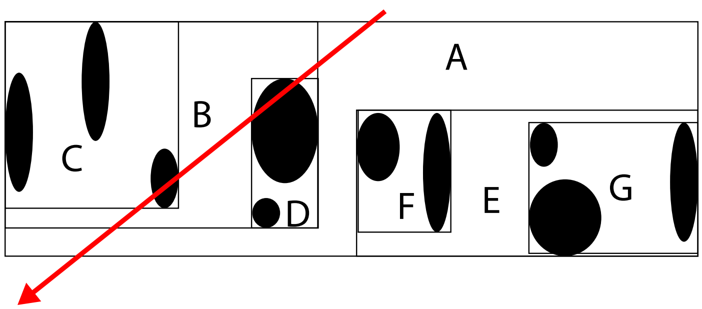
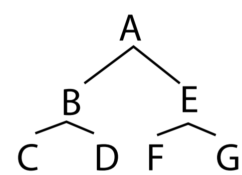
Stanford CS248: Interactive Computer Graphics
Participation Exercise 5

Miscellaneous Short Problems

A. This was Thursday's pre-class warmup problem, but I want everyone to do it! Given the BVH below, please list the sequence of BVH nodes visited by the ray marked in the figure. By "vistied" we mean that the ray "enters" the node and tests whether it hits child boxes (in the case of an interior node) or leaf node geometry. (*Hint: the first node is the BVH root node A.*) Please assume that during ray BVH traversal, **the ray always visits the child bounding box with the closer ray-box intersection first**, and that it WILL NOT descend into the second child node if the closest hit found so far (after traversing the first child) is closer than the ray's closest intersection with the second child's bounding box.

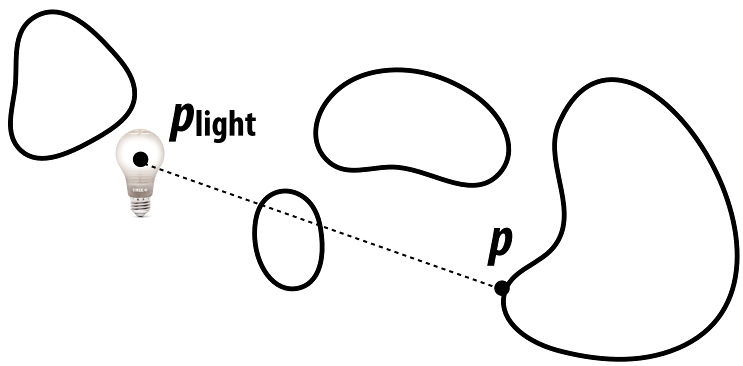




B. Imagine I give you a ray tracer that implements the following function `trace()`:

```
// returns TRUE if ray 'r' hits the scene geometry given by 'scene_bvh_root'.
// If there is a hit, then 'closest_t' is the value for the hit point along 'r'.
bool trace(Ray r, float* closest_t, BVHNode* scene_bvh_root);
```

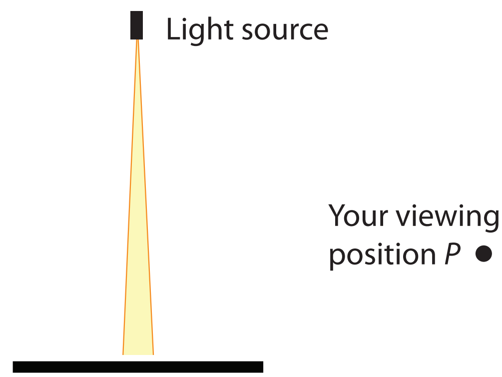
Now imagine there is a point light source located at point P_{light} as shown below, and you want to know if another point P on the surface of an object is in shadow. Given P_{light} and P, how would you use `trace()` to determine if P is in shadow? You can assume that ray $\mathbf{r}$ has an origin and a normalized direction $\mathbf{d}$. How do you compute $\mathbf{o}$ and $\mathbf{d}$ for the necessary ray, and how do you use the results of `trace(r, &t, scene_bvh_root)` to perform the shadow computation?



C. **A mysterious floor material.** You are standing in a room with a floor that is completely flat, but covered with two different types of materials (denoted as 1 and 2 in the figure below). The room only has one light source, a far away point light that is directly above the floor, and shines light directly down on the floor. (You can think of it as a very, very narrow spotlight, shining straight down.) Material 1 has a **completely diffuse BRDF** (white material) and Material 2 is a **perfect mirror** that reflects all light that hits it. If you are standing on the side of the floor at point P (as shown in the figure) what do you see? In particular be precise about what the mirror tiles look like. (Can you see anything in them, yes or no?) *Remember, there is no other light source in the room other than the spotlight from above..*

2	1	2	1
1	2	1	2
2	1	2	1
1	2	1	2

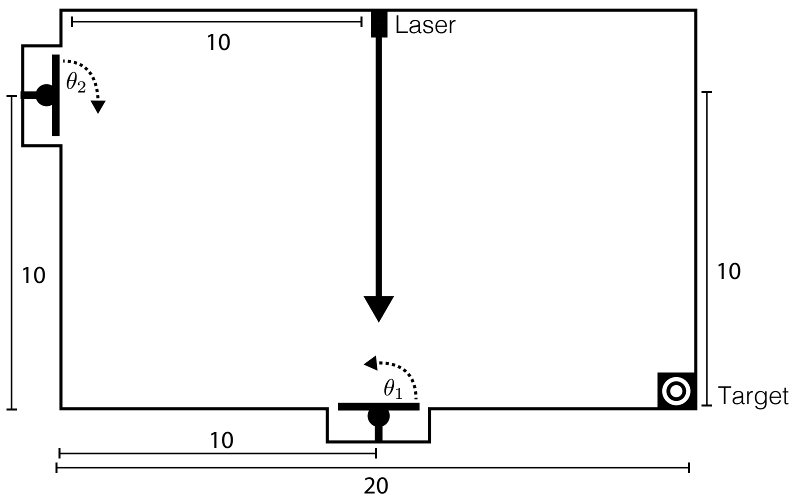
Top down view of floor

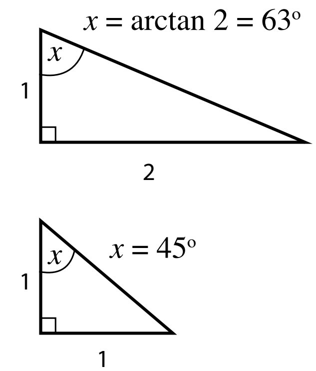


Side view of floor

Problem 2: Everyone Loves Lasers

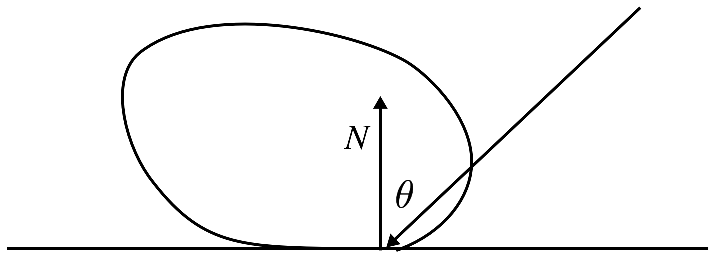
A mad scientist decides to design a fun physics experiment to amuse students in class. The goal of the experiment is to use two **perfectly reflective mirrors** to direct a laser beam, positioned downward from the top of the box, to hit a target in the bottom right corner of the box. The two mirrors can be rotated about their center point by the angles θ_1 and θ_2 as shown in the figure.





A. Please compute positive values of θ_1 and θ_2 to hit the box. Some helpful triangles are given for you, which may or may not be useful. Hint: first determine how to orient the first mirror to direct the beam to hit the second mirror. Then orient the second mirror to hit the target.

B. One challenge with perfect mirrors is that if you don't get them tilted just right, the laser will miss the target. One of the students, frustrated they couldn't hit the target, takes out a piece of sandpaper and scruffs up the two mirrors. The result is that the mirrors now have a BRDF that is almost fully diffuse, as given by the plot below. Note the surface reflects non-zero incoming light in all directions, but the fraction of light reflected in each of these directions is angle dependent. (More light is still reflected in the direction of perfect specular reflection.)



Assuming that (1) the mirrors are set so that $\theta_1 = \theta_2 = 0$ and that all the walls of the room reflect no light (they are perfectly black), does any laser light hit the target? If your answer is no, explain why not. If your answer is yes, please explain why, and also state whether target is brighter or darker compared to what it would look like in the case of well-aligned perfect mirrors from part A.