Multimedia-Programmierung Übung 7

Ludwig-Maximilians-Universität München

Sommersemester 2017

Today

- Particles
- Sound

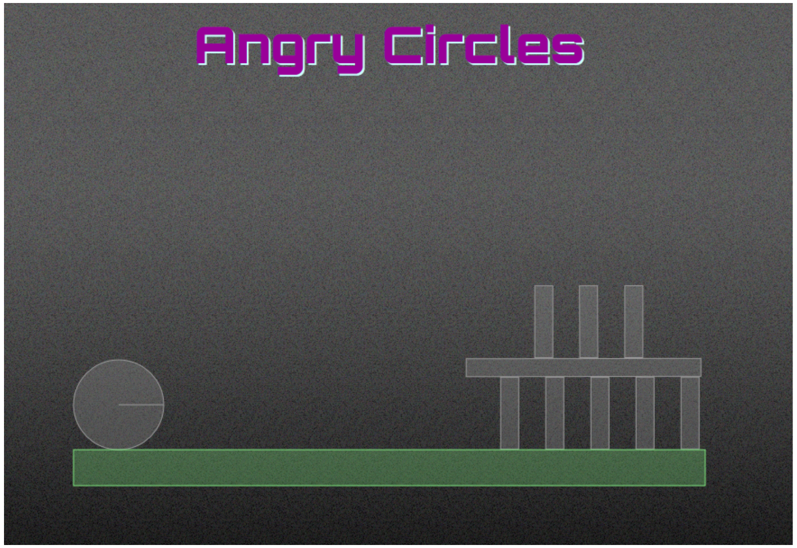
- Illustrated with pygame + COCOS2DX

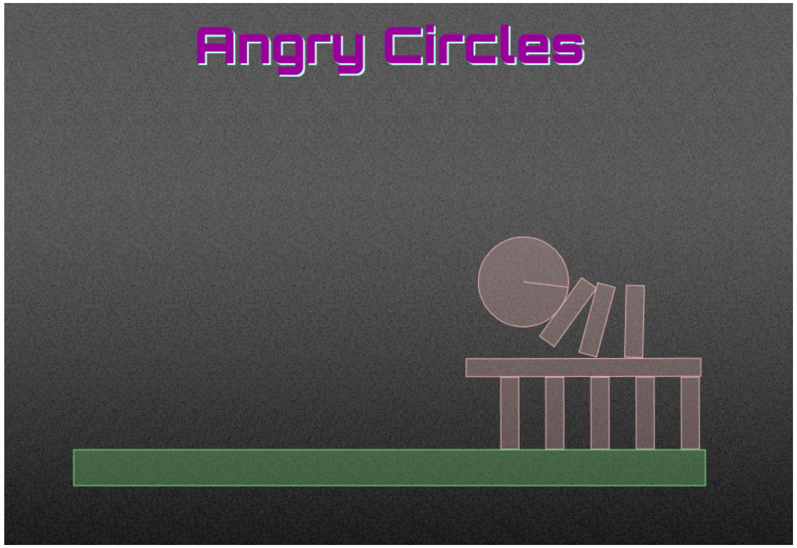
Physics

Users have specific expectations

For example, if something hits a wall it should bounce or create some damage

Adding physics to applications helps to improve usability and user experience





Collision Detection in PyGame

- Rect.collidepoint(point) can be used to see whether a coordinate is within the area of a Rect object
- pygame.sprite has advanced methods to check for collisions
  - E.g. pygame.sprite.collide_rect(a,b) checks whether two sprites intersect

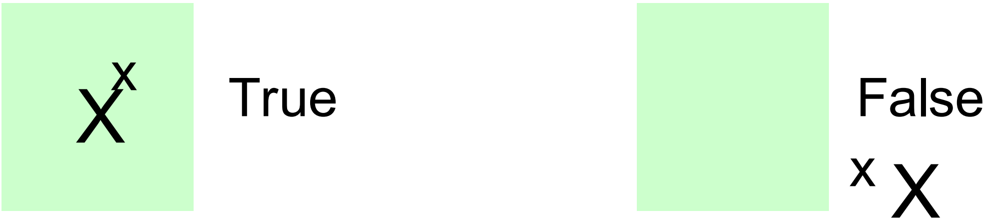
A simple collision detection

```
import pygame
from pygame.locals import *

...

pygame.init()

screen = pygame.display.set_mode((640,  480),  0, 32)
box = Box((255,0,0),(0,0))

while True:
    for event in pygame.event.get():
        if event.type == QUIT:
            exit()
        if event.type == MOUSEBUTTONDOWN:
                if box.rect.collidepoint(event.pos):
                                print "in"
                else:
                                print "out"
    box.update()
    screen.blit(box.image,box.rect)
    pygame.display.update()
```

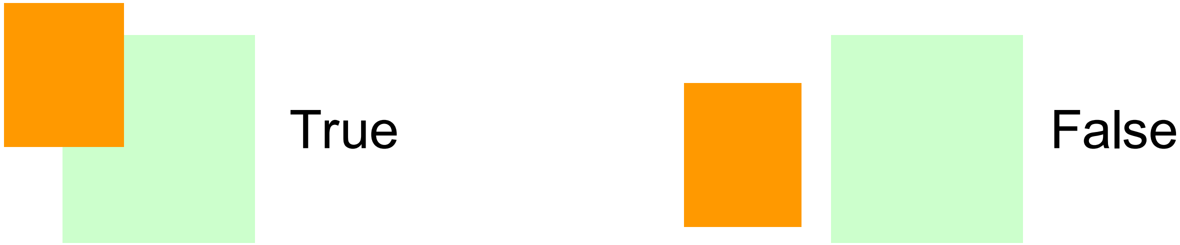
Collision Detection

Rect

- Rect provides several methods to test collisions
  http://www.pygame.org/docs/ref/rect.html
- Rect.collidepoint(point) tests whether a point is within the Rect’s area



- Rect.colliderect(rect) tests whether two Rects intersect



Collision Detection

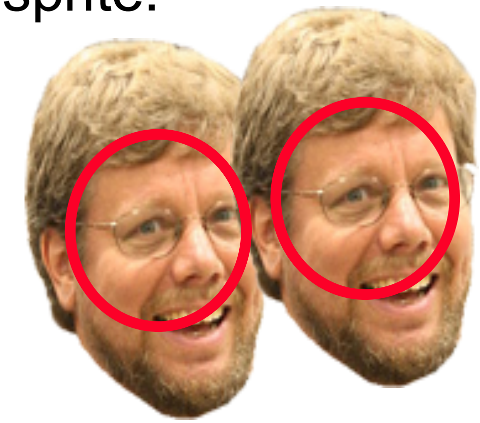
Rect II

- Rect.collidelist(list) tests whether the Rect collides with **at least one** Rect in the given list
- Rect.collidelistall(list) tests whether the Rect collides with **all** Rects in the list
- Rect.collidedict(dict) tests whether the Rect collides with **at least one** Rect in the given dictionary
- Rect.collidedictall(dict) tests whether the Rect collides with **all** Rects in the dictionary

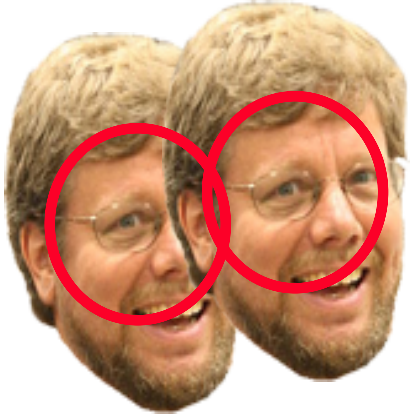
Collision Detection

Sprites

- The module sprite provides several methods to test collision http://www.pygame.org/docs/ref/sprite.html
- sprite.spritecollide(...) returns a list of sprites within a group that intersect with a given sprite
- sprite.collide_rect(a,b) checks whether two sprites intersect (must have rects)
- sprite.collide_circle(a,b) checks whether the radius of two sprites intersect. Radius attribute should be defined in the sprite.



False



True

Collision Detection

Sprites 2

- sprite.groupcollide(a,b) returns a list of sprites of two groups that intersect
- sprite.collide_mask(a,b) checks whether two

```
if pygame.sprite.collide_mask(head1,head2):
		print "collide"
```

False

True

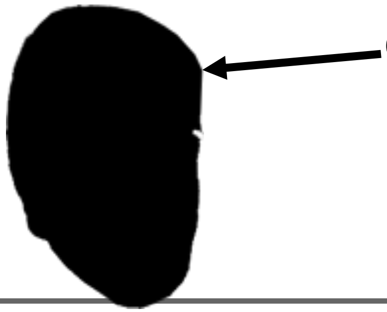
Collision Detection

Masks

- Masks are 1bit per pixel representations of areas that can collide
- Module mask contains functions and classes to create and use masks
  http://www.pygame.org/docs/ref/mask.html
- mask.from_surface(surface,threshold=127) creates a mask of a surface. Threshold defines the alpha value that counts as collideable
- Class Mask contains methods to work with classes

Original

Mask



Collision Detection

Conclusion

- Pygame offers various ways to check for collisions
- **Choose your collision detection algorithm wisely depending on the task**
- Pixel based collision detection is precise but slow
- Rect or radius based collision detection is fast but imprecise

Programming Physics
(LOW-LEVEL)

Frameworks like Cocos2d-x offer physics engines (e.g. 3D game engines, Interpolators in Flash or Box2D for JavaScript (..and python))

In Python, **WE have** to do the physics!!

Tutorials

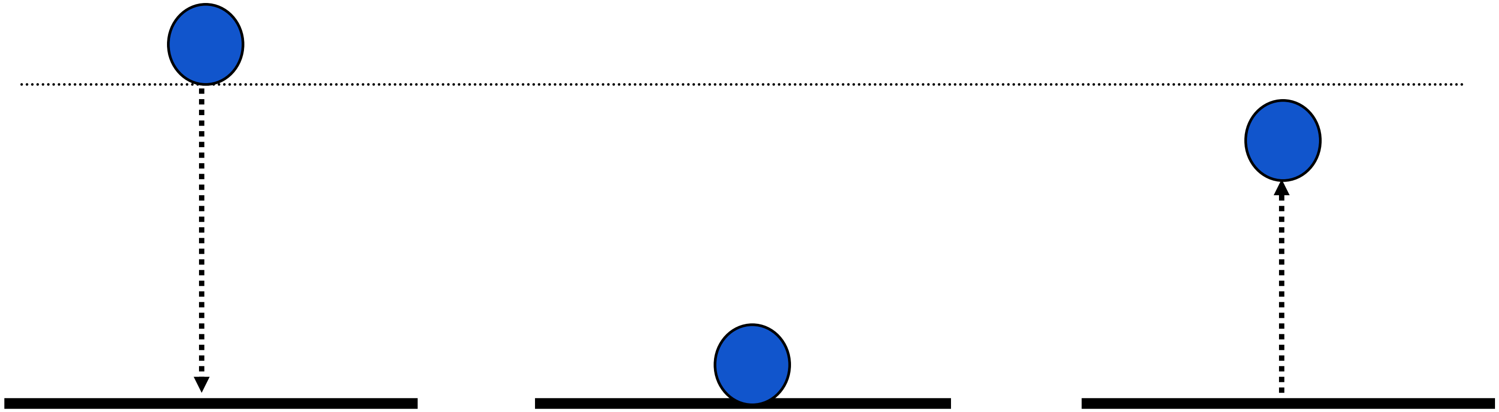
http://pet.timetocode.org

http://www.petercollingridge.co.uk/pygame-physics-simulation

Bouncing Ball Example 1

Let’s make a ball bounce in a realistic way

1. We need a concept:



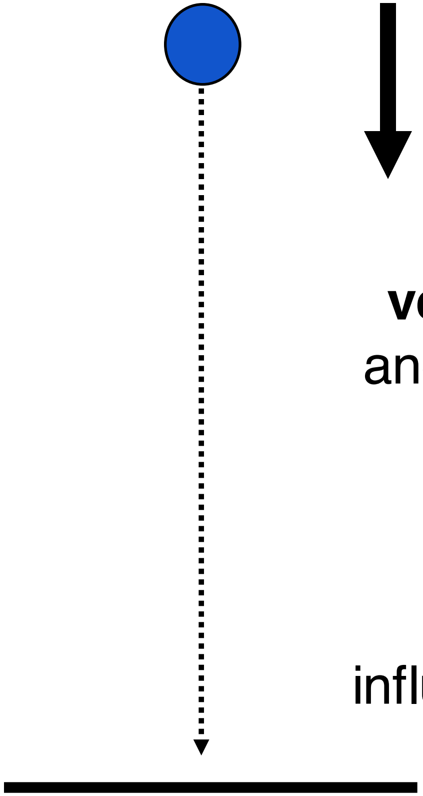
falling ball

bounces off the ground

and looses energy

Bouncing Ball Example 2

2. What makes the ball fall and bounce?



gravity makes the ball fall

velocity depends on gravity and increases/decreases over time

the material of the ball influences how far it will **bounce** back

Bouncing Ball Example 3

```
class Ball(pygame.sprite.Sprite):
    def __init__(self, color, initial_position):
        pygame.sprite.Sprite.__init__(self)
        size = 20
        self.gravity = 900
        self.velocity = 0
        self.bounce = 0.9

        self.image =
pygame.Surface((size,size),pygame.SRCALPHA,32)
        pygame.draw.circle(self.image,color,(size/2,size/2),size/2)
        self.rect = self.image.get_rect()
        self.rect.center = initial_position

    def update(self, time_passed, size):

        self.velocity += (self.gravity * time_passed)
        self.rect.bottom += int(self.velocity * time_passed)

        if self.rect.bottom >= size[1]:
            self.rect.bottom = size[1]
            self.velocity = -self.velocity * self.bounce
```

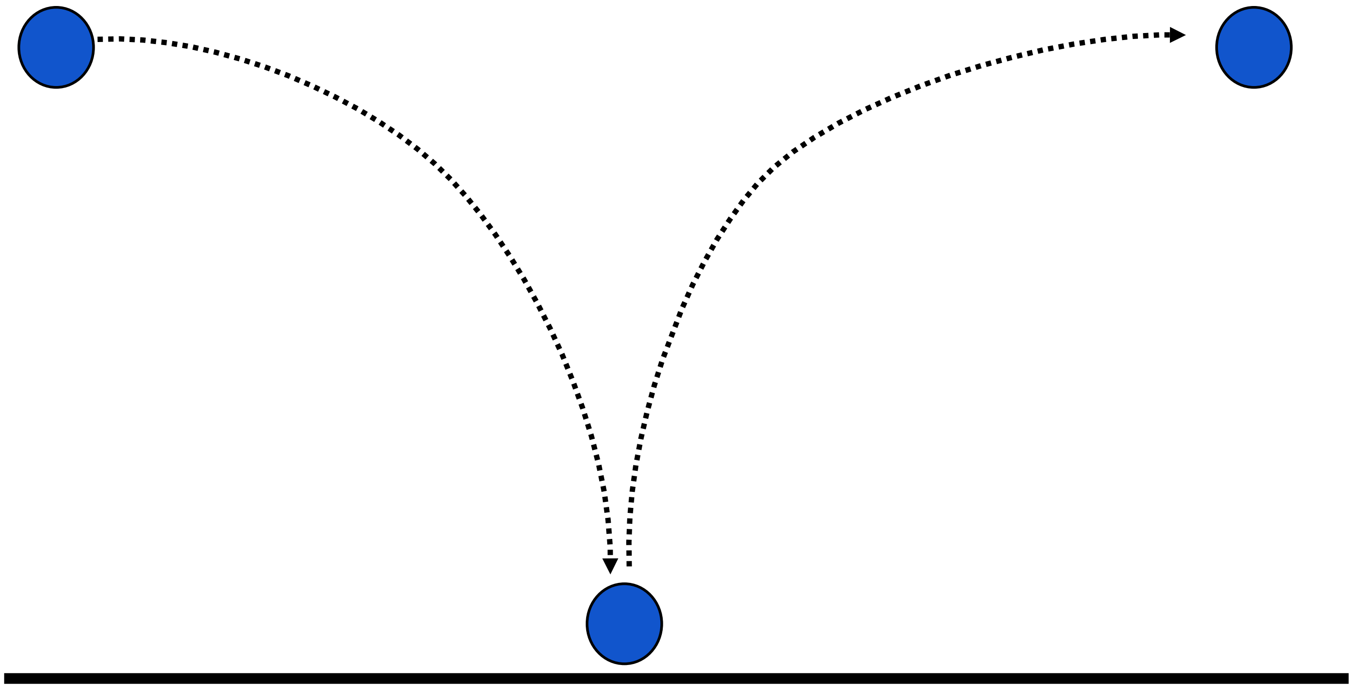
gravity per second, current velocity and bounce factor of the material

velocity is increased/decreased by the gravity

if the ball hits the ground, reduce velocity based on the bounce factor

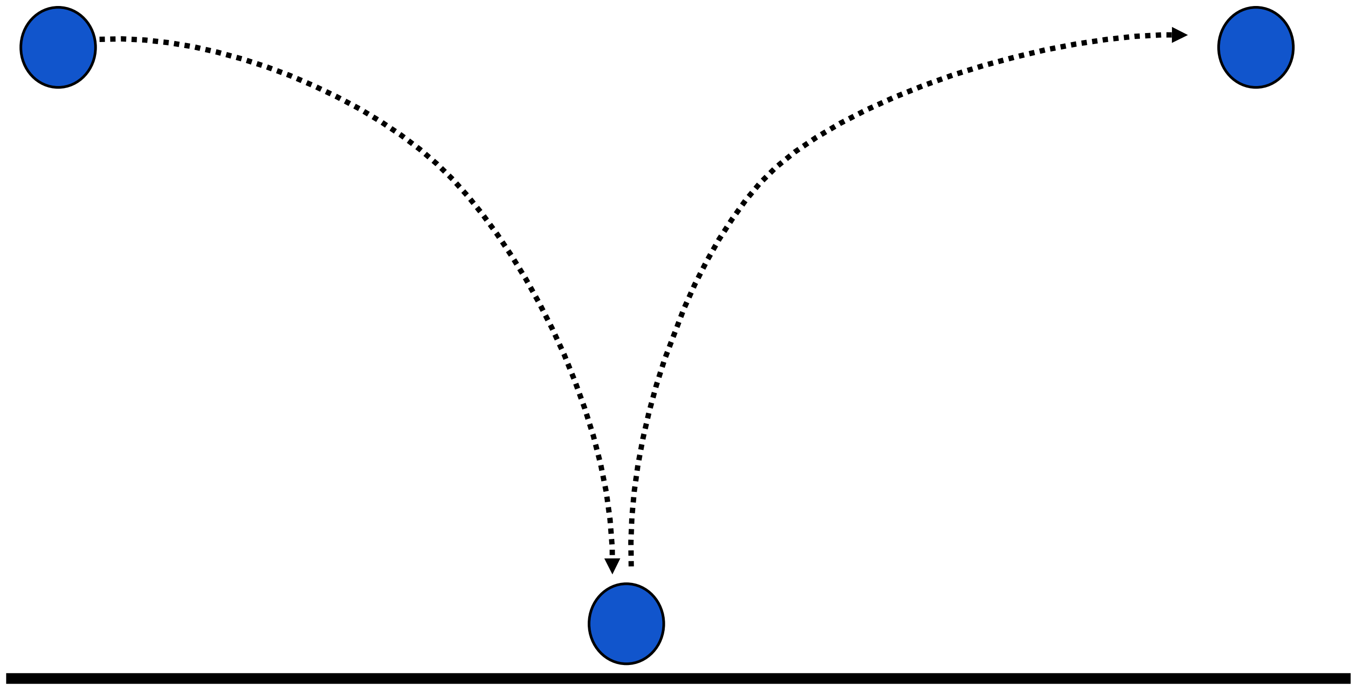
Bouncing Ball Example 4

Making the ball bounce and move vertically



In-class exercise

Implement this movement:



Bouncing Ball Example 5

```
class Ball(pygame.sprite.Sprite):
    def __init__(self, color, initial_position):
        pygame.sprite.Sprite.__init__(self)
        size = 20
        self.gravity = 900
        self.vx = 0
        self.vy = 0
        self.bounce = 0.9
        …
    def update(self, time_passed, size):
        self.velocity += (self.gravity * time_passed)
        ydistance = int(self.vy * time_passed)
        self.rect.bottom += ydistance
        if ydistance == 0 and self.rect.bottom == size[1]: self.vx = 0
        self.rect.left += int(self.vx * time_passed)
        if self.rect.right >= size[0]:
            self.rect.right = size[0]
            self.vx = -self.vx
        if self.rect.left <= 0:
            self.rect.left = 0
            self.vx = -self.vx
        if self.rect.bottom >= size[1]:
            self.rect.bottom = size[1]
            self.vy = -self.vy* self.bounce
```

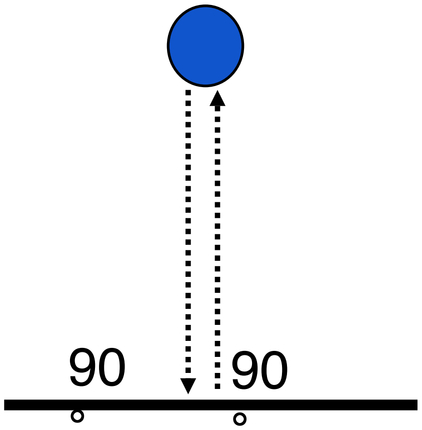
x and y velocity

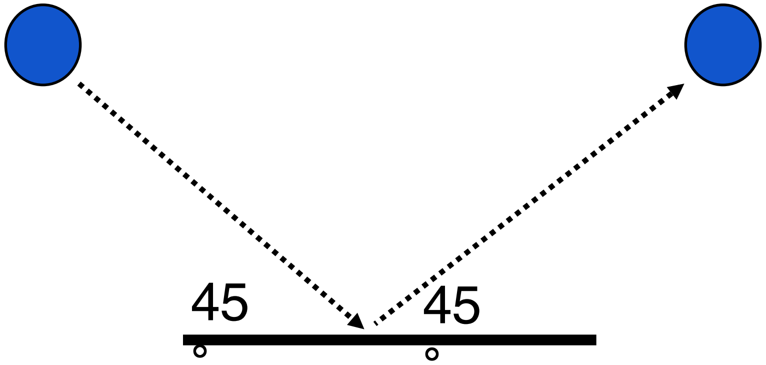
clumsy way to make the ball stop

if the ball hits the sidewalls, make it change the direction

Arrival Angle = Angle of Reflection

What if the Ball doesn’t drop perfectly vertically?



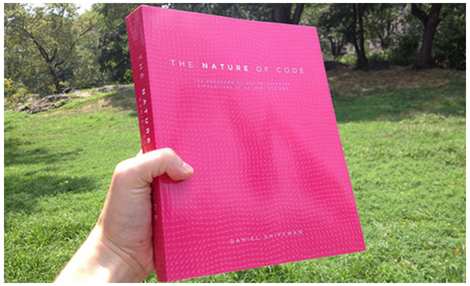


Programming Physics
(HIGH-LEVEL)

When do you need a physics engine?

- You want to simulate real world situations
- You need a lot of **collision detection**, **gravity**, **elasticity** and **friction**
- You deal with many objects

- Often, using a physics engine **is not necessary** (e.g., simple gravity simulation, detecting rectangle collisions)
- **Good read**: *Daniel Shiffman, The Nature of Code* (http://natureofcode.com/book/)



Physics in Cocos

Two engines:

- Chipmunk (built-in)
- Box2D

Games based on physics engines

Intertwining of:

- Graphical world (displayed)
- E.g., Cocos scenegraph
- Physics world (simulated)
- E.g., Box2D physics simulation

- 2D graphics/2D physics simulation
- 3D graphics/3D physics simulation

Important concepts

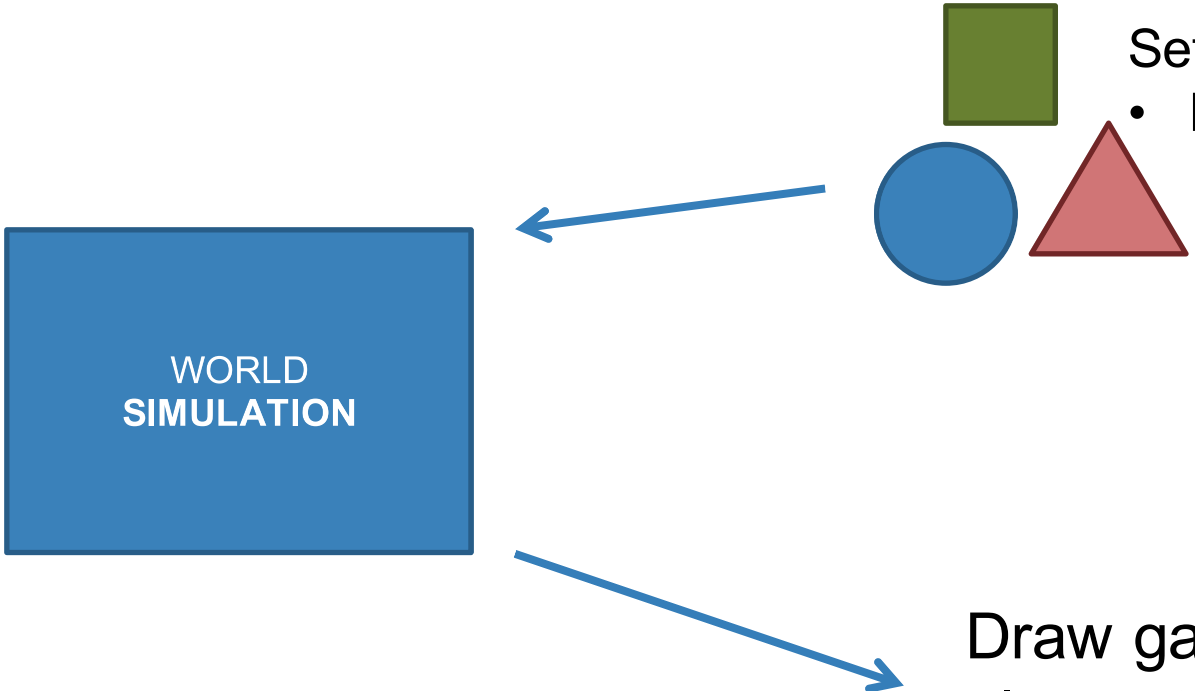
Physics world:

- Coordinate systems and units can be different from the graphical rendering (mapping!)
- Forces, collisions etc. are calculated and solved in steps (update rate)
- With every update, graphical objects are moved and oriented according to the current state of the simulation

Important Aspects

- Bodies
- Shapes
- Materials
- Contacts/Joints
- World

Simulated World as a “Magic Box”



Setup world definitions:

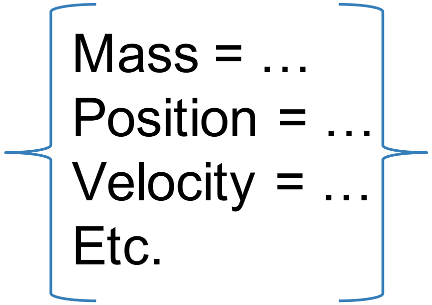
- Bodies, forces, etc.

With every step:

Draw game elements according to simulated position and orientation

Bodies

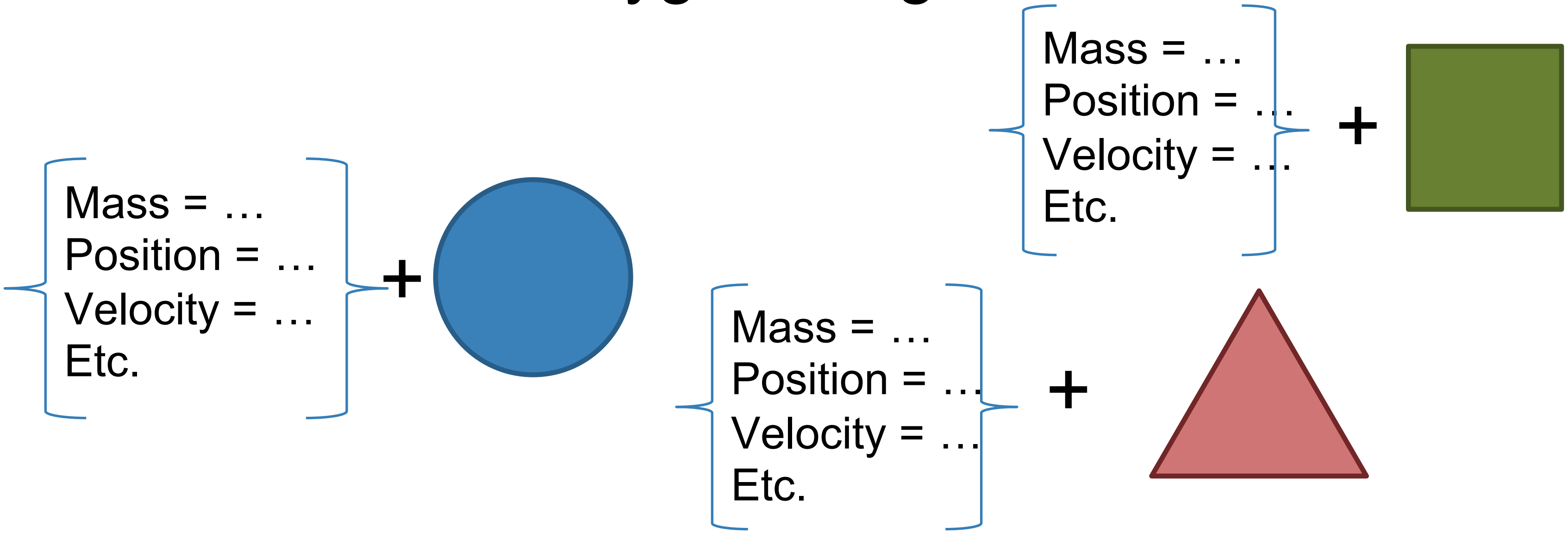
- A *Body* defines the physical properties of an object, such as *mass*, *position*, *rotation*, *velocity*, *damping*
- Has no shape!
- *Static* bodies don’t move in the simulation and behave like they have infinite mass
- *Dynamic* bodies are fully simulated and move according to simulated forces and/or manual input



Mass = …
Position = …
Velocity = …
Etc.

Shapes

- *Shapes* describe collision geometry
- Are attached to bodies
- Predefined shapes in Box2D/Chipmunk:
- Box, Circle, Polygon, Edges, …



Mass = …
Position = …
Velocity = …
Etc.

+

Mass = …
Position = …
Velocity = …
Etc.

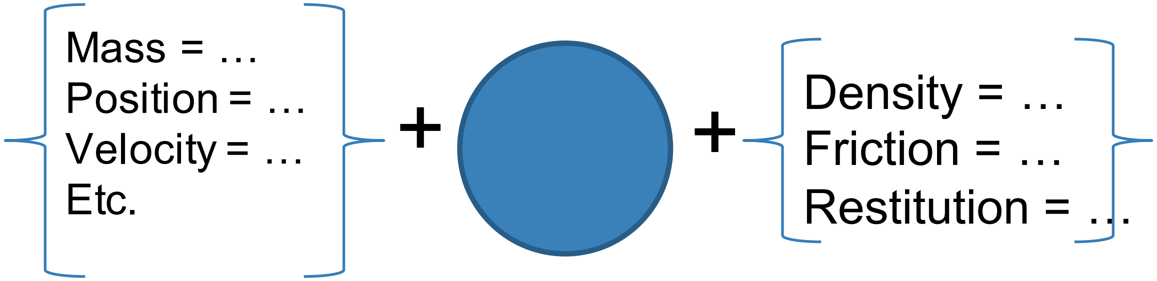
+

Mass = …
Position = …
Velocity = …
Etc.

+

Materials

- *Materials* describe material properties:
- Density: mass properties of the parent body
- Restitution: bouncing properties of the parent body
- Friction: sliding properties of the parent body



Mass = …
Position = …
Velocity = …
Etc.

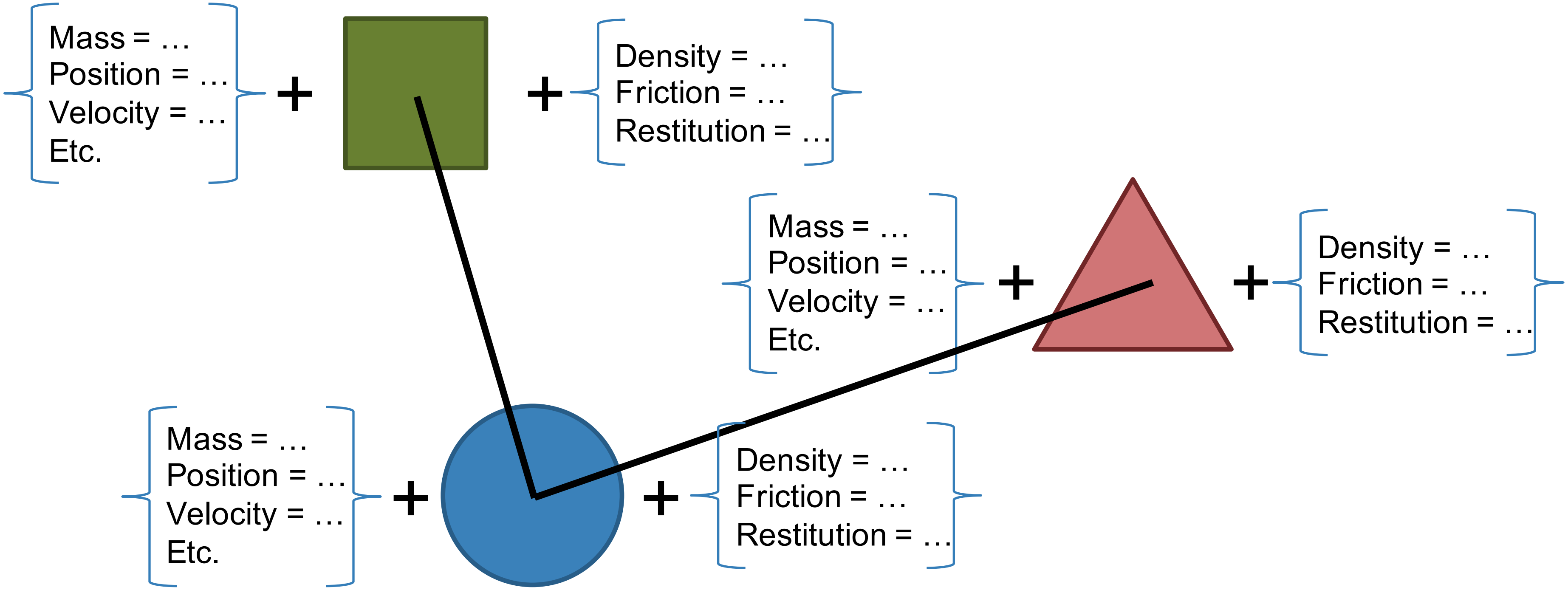
+

+

Density = …
Friction = …
Restitution = …

Contacts/Joints

- Describe how bodies are attached to each other



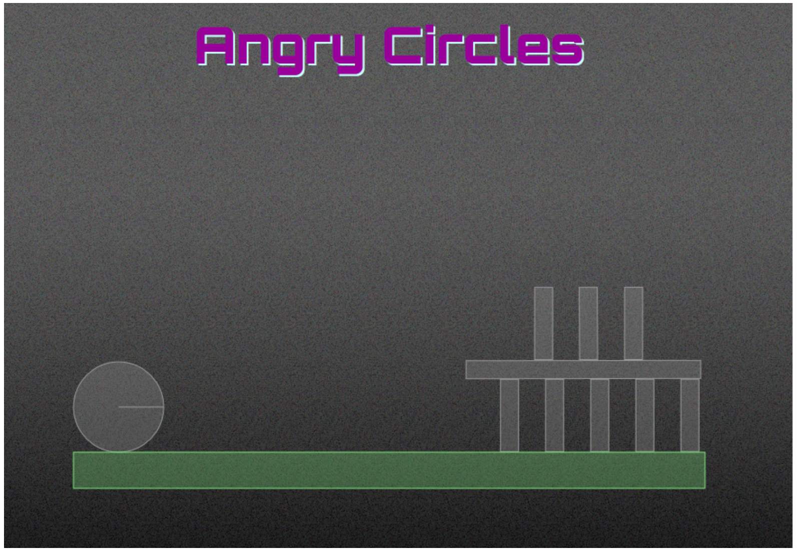
World

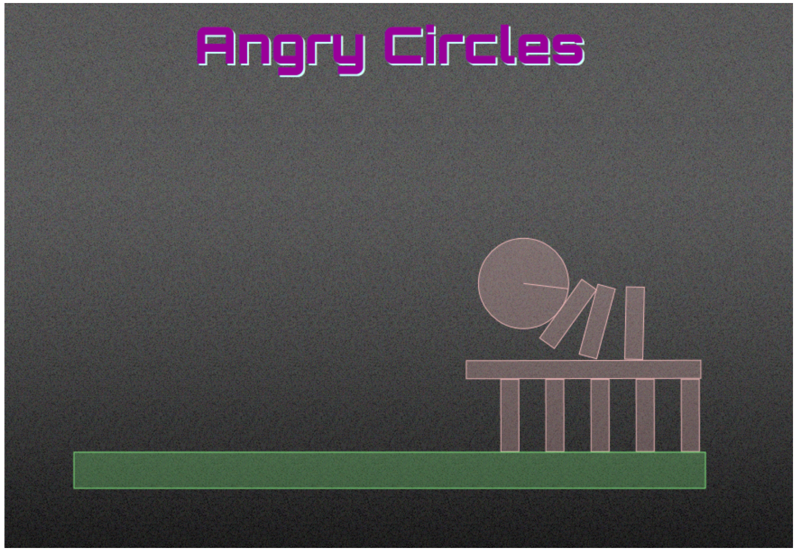
- The *World* object is the container for the simulation
- Physics bodies, shapes and constraints are added to it
- *World* updates control how all of the added objects interact together

- Important *World* properties:
- *Gravity*
- *Speed (of simulation)*
- *Update rate*

Recap

Debug drawing of a box2d simulation:

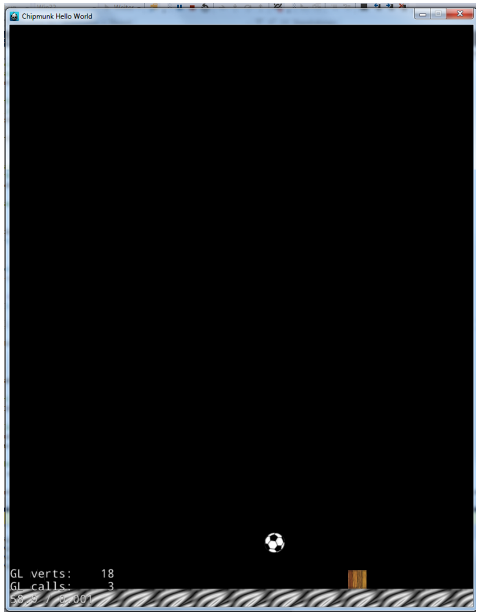




Static bodies?
Dynamic bodies?
Forces?
Updates?

Cocos and Chipmunk “Hello World“

- Chipmunk is integrated into Cocos
- World is based on pixels as units
- Deeply integrated with *Scene*



```
GL verts:    18
GL calls:     3
58.9 / 0.001
```

Creating a world

```
auto scene = Scene::createWithPhysics();
scene->getPhysicsWorld()->setDebugDrawMask(PhysicsWorld::DEBUGDRAW_ALL);
scene->getPhysicsWorld()->setGravity(Vec2(0.0f,  -350.0f));
```

Creating a static body

```
auto groundBody = PhysicsBody::createBox(
          Size(65.0f, 81.0f),
          PhysicsMaterial(0.1f, 1.0f, 0.0f)
);

groundBody >setDynamic(false);
```

1. Defining a body
2. Defining and attaching a shape
3. Defining material properties

Attaching a body to a sprite

```
//add sprite to scene
_ground = GameSprite::gameSpriteWithFile("res/ground.png");
_ground->setPosition(Vec2(_center.x, 16.0f));
this->addChild(_ground);

//attach groundBody to the sprite
_ground->setPhysicsBody(groundBody);
```

Creating a dynamic body

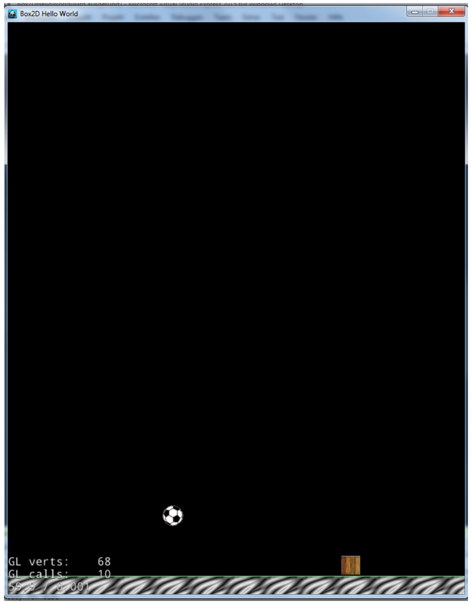
```
//body definition
auto ballBody = PhysicsBody::createCircle(
            17.5f,
            PhysicsMaterial(0.1f, 0.4f, 0.0f)
);
ballBody->setMass(10.0f);

//sprite definition
_ball = GameSprite::gameSpriteWithFile("res/ball.png");
_ball->setPosition(Vec2(400.0f, 500.0f));
this->addChild(_ball);

_ball->setPhysicsBody(ballBody);
```

Applying a force

```
Vec2 force = Vec2(0.0f, 550.0f);
_ball->getPhysicsBody()->applyImpulse(force);
```

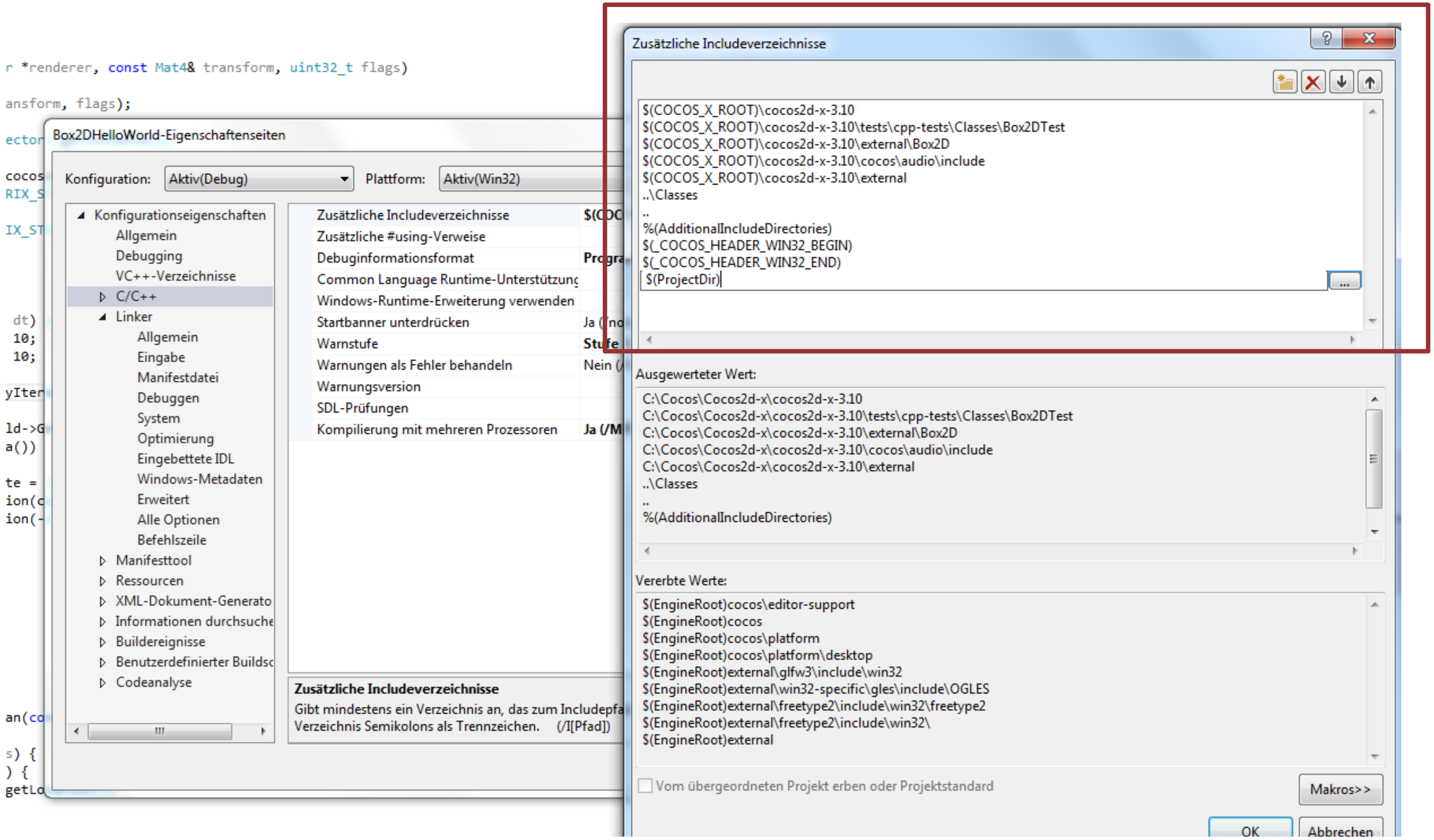
Cocos and Box2D “Hello World“

- Box2D is very popular (e.g. Angry Birds)
- A lot of Documentation, Tutorials etc.
- Based on **MKS** (meters, kilograms, and seconds)



```
GL verts:     68
GL calls:     10
59.9 / 0.001
```

Box2D and Visual Studio



```
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```

Box2DHelloWorld-Eigenschaftenseiten

Konfiguration: Aktiv(Debug)   Plattform: Aktiv(Win32)

- Konfigurationseigenschaften
  - Allgemein
  - Debugging
  - VC++-Verzeichnisse
  - C/C++
  - Linker
    - Allgemein
    - Eingabe
    - Manifestdatei
    - Debuggen
    - System
    - Optimierung
    - Eingebettete IDL
    - Windows-Metadaten
    - Erweitert
    - Alle Optionen
    - Befehlszeile
  - Manifesttool
  - Ressourcen
  - XML-Dokument-Generato
  - Informationen durchsuche
  - Buildereignisse
  - Benutzerdefinierter Buildsc
  - Codeanalyse

Zusätzliche Includeverzeichnisse	$(COC
Zusätzliche #using-Verweise	
Debuginformationsformat	Progra
Common Language Runtime-Unterstützung	
Windows-Runtime-Erweiterung verwenden	
Startbanner unterdrücken	Ja (/no
Warnstufe	Stufe
Warnungen als Fehler behandeln	Nein (/
Warnungsversion	
SDL-Prüfungen	
Kompilierung mit mehreren Prozessoren	Ja (/M

Zusätzliche Includeverzeichnisse
Gibt mindestens ein Verzeichnis an, das zum Includepfa
Verzeichnis Semikolons als Trennzeichen. (/I[Pfad])

Zusätzliche Includeverzeichnisse

```
$(COCOS_X_ROOT)\cocos2d-x-3.10
$(COCOS_X_ROOT)\cocos2d-x-3.10\tests\cpp-tests\Classes\Box2DTest
$(COCOS_X_ROOT)\cocos2d-x-3.10\external\Box2D
$(COCOS_X_ROOT)\cocos2d-x-3.10\cocos\audio\include
$(COCOS_X_ROOT)\cocos2d-x-3.10\external
..\Classes
..
%(AdditionalIncludeDirectories)
$(_COCOS_HEADER_WIN32_BEGIN)
$(_COCOS_HEADER_WIN32_END)
$(ProjectDir)
```

Ausgewerteter Wert:

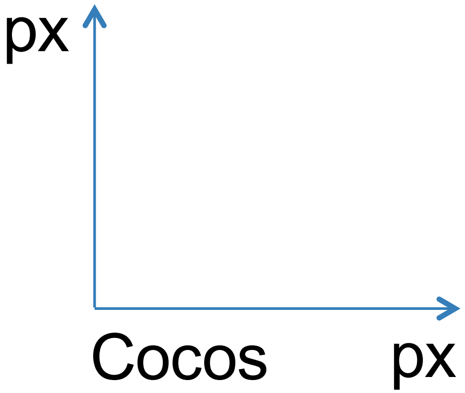
```
C:\Cocos\Cocos2d-x\cocos2d-x-3.10
C:\Cocos\Cocos2d-x\cocos2d-x-3.10\tests\cpp-tests\Classes\Box2DTest
C:\Cocos\Cocos2d-x\cocos2d-x-3.10\external\Box2D
C:\Cocos\Cocos2d-x\cocos2d-x-3.10\cocos\audio\include
C:\Cocos\Cocos2d-x\cocos2d-x-3.10\external
..\Classes
..
%(AdditionalIncludeDirectories)
```

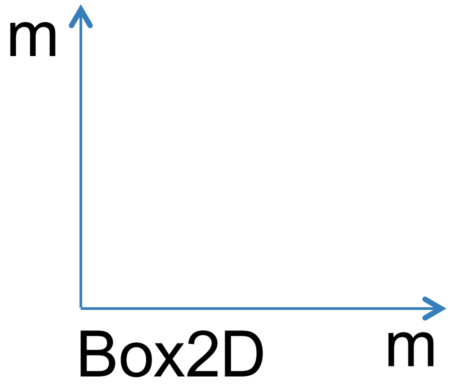
Vererbte Werte:

```
$(EngineRoot)cocos\editor-support
$(EngineRoot)cocos
$(EngineRoot)cocos\platform
$(EngineRoot)cocos\platform\desktop
$(EngineRoot)external\glfw3\include\win32
$(EngineRoot)external\win32-specific\gles\include\OGLES
$(EngineRoot)external\freetype2\include\win32\freetype2
$(EngineRoot)external\freetype2\include\win32\
$(EngineRoot)external
```

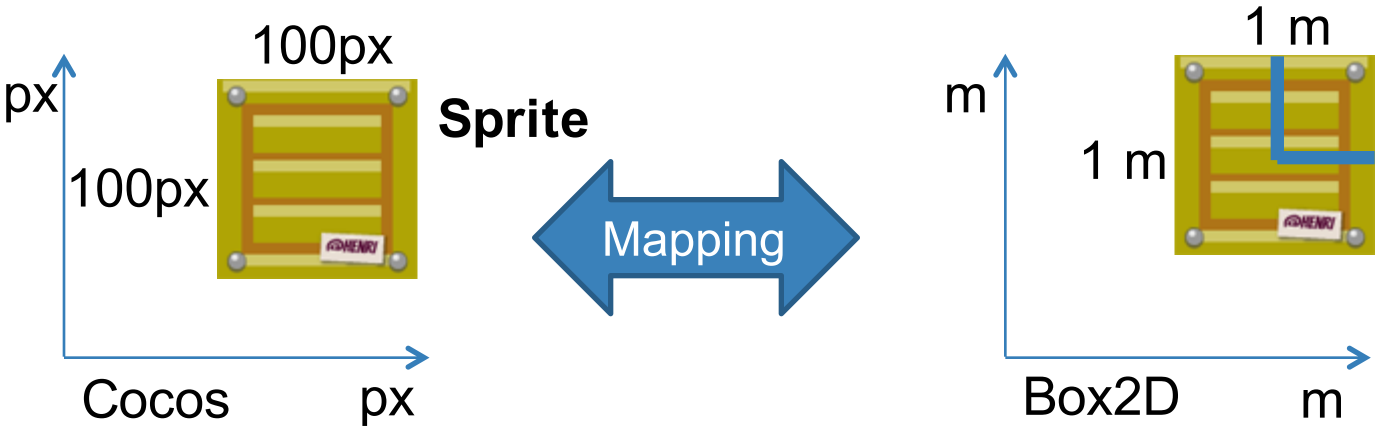
□ Vom übergeordneten Projekt erben oder Projektstandard

Cocos and Box2D “Hello World“





Cocos and Box2D “Hello World“



In **Box2D**:
A box (width = 0.5, height = 0.5)

Creating a world

```
// Create a world, define gravity
b2Vec2 gravity = b2Vec2(0.0f, -8.0f);
_world = new b2World(gravity);
```

Creating a static body

```
b2BodyDef groundBodyDef;
groundBodyDef.position.Set(_center.x / SCALE_RATIO, 16.0f /
SCALE_RATIO);
_staticBody = _world->CreateBody(&groundBodyDef);

b2PolygonShape groundBox;
groundBox.SetAsBox(800.0f / 2 / SCALE_RATIO, 32.0f / 2 /
SCALE_RATIO);

_staticBody->CreateFixture(&groundBox, 0.0f);
```

1. Defining a body
2. Defining and attaching a shape
3. Defining material properties

Attaching a body to a sprite

- Not possible, you have to take care of that manually
- With every update of the simulation, go through list of bodies and manipulate associated sprites accordingly

- **Help**:
- bodyDef.userData = *Reference to Sprite*;
- GameSprite *sprite = (GameSprite *)body->GetUserData();

Attaching a body to a sprite

```
void GameLayer::update(float dt) {
//get current state of the world
_world->Step(dt, velocityIterations, positionIterations);
//iterate through bodies and update sprites
for (b2Body *body = _world->GetBodyList(); body != NULL; body = body-
>GetNext())
          if (body->GetUserData())
          {
                    GameSprite *sprite = (GameSprite *)body->GetUserData();

                    sprite->setPosition(ccp(body->GetPosition().x *
SCALE_RATIO,                                                  body->GetPosition().y *
SCALE_RATIO));
                    sprite->setRotation(-1 * CC_RADIANS_TO_DEGREES(
                                        body->GetAngle()));
          }
}
```

Creating a dynamic body

```
//create a dynamic body
b2BodyDef bodyDef;
bodyDef.type = b2_dynamicBody;
bodyDef.userData = _box;
bodyDef.position.Set(xPos / SCALE_RATIO, yPos / SCALE_RATIO);
b2Body * box = _world->CreateBody(&bodyDef);

b2PolygonShape boxShape;
boxShape.SetAsBox(width / 2 / SCALE_RATIO, height / 2 / SCALE_RATIO);

b2FixtureDef fixtureDef;
fixtureDef.shape = &boxShape;
fixtureDef.density = 10.0f;
fixtureDef.friction = 0.4f;
fixtureDef.restitution = 0.1f;
box->CreateFixture(&fixtureDef);
```

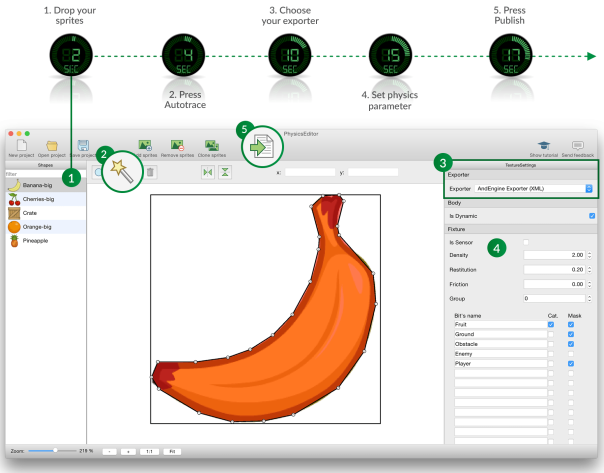
Applying a force

```
Vec2 force = Vec2(0.0f, 550.0f);
_dynamicBody->ApplyForce(
                     force.x,
                     force.y,
                     _dynamicBody->GetWorldCenter(),
                     true
              );
```

What’s next?

- Check for collisions
- Joints
- Complex shapes

- **Tool**: https://www.codeandweb.com/physicseditor



1. Drop your sprites
2. Press Autotrace
3. Choose your exporter
4. Set physics parameter
5. Press Publish

Exporter: AndEngine Exporter (XML)

Is Dynamic ☑

Is Sensor □

Density 2.00

Restitution 0.20

Friction 0.00

Group 0

Bit's name	Cat.	Mask
Fruit	☑	☑
Ground	□	☑
Obstacle	□	☑
Enemy	□	□
Player	□	☑