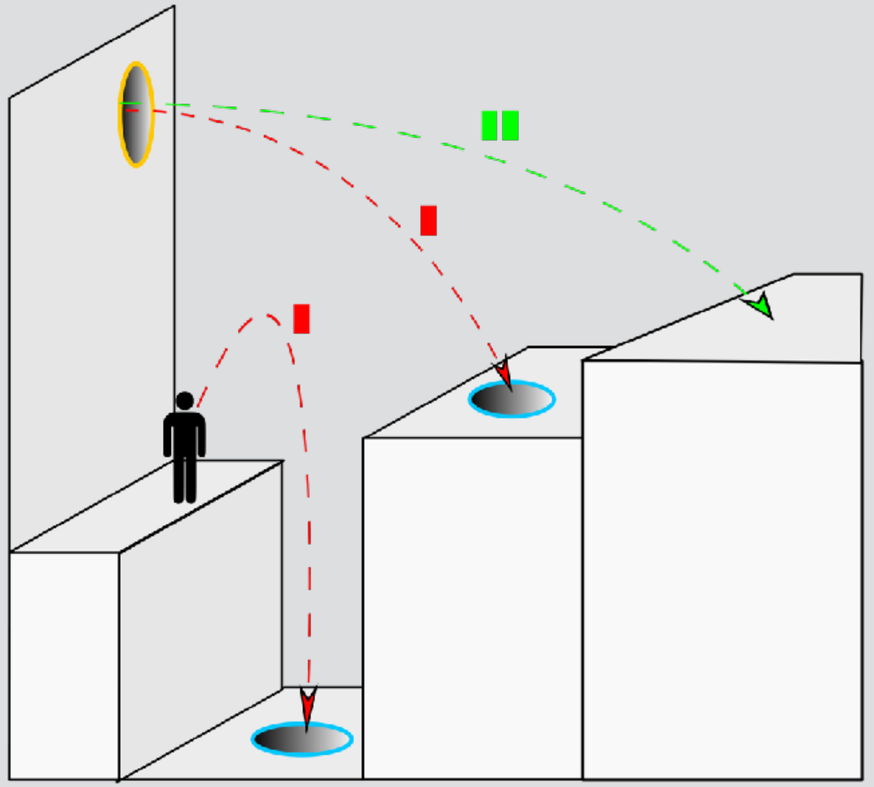
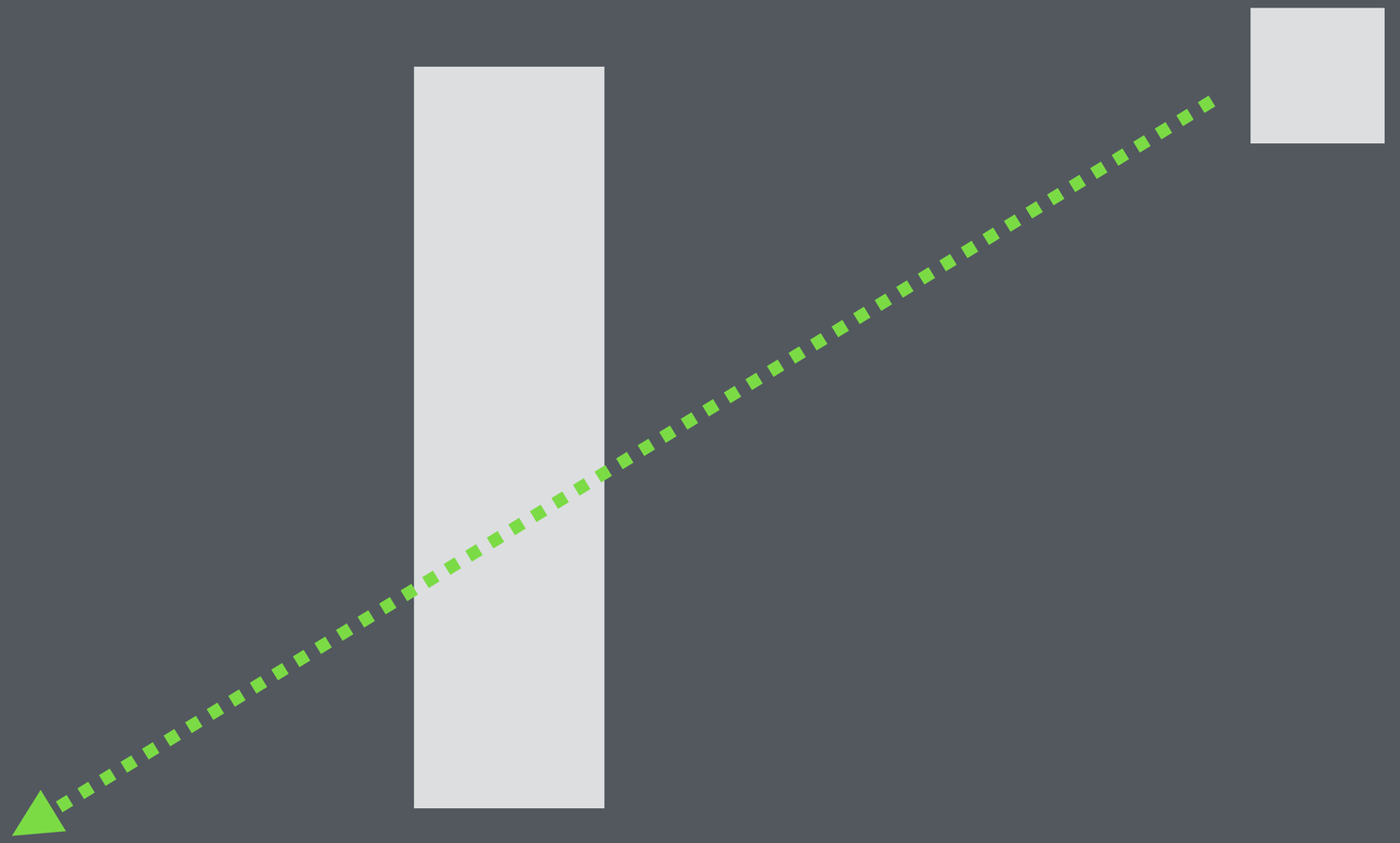
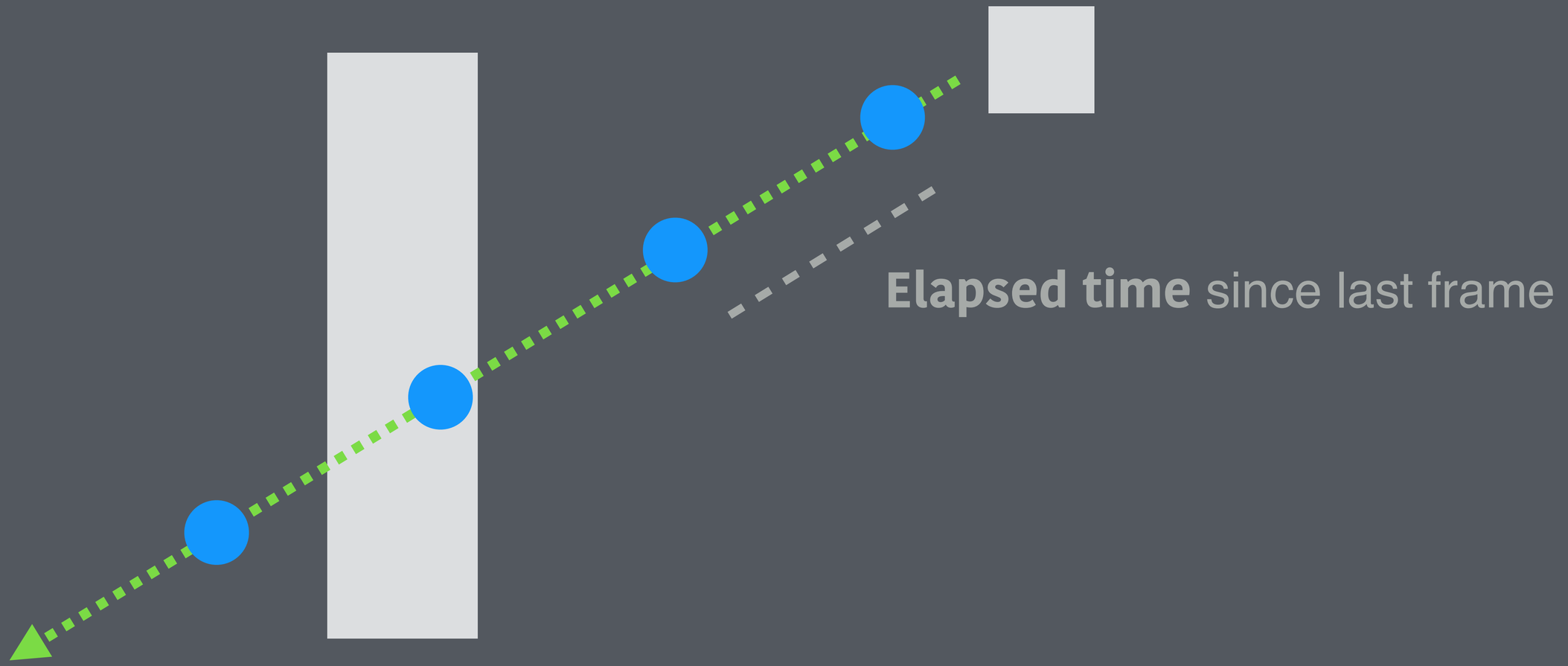
Basic physics and collision response.

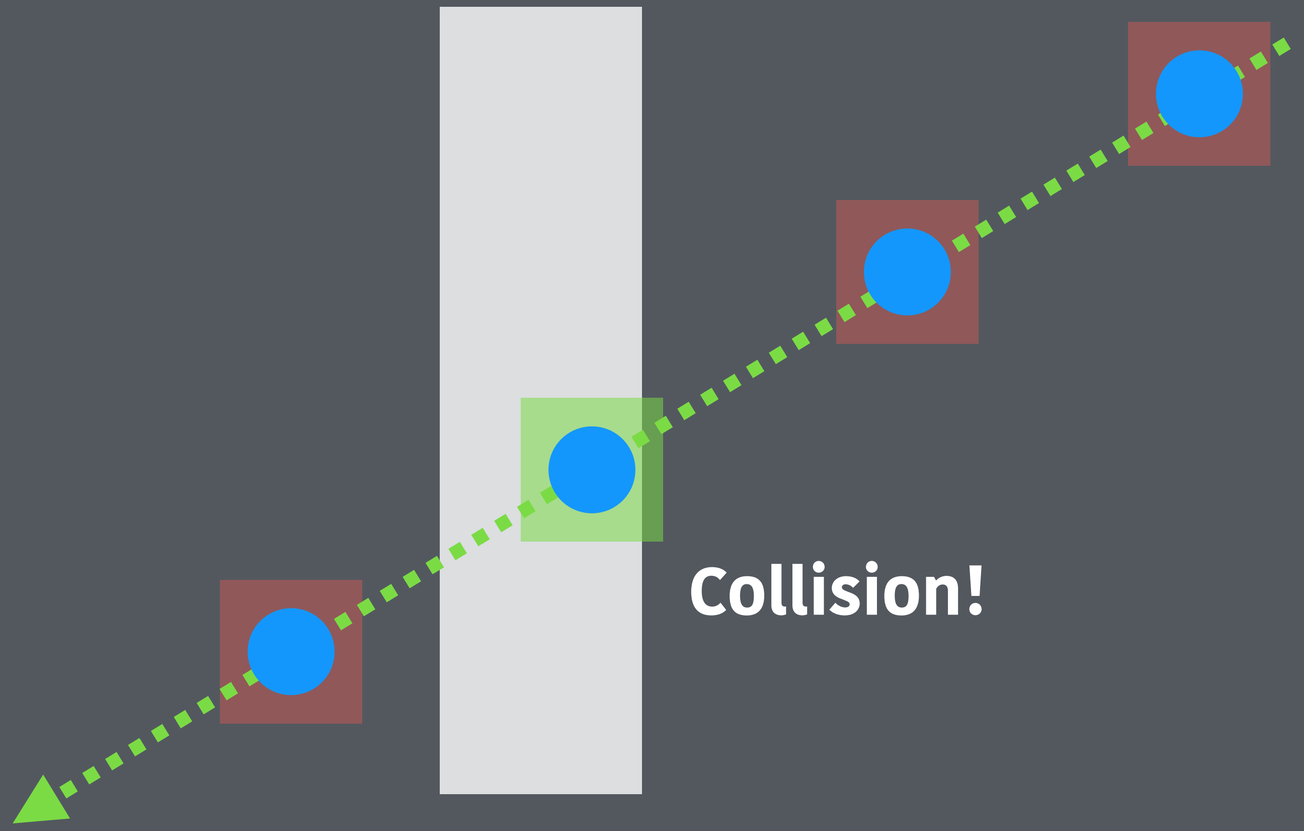


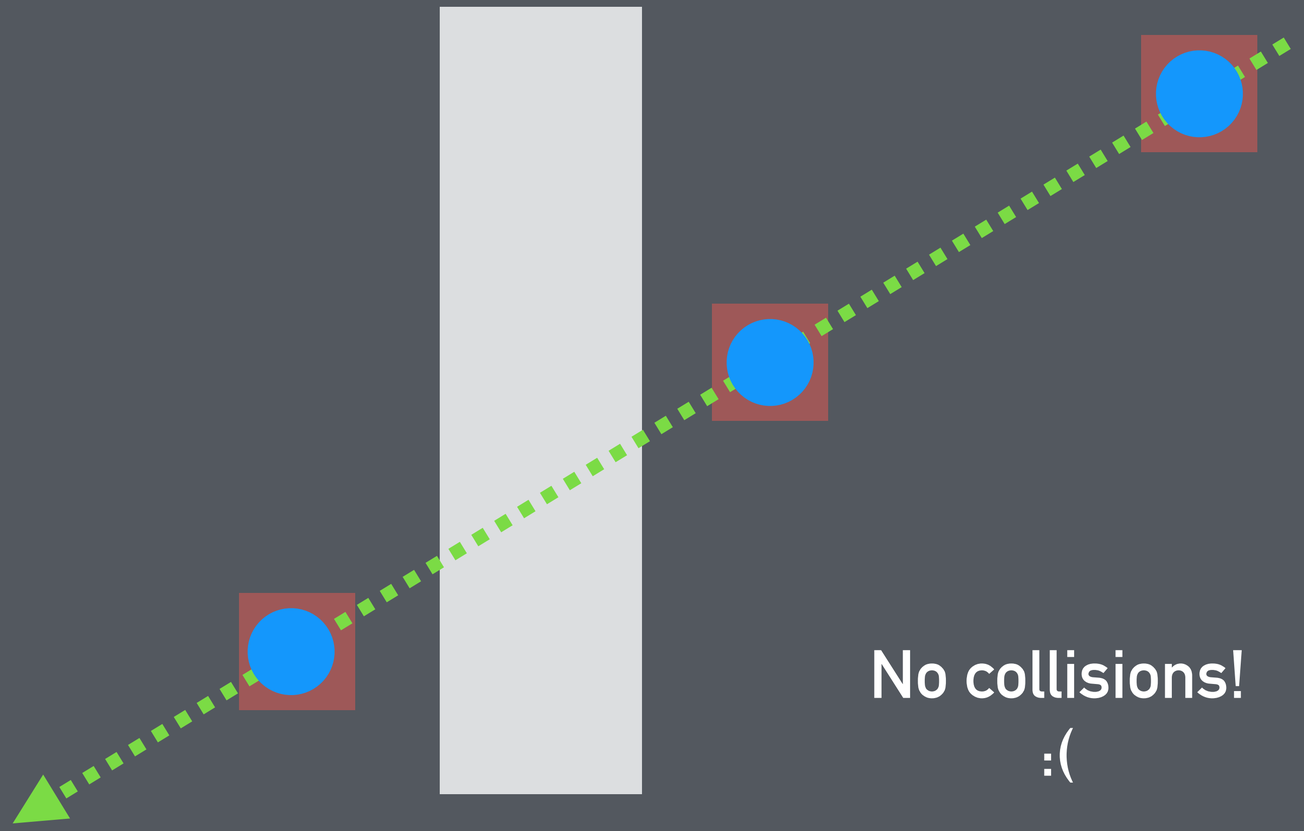
Fixing the timestep.

Problems with variable timestep.



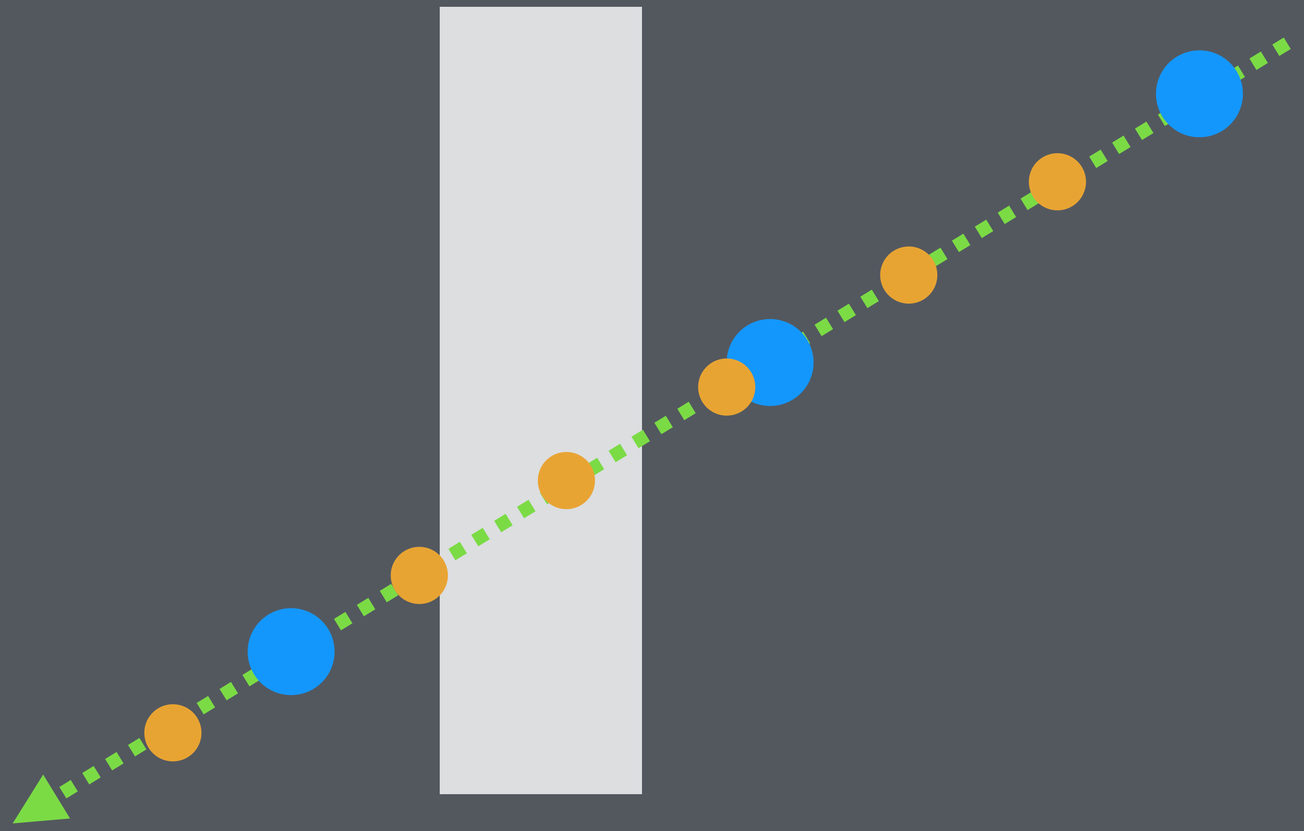

Elapsed time since last frame

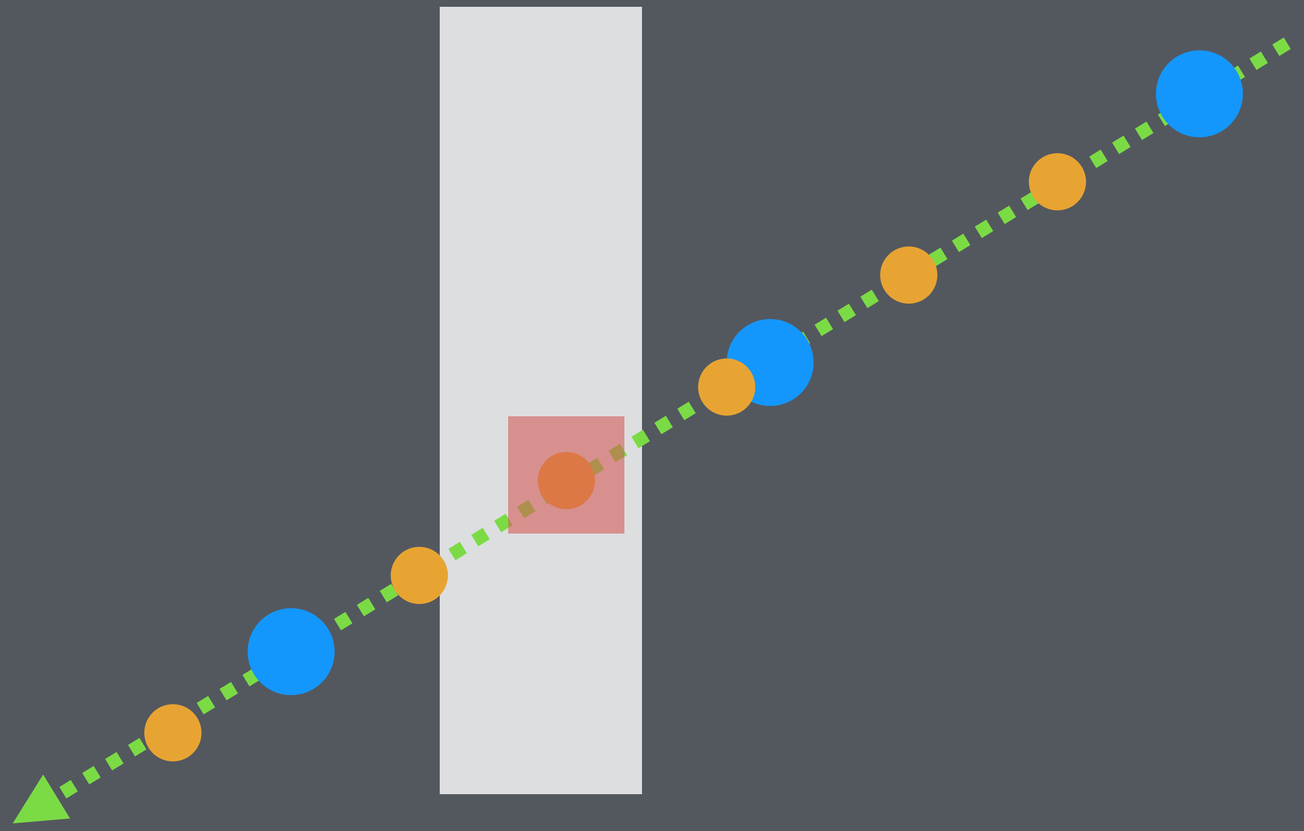

Collision!



No collisions!
:(

Fixed timestep.





```
// 60 FPS (1.0f/60.0f) (update sixty times a second)
#define FIXED_TIMESTEP 0.0166666f
#define MAX_TIMESTEPS 6

float accumulator = 0.0f;

while(!done) {
    // get elapsed time
    elapsed += accumulator;
    if(elapsed < FIXED_TIMESTEP) {
        accumulator = elapsed;
        continue;
    }

    while(elapsed >= FIXED_TIMESTEP) {
        Update(FIXED_TIMESTEP);
        elapsed -= FIXED_TIMESTEP;

    }
    accumulator = elapsed;
    Render();
}
```

Basic game physics.

Velocity and acceleration.

Velocity.

The rate of change of the position of an object.

(speed * direction)

```
position_x += velocity_x * elapsed;
position_y += velocity_y * elapsed;
```

Acceleration.

The rate of change of velocity.

```
velocity_x += acceleration_x * elapsed;
velocity_y += acceleration_y * elapsed;
```

Friction.

Friction.

The rate of decrease of velocity.

```
velocity_x = lerp(velocity_x, 0.0f, elapsed * friction_x);
velocity_y = lerp(velocity_y, 0.0f, elapsed * friction_y);
```

Lerp?

LERP

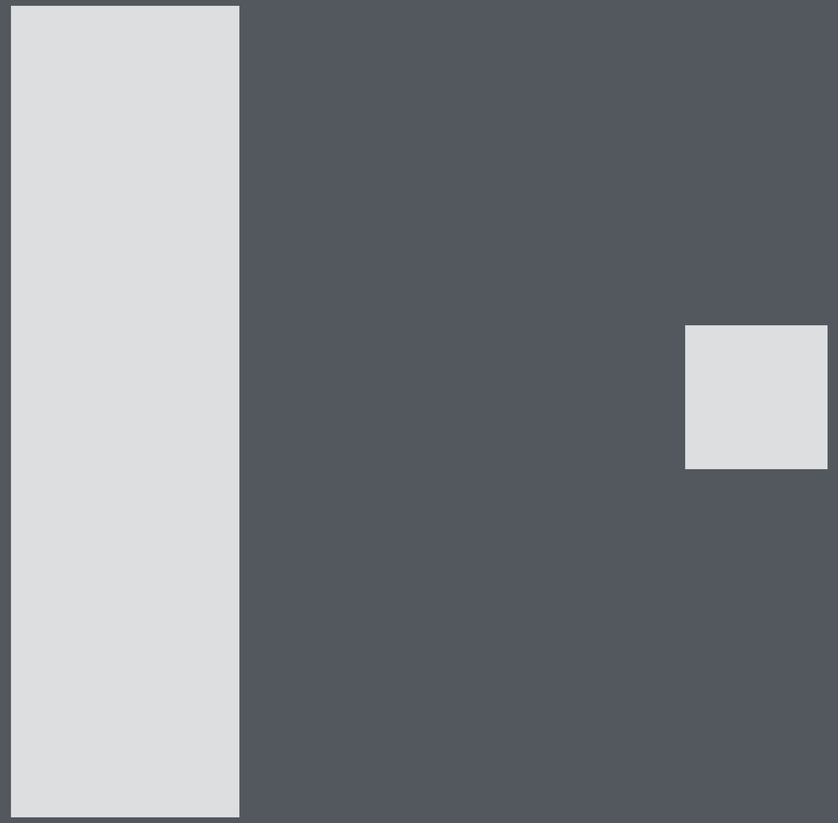
Linear IntERPolation

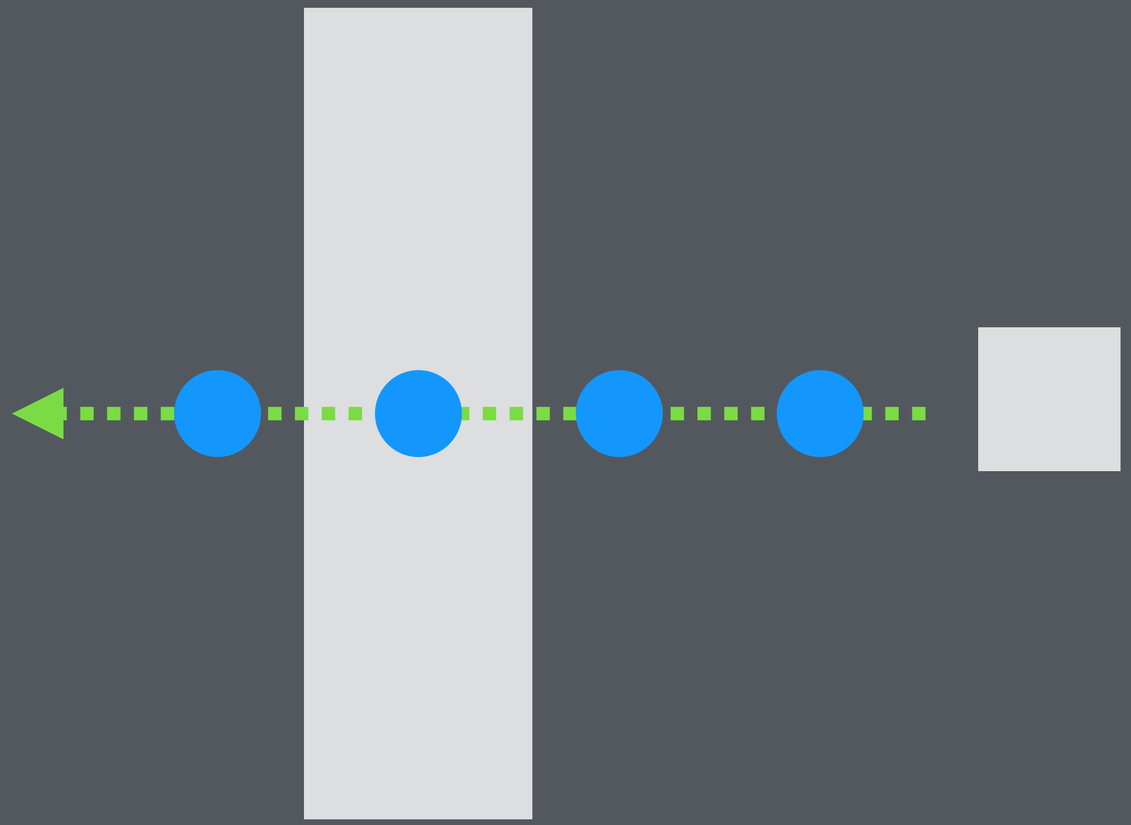
```
float lerp(float v0, float v1, float t) {
    return (1.0-t)*v0 + t*v1;
}
```

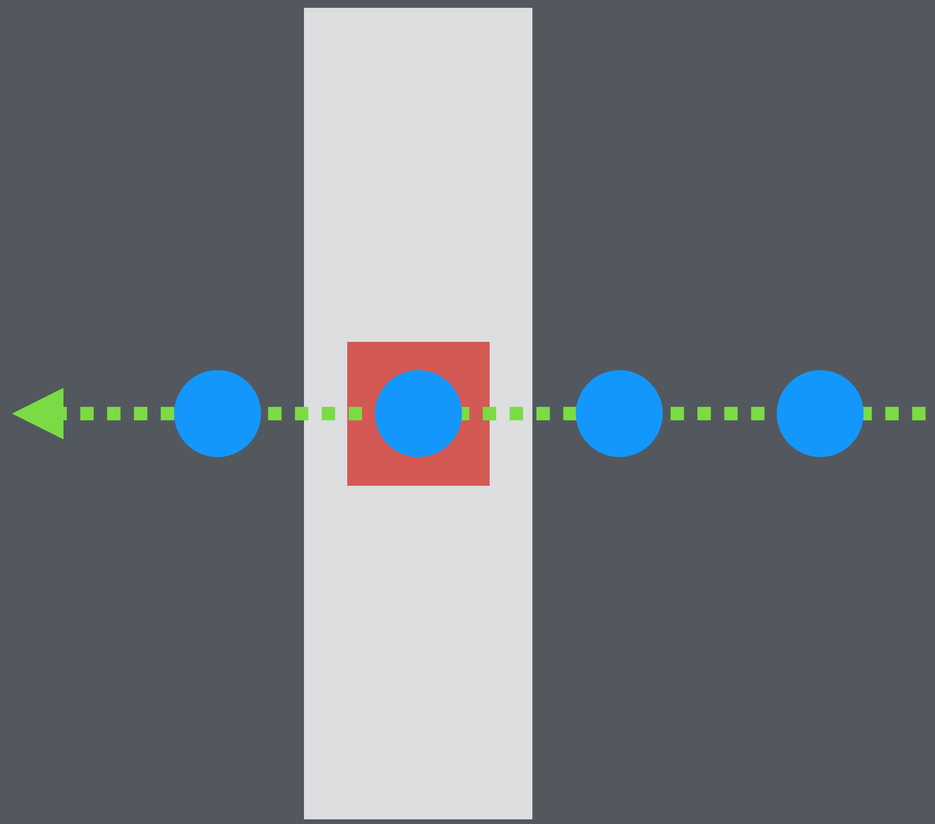
Combined movement.

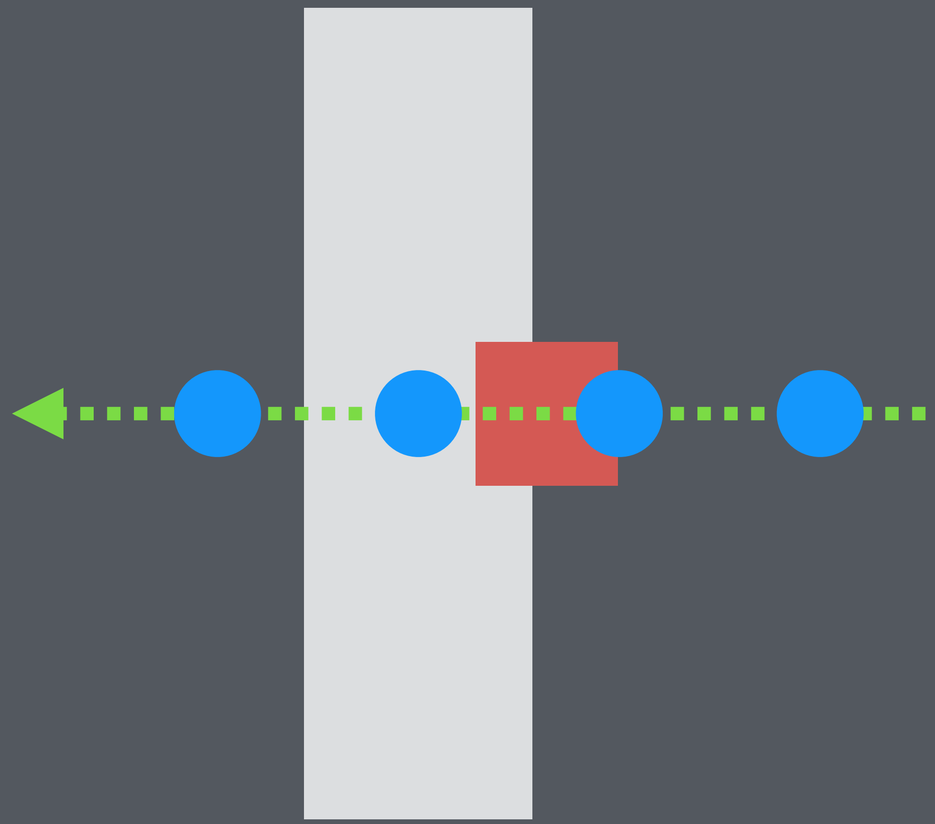
```
velocity_x = lerp(velocity_x, 0.0f, elapsed * friction_x);
velocity_y = lerp(velocity_y, 0.0f, elapsed * friction_y);

velocity_x += acceleration_x * elapsed;
velocity_y += acceleration_y * elapsed;

x += velocity_x * elapsed;
y += velocity_y * elapsed;
```

Collision response.



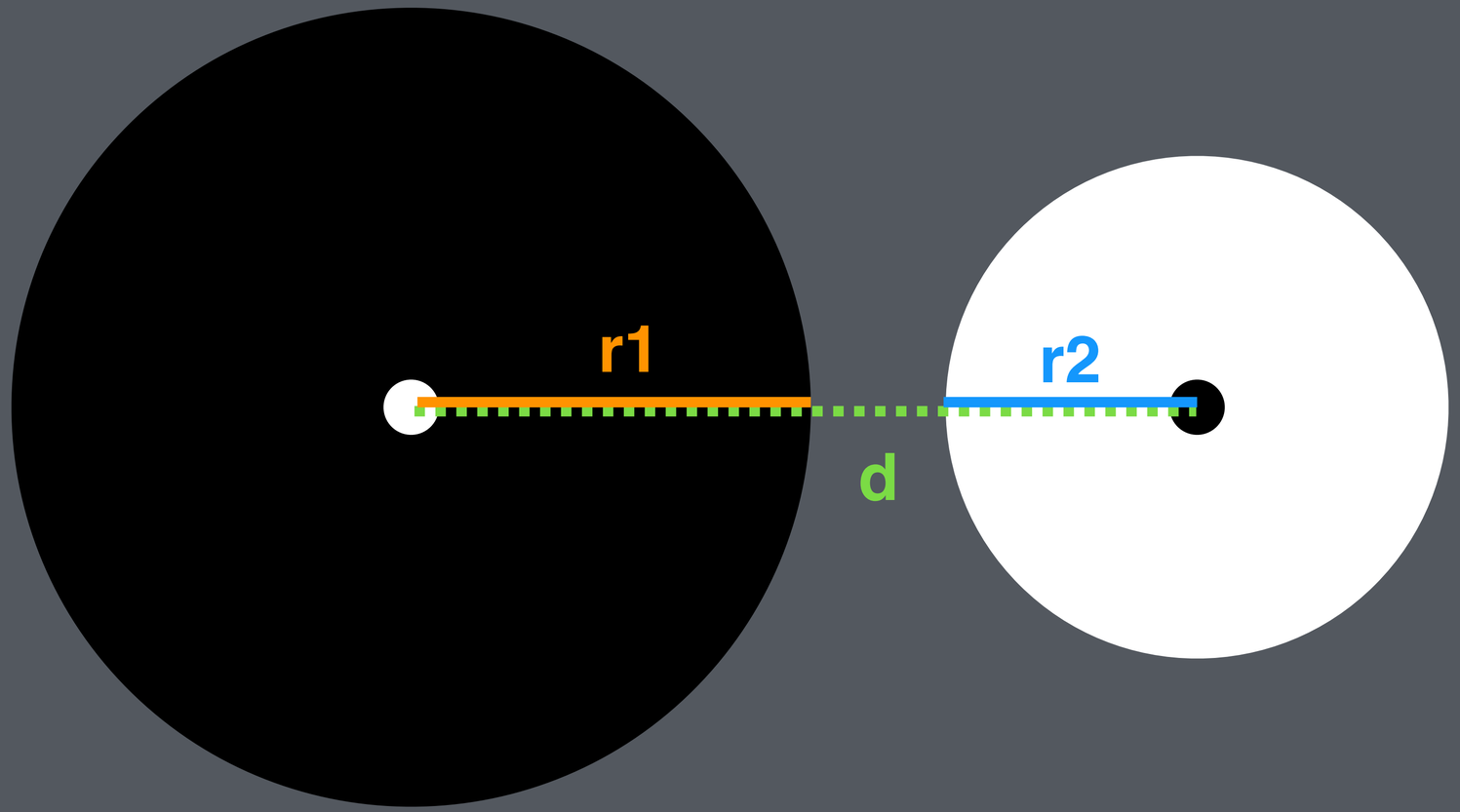




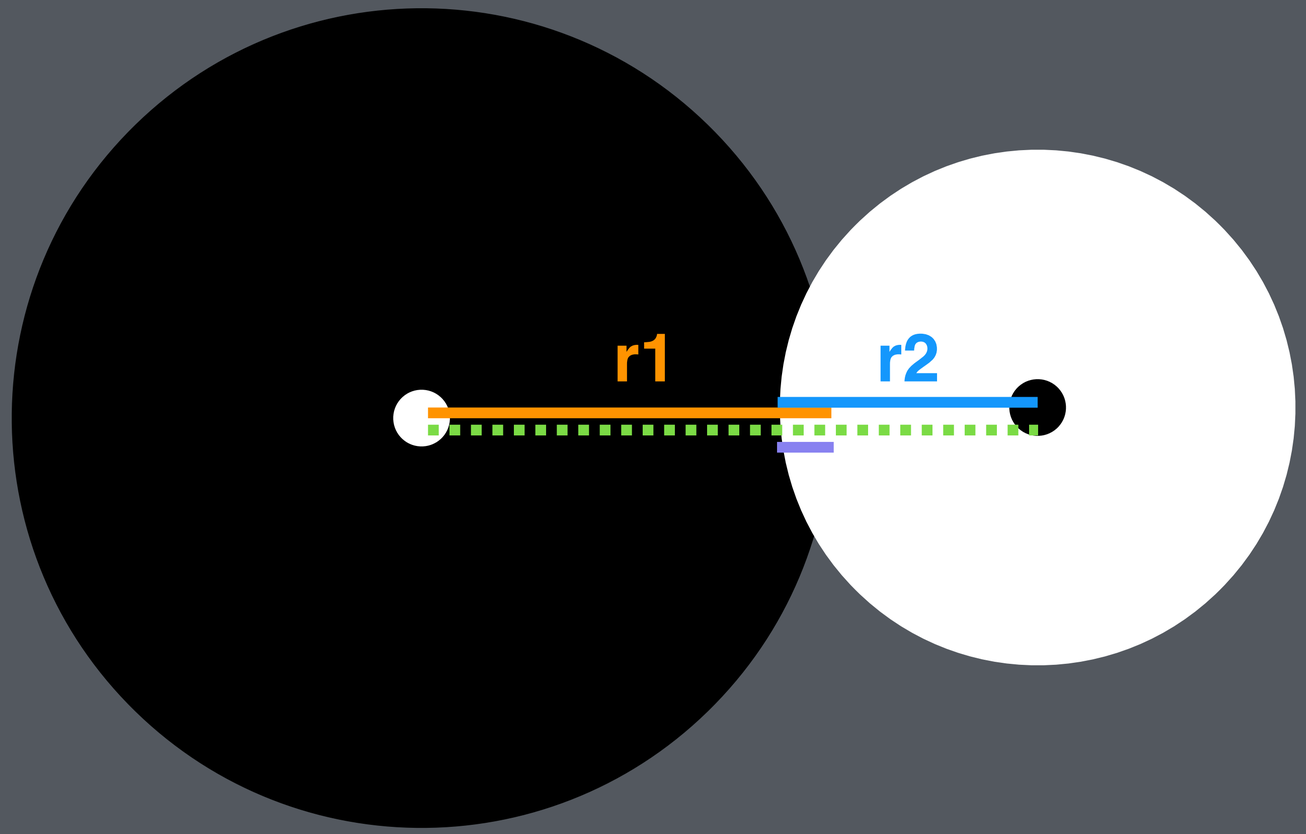


Calculating collision penetration.

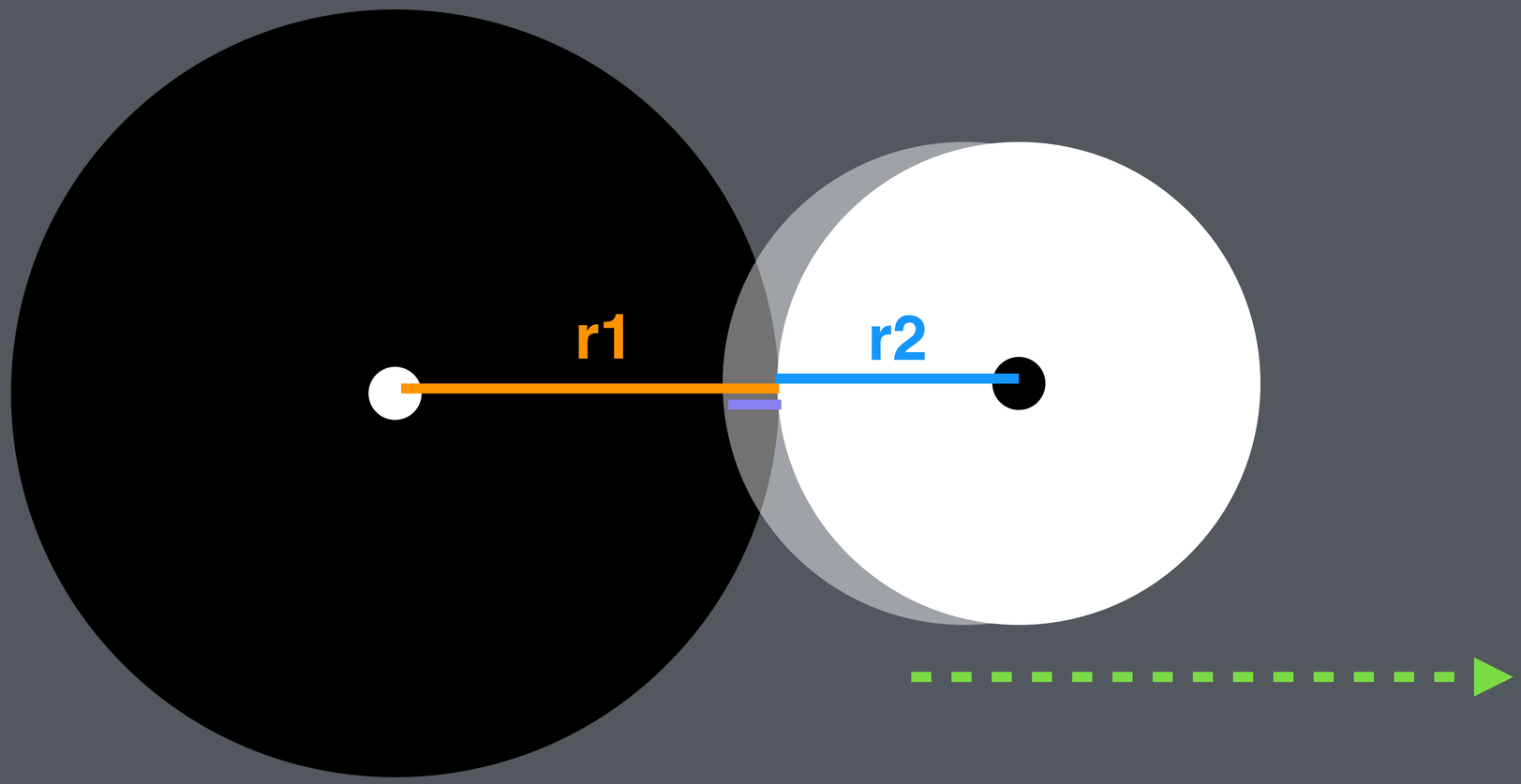
Circle - circle collision penetration.



If the **distance** **between two circles** is **less than the sum of their radii**, the circles are **colliding**!




```
penetration = fabs(distance - radius1 - radius2)
```

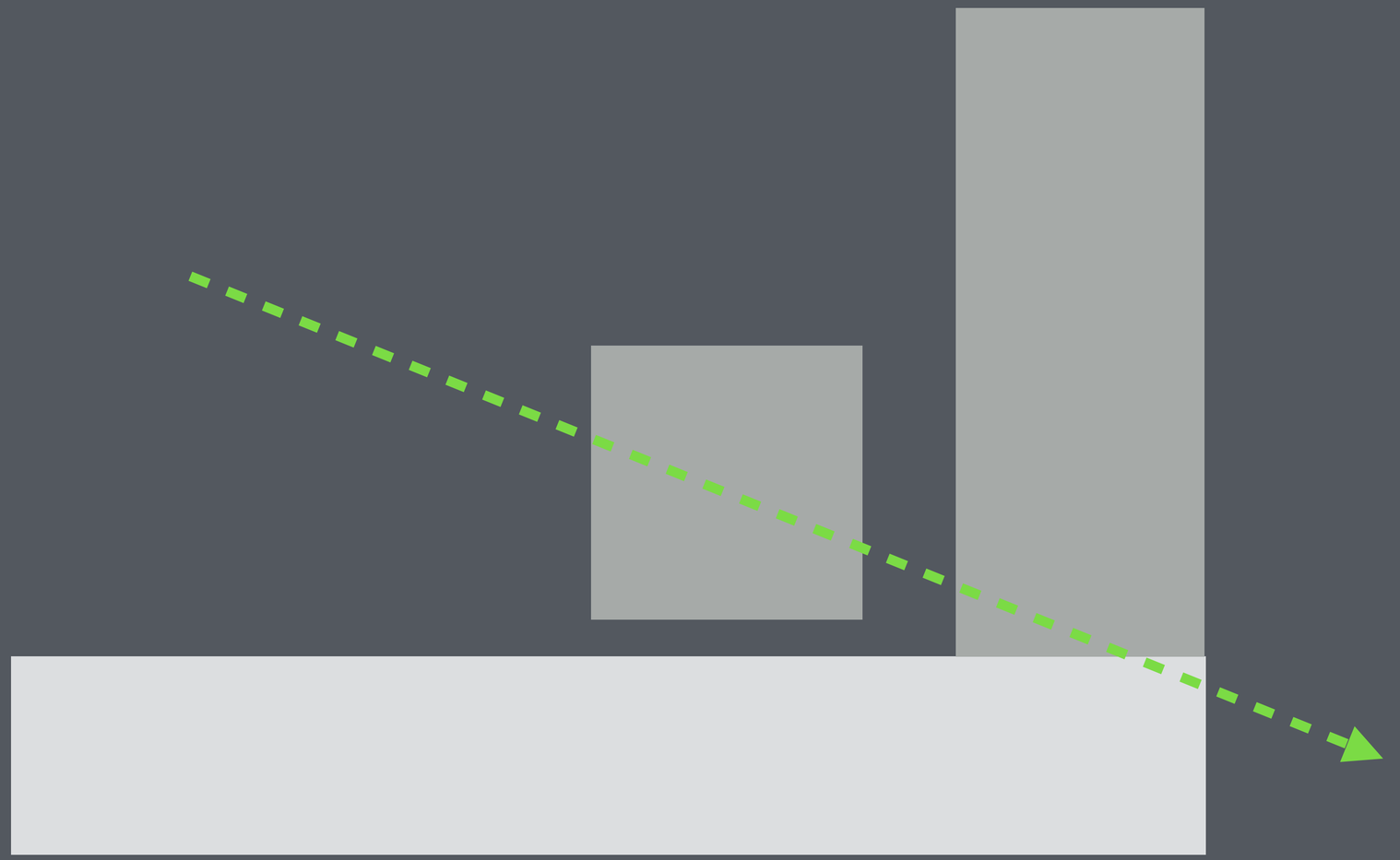



```
adjust = penetration * direction_vector
```

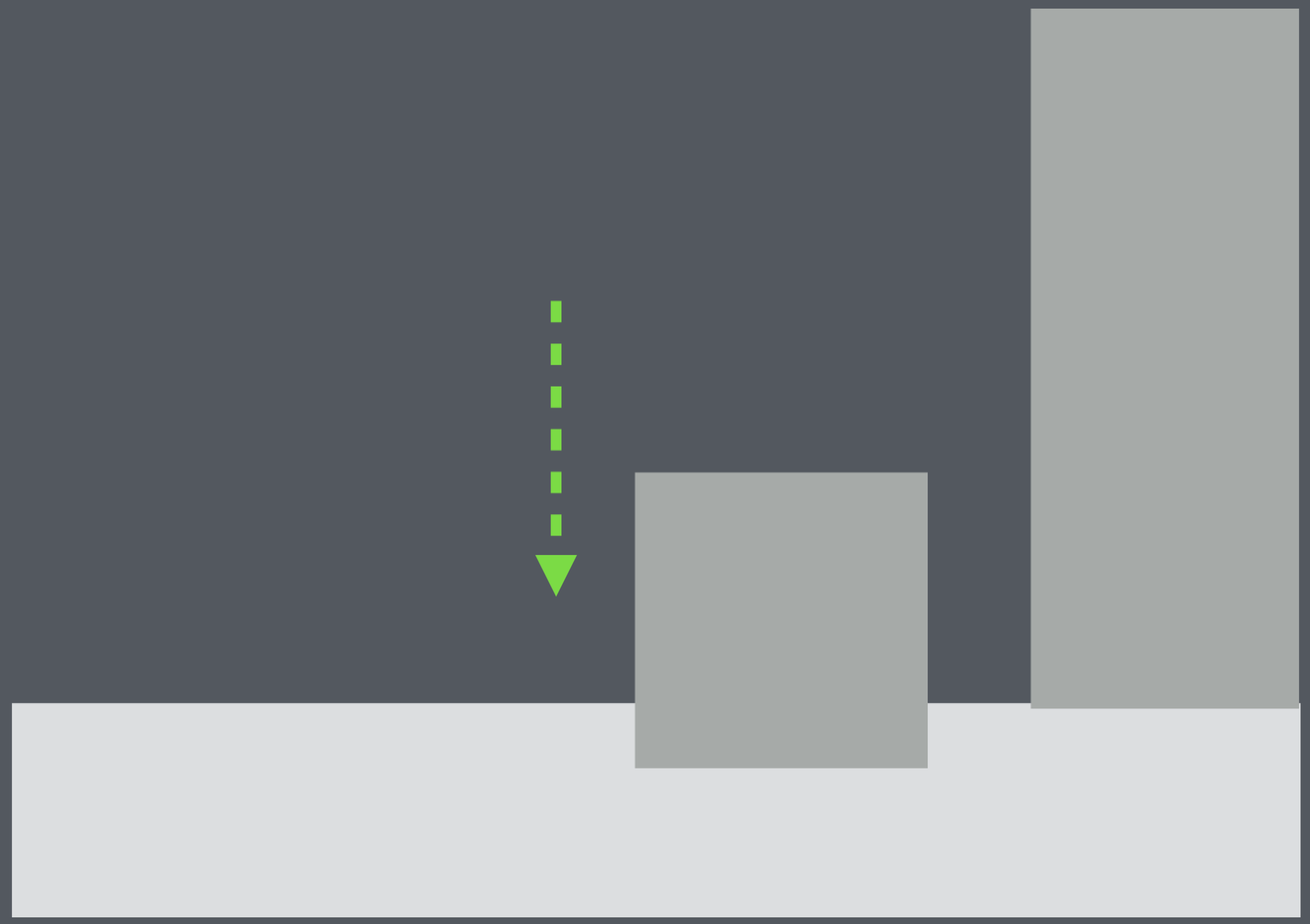
Box-box collision detection.

In which direction should the collision resolve?

Separate movement and collision on each axis!

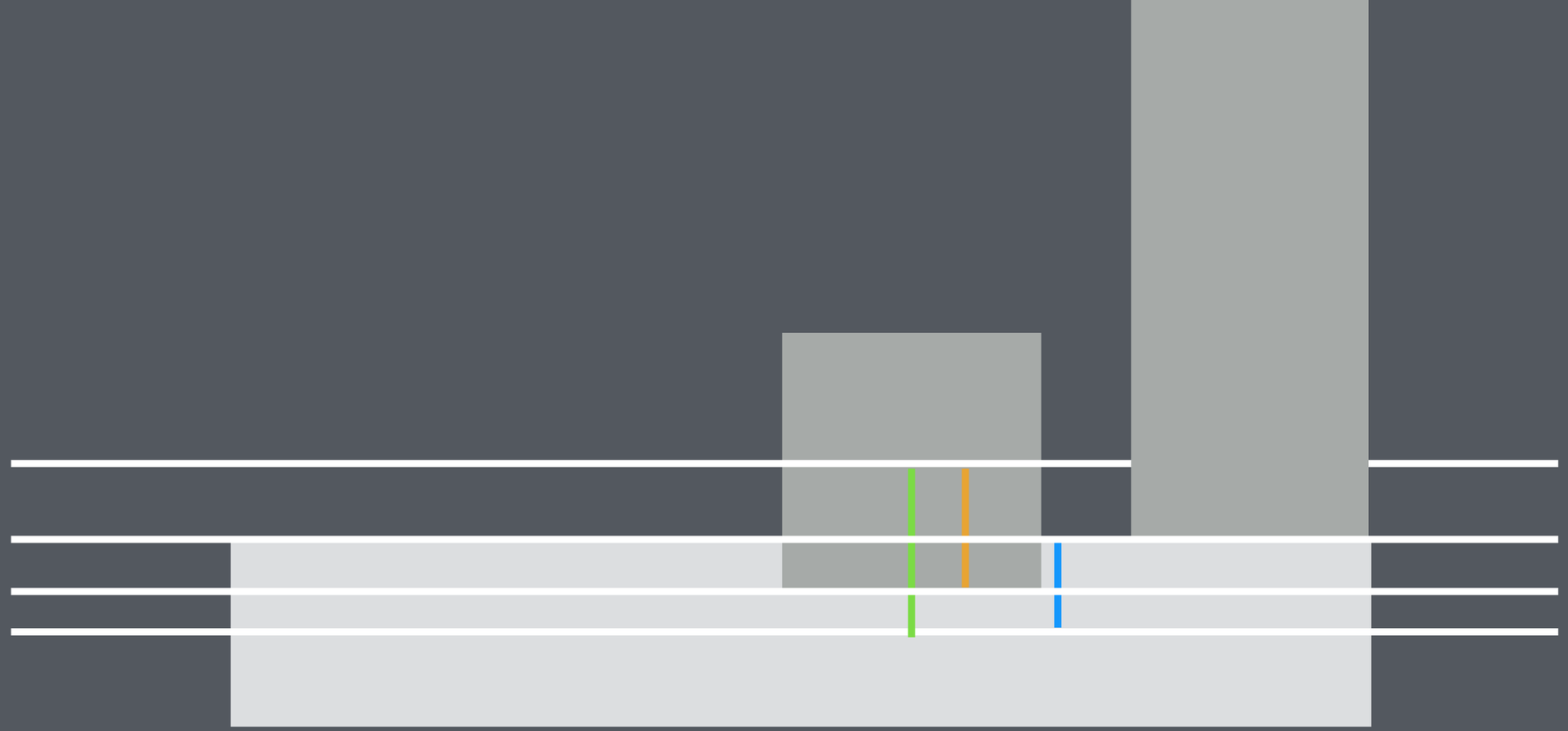


First only apply velocity to position on Y-axis!



Check full box/box collision against all entities.

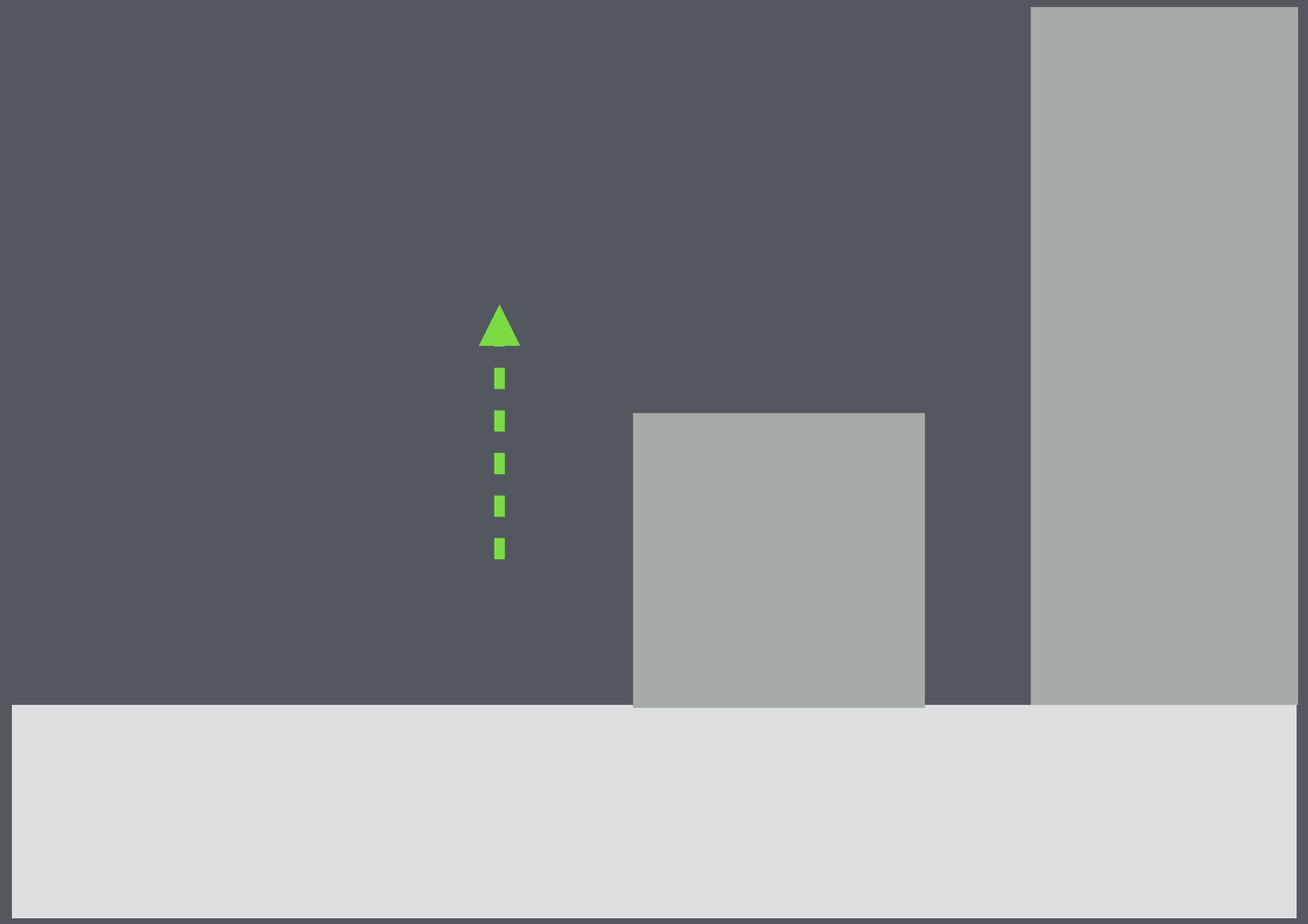
If collided check Y-penetration.



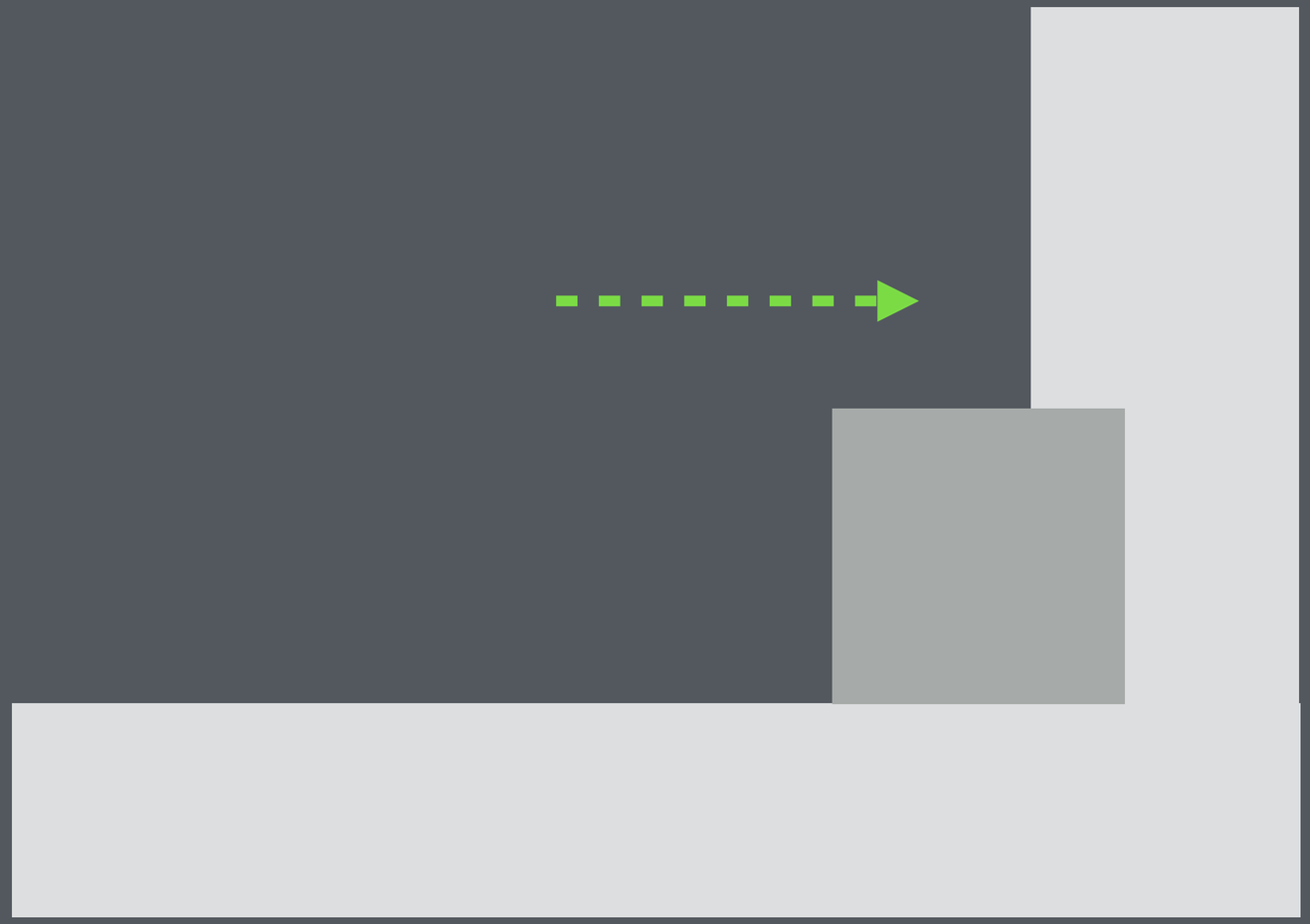
```
penetration = fabs(y_distance - height1/2 -
height2/2)
```

Move on Y-axis by the amount of penetration + tiny amount.

(Move up if above the other entity, otherwise move down!)

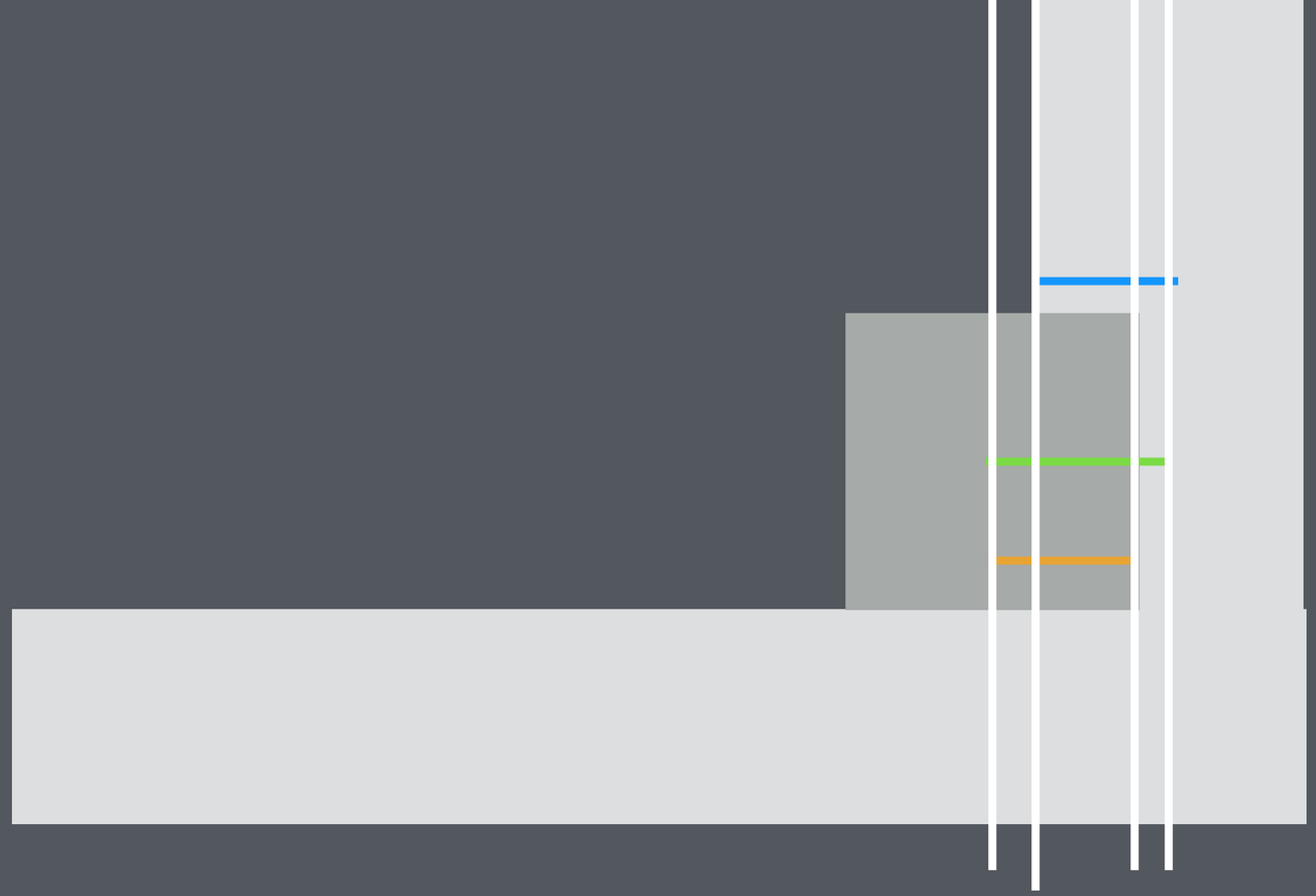


Now only apply velocity to position on X-axis!



Check full box/box collision against all entities.

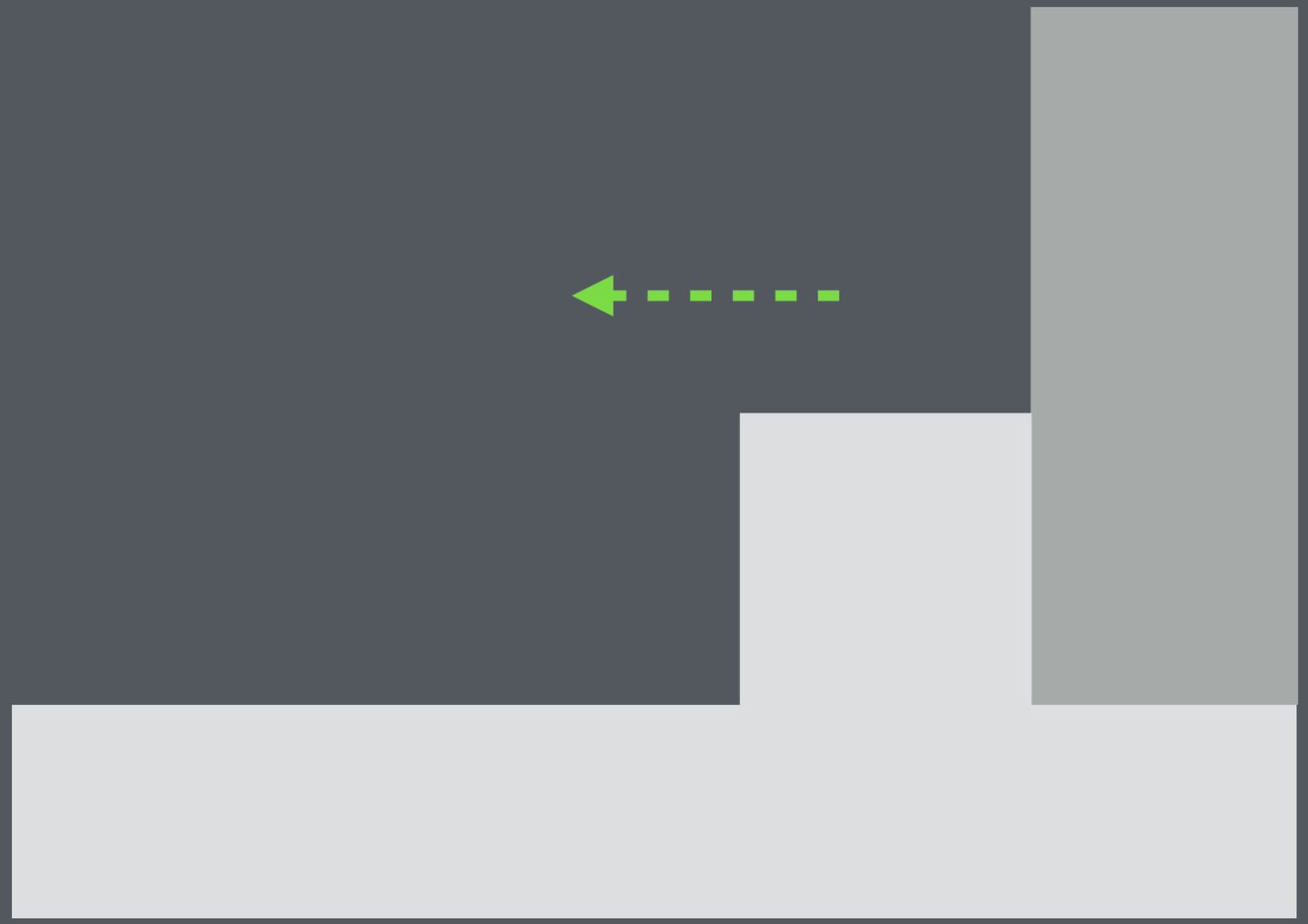
If collided check X-penetration.



```
penetration = fabs(x_distance - width1/2 - width2/2)
```

Move on X-axis by the amount of penetration + tiny amount.

(Move left if to the left of the other entity, otherwise move right!)



```
velocity_x = lerp(velocity_x, 0.0f, elapsed * friction_x);
velocity_y = lerp(velocity_y, 0.0f, elapsed * friction_y);

velocity_x += acceleration_x * elapsed;
velocity_y += acceleration_y * elapsed;

y += velocity_y * elapsed;
collisionY();

x += velocity_x * elapsed;
collisionX();
```

Gravity.

Gravity.

A constant acceleration.

```
velocity_x += gravity_x * elapsed;
velocity_y += gravity_y * elapsed;
```

Restitution (bounciness!)

Inverting velocity on collision and
multiplying it with a dampening factor (0 -1).