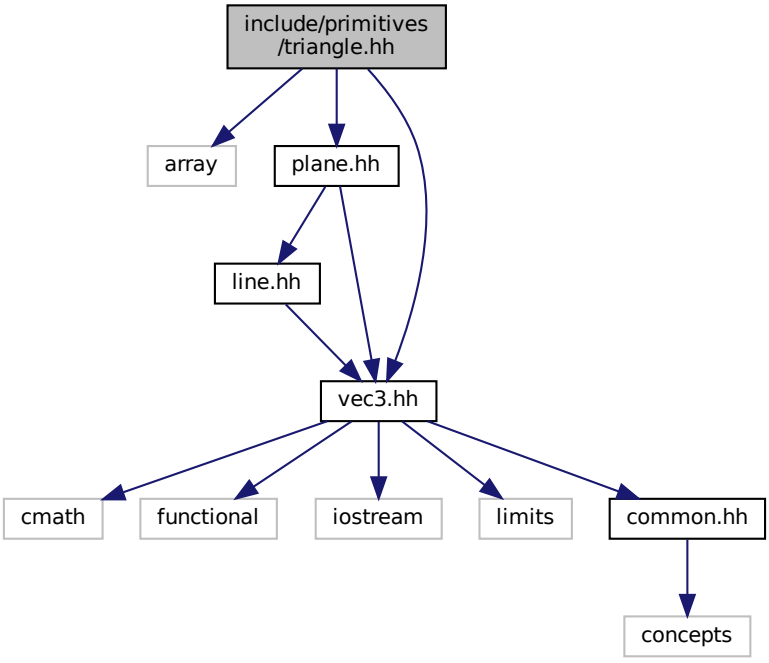
6.12 primitives.hh

```
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__
```

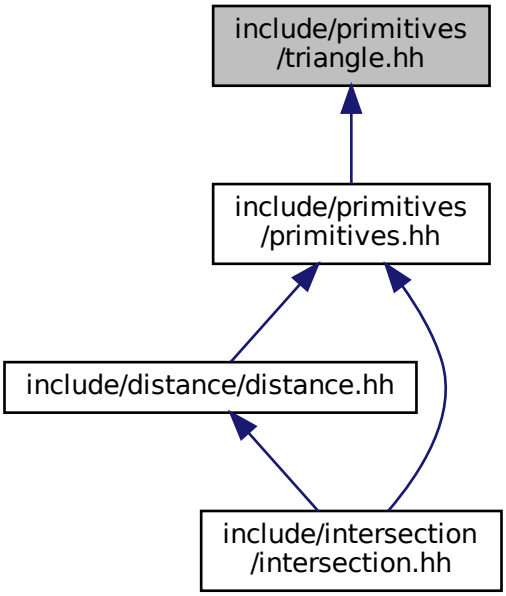
6.13 include/primitives/triangle.hh File Reference

```
#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

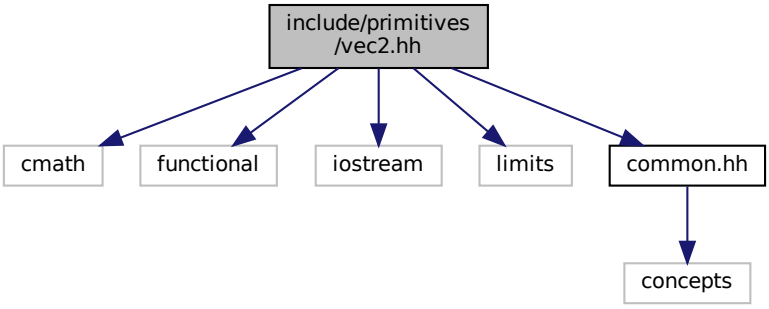
```
00001 #ifndef __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00002 #define __INCLUDE_PRIMITIVES_TRIANGLE_HH__
00003
00004 #include <array>
00005
00006 #include "plane.hh"
00007 #include "vec3.hh"
00008
00009 /**
00010  * @brief triangle.hh
00011  * Triangle class implementation
00012  */
00013
00014 namespace 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__
```

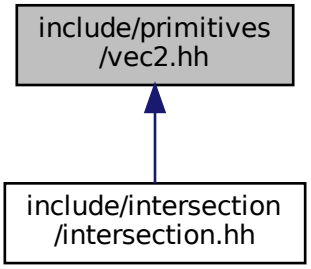
6.15 include/primitives/vec2.hh File Reference

```
#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
00376   return *this;
00377 }
00378
00379 template <std::floating_point T>
00380 Vec2<T> &Vec2<T>::operator-=(const Vec2 &vec)
00381 {
00382   x -= vec.x;
00383   y -= vec.y;
00384
00385   return *this;
00386 }
00387
00388 template <std::floating_point T>
00389 Vec2<T> Vec2<T>::operator-() const
00390 {
00391   return Vec2{-x, -y};
00392 }
00393
00394 template <std::floating_point T>
00395 template <Number nType>
00396 Vec2<T> &Vec2<T>::operator*=(nType val)
00397 {
00398   x *= val;
00399   y *= val;
00400
00401   return *this;
00402 }
00403
00404 template <std::floating_point T>
00405 template <Number nType>
00406 Vec2<T> &Vec2<T>::operator/=(nType val)
00407 {
00408   x /= static_cast<T>(val);
00409   y /= static_cast<T>(val);
00410
00411   return *this;
00412 }
00413
00414 template <std::floating_point T>
00415 T Vec2<T>::dot(const Vec2 &rhs) const
00416 {
00417   return x * rhs.x + y * rhs.y;
00418 }
00419
00420 template <std::floating_point T>
00421 T Vec2<T>::length2() const
00422 {
00423   return dot(*this);
00424 }
00425
00426 template <std::floating_point T>
00427 T Vec2<T>::length() const
00428 {
00429   return std::sqrt(length2());
00430 }
00431
00432 template <std::floating_point T>
00433 Vec2<T> Vec2<T>::getPerp() const
00434 {
00435   return {y, -x};
00436 }
00437
00438 template <std::floating_point T>
00439 Vec2<T> Vec2<T>::normalized() const
00440 {
00441   Vec2 res{*this};
00442   res.normalize();
00443   return res;
00444 }
00445
00446 template <std::floating_point T>
00447 Vec2<T> &Vec2<T>::normalize()
00448 {
00449   T len2 = length2();
00450   if (isNumEq(len2, 0) || isNumEq(len2, 1))
00451     return *this;
00452   return *this /= std::sqrt(len2);
00453 }
00454
00455 template <std::floating_point T>
00456 T &Vec2<T>::operator[](size_t i)
```

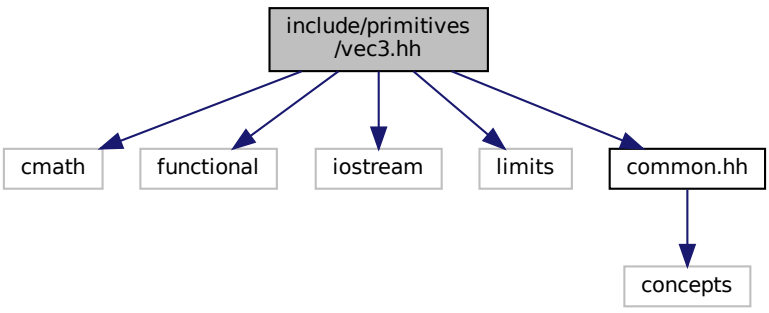
```
00457 {
00458   switch (i % 2)
00459   {
00460   case 0:
00461     return x;
00462   case 1:
00463     return y;
00464   default:
00465     throw std::logic_error{"Impossible case in operator[]\n"};
00466   }
00467 }
00468
00469 template <std::floating_point T>
00470 T Vec2<T>::operator[](size_t 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

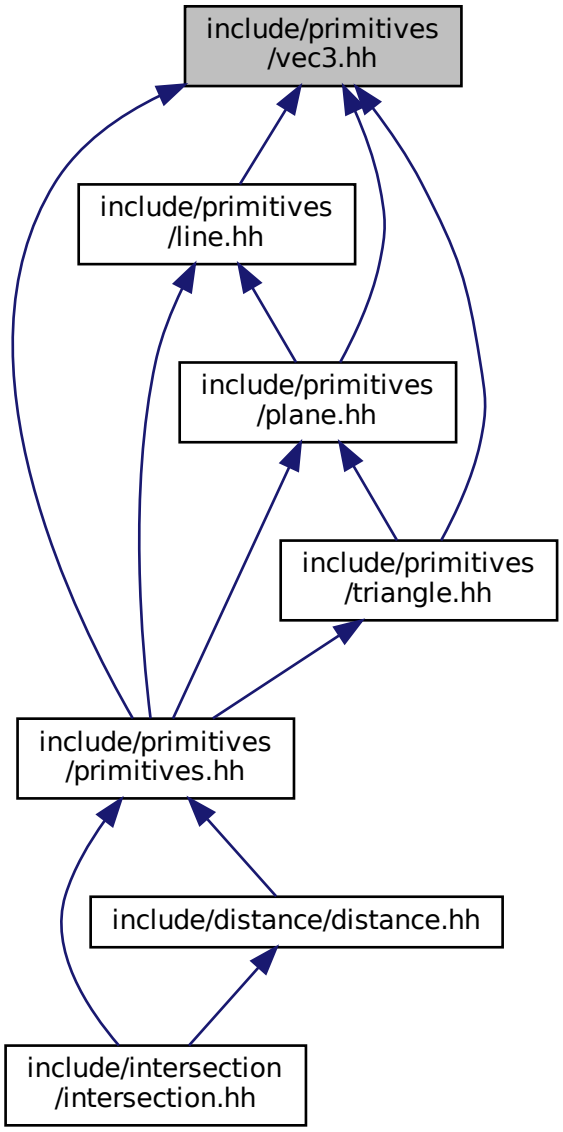
```
#include <cmath>
#include <functional>
#include <iostream>
#include <limits>
```

```
#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 stram
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
00423   return *this;
00424 }
00425
00426 template <std::floating_point T>
00427 Vec3<T> &Vec3<T>::operator-=(const Vec3 &vec)
00428 {
00429   x -= vec.x;
00430   y -= vec.y;
00431   z -= vec.z;
00432
00433   return *this;
```

```
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
00450   return *this;
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
00461   return *this;
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__
```