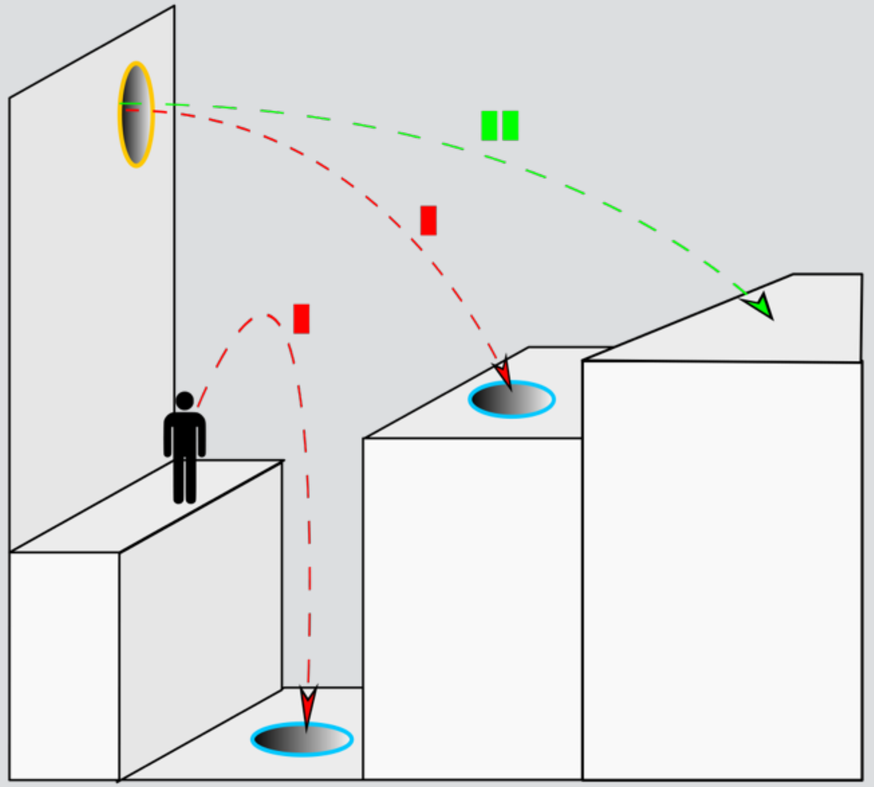
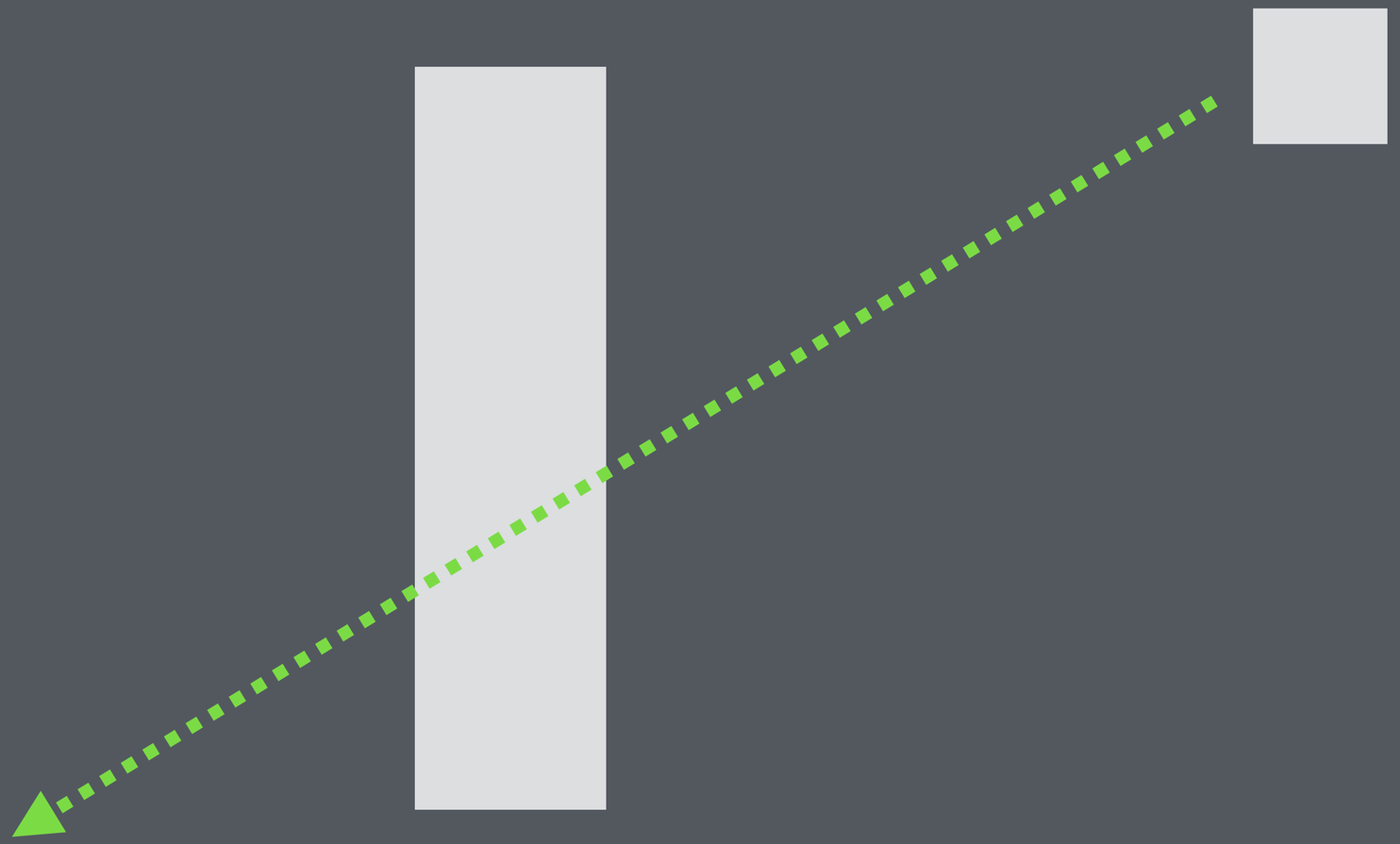
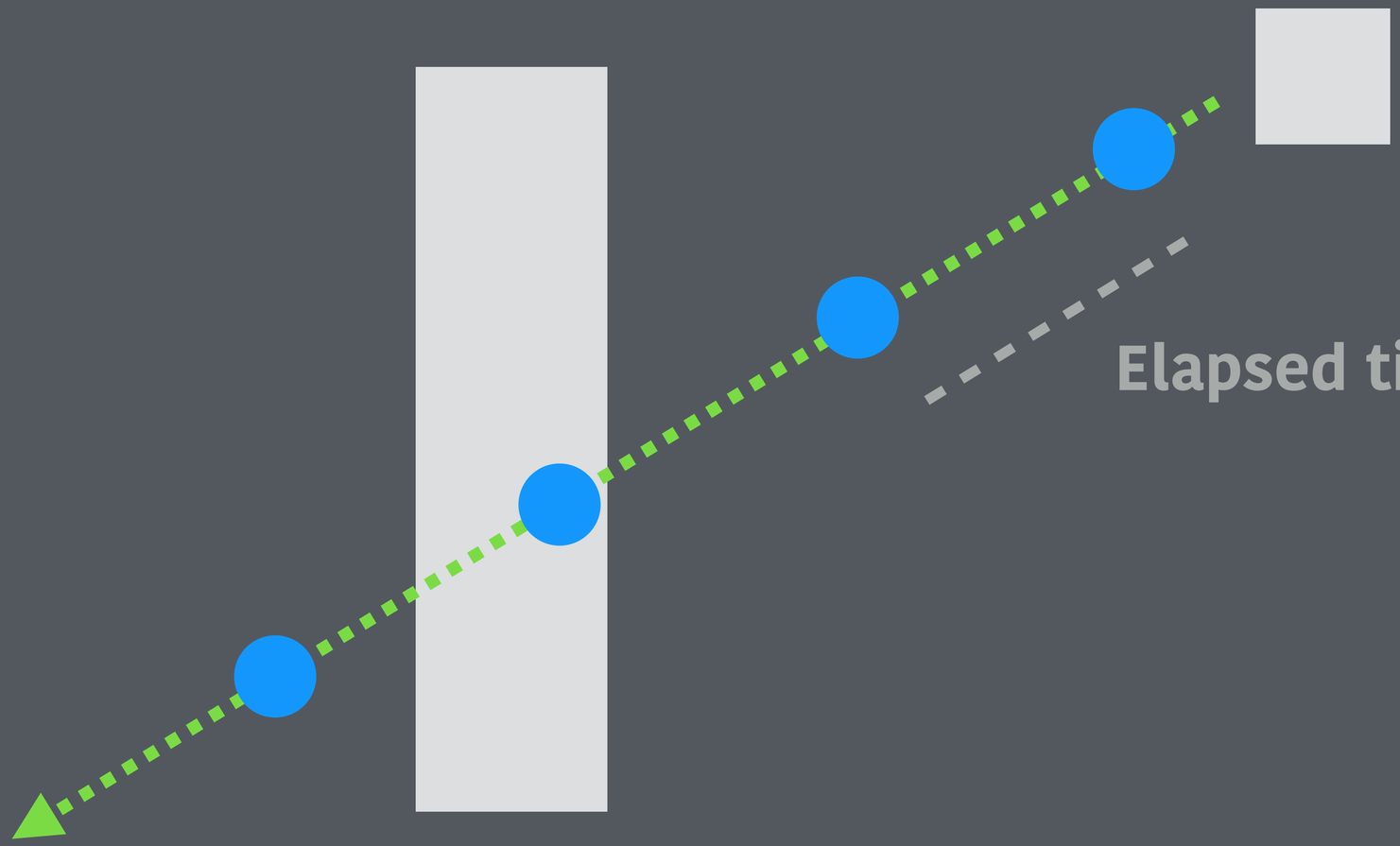
Basic physics and collision response.



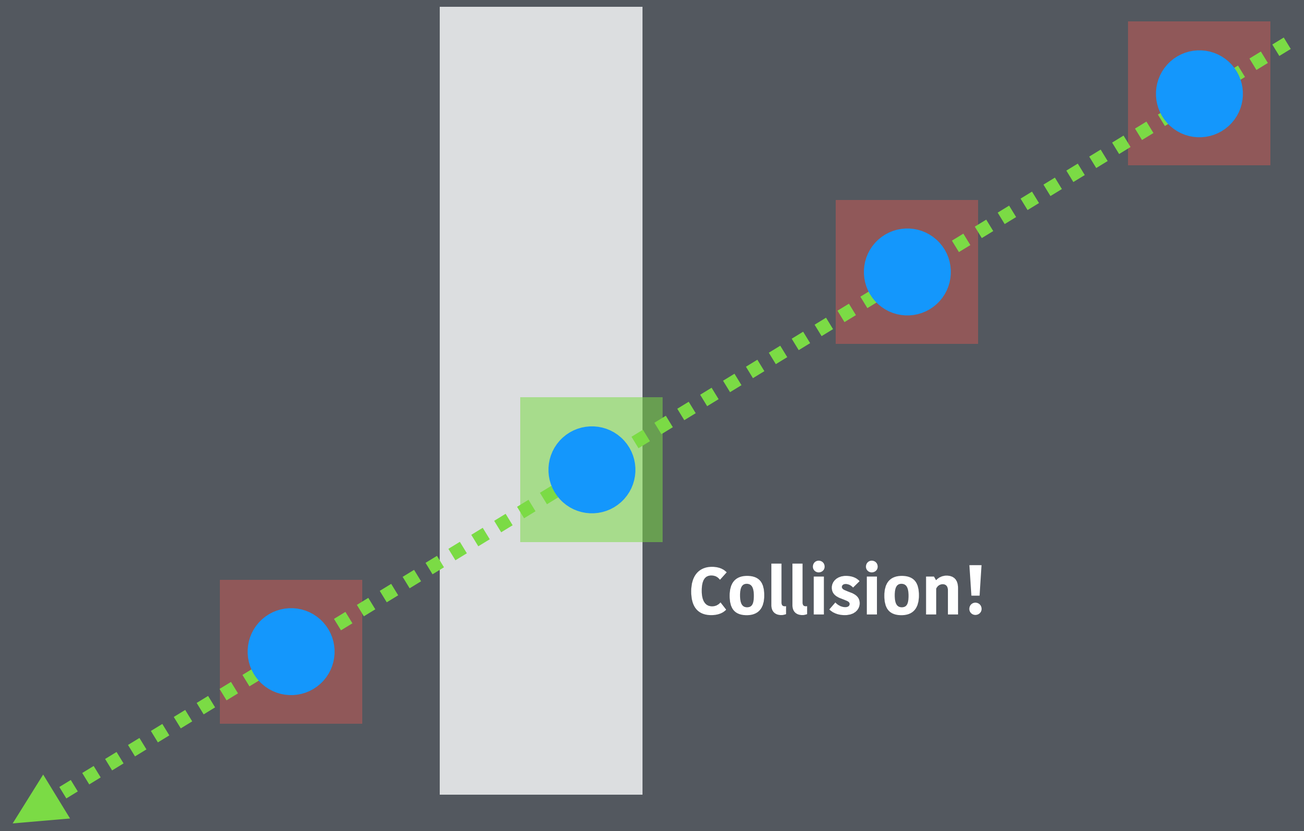
Fixing the **timestep.**

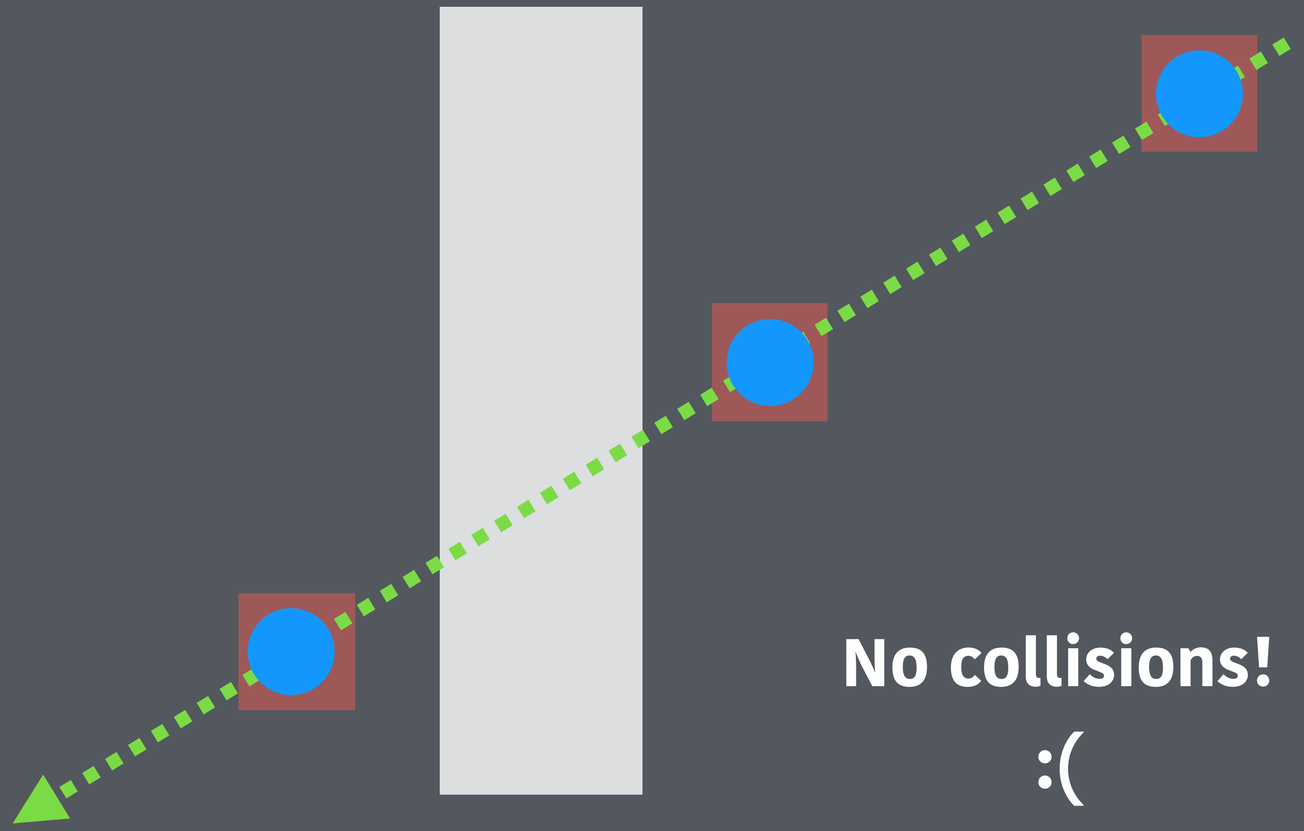
Problems with **variable** timestep.





Elapsed time since last frame

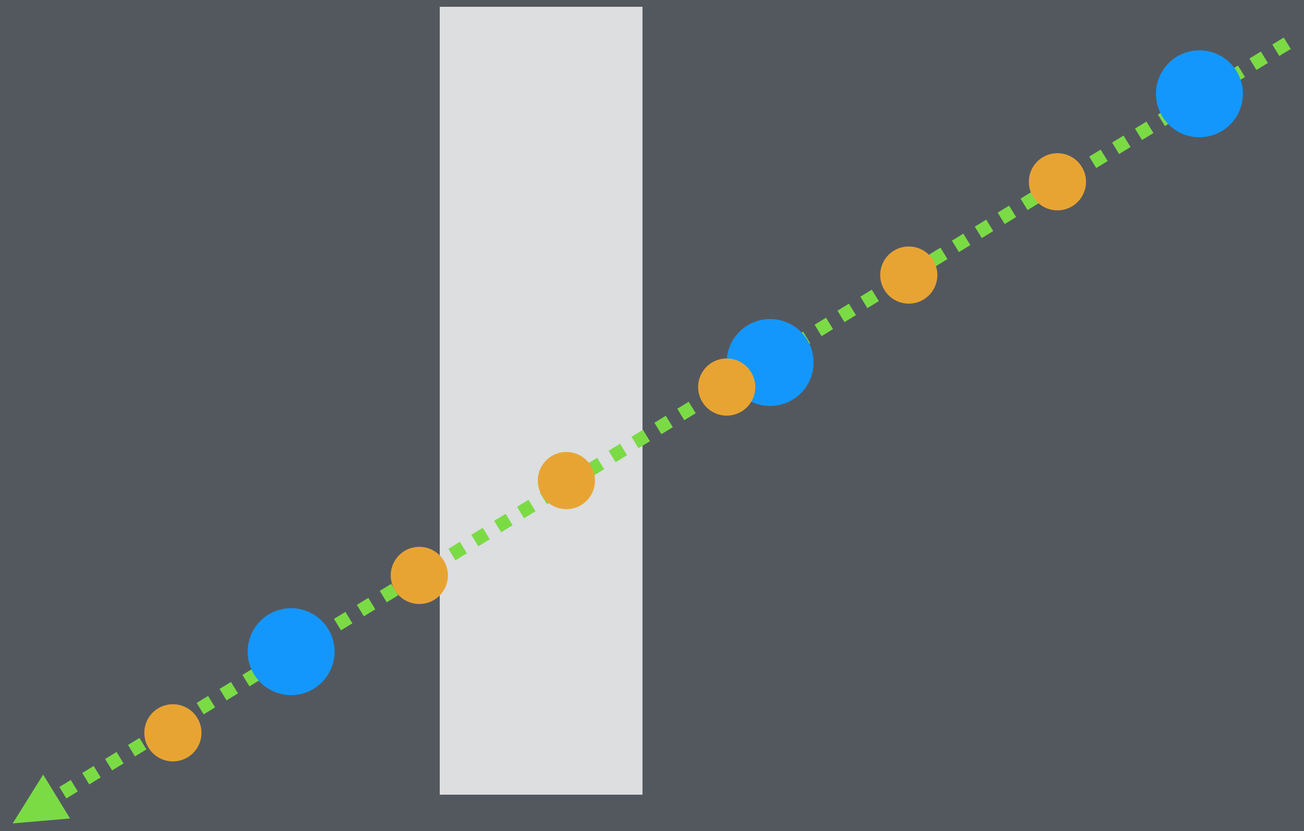

Collision!

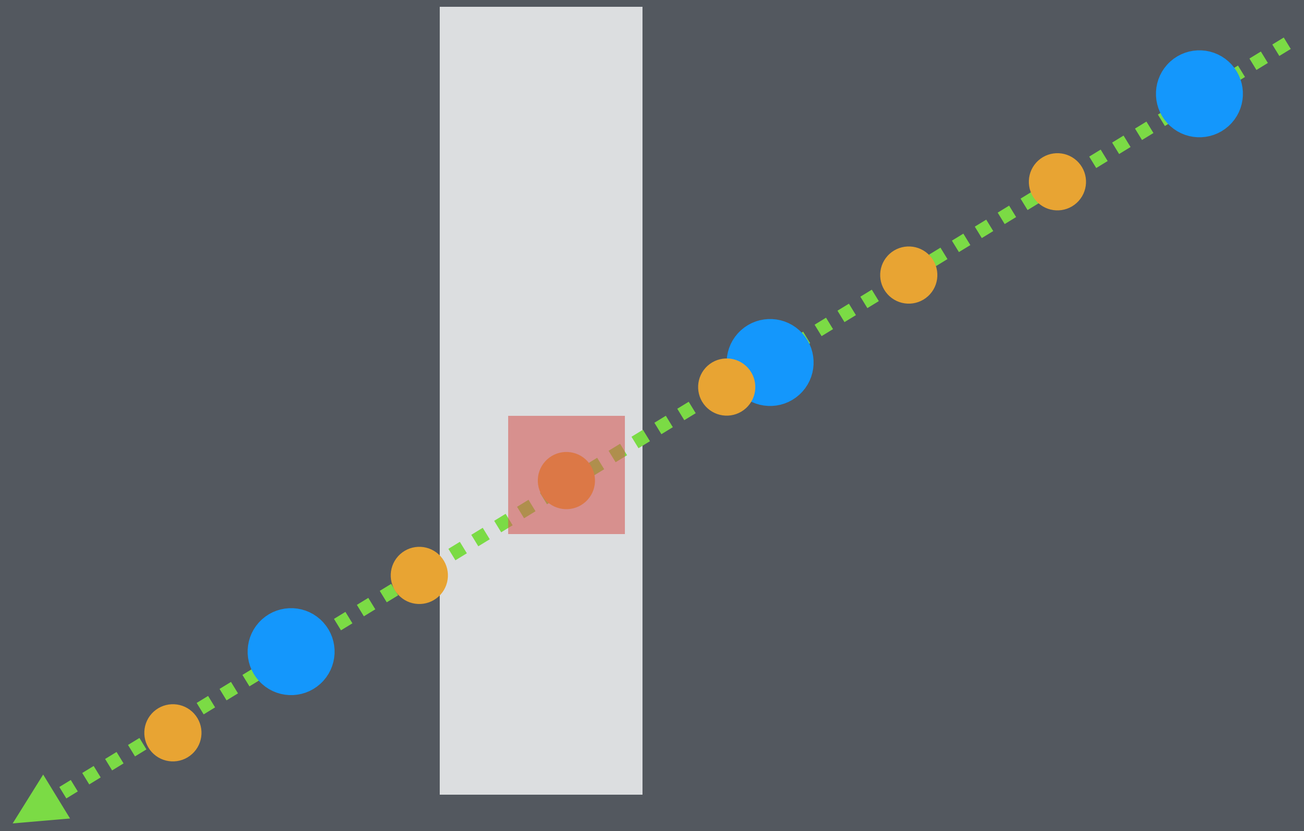


No collisions!

:(

Fixed timestep.





```
// 60 FPS (1.0f/60.0f)
#define FIXED_TIMESTEP 0.0166666f
#define MAX_TIMESTEPS 6
float timeLeftOver = 0.0f;
```

```
float fixedElapsed = elapsed + timeLeftOver;
if(fixedElapsed > FIXED_TIMESTEP * MAX_TIMESTEPS) {
    fixedElapsed = FIXED_TIMESTEP * MAX_TIMESTEPS;
}
while (fixedElapsed >= FIXED_TIMESTEP ) {
    fixedElapsed -= FIXED_TIMESTEP;
    Update(FIXED_TIMESTEP);
}
timeLeftOver = fixedElapsed;
```

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

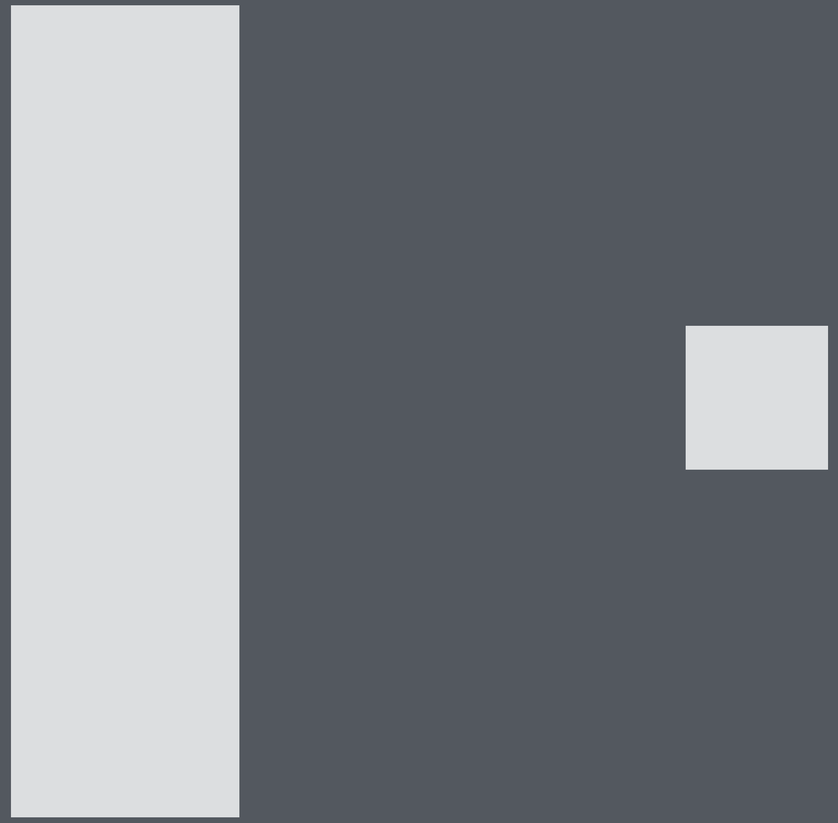
LinEar InteRPolation

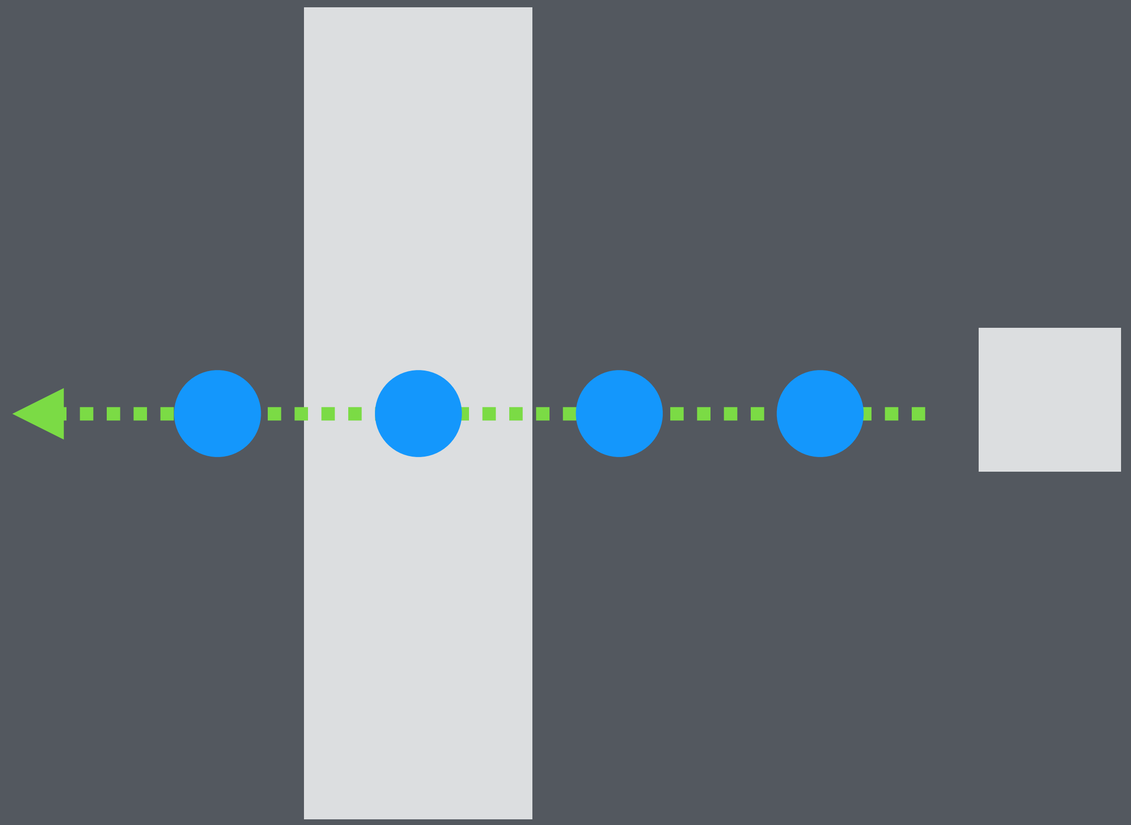
```
float lerp(float v0, float v1, float t) {
    return (1.0-t)*v0 + t*v1;
}
```

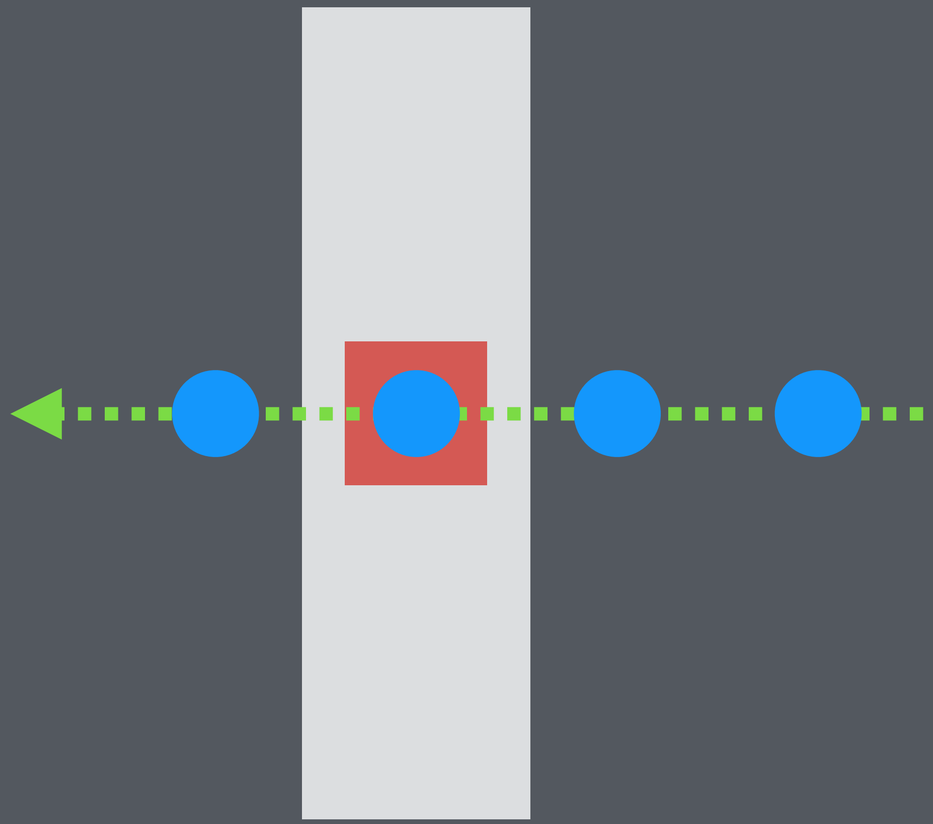
Combined movement.

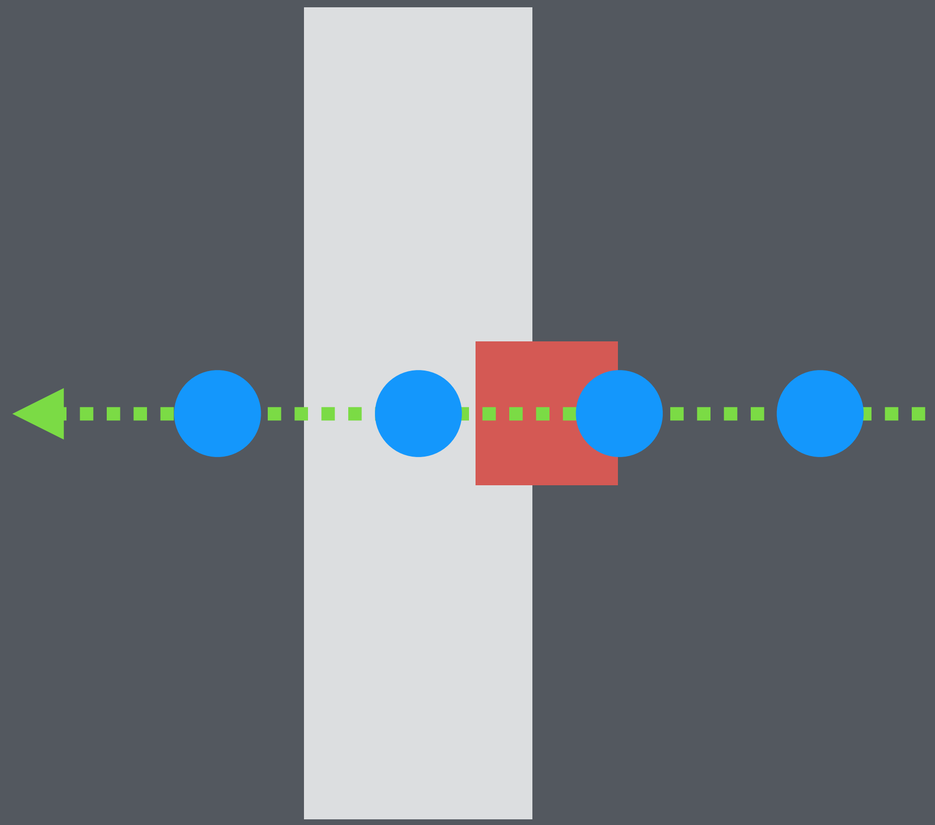
```
velocity_x = lerp(velocity_x, 0.0f, FIXED_TIMESTEP * friction_x);
velocity_y = lerp(velocity_y, 0.0f, FIXED_TIMESTEP * friction_y);

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

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

Collision **response.**



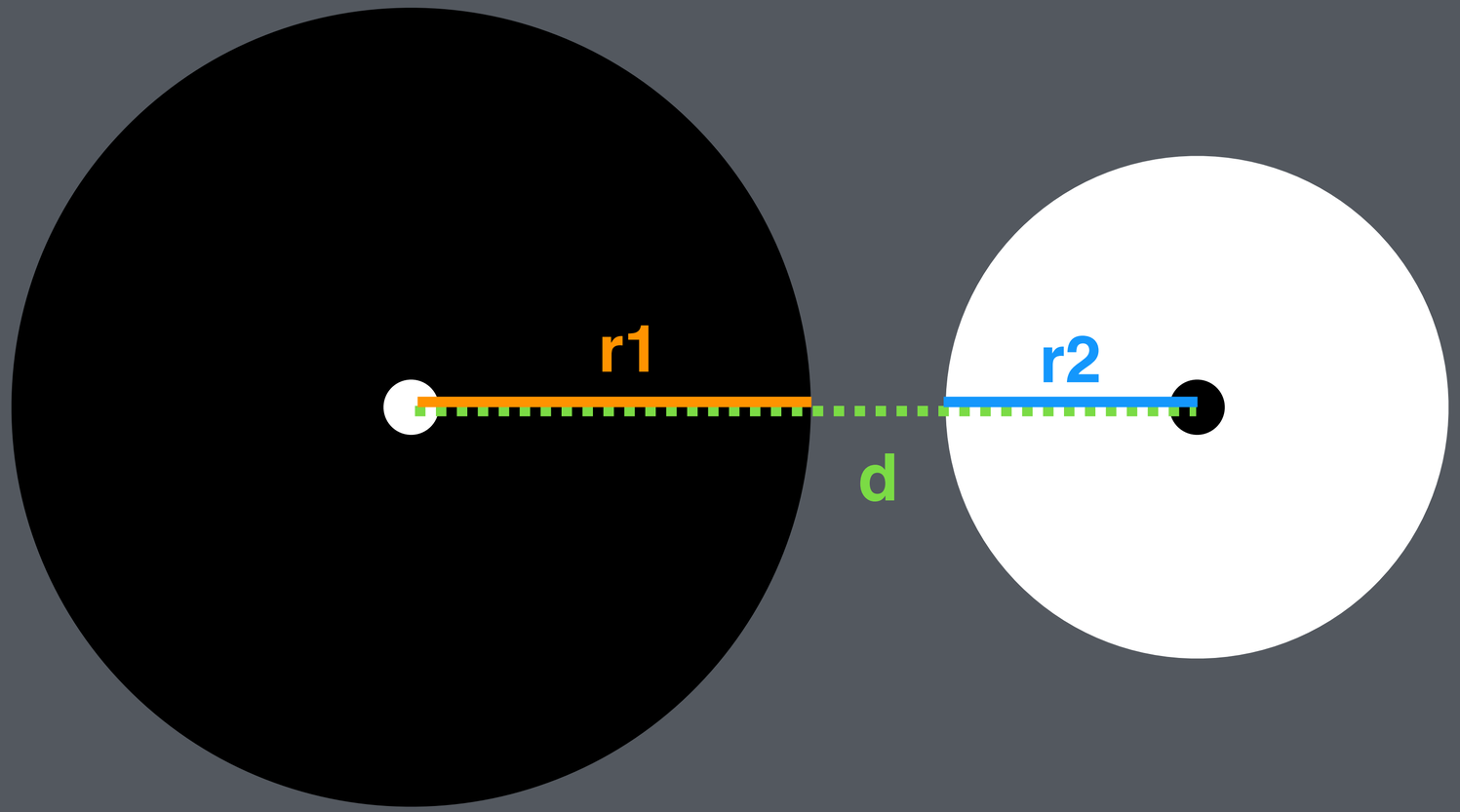




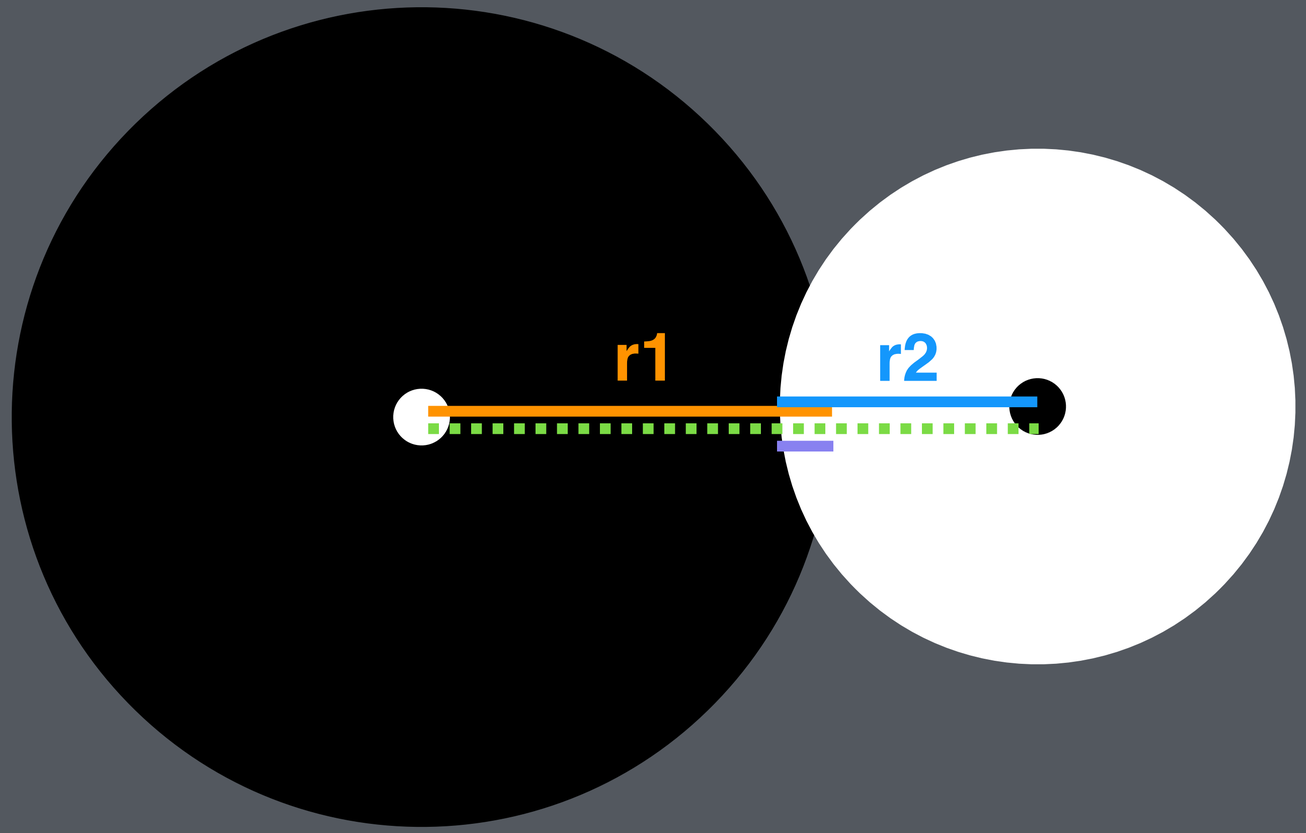


Calculating **collision penetration**.

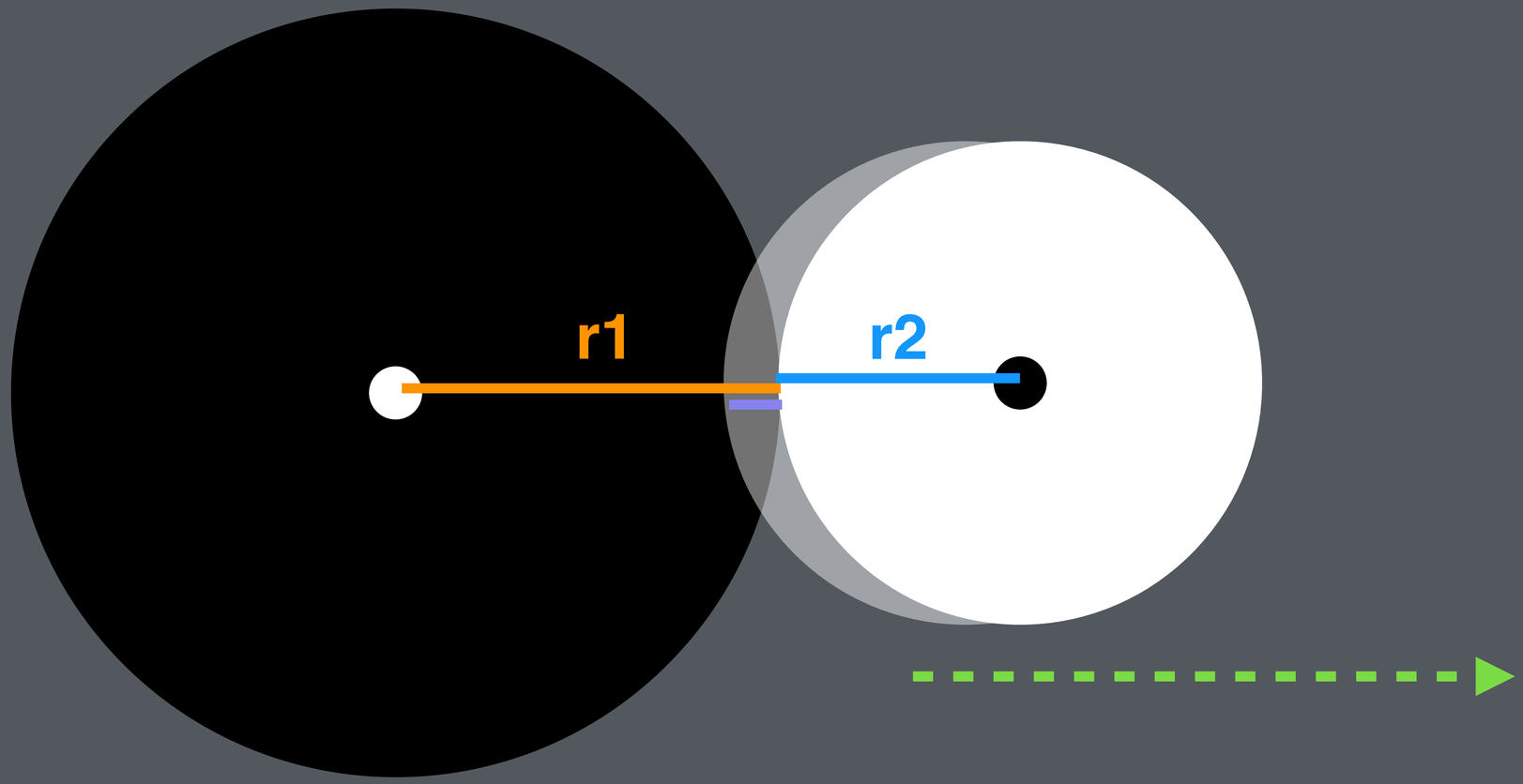
Circle - **circle** collision penetration.



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




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




```
adjust = penetration * direction_vector
```

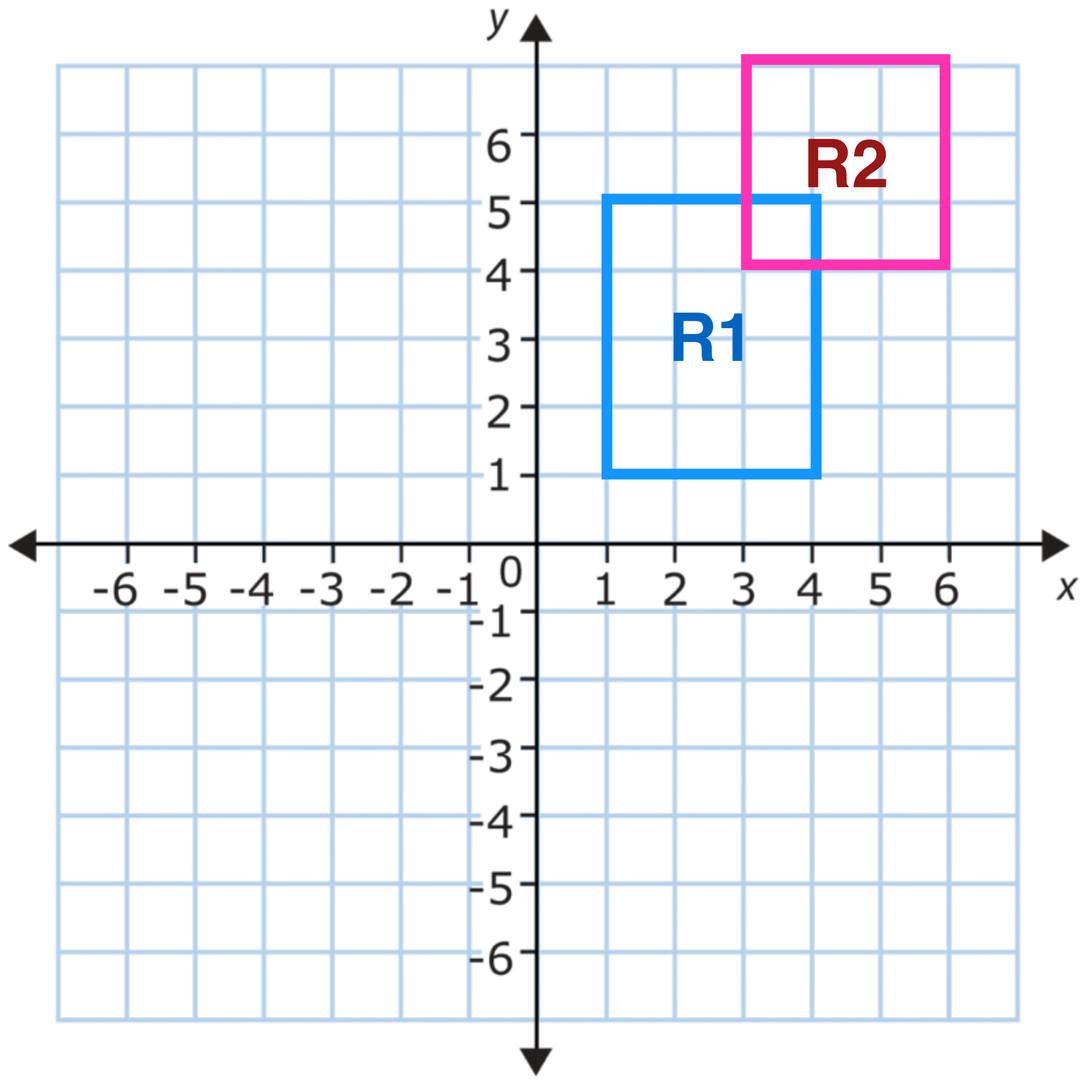
Box-box collision detection.

a) is R1's bottom higher than R2's top?
b) is R1's top lower than R2's bottom?
c) is R1's left larger than R2's right?
d) is R1's right smaller than R2's left

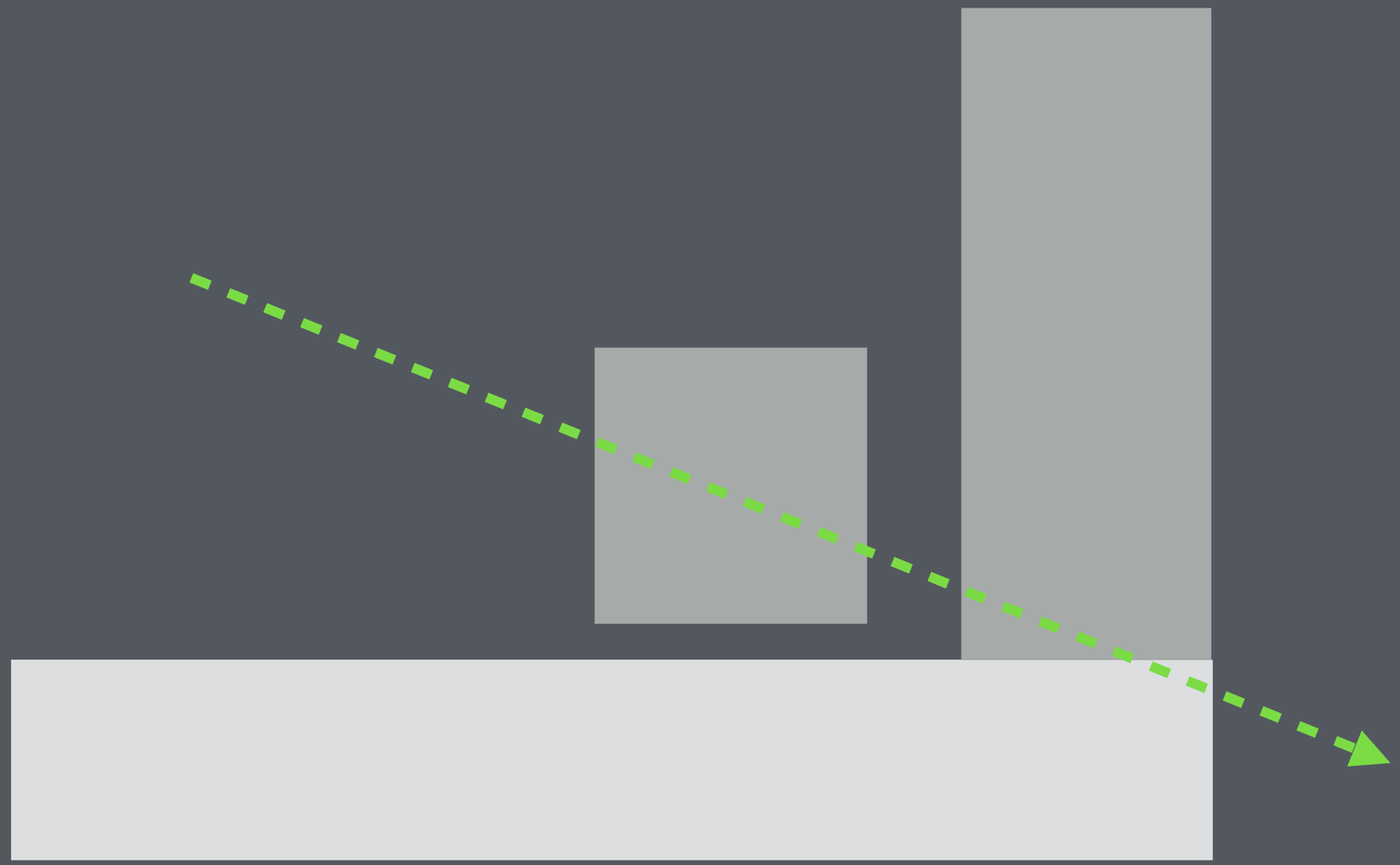
If **ANY** of the above are **true**, then the two rectangles are **NOT** intersecting!

OR

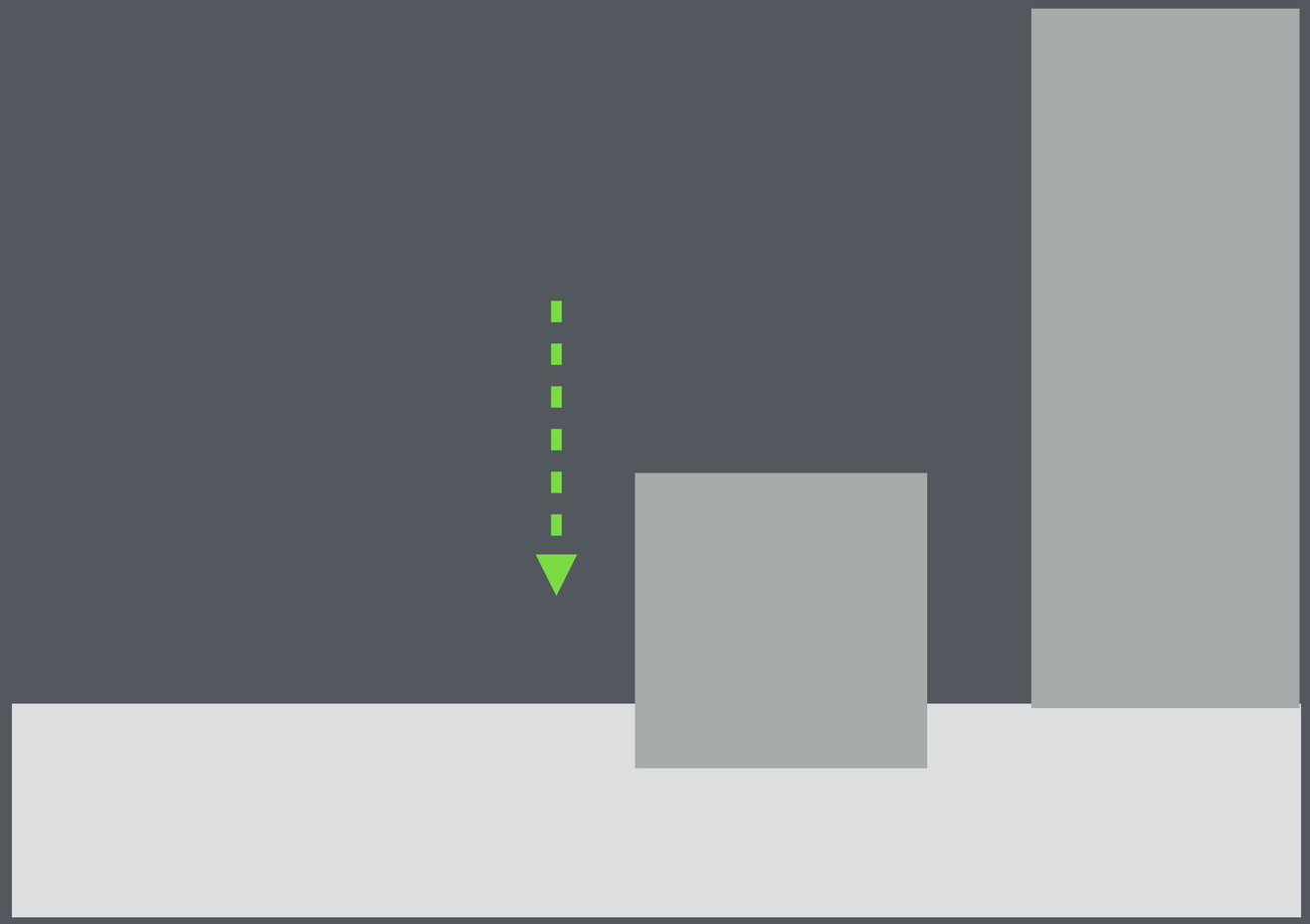
The rectangles are intersecting **if NONE of the above are true.**



Separate movement and collision on each axis!

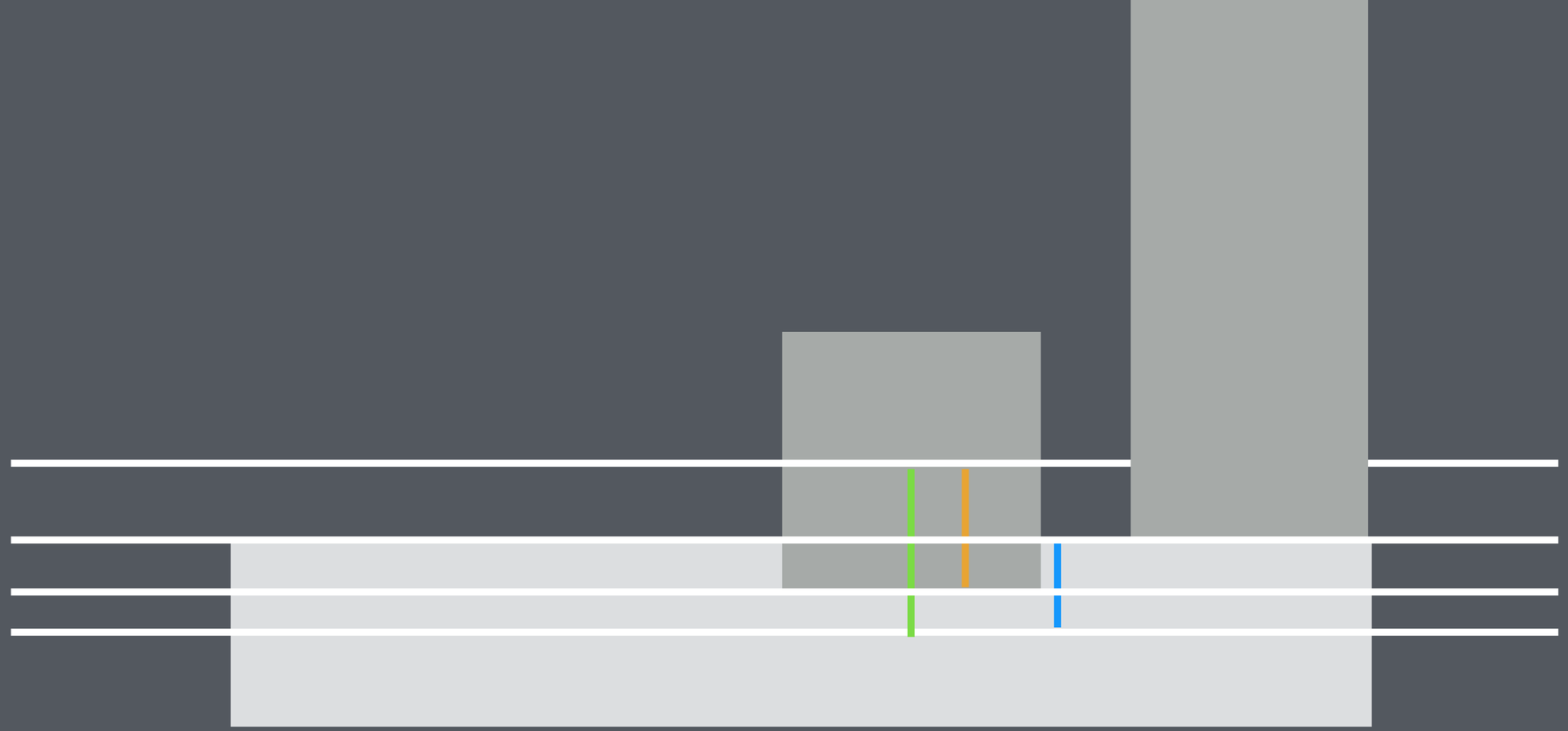


First **only** movement on **Y-axis!**



Check **full collision** against **all entities**.

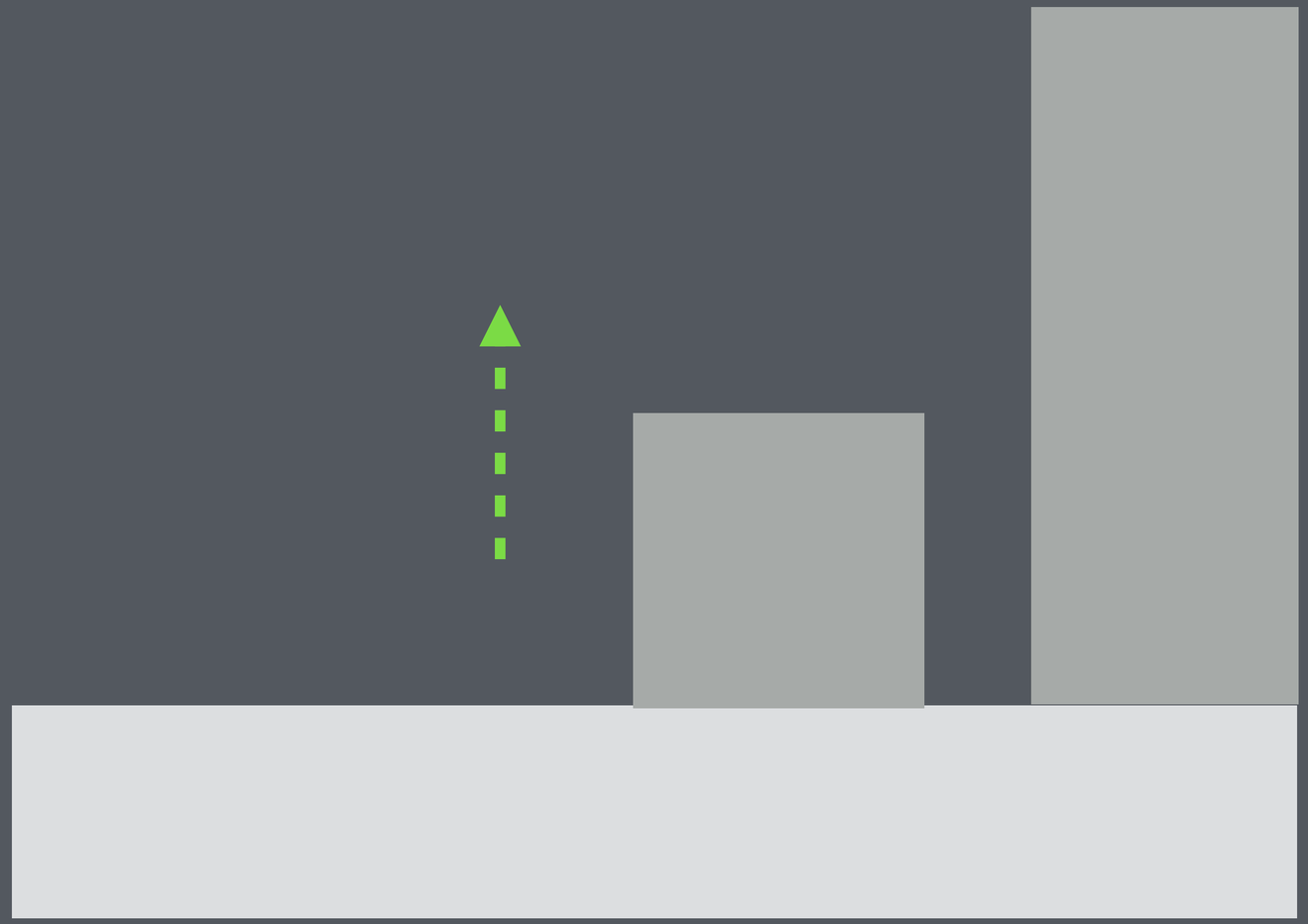
If **collided** check **Y-penetration.**



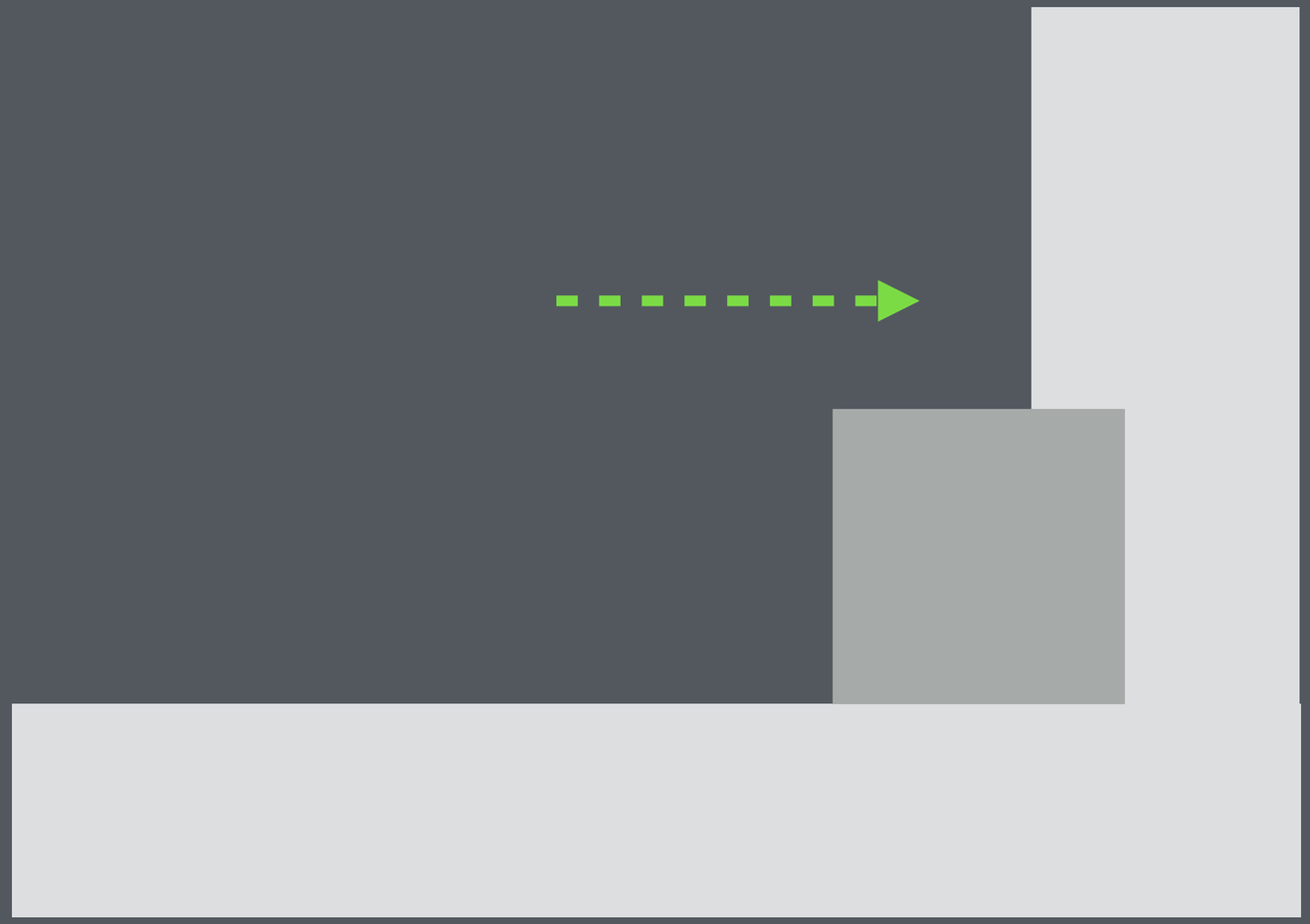
```
penetration = fabs(y_distance - height1/2 -
height2/2)
```

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

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

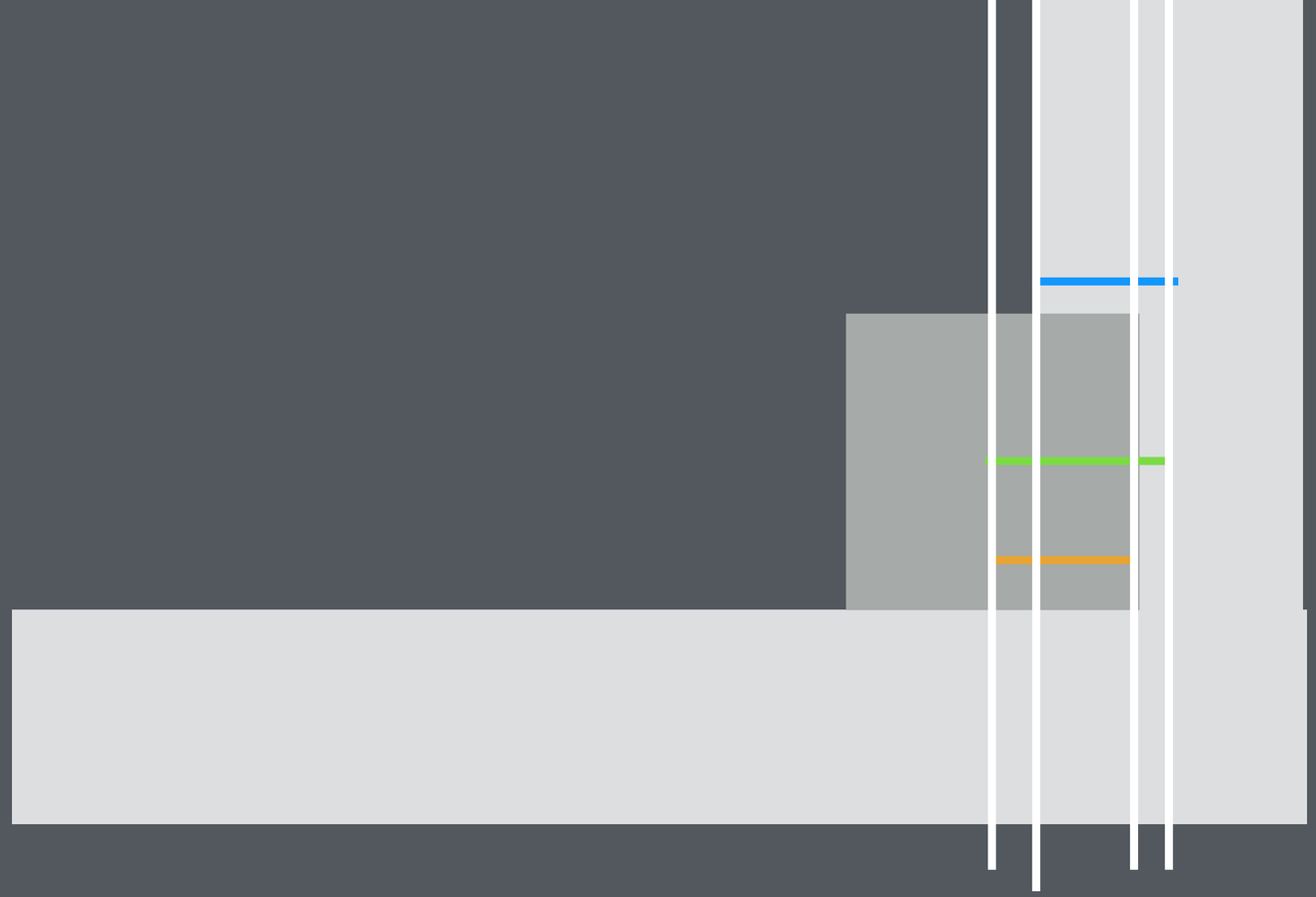


Now **only** movement on **X-axis!**



Check **full collision** against **all entities**.

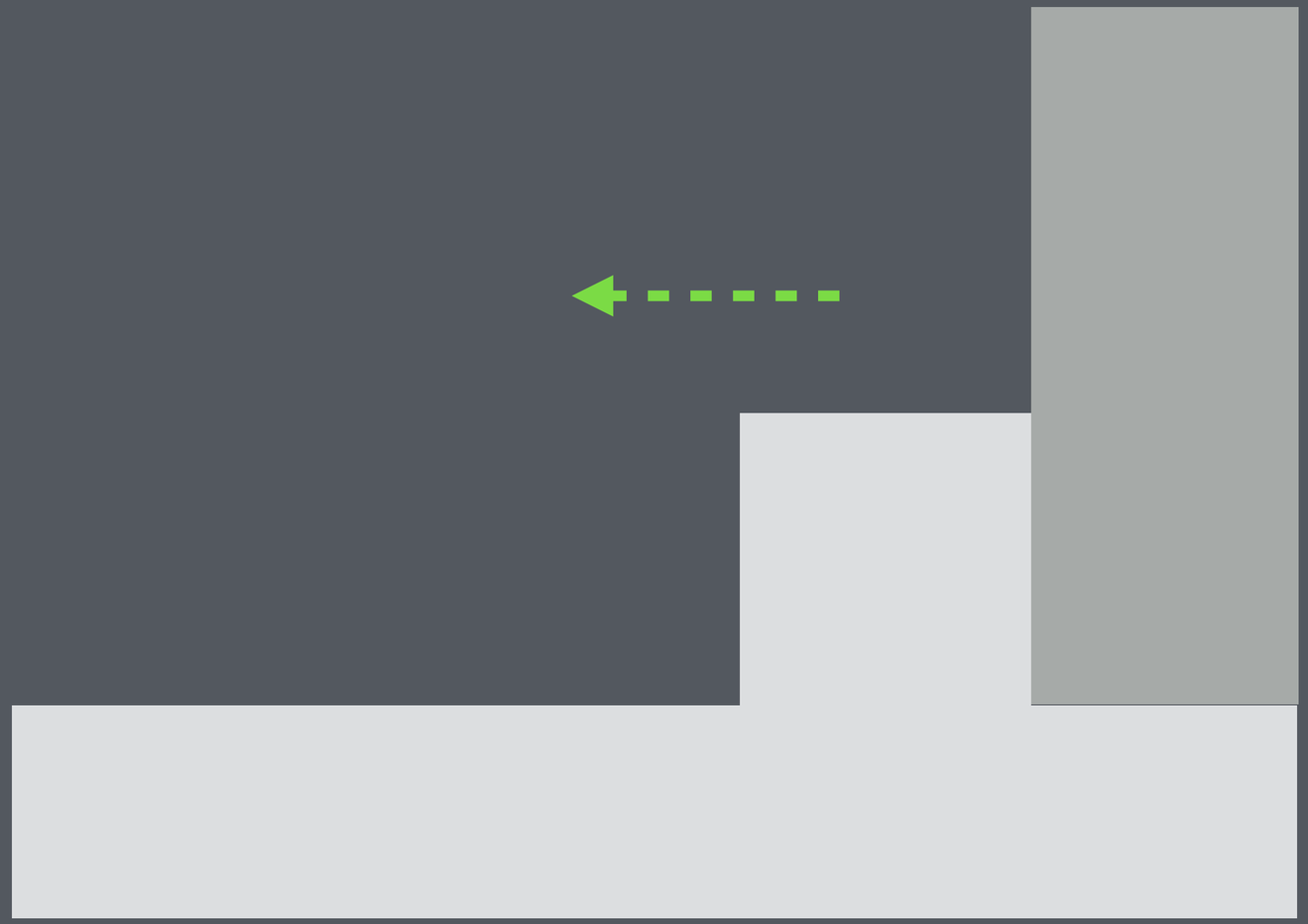
If **collided** check **X-penetration.**



```
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!)



Gravity.

Gravity.

A **constant** acceleration.

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