

# Assignment 1: Exploring OpenGL Programming

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## 1 INTRODUCTION

### 1.1 Ray-Triangle Intersection

Complete the implementation of the ray-triangle intersection function TriangleIntersect in src/accel.cpp.

### 1.2 Ray-AABB Intersection

Complete the AABB (Axis-Aligned Bounding Box) intersection in the function AABB::intersect in the file src/accel.cpp.

### 1.3 BVH Construction

Implement BVH Construction.

### 1.4 Direct Illumination Integrator

Implement the IntersectionTestIntegrator class.

### 1.5 Integrate with Refractive Materials

Add support for refractive materials in the IntersectionTestIntegrator class.

## 2 IMPLEMENTATION DETAILS

### 2.1 Ray-Triangle Intersection

Through the calculation of the intersection point of the ray and the triangle plane in the triangle coordinate system, determine whether the point is inside the triangle.

### 2.2 Ray-AABB Intersection

Calculate the intersection time of the ray and the three pairs of parallel planes of the AABB. If the ray intersects the AABB, return true. Otherwise, return false.

### 2.3 BVH Construction

Build the BVH tree using the median split method.

### 2.4 Direct Illumination Integrator

For every pixel it spawns one camera ray per sample; the ray is traced until it hits either an ideal-diffuse or a perfect-refraction surface. Specular refractions are followed recursively by sampling the BSDF and spawning a new ray, while diffuse surfaces terminate the path. Once a diffuse hit is found, direct illumination from the single point light is computed: a shadow ray is cast toward the light position and, if unoccluded, the reflected radiance is estimated

with a simple Lambertian model—albedo from bsdf->evaluate multiplied by the clamped cosine between the surface normal and the light direction. All other surface types are ignored, so only direct lighting on ideal-diffuse surfaces contributes to the final pixel color.

### 2.5 Integrate with Refractive Materials

Judge whether it is a total reflection to call refraction or reflection.

## 3 RESULTS

### 3.1 Ray-Triangle Intersection & Ray-AABB Intersection

```
C:\windows\system32\cmd.exe

D:\cs171-hw3-2025fall-oierlin\build\tests>intersection_tests_exe.exe
Running main() from D:\cs171-hw3-2025fall-oierlin\build\_deps\googletest-src\googletest\
[=====] Running 7 tests from 2 test suites.
[-----] Global test environment set-up.
[-----] 1 test from AABB
[RUN] AABB.AxisAligned_EnterExit_PositiveAndNegativeDirs
[OK] AABB.AxisAligned_EnterExit_PositiveAndNegativeDirs (0 ms)
[-----] 1 test from AABB (2 ms total)

[-----] 6 tests from TriangleIntersect
[RUN] TriangleIntersect.Basic
[OK] TriangleIntersect.Basic (0 ms)
[RUN] TriangleIntersect.MissCases
[OK] TriangleIntersect.MissCases (0 ms)
[RUN] TriangleIntersect.TimeWindow_RejectionAndClamping
[OK] TriangleIntersect.TimeWindow_RejectionAndClamping (0 ms)
[RUN] TriangleIntersect.TriangleInXZPlane_Hit
[OK] TriangleIntersect.TriangleInXZPlane_Hit (0 ms)
[RUN] TriangleIntersect.DegenerateTriangle_ReturnsFalse
[OK] TriangleIntersect.DegenerateTriangle_ReturnsFalse (0 ms)
[RUN] TriangleIntersect.MultiTriangleMesh_HitCorrectTriangle
[OK] TriangleIntersect.MultiTriangleMesh_HitCorrectTriangle (0 ms)
[-----] 6 tests from TriangleIntersect (12 ms total)

[-----] Global test environment tear-down
[=====] 7 tests from 2 test suites ran. (19 ms total)
[ PASSED ] 7 tests.

D:\cs171-hw3-2025fall-oierlin\build\tests>
```

### 3.2 BVH Intersection

```
D:\cs171-hw3-2025fall-oierlin\build\tests>bvh_tests_exe.exe
Running main() from D:\cs171-hw3-2025fall-oierlin\build\_deps\googletest-src\googletest\
[=====] Running 3 tests from 1 test suite.
[-----] Global test environment set-up.
[-----] 3 tests from BVH
[RUN] BVH.BasicConstruction
[OK] BVH.BasicConstruction (0 ms)
[RUN] BVH.SingleObject
[OK] BVH.SingleObject (0 ms)
[RUN] BVH.EmptyTree
[OK] BVH.EmptyTree (0 ms)
[-----] 3 tests from BVH (6 ms total)

[-----] Global test environment tear-down
[=====] 3 tests from 1 test suite ran. (12 ms total)
[ PASSED ] 3 tests.

D:\cs171-hw3-2025fall-oierlin\build\tests>
```

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3.3 Final

