Graphics and Animation

Mobile Application Development in iOS

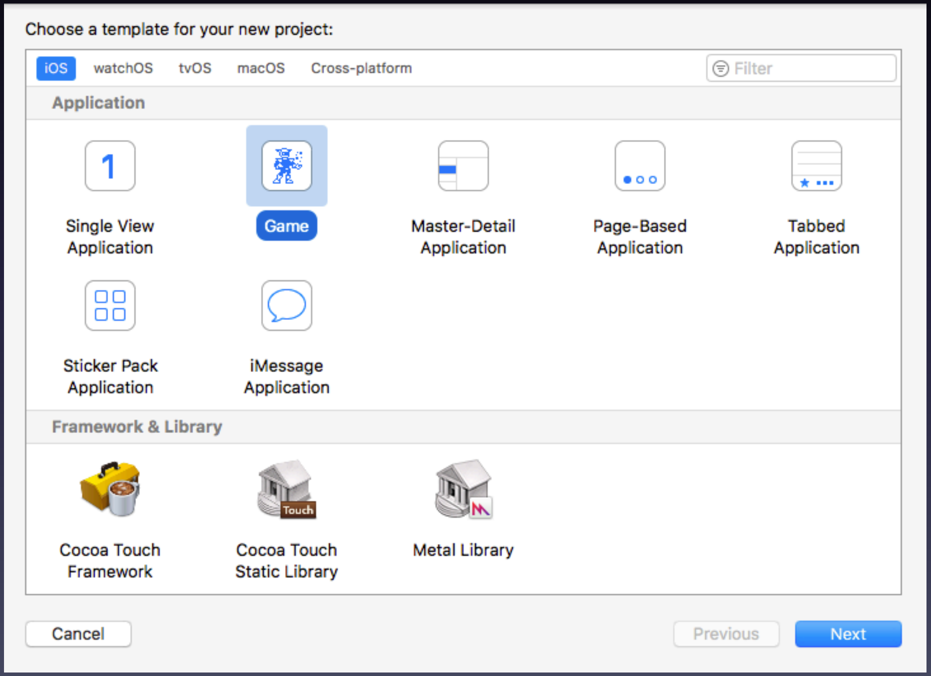
School of EECS

Washington State University

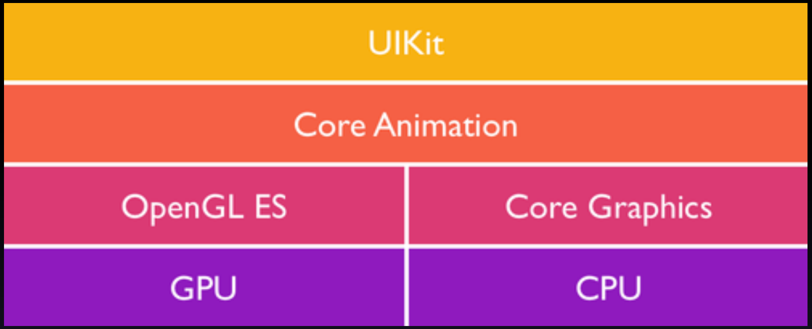
Instructor: Larry Holder

Outline

- iOS frameworks for graphics and animation
- Core Graphics
- SpriteKit
- SceneKit


Choose a template for your new project:

iOS Frameworks (old)

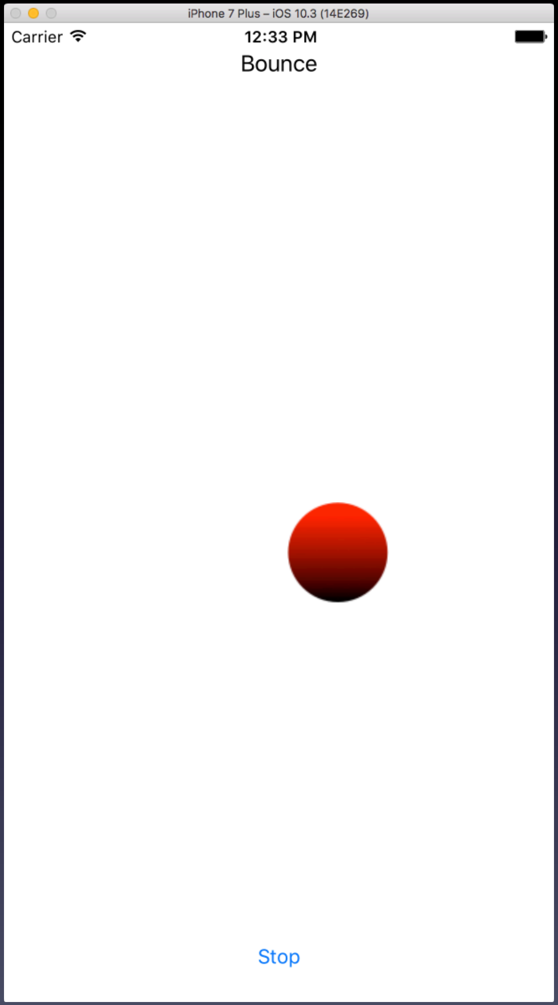


- UIKit graphics
  - Animate elements of view
- Core Graphics and Core Animation
  - 2D graphics and animation engine
  - Part of UIView
- OpenGL ES and GLKit
  - 2D and 3D rendering for GPUs on Embedded Systems (ES)

iOS Frameworks (new)

- SpriteKit
  - 2D game engine
  - Most components accessible via Storyboard
- SceneKit
  - 3D game engine
  - Most components accessible via Storyboard
- Metal
  - More direct access to GPU for graphics and computation

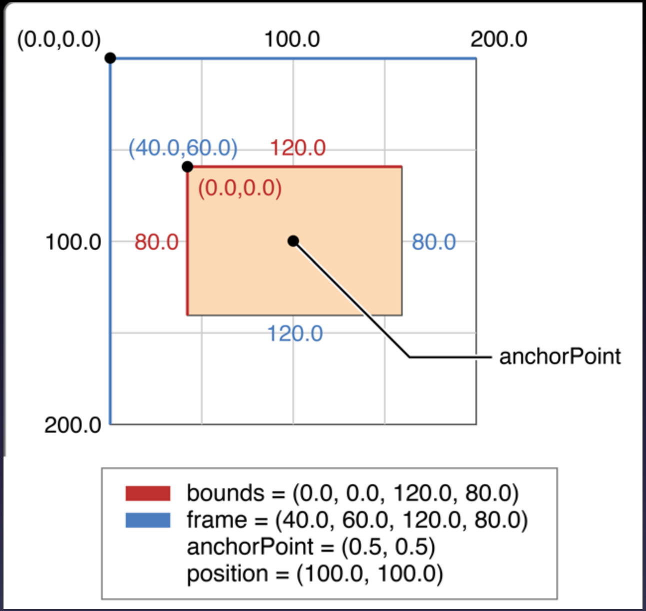
Bounce



Core Graphics

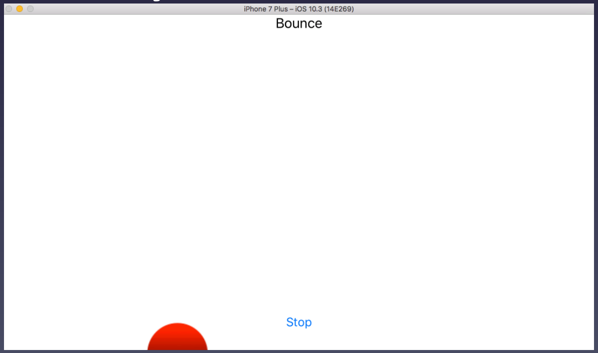
Core Graphics Approach

- Coordinate system (upper-left origin)
- Points vs. pixels
- Frame vs. bounds
  - CGRect = {origin.x, origin.y, size.width, size.height}
  - CGRect self.frame, self.bounds



Core Graphics Approach

- Add a UIView as a subView of the main view
- Implement gameUpdate() method
  - Modify subView's position, etc.
- Use Timer to call gameUpdate() method repeatedly
- Watch out for auto layout and orientation changes



Core Graphics Approach

```swift
class ViewController: UIViewController {

  let frameRate = 30.0 // updates per seconds
  let ballSpeed = 200.0 // points per second
  var ballDirection = CGPoint(x: 1.0, y: -1.0)
  var ballImageView: UIImageView!
  var gameTimer: Timer!

  func initGame() {
    let ballImage = UIImage(named: "redball.png")!
    ballImageView = UIImageView()
    ballImageView.image = ballImage
    ballImageView.frame = CGRect(x: 0, y: 0, width:
      ballImage.size.width, height: ballImage.size.height)
    self.view.addSubview(ballImageView)
  }
```

Core Graphics Approach

```
func startGame () {
  self.gameTimer = Timer.scheduledTimer(withTimeInterval:
   (1.0 / frameRate), repeats: true, block: updateGame)
}

func pauseGame () {
  self.gameTimer.invalidate()
}
```

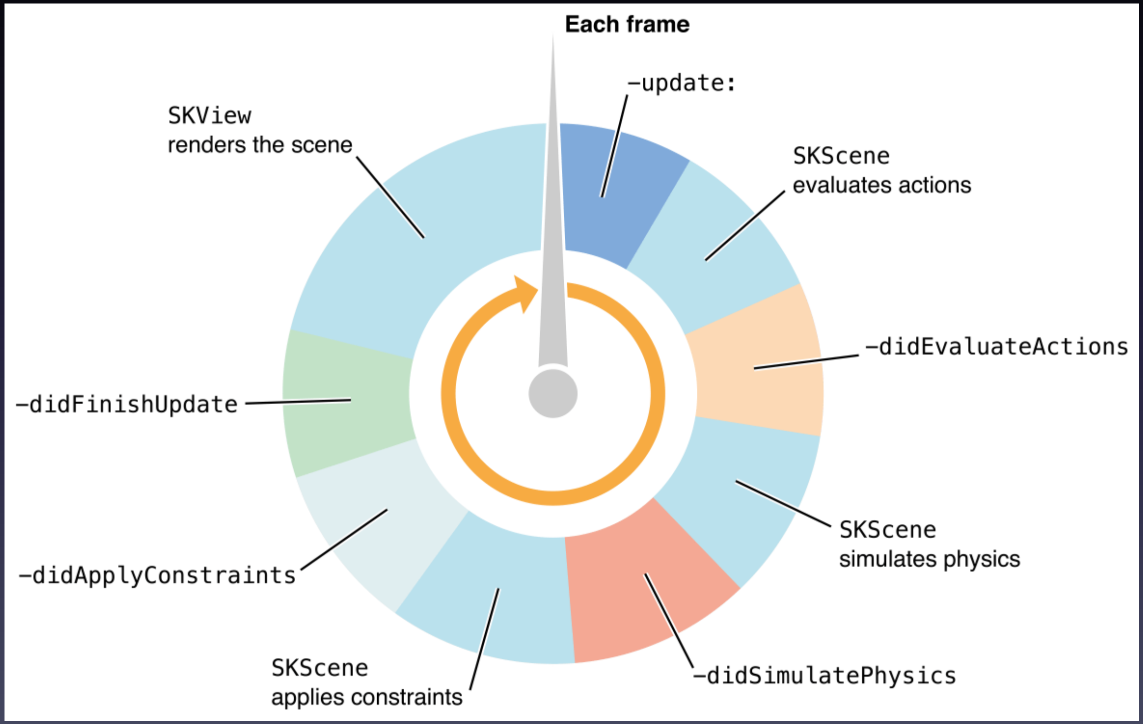
Core Graphics Approach

```
func updateGame (timer: Timer) {
  let x = self.ballImageView.frame.origin.x
  let y = self.ballImageView.frame.origin.y
  let width = self.ballImageView.frame.width
  let height = self.ballImageView.frame.height
  // if ball hits wall, then change direction
  if (x < 0) { // Hit left wall
    self.ballDirection.x = -self.ballDirection.x
  }
  if ((x + width) > self.view.frame.width) { // Hit right wall
    self.ballDirection.x = -self.ballDirection.x
  }
  // Handle top and bottom walls...
  // Update ball location
  let xOffset = CGFloat(self.ballSpeed / self.frameRate) * self.ballDirection.x
  let yOffset = CGFloat(self.ballSpeed / self.frameRate) * self.ballDirection.y
  self.ballImageView.frame.origin.x = x + xOffset
  self.ballImageView.frame.origin.y = y + yOffset
}
```

SpriteKit

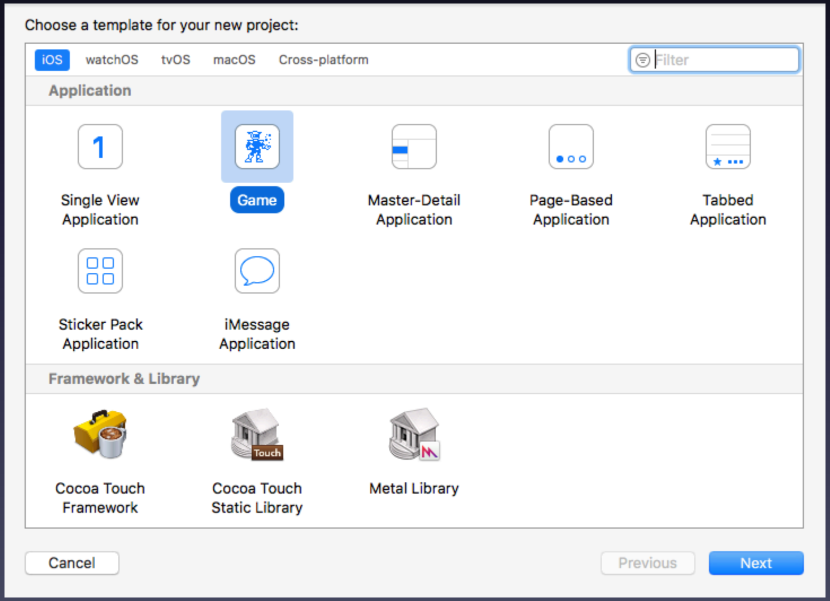
SpriteKit Approach

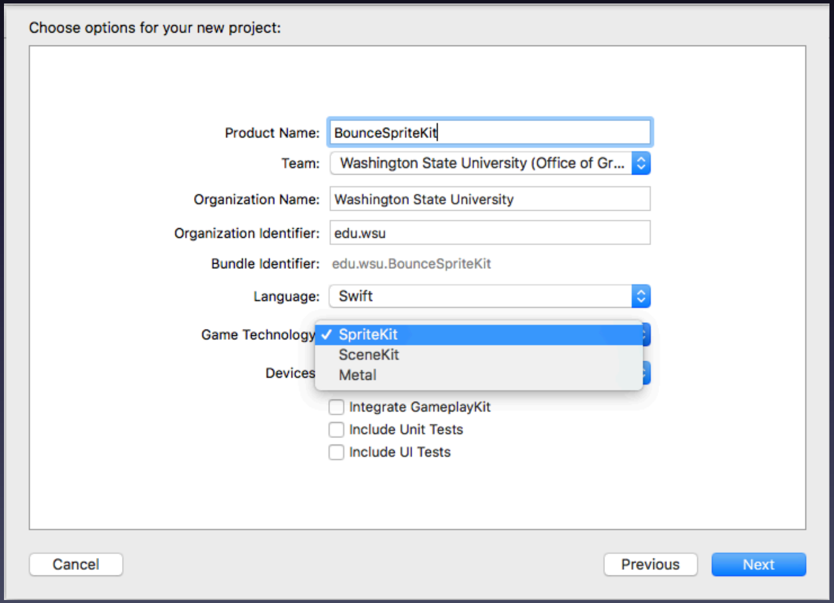
- Update/render loop



SpriteKit Approach

- Create new Game project
  - Game Technology: SpriteKit


Choose a template for your new project:

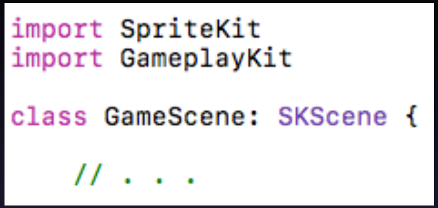

Choose options for your new project:

Product Name:	BounceSpriteKit
Team:	Washington State University (Office of Gr...
Organization Name:	Washington State University
Organization Identifier:	edu.wsu
Bundle Identifier:	edu.wsu.BounceSpriteKit
Language:	Swift
Game Technology	✓ SpriteKit
Devices	

SpriteKit Organization

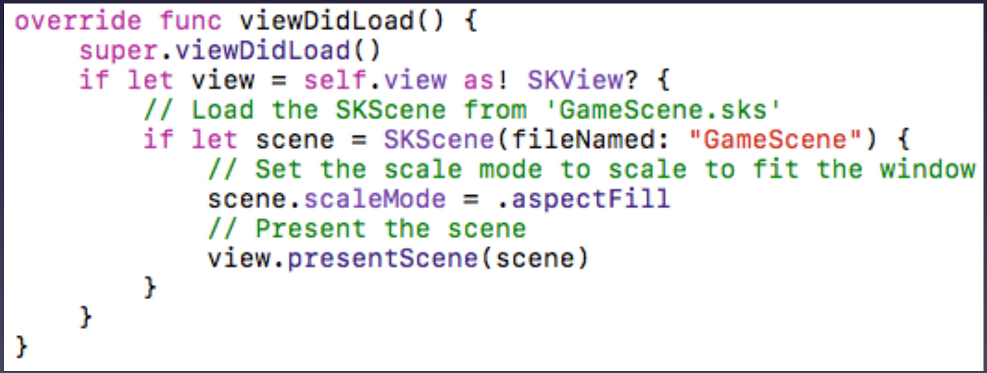
- Scene(s) of type SKScene
  - Edit in Sprite Editor (.sks file)
- Main view of type SKView
- Present SKScene in SKView

GameScene.swift



```
import SpriteKit
import GameplayKit

class GameScene: SKScene {

    // . . .
```

GameViewController.swift



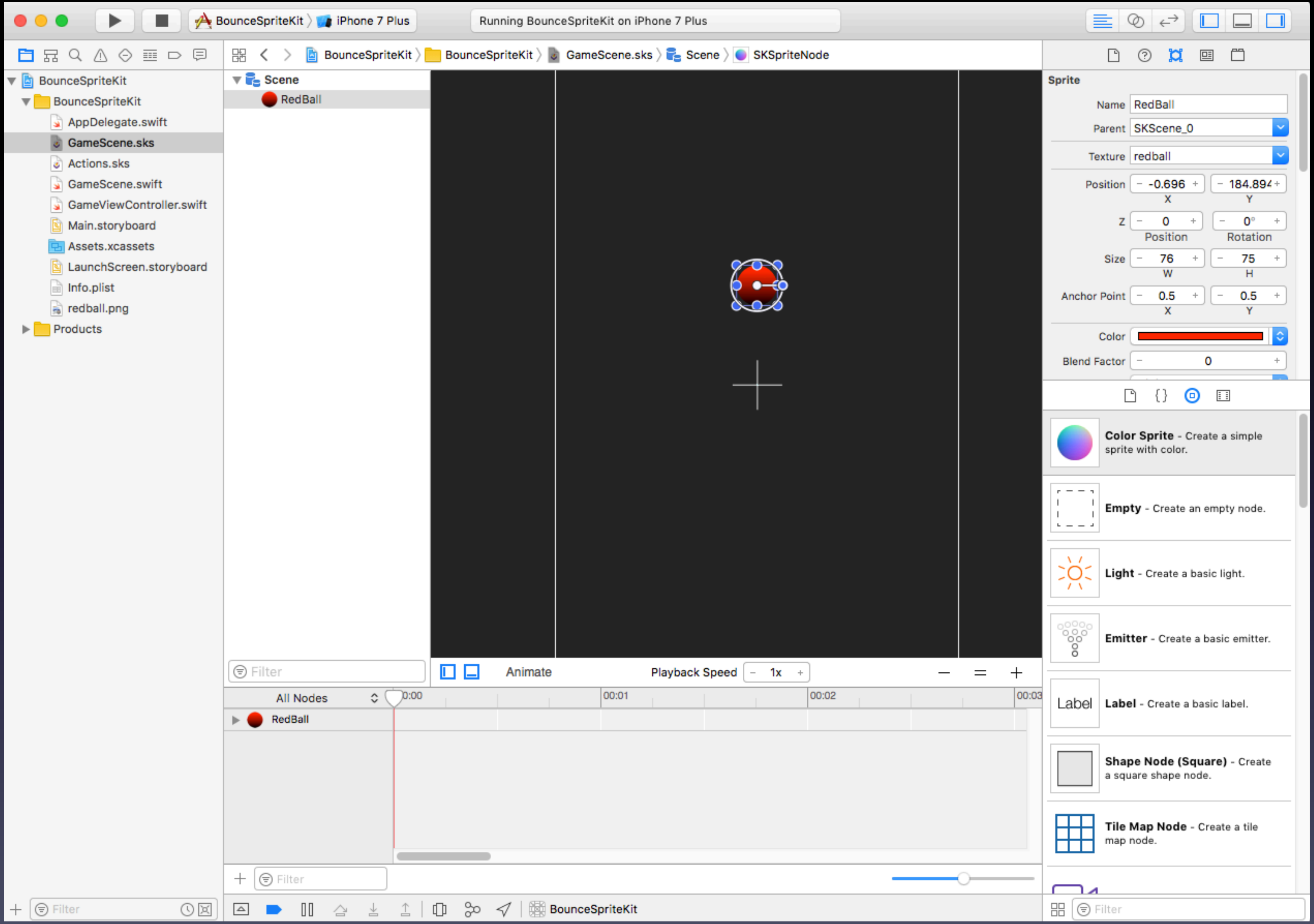
```
override func viewDidLoad() {
    super.viewDidLoad()
    if let view = self.view as! SKView? {
        // Load the SKScene from 'GameScene.sks'
        if let scene = SKScene(fileNamed: "GameScene") {
            // Set the scale mode to scale to fit the window
            scene.scaleMode = .aspectFill
            // Present the scene
            view.presentScene(scene)
        }
    }
}
```

Sprites

redball.png

- Sprite is a rectangle with a texture (image)
- SKSpriteNode is a sprite with many properties
  - SKAction for actions to execute (e.g., fade in/out)
  - SKPhysicsBody for physical effects (e.g., gravity)
- Other types of SKNode's (e.g., SKLabelNode)
- SKScene is a collection of SKNode's

SpriteKit Scene Editor



Name: RedBall
Parent: SKScene_0
Texture: redball
Position: X -0.696, Y 184.894
Z Position: 0; Rotation: 0°
Size: W 76, H 75
Anchor Point: X 0.5, Y 0.5
Color
Blend Factor: 0

Playback Speed: 1x

Color Sprite - Create a simple sprite with color.

Empty - Create an empty node.

Light - Create a basic light.

Emitter - Create a basic emitter.

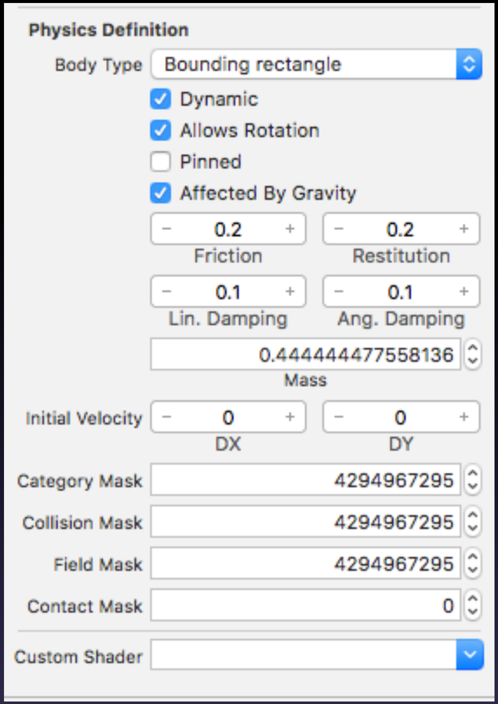
Label - Create a basic label.

Shape Node (Square) - Create a square shape node.

Tile Map Node - Create a tile map node.

SpriteKit Physics

- Body Type
- Dynamic
- Pinned (fixed to parent)
- Allows Rotation, Ang. Damping
- Affected By Gravity, Linear Damping, Mass
- Friction, Restitution



Physics Definition

Body Type: Bounding rectangle

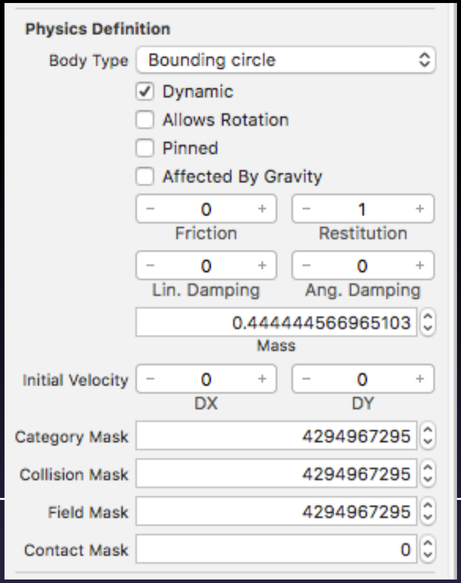
[✓] Dynamic
[✓] Allows Rotation
[ ] Pinned
[✓] Affected By Gravity

Friction: 0.2	Restitution: 0.2
Lin. Damping: 0.1	Ang. Damping: 0.1
Mass: 0.444444477558136	
Initial Velocity DX: 0	DY: 0
Category Mask	4294967295
Collision Mask	4294967295
Field Mask	4294967295
Contact Mask	0
Custom Shader	

SpriteKit Physics

- Bouncing off edge of screen

Ball:



Physics Definition

Body Type	Bounding circle
	☑ Dynamic
	☐ Allows Rotation
	☐ Pinned
	☐ Affected By Gravity
Friction	0
Restitution	1
Lin. Damping	0
Ang. Damping	0
Mass	0.444444566965103
Initial Velocity DX	0
Initial Velocity DY	0
Category Mask	4294967295
Collision Mask	4294967295
Field Mask	4294967295
Contact Mask	0

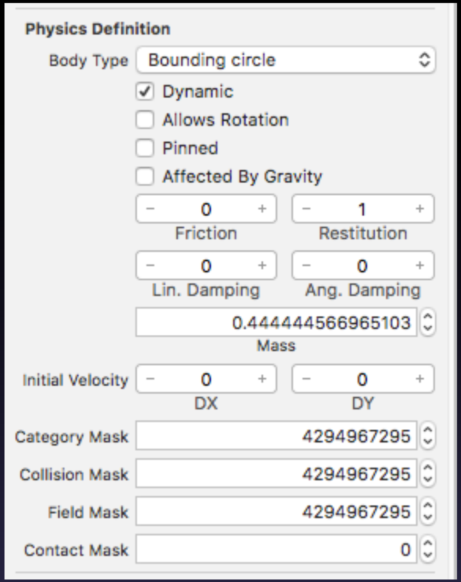
```
override func didMove(to view: SKView) {
  . . .
  // Set screen edge to bounce with no friction
  let screenPhysicsBody = SKPhysicsBody(edgeLoopFrom: self.frame)
  screenPhysicsBody.friction = 0.0
  self.physicsBody = screenPhysicsBody
}

redBallNode.physicsBody?.applyImpulse(CGVector(dx: 200.0, dy: 200.0))
```

SpriteKit: Adding Nodes Programmatically

```
// Add green ball programmatically
greenBallNode = SKSpriteNode(imageNamed: "greenball.png")
greenBallNode.physicsBody = SKPhysicsBody(circleOfRadius: 50.0)
greenBallNode.physicsBody?.affectedByGravity = false
greenBallNode.physicsBody?.friction = 0.0
greenBallNode.physicsBody?.restitution = 1.0
greenBallNode.physicsBody?.linearDamping = 0.0
self.addChild(greenBallNode)
```

SpriteKit Physics: Collisions

- Mask is a bit string (4294967295 = all 1s)
- Category
  - Mask that is a unique power of 2 for each object type
  - E.g., ball: 0001, brick: 0010, wall: 0100
- Category Mask (SKPhysicsBody.categoryBitMask)
  - Categories this body belongs to
- Collision Mask (SKPhysicsBody.collisionBitMask)
  - Categories this body collides with
- Field Mask (SKPhysicsBody.fieldBitMask)
  - Fields this body is affected by
- Contact Mask (SKPhysicsBody.contactTestBitMask)
  - Categories generating Contact delegate call, if contact this body


Physics Definition

Body Type	Bounding circle
	✓ Dynamic
	☐ Allows Rotation
	☐ Pinned
	☐ Affected By Gravity
Friction	0
Restitution	1
Lin. Damping	0
Ang. Damping	0
Mass	0.444444566965103
Initial Velocity DX	0
Initial Velocity DY	0
Category Mask	4294967295
Collision Mask	4294967295
Field Mask	4294967295
Contact Mask	0

```
Body 1 Category Mask:  0010
Body 2 Collision Mask: 0011
Bitwise And:           0010 > 0
        Collision!
```

SpriteKit Physics: Contacts

- Delegate
  - SKPhysicsContactDelegate
  - SKScene.physicsWorld.contactDelegate = self
- Delegate methods
  - didBegin(_ contact: SKPhysicsContact)
  - didEnd(_ contact: SKPhysicsContact)
    - contact.bodyA.node
    - contact.bodyB.node

SpriteKit Physics: Contacts

```
func didBegin(_ contact: SKPhysicsContact) {
  let bodyNameA = String(describing: contact.bodyA.node?.name)
  let bodyNameB = String(describing: contact.bodyB.node?.name)
  print("Contact: \(bodyNameA), \(bodyNameB)")
}
```

SpriteKit Touches

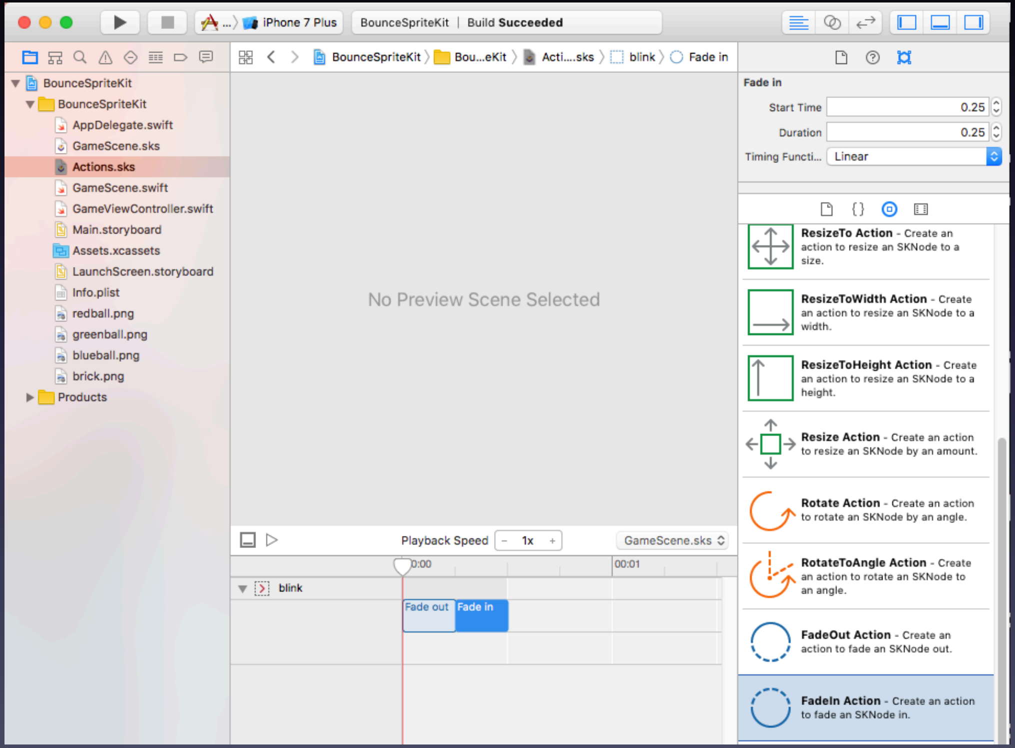
- Same as for UIView
  - func touchesBegan(_ touches: Set<UITouch>, with event: UIEvent?)
  - func touchesMoved(_ touches: Set<UITouch>, with event: UIEvent?)
  - func touchesEnded(_ touches: Set<UITouch>, with event: UIEvent?)

SpriteKit Touches

```
override func touchesEnded(_ touches: Set<UITouch>, with event: UIEvent?) {
  for touch in touches {
    let point = touch.location(in: self)
    let nodeArray = nodes(at: point)
    for node in nodeArray {
      if node.name == "StartStop" {
        if (self.isPaused) {
          self.startGame()
        } else {
          self.pauseGame()
        }
      }
    }
  }
}
```

SpriteKit Actions: Option 1

- Create SKAction in SpriteKit Action Editor
  - Execute SKNode.run(SKAction.init(named: “blink”))



Fade in

Start Time 0.25
Duration 0.25
Timing Functi... Linear

ResizeTo Action - Create an action to resize an SKNode to a size.

ResizeToWidth Action - Create an action to resize an SKNode to a width.

ResizeToHeight Action - Create an action to resize an SKNode to a height.

Resize Action - Create an action to resize an SKNode by an amount.

Rotate Action - Create an action to rotate an SKNode by an angle.

RotateToAngle Action - Create an action to rotate an SKNode to an angle.

FadeOut Action - Create an action to fade an SKNode out.

FadeIn Action - Create an action to fade an SKNode in.

SpriteKit Actions: Option 1

```swift
// Only called when two balls contact
func didBegin(_ contact: SKPhysicsContact) {
  let nodeA = contact.bodyA.node!
  let nodeB = contact.bodyB.node!
  let blinkAction = SKAction.init(named: "blink")!
  nodeA.run(blinkAction)
  nodeB.run(blinkAction)
}
```

SpriteKit Actions: Option 2

- Create SKAction programmatically
- Execute SKNode.run(SKAction)

```swift
// Only called when two balls contact
func didBegin(_ contact: SKPhysicsContact) {
  let nodeA = contact.bodyA.node!
  let nodeB = contact.bodyB.node!
  let action1 = SKAction.fadeOut(withDuration: 0.25)
  let action2 = SKAction.fadeIn(withDuration: 0.25)
  let blinkAction = SKAction.sequence([action1,action2])
  nodeA.run(blinkAction)
  nodeB.run(blinkAction)
}
```

SpriteKit Audio

- Sound effects
  - SKAction.playSoundFileNamed
- Background music
  - AVAudioPlayer
- SKAudioNode (work in progress…)
  - Positional
  - Effects, e.g., reverb

SpriteKit Audio: Sound Effects

- Create SKAction.playSoundFileNamed
- Execute SKScene.run(SKAction)

```
let bounceSoundAction = SKAction.playSoundFileNamed("bounce.mp3",
      waitForCompletion: false)

func didBegin(_ contact: SKPhysicsContact) {
  let nodeA = contact.bodyA.node!
  let nodeB = contact.bodyB.node!
  ...
  run(bounceSoundAction)
}
```

Background Music

- Import AVFoundation
- Create AVAudioPlayer from URL to music file
  - AVAudioPlayer(contentsOf: URL)
- Set volume, numberOfLoops (-1 = loop continuously), …
- Methods: play, pause, stop, …

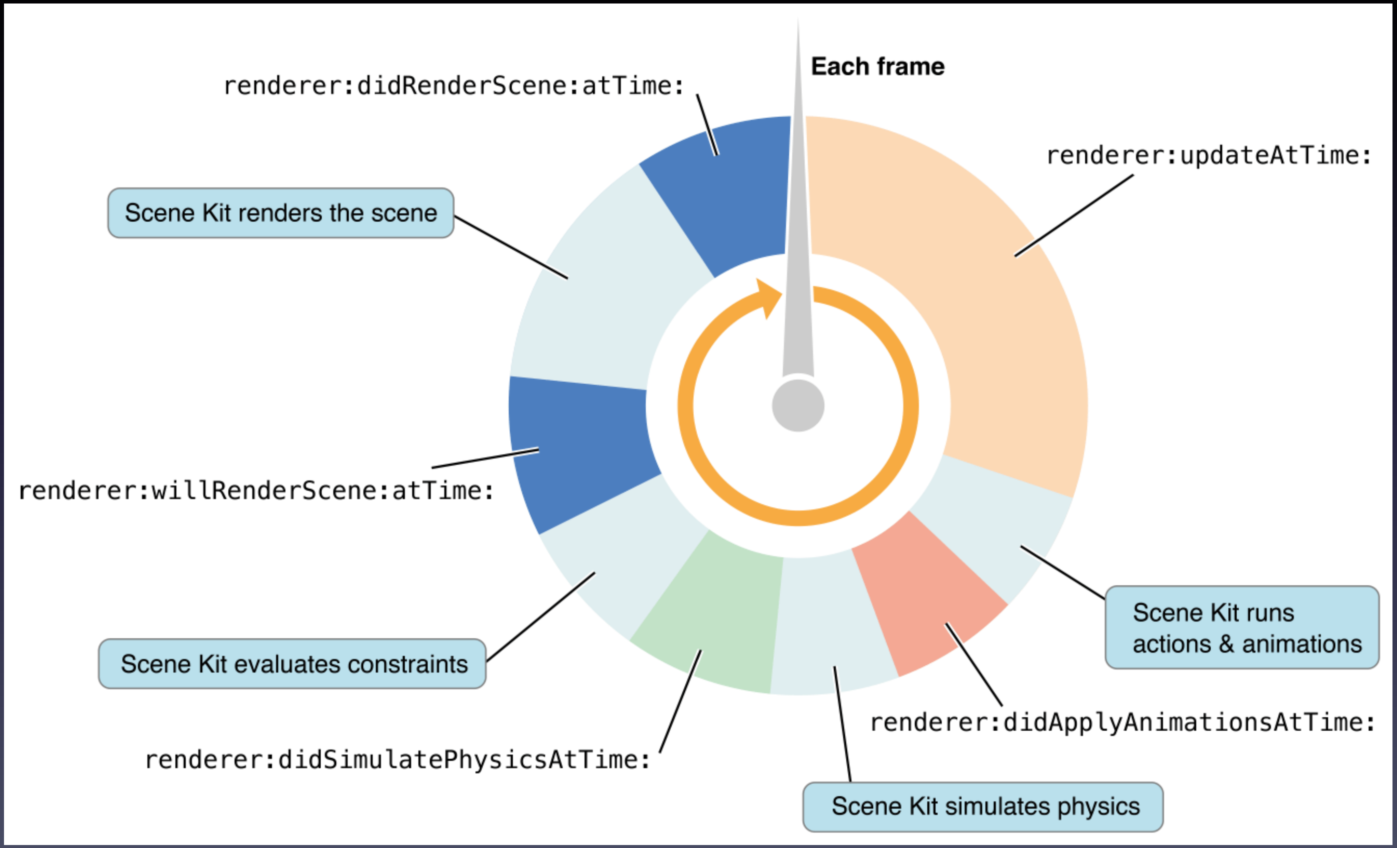
Background Music

```swift
import AVFoundation

var audioPlayer: AVAudioPlayer!

let musicURL = Bundle.main.url(forResource: "WSU-Fight-Song.mp3",
      withExtension: nil)
do {
  audioPlayer = try AVAudioPlayer(contentsOf: musicURL!)
} catch {
  print("error accessing music")
}
audioPlayer.volume = 0.25
audioPlayer.numberOfLoops = -1 // loop forever

audioPlayer.play() // In startGame()
audioPlayer.pause() // In pauseGame()
```

SceneKit

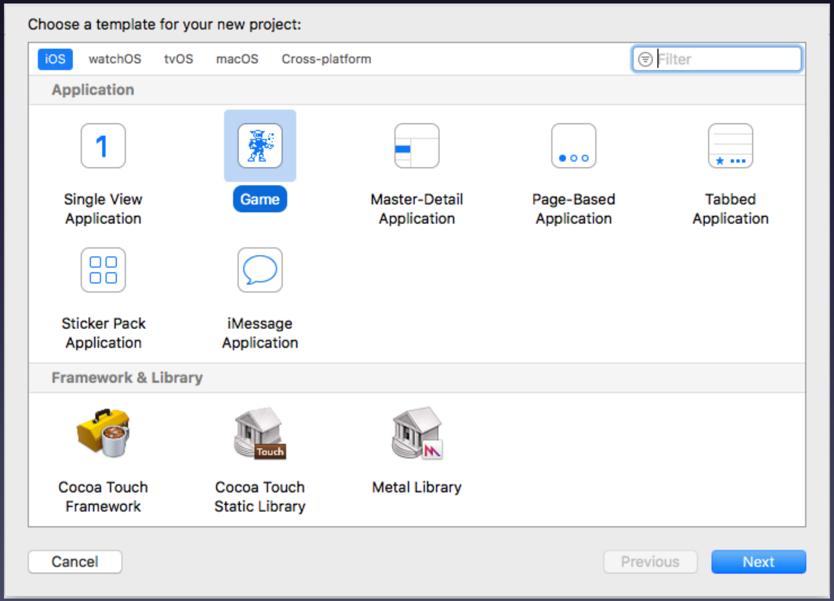
SceneKit Approach

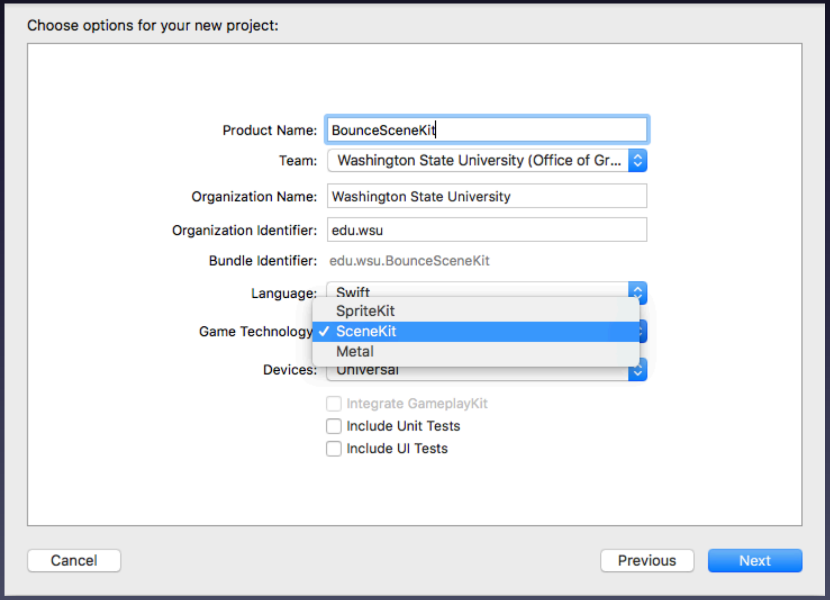
- Update/render loop


Each frame
renderer:updateAtTime:
Scene Kit runs actions & animations
renderer:didApplyAnimationsAtTime:
Scene Kit simulates physics
renderer:didSimulatePhysicsAtTime:
Scene Kit evaluates constraints
renderer:willRenderScene:atTime:
Scene Kit renders the scene
renderer:didRenderScene:atTime:

SceneKit Approach

- Create new Game project
  - Game Technology: SceneKit


Choose a template for your new project:

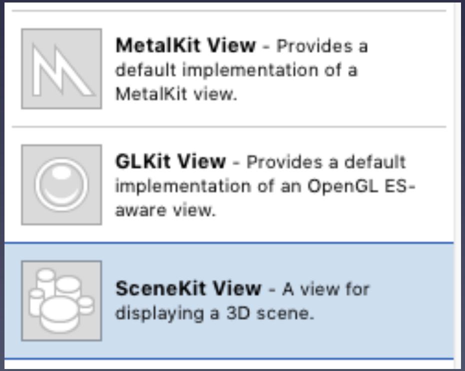

Choose options for your new project:

Product Name:	BounceSceneKit
Team:	Washington State University (Office of Gr...
Organization Name:	Washington State University
Organization Identifier:	edu.wsu
Bundle Identifier:	edu.wsu.BounceSceneKit
Language:	Swift
Game Technology	SpriteKit [✓ SceneKit] Metal
Devices:	Universal

- [ ] Integrate GameplayKit
- [ ] Include Unit Tests
- [ ] Include UI Tests

SceneKit Organization

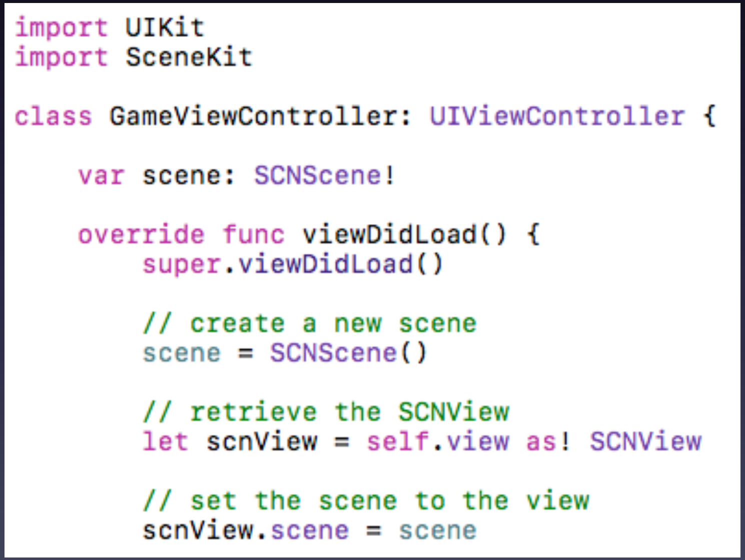
- Scene(s) of type SCNScene
  - Edit in SceneKit Editor (.scn file)
  - Or, build programmatically
- Main view of type SCNView
- Also available in StoryBoard


MetalKit View - Provides a default implementation of a MetalKit view.

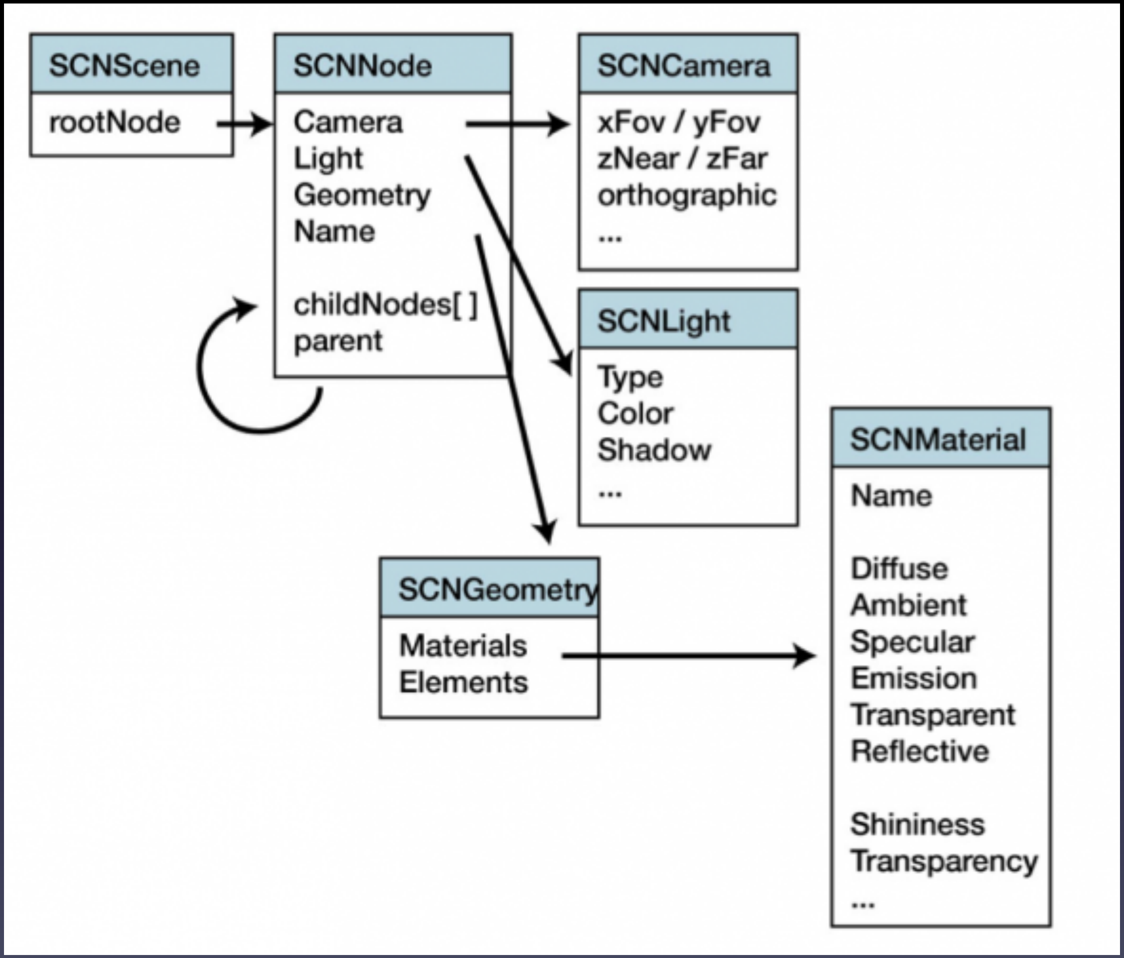
GLKit View - Provides a default implementation of an OpenGL ES-aware view.

SceneKit View - A view for displaying a 3D scene.

GameViewController.swift

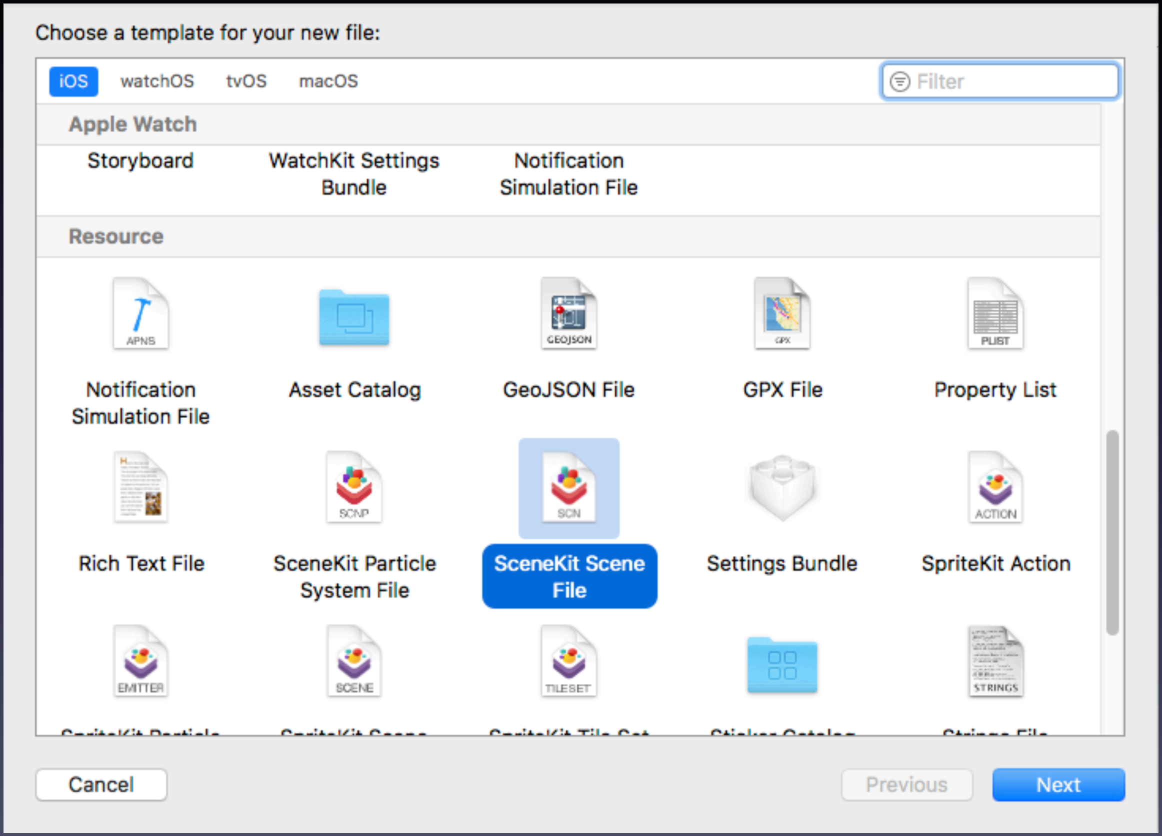

```
import UIKit
import SceneKit

class GameViewController: UIViewController {

    var scene: SCNScene!

    override func viewDidLoad() {
        super.viewDidLoad()

        // create a new scene
        scene = SCNScene()

        // retrieve the SCNView
        let scnView = self.view as! SCNView

        // set the scene to the view
        scnView.scene = scene
```

Scene Graph Layout



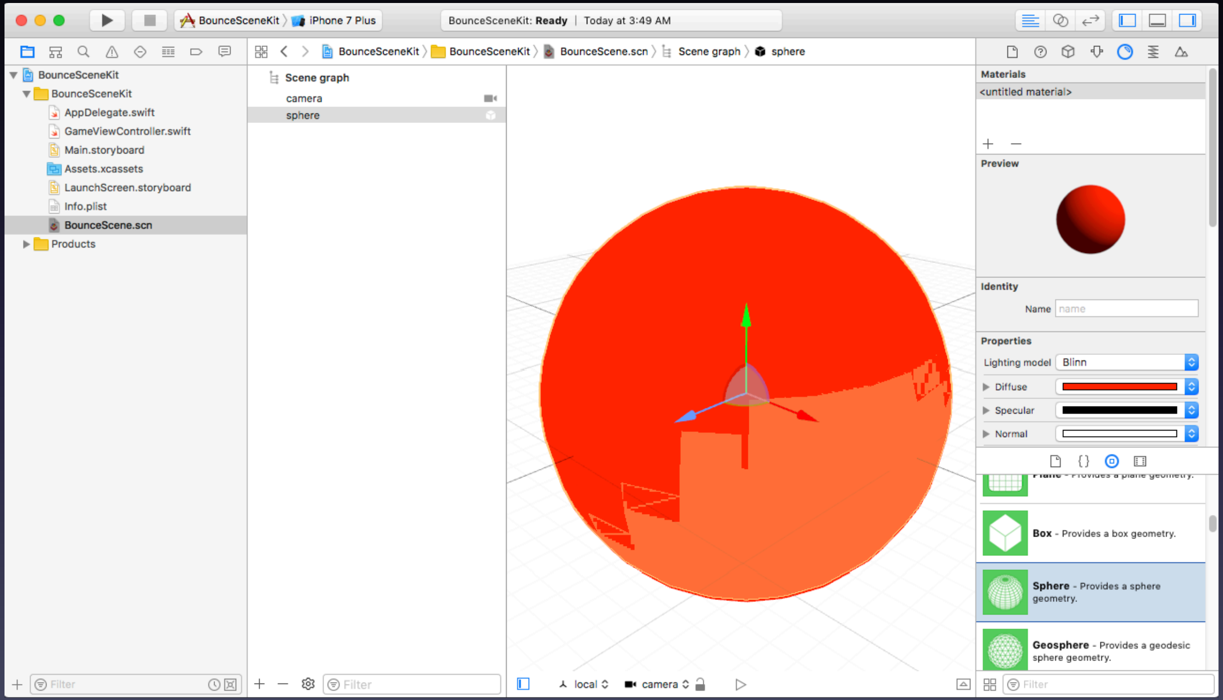
SceneKit Scene Editor

- First, add scene file (.scn)



SceneKit Scene Editor

- Add SCNNode's to scene

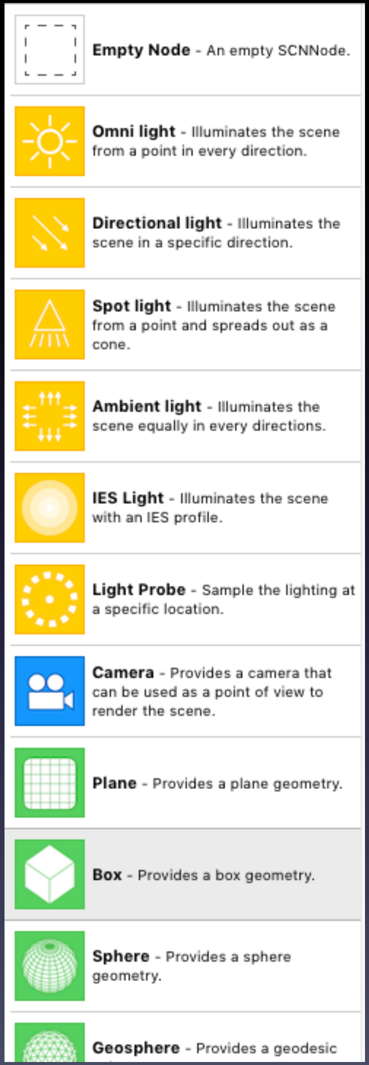


Lighting model: Blinn

Diffuse

Specular

Normal



Empty Node - An empty SCNNode.

Omni light - Illuminates the scene from a point in every direction.

Directional light - Illuminates the scene in a specific direction.

Spot light - Illuminates the scene from a point and spreads out as a cone.

Ambient light - Illuminates the scene equally in every directions.

IES Light - Illuminates the scene with an IES profile.

Light Probe - Sample the lighting at a specific location.

Camera - Provides a camera that can be used as a point of view to render the scene.

Plane - Provides a plane geometry.

Box - Provides a box geometry.

Sphere - Provides a sphere geometry.

Geosphere - Provides a geodesic

SceneKit Scene Editor

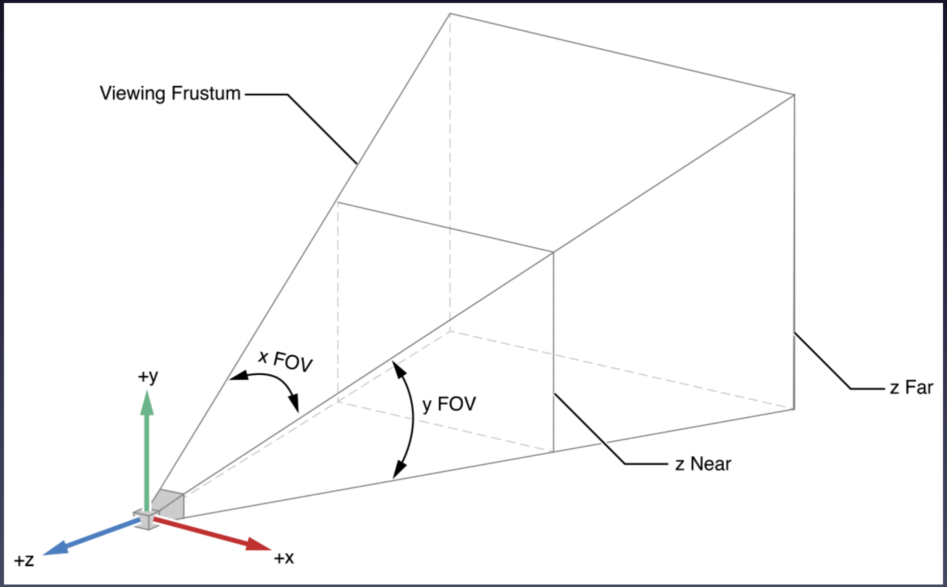
- Load scene file into SCNView
  - let scene = SCNScene(named: “BounceScene.scn”)!
- Good for creating specific elements of game
  - Collections of nodes
  - Fields
  - Actions
- Cumbersome for creating entire game

Elements of a Scene: SCNNode

- Camera
- Light: Ambient, Directional, Omni, Spot
- Geometry: Plane, Box, Sphere, Text, …
- Physics
  - Fields: Drag, Gravity, Electric, Magnetic, ...
- Actions: Move, Scale, Rotate, Fade
- Materials

SceneKit Camera

- Default camera unless you add one
- Can allow user control

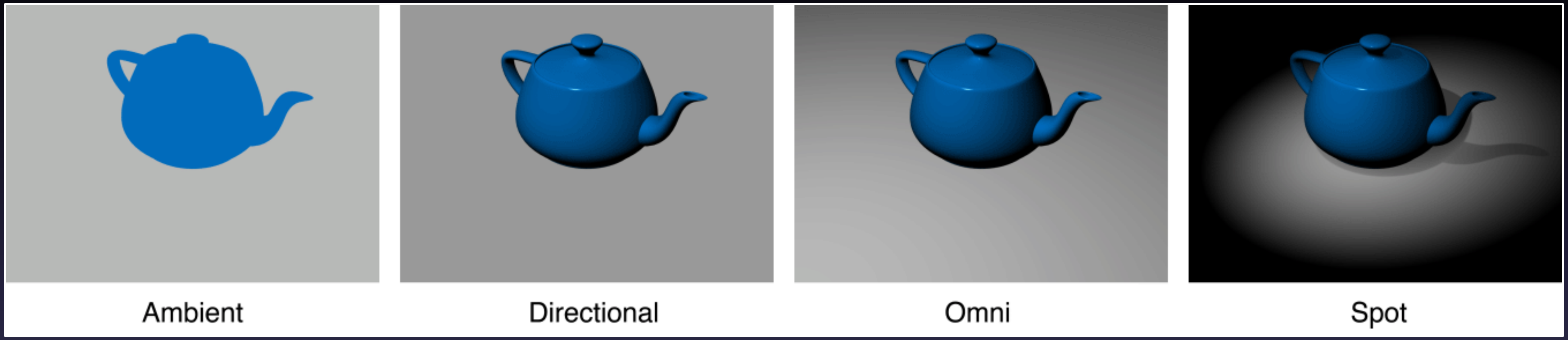


SceneKit Camera

```
// create and add a camera to the scene
let cameraNode = SCNNode()
cameraNode.camera = SCNCamera()
self.scene.rootNode.addChildNode(cameraNode)

// place the camera
cameraNode.position = SCNVector3(x: 0, y: 0, z: 30)

// allow the user to manipulate the camera
scnView.allowsCameraControl = true
```

SceneKit Light

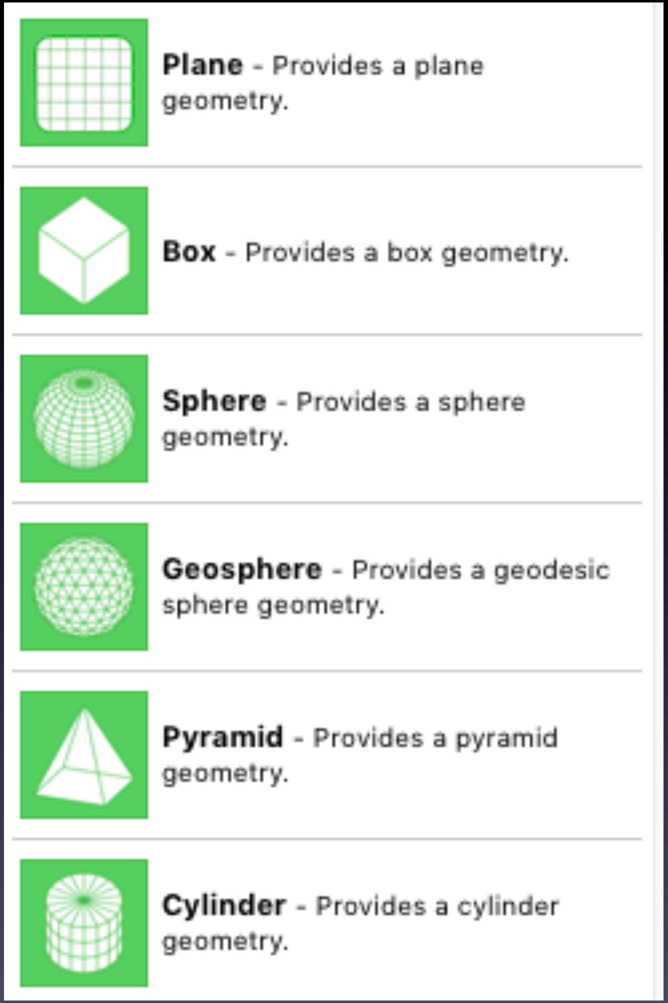
- Default ambient light unless you add more



SceneKit Light

```
// create and add point light source to the scene
let lightNode = SCNNode()
lightNode.light = SCNLight()
lightNode.light!.type = .omni
lightNode.position = SCNVector3(x: 0, y: 10, z: 10)
self.scene.rootNode.addChildNode(lightNode)

// create and add ambient light to the scene
let ambientLightNode = SCNNode()
ambientLightNode.light = SCNLight()
ambientLightNode.light!.type = .ambient
ambientLightNode.light!.color = UIColor.darkGray
self.scene.rootNode.addChildNode(ambientLightNode)
```

SceneKit Geometry



Plane - Provides a plane geometry.

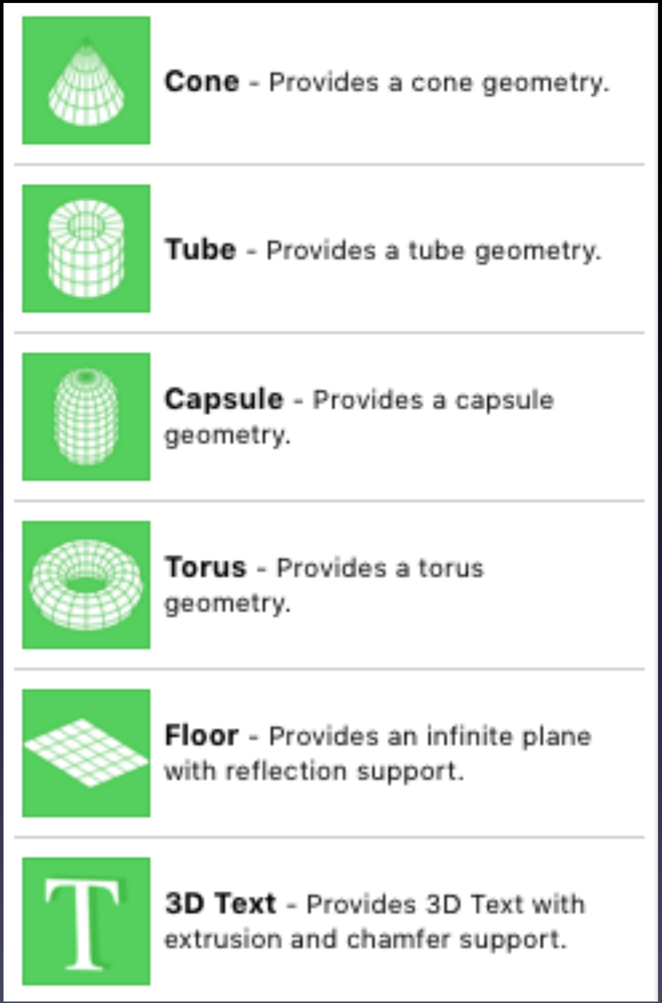
Box - Provides a box geometry.

Sphere - Provides a sphere geometry.

Geosphere - Provides a geodesic sphere geometry.

Pyramid - Provides a pyramid geometry.

Cylinder - Provides a cylinder geometry.



Cone - Provides a cone geometry.

Tube - Provides a tube geometry.

Capsule - Provides a capsule geometry.

Torus - Provides a torus geometry.

Floor - Provides an infinite plane with reflection support.

3D Text - Provides 3D Text with extrusion and chamfer support.

SceneKit SCNNode

- Create SCNGeometry
  - Set geometry properties
- Create SCNNode from geometry
  - Set node properties
- Add node as child of scene's root node

SceneKit Geometry: SCNSphere

```
// Red ball
let redBallGeometry = SCNSphere(radius: 1.0)
let redBallPhysicsShape = SCNPhysicsShape(geometry:
      redBallGeometry, options: [:])
redBallGeometry.firstMaterial!.diffuse.contents = UIColor.red
redBallNode = SCNNode(geometry: redBallGeometry)
redBallNode.name = "RedBall"
redBallNode.physicsBody = SCNPhysicsBody(type: .dynamic,
      shape: redBallPhysicsShape)
redBallNode.physicsBody!.isAffectedByGravity = false
redBallNode.physicsBody!.friction = 0.0
redBallNode.physicsBody!.restitution = 1.0
redBallNode.physicsBody!.damping = 0.0
redBallNode.physicsBody!.angularDamping = 0.0
self.scene.rootNode.addChildNode(redBallNode)
```

SceneKit Geometry: SCNText

```
// Bounce text
let bounceTextGeometry = SCNText(string: "Bounce",
      extrusionDepth: 0.5)
bounceTextGeometry.firstMaterial!.diffuse.contents =
      UIColor.lightGray
let bounceTextNode = SCNNode(geometry: bounceTextGeometry)
// Primitive positioning and scaling; could do better
bounceTextNode.position = SCNVector3(-2.0, 10.0, 0.0)
bounceTextNode.scale = SCNVector3(0.1, 0.1, 0.1)
self.scene.rootNode.addChildNode(bounceTextNode)
```

SceneKit Geometry: SCNText

```
// Start/Stop text
let startStopTextGeometry = SCNText(string: "Start",
      extrusionDepth: 0.5)
startStopTextGeometry.firstMaterial!.diffuse.contents =
      UIColor.lightGray
startStopTextNode = SCNNode(geometry: startStopTextGeometry)
startStopTextNode.position = SCNVector3(-2.0, -10.0, 0.0)
startStopTextNode.scale = SCNVector3(0.1, 0.1, 0.1)
startStopTextNode.name = “StartStop”
self.scene.rootNode.addChildNode(startStopTextNode)

// Change start/stop text
let textGeom = startStopTextNode.geometry as! SCNText
textGeom.string = "Stop"
```

SceneKit Geometry: SCNPlane

```
// Top wall
let wallGeometry = SCNPlane(width: 20.0, height: 20.0)
let wallPhysicsShape = SCNPhysicsShape(geometry: wallGeometry,
      options: [:])
let wallNode = SCNNode(geometry: wallGeometry)
wallNode.opacity = 0.0 // invisible
wallNode.physicsBody = SCNPhysicsBody(type: .static,
      shape: wallPhysicsShape)
wallNode.physicsBody!.friction = 0.0
wallNode.physicsBody!.restitution = 1.0
wallNode.physicsBody!.rollingFriction = 0.0
wallNode.position = SCNVector3(0.0, 10.0, 0.0)
wallNode.rotation = SCNVector4(1.0, 0.0, 0.0, -Double.pi / 2.0)
```

```
// Show walls
wallGeometry.firstMaterial!.isDoubleSided = true
wallGeometry.firstMaterial!.diffuse.contents = UIColor.blue
wallNode.opacity = 0.2
```

SceneKit Physics: Contacts

- Delegate
  - SCNPhysicsContactDelegate
  - SCNScene.physicsWorld.contactDelegate = self
- Delegate methods
  - func physicsWorld(_ world: SCNPhysicsWorld, didBegin contact: SCNPhysicsContact)
  - func physicsWorld(_ world: SCNPhysicsWorld, didEnd contact: SCNPhysicsContact)
    - contact.nodeA
    - contact.nodeB
- Category, collision, contact bit masks same as for SpriteKit

SceneKit Physics: Contacts

```
func physicsWorld(_ world: SCNPhysicsWorld, didBegin contact:
       SCNPhysicsContact) {
  let nodeA = contact.nodeA
  let nodeB = contact.nodeB
  let nameA = nodeA.name!
  let nameB = nodeB.name!
  print("contact between \(nameA) and \(nameB)")
}
```

SceneKit Interaction

- Option 1: touchesEnded with hitTest

```
override func touchesEnded(_ touches: Set<UITouch>, with event: UIEvent?) {
  let scnView = self.view as! SCNView
  for touch in touches {
    let point = touch.location(in: scnView)
    let hitResults = scnView.hitTest(point, options: nil)
    for hitResult in hitResults {
      print(”touched node \(hitResult.node.name)”)
    }
  }
}
```

SceneKit Interaction

- Option 2: UITapGestureRecognizer with hitTest

```
// In viewDidLoad...
let tapRecognizer = UITapGestureRecognizer()
tapRecognizer.numberOfTapsRequired = 1
tapRecognizer.numberOfTouchesRequired = 1
tapRecognizer.addTarget(self, action: #selector(sceneTapped))
scnView.gestureRecognizers = [tapRecognizer]

func sceneTapped(recognizer: UITapGestureRecognizer) {
  let scnView = self.view as! SCNView
  let location = recognizer.location(in: scnView)
  let hitResults = scnView.hitTest(location, options: nil)
  for hitResult in hitResults {
    print("tapped node \(hitResult.node.name)")
  }
}
```

SceneKit Update

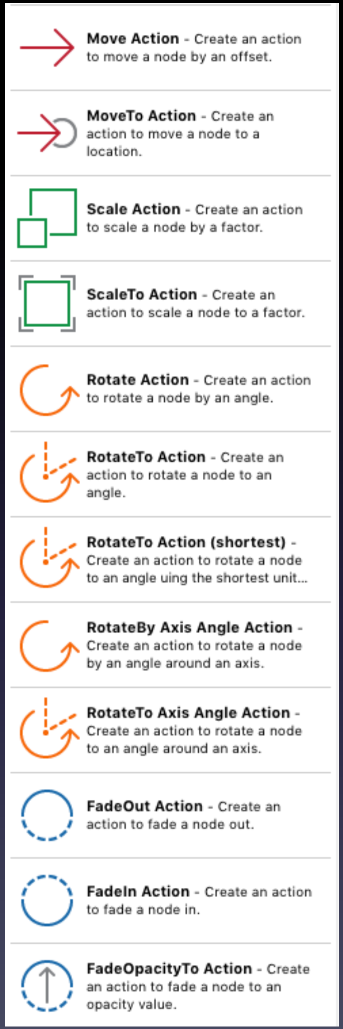
- Add SCNSceneRendererDelegate to scnView
- scnView.delegate = self
- Implement updateAtTime delegate method

```
func renderer(_ renderer: SCNSceneRenderer, updateAtTime time: TimeInterval) {
  print("rendered called at \(time)")
}
```

SceneKit Actions

- Create SCNAction programmatically
- Execute SCNNode.runAction(SCNAction)

```swift
func physicsWorld(_ world: SCNPhysicsWorld,
          didBegin contact: SCNPhysicsContact) {
  let nodeA = contact.nodeA
  let nodeB = contact.nodeB
  let nameA = nodeA.name!
  let nameB = nodeB.name!
  if ((nameA == "Box" ) || (nameB == "Box")) {
    print("You hit the box!")
    let action1 = SCNAction.fadeOut(duration: 0.25)
    let action2 = SCNAction.fadeIn(duration: 0.25)
    let blinkAction = SCNAction.sequence([action1,action2])
    self.redBallNode.runAction(blinkAction)
  }
}
```



Move Action - Create an action to move a node by an offset.

MoveTo Action - Create an action to move a node to a location.

Scale Action - Create an action to scale a node by a factor.

ScaleTo Action - Create an action to scale a node to a factor.

Rotate Action - Create an action to rotate a node by an angle.

RotateTo Action - Create an action to rotate a node to an angle.

RotateTo Action (shortest) - Create an action to rotate a node to an angle uing the shortest unit...

RotateBy Axis Angle Action - Create an action to rotate a node by an angle around an axis.

RotateTo Axis Angle Action - Create an action to rotate a node to an angle around an axis.

FadeOut Action - Create an action to fade a node out.

FadeIn Action - Create an action to fade a node in.

FadeOpacityTo Action - Create an action to fade a node to an opacity value.

SceneKit Audio

- Sound effects
  - Create SCNAudioSource
  - Create SCNAction.playAudio
  - Run action on some SCNNode
- Background music
  - Same as SpriteKit, i.e., AVAudioPlayer
- SCNAudioPlayer (work in progress…)
  - Positional
  - Effects, e.g., reverb

SceneKit Audio: Sound Effects

```
var bounceSoundAction: SCNAction!

let audioSource = SCNAudioSource(named: "bounce.mp3")
bounceSoundAction = SCNAction.playAudio(audioSource!,
    waitForCompletion: false)

func physicsWorld(_ world: SCNPhysicsWorld, didBegin contact:
       SCNPhysicsContact) {
  let nodeA = contact.bodyA.node!
  let nodeB = contact.bodyB.node!
  ...
  nodeA.runAction(bounceSoundAction)
}
```

Resources

- Core Graphics
  - developer.apple.com/reference/coregraphics
- Sprite Kit
  - developer.apple.com/spritekit/
- Scene Kit
  - developer.apple.com/scenekit/
- Gameplay Kit
  - developer.apple.com/reference/gameplaykit
- AVFoundation
  - developer.apple.com/av-foundation/