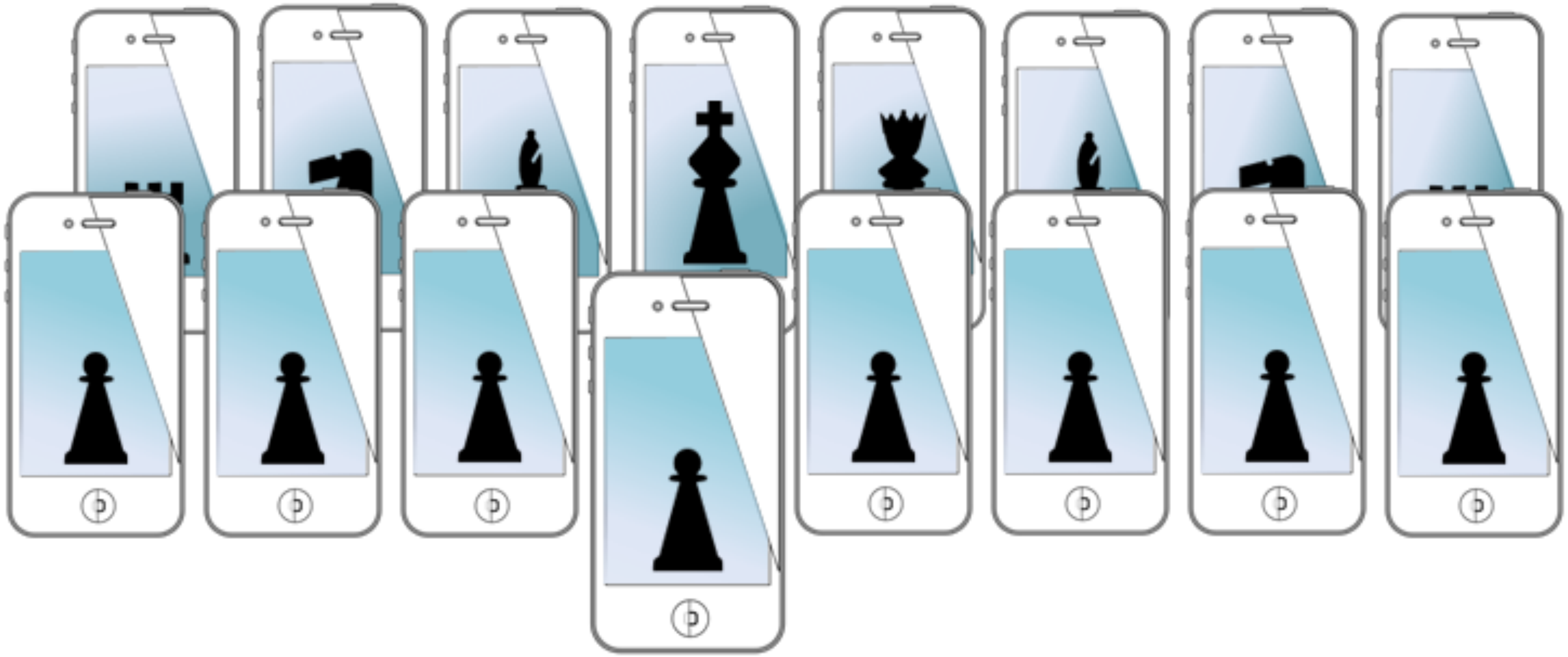
MOBILE SENSING LEARNING



CSE5323 & 7323

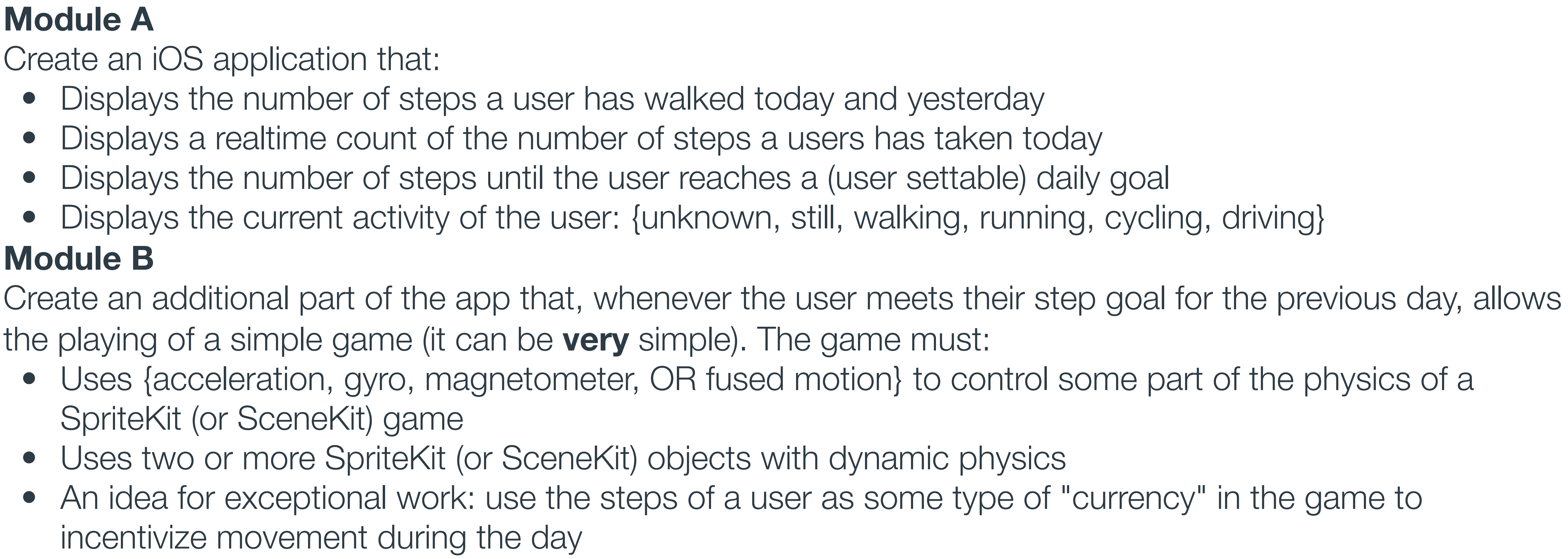
Mobile Sensing and Learning

week 5 lecture b: activity, pedometers, and motion sensing

Eric C. Larson, Lyle School of Engineering,
Computer Science and Engineering, Southern Methodist University

course logistics

- A2 is due Friday
  - everyone okay?
- A3 is due a week from Friday
  - smaller set of deliverables



Module A

Create an iOS application that:

- Displays the number of steps a user has walked today and yesterday
- Displays a realtime count of the number of steps a users has taken today
- Displays the number of steps until the user reaches a (user settable) daily goal
- Displays the current activity of the user: {unknown, still, walking, running, cycling, driving}

Module B

Create an additional part of the app that, whenever the user meets their step goal for the previous day, allows the playing of a simple game (it can be **very** simple). The game must:

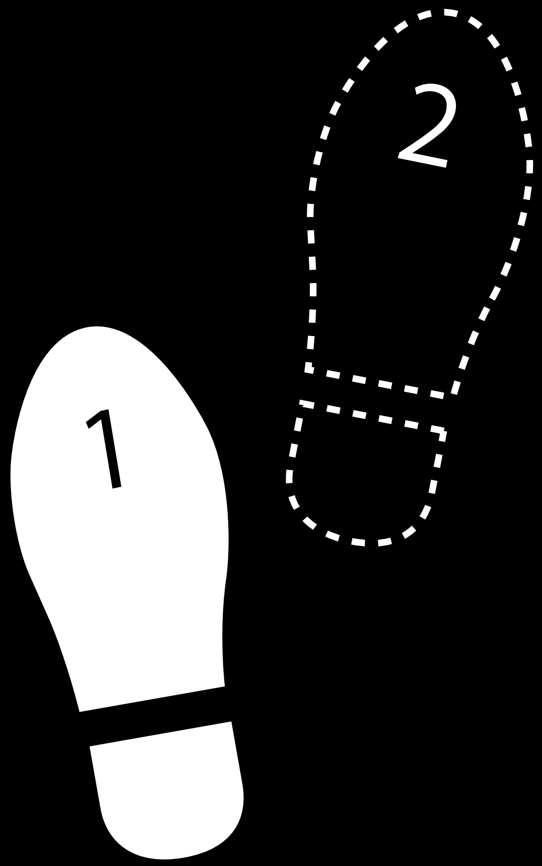
- Uses {acceleration, gyro, magnetometer, OR fused motion} to control some part of the physics of a SpriteKit (or SceneKit) game
- Uses two or more SpriteKit (or SceneKit) objects with dynamic physics
- An idea for exceptional work: use the steps of a user as some type of "currency" in the game to incentivize movement during the day

agenda

- core motion (continued)
  - M- co-processor
- demo
- accelerometers, gyros, and magnetometers
- demo
- SpriteKit
- demo

Pedometer

Step counting



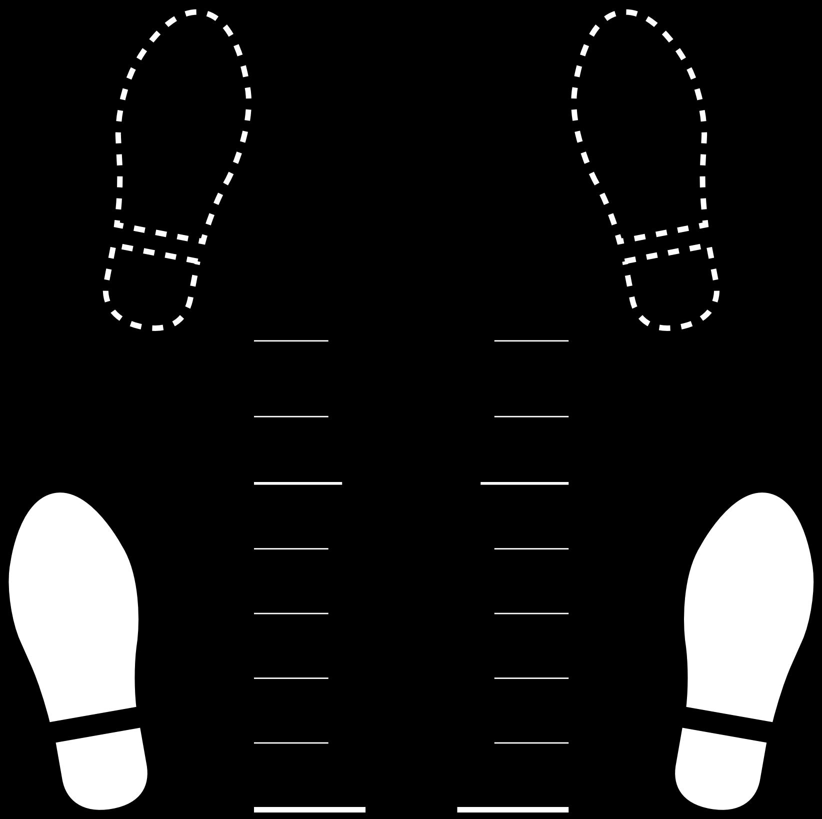
Consistent performance across body locations

Extremely accurate

Robust to extraneous motions

Pedometer

Stride estimation



Consistent performance across body locations

Consistent performance across pace

Extremely accurate

Adapts to the user over time

querying past steps

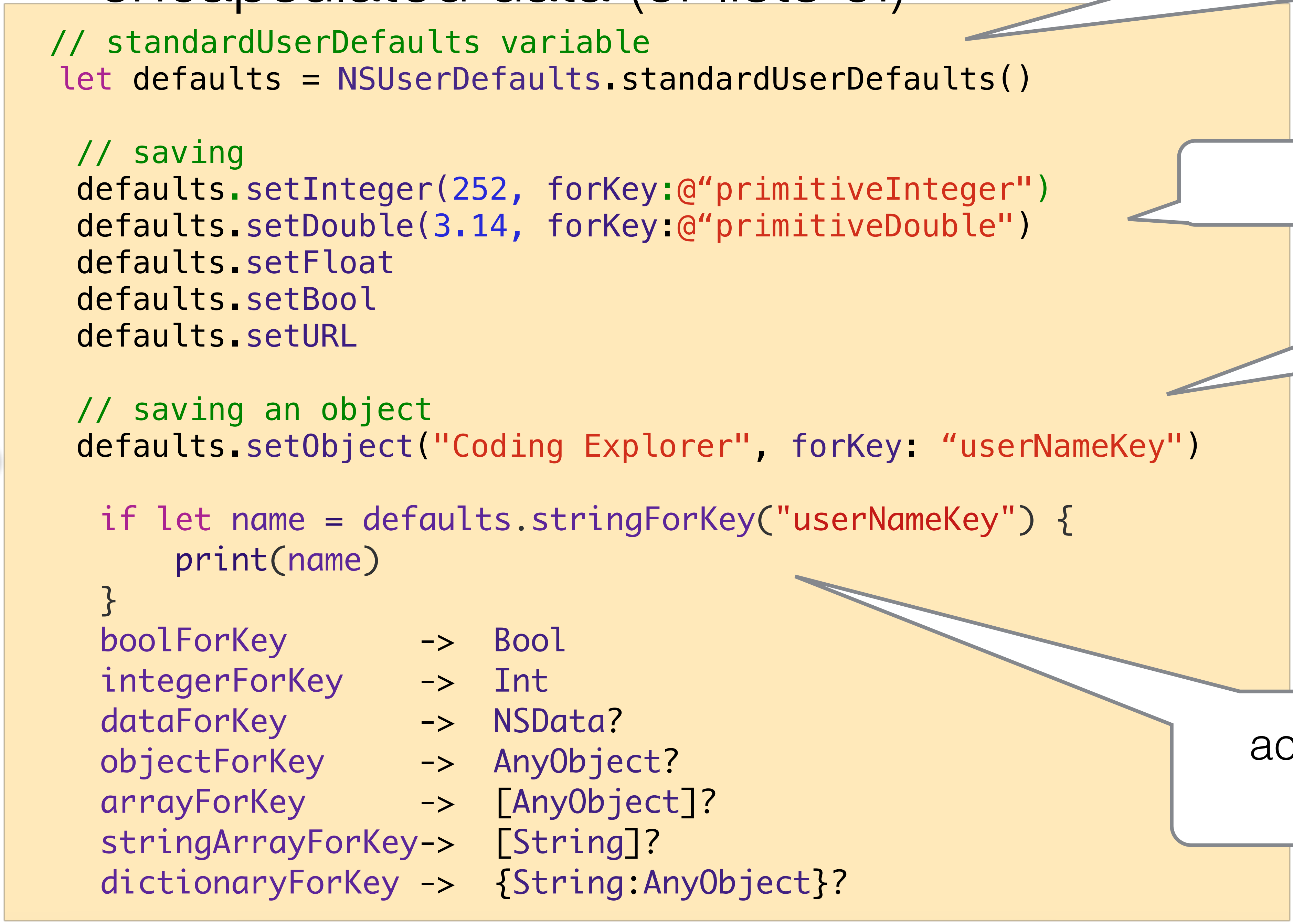
handle error!

```
let now = NSDate()
let from = now.dateByAddingTimeInterval(-60*60*24)

self.pedometer.queryPedometerDataFromDate(from, toDate: now)
{ (pedData: CMPedometerData?, error: NSError?) -> Void in

   let aggregated_string = "Steps: \(pedData.numberOfSteps) \n
          Distance \(pedData.distance) \n
          Floors: \(pedData.floorsAscended.integerValue)”

   dispatch_async(dispatch_get_main_queue()){
      self.activityLabel.text = aggregated_string
   }
}
```

access properties

storing persistent defaults

- iOS supports NSUserDefaults for primitives and encapsulated data (or lists of)



```
// standardUserDefaults variable
 let defaults = NSUserDefaults.standardUserDefaults()

  // saving
  defaults.setInteger(252, forKey:@“primitiveInteger")
  defaults.setDouble(3.14, forKey:@“primitiveDouble")
  defaults.setFloat
  defaults.setBool
  defaults.setURL

  // saving an object
  defaults.setObject("Coding Explorer", forKey: “userNameKey")

   if let name = defaults.stringForKey("userNameKey") {
       print(name)
   }
   boolForKey        ->  Bool
   integerForKey     ->  Int
   dataForKey        ->  NSData?
   objectForKey      ->  AnyObject?
   arrayForKey       ->  [AnyObject]?
   stringArrayForKey->  [String]?
   dictionaryForKey ->  {String:AnyObject}?
```

import defaults

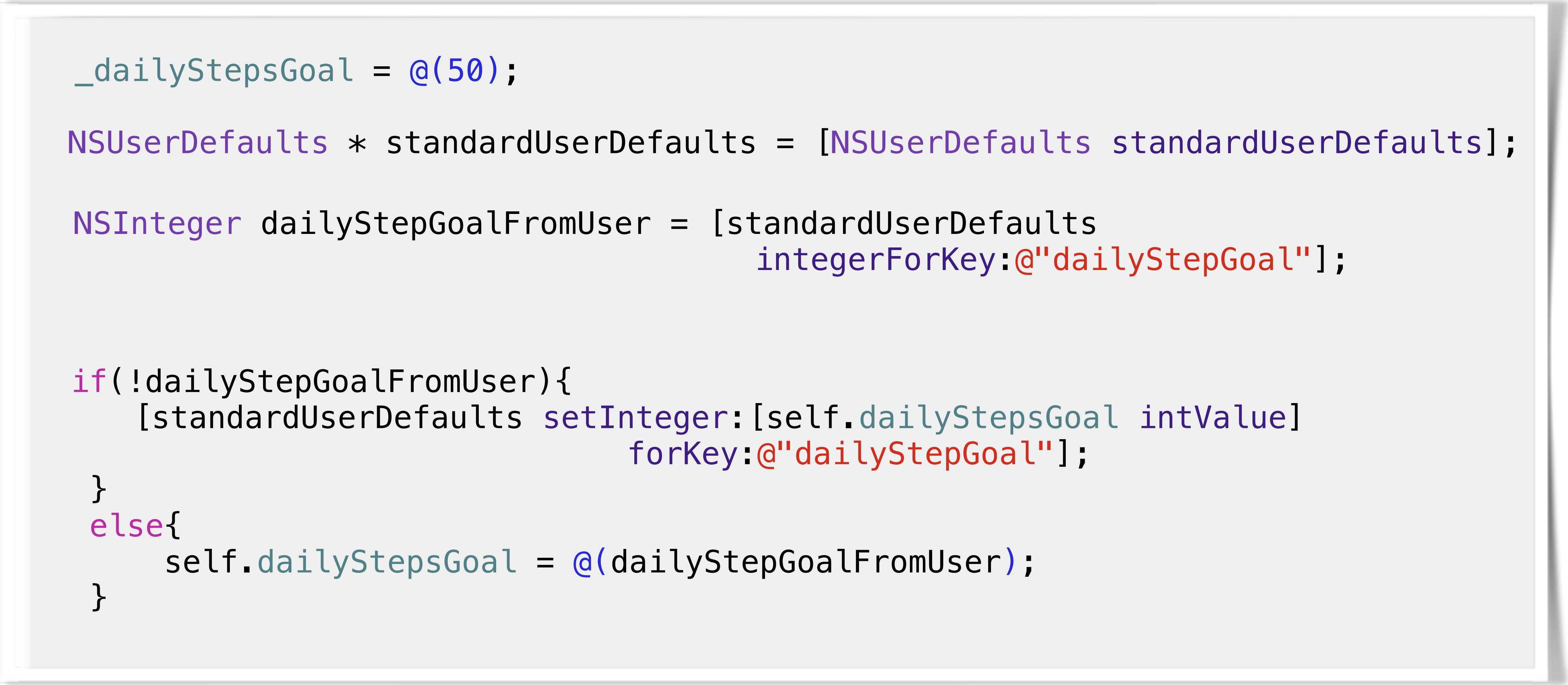
primitives

objects

access saved objects

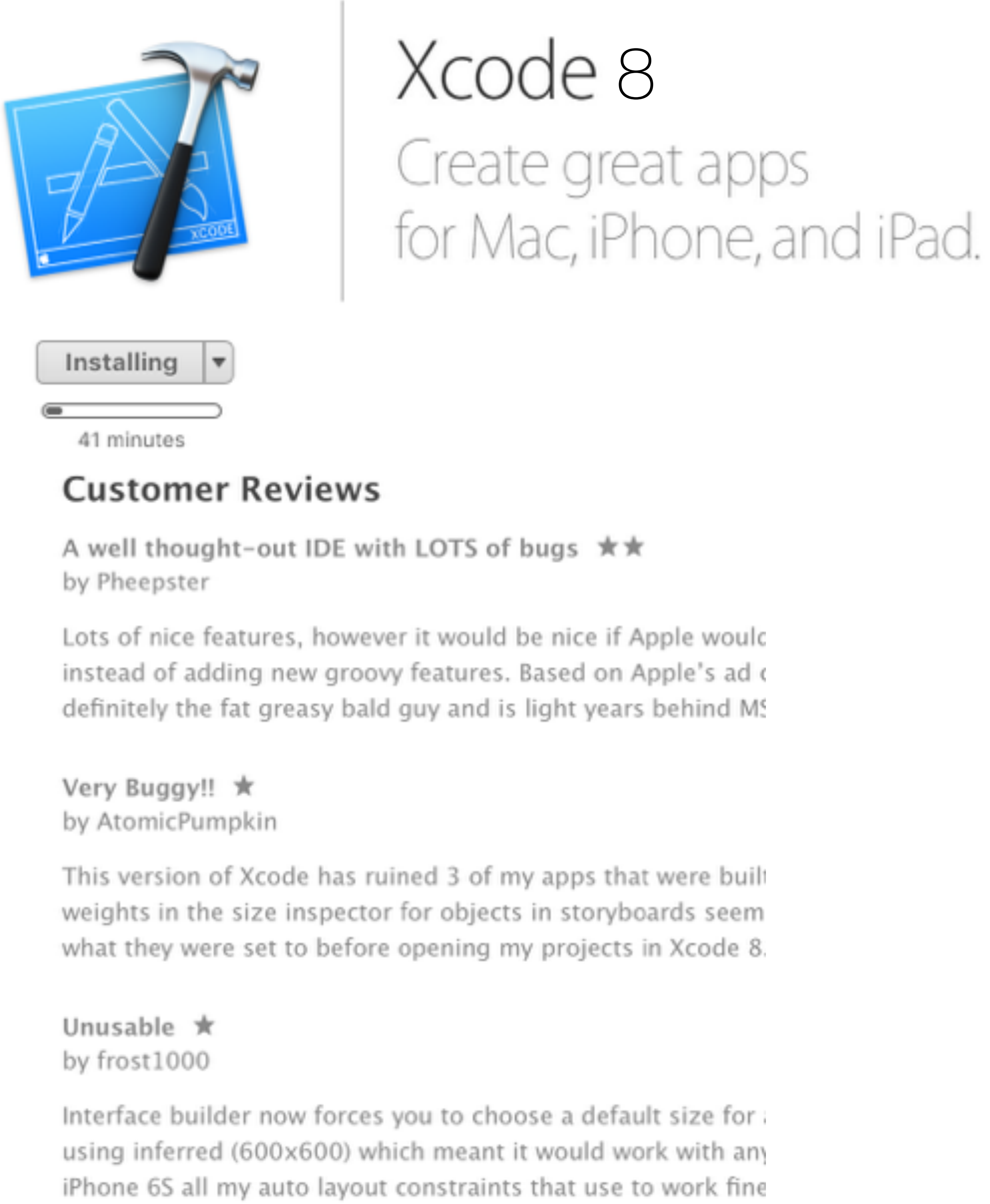
user defaults

key value behavior for setting and getting!



```
_dailyStepsGoal = @(50);

NSUserDefaults * standardUserDefaults = [NSUserDefaults standardUserDefaults];

NSInteger dailyStepGoalFromUser = [standardUserDefaults
                                     integerForKey:@"dailyStepGoal"];



if(!dailyStepGoalFromUser){
    [standardUserDefaults setInteger:[self.dailyStepsGoal intValue]
                              forKey:@"dailyStepGoal"];
 }
 else{
     self.dailyStepsGoal = @(dailyStepGoalFromUser);
 }
```

M- pedometer/activity demo



Xcode 8

Create great apps
for Mac, iPhone, and iPad.

Customer Reviews

A well thought-out IDE with LOTS of bugs ★★
by Pheepster

Lots of nice features, however it would be nice if Apple woulc
instead of adding new groovy features. Based on Apple's ad c
definitely the fat greasy bald guy and is light years behind MS

Very Buggy!! ★
by AtomicPumpkin

This version of Xcode has ruined 3 of my apps that were built
weights in the size inspector for objects in storyboards seem
what they were set to before opening my projects in Xcode 8.

Unusable ★
by frost1000

Interface builder now forces you to choose a default size for
using inferred (600x600) which meant it would work with any
iPhone 6S all my auto layout constraints that use to work fine

M- “raw” motion data

Barometer

The barometer senses air pressure to determine your relative elevation. So as you move, you can keep track of the elevation you’ve gained. It can even measure stairs climbed or hills conquered.

Accelerometer

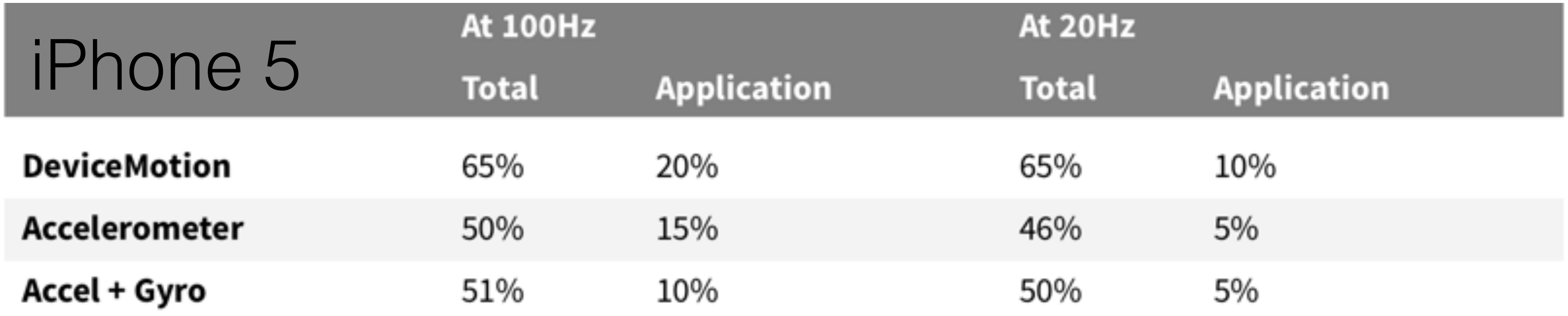
The accelerometer can measure your distance for walking and running. And by using GPS to calibrate for your running stride, the sensor more accurately captures your movement.

Gyroscope

In addition to knowing whether you’re on the move or stationary, M8 works with the gyroscope to detect when you’re driving. It also kicks into action when you’re taking panoramic photos or playing games that react to your movement.

M- “raw” motion data

- M- mediates access to data
- much lower battery consumption

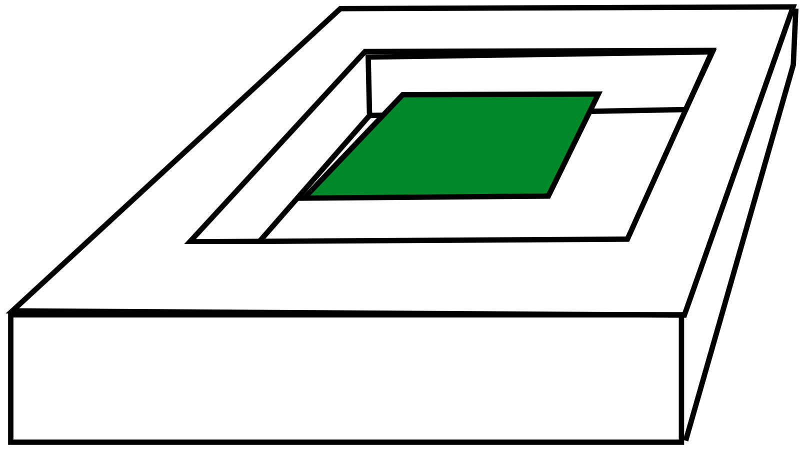


iPhone 5	At 100Hz		At 20Hz	
	Total	Application	Total	Application
DeviceMotion	65%	20%	65%	10%
Accelerometer	50%	15%	46%	5%
Accel + Gyro	51%	10%	50%	5%

iPhone 5s	4%	1%
iPhone 6, 6S	~2%	1%
iPhone 7	~?%	?%

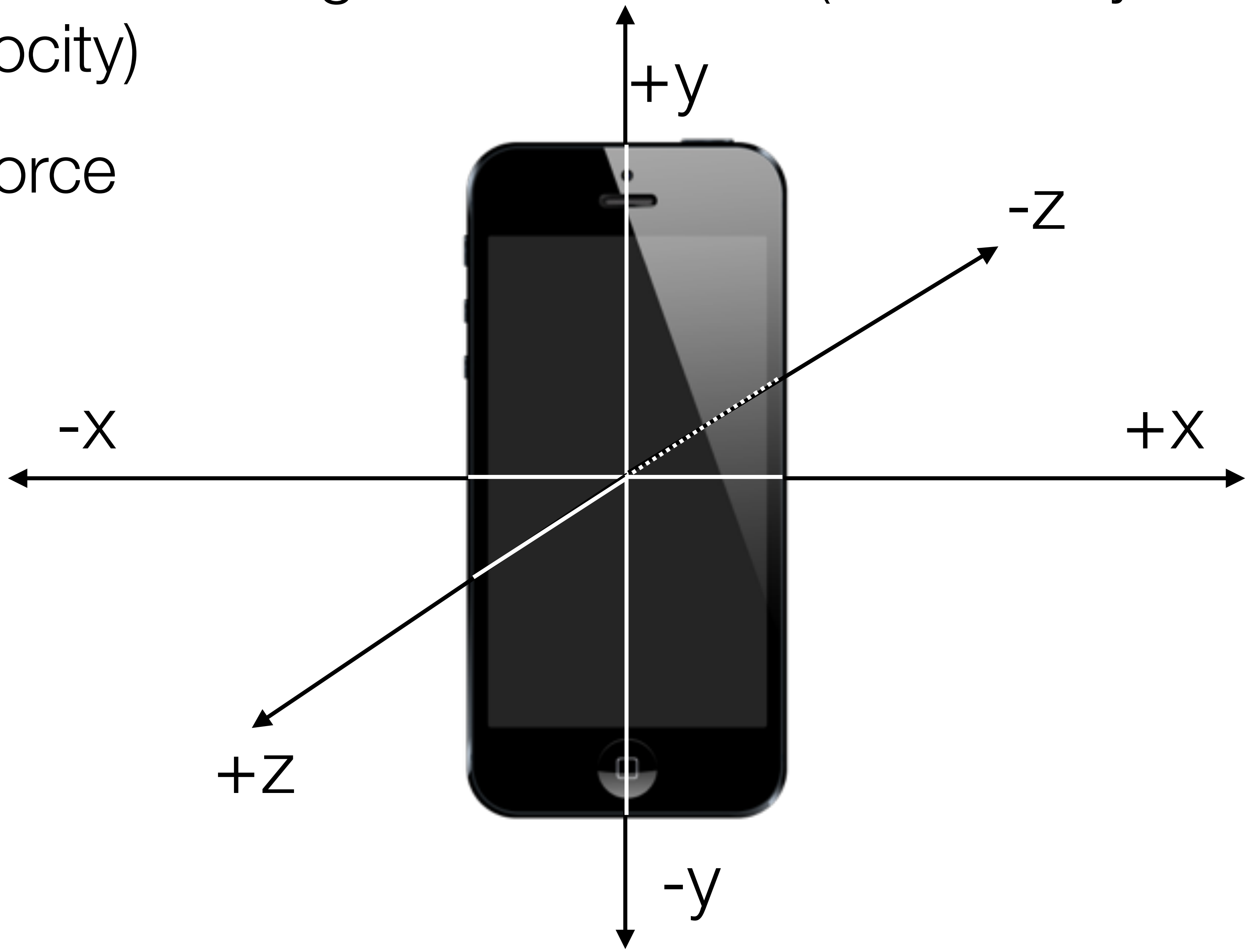
accelerometers

- how does it work?
- solid state device (fabricated on a chip)
- it has specs (not made public by Apple)
  - swing
    - +-8g (force)
  - bias and variance
    - bias can be high, easy to zero out
  - resolution
    - 20 bits or 0.000015g
  - bandwidth
    - 100Hz sampling is highest recommended



accelerometer

- measures “proper acceleration”
  - due to the weight of the device (not exactly derivative of velocity)
  - g-force



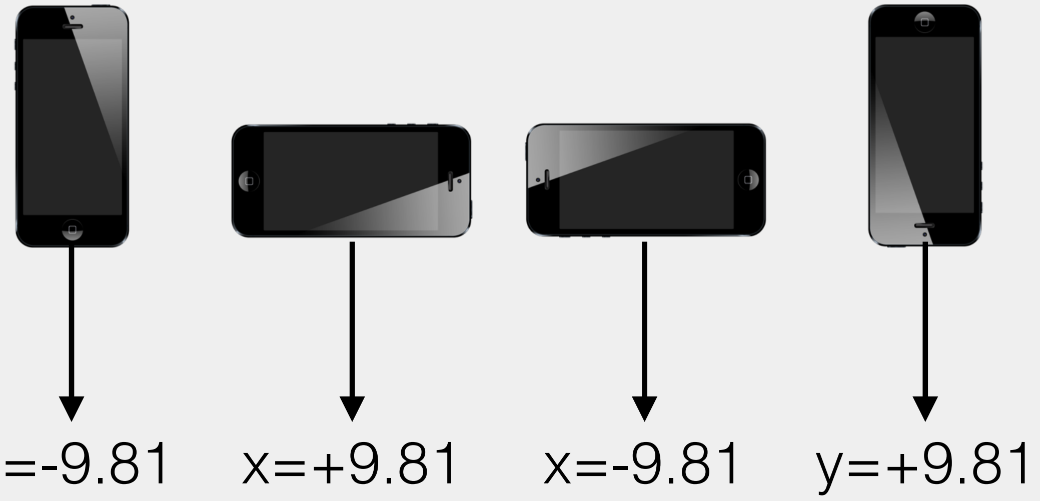
accessing the accelerometer

- usually don’t want the raw accelerometer value
- gravity is always pulling “down” on the device at a constant force of ~9.81g
- the core motion API automatically subtracts gravity from the user acceleration

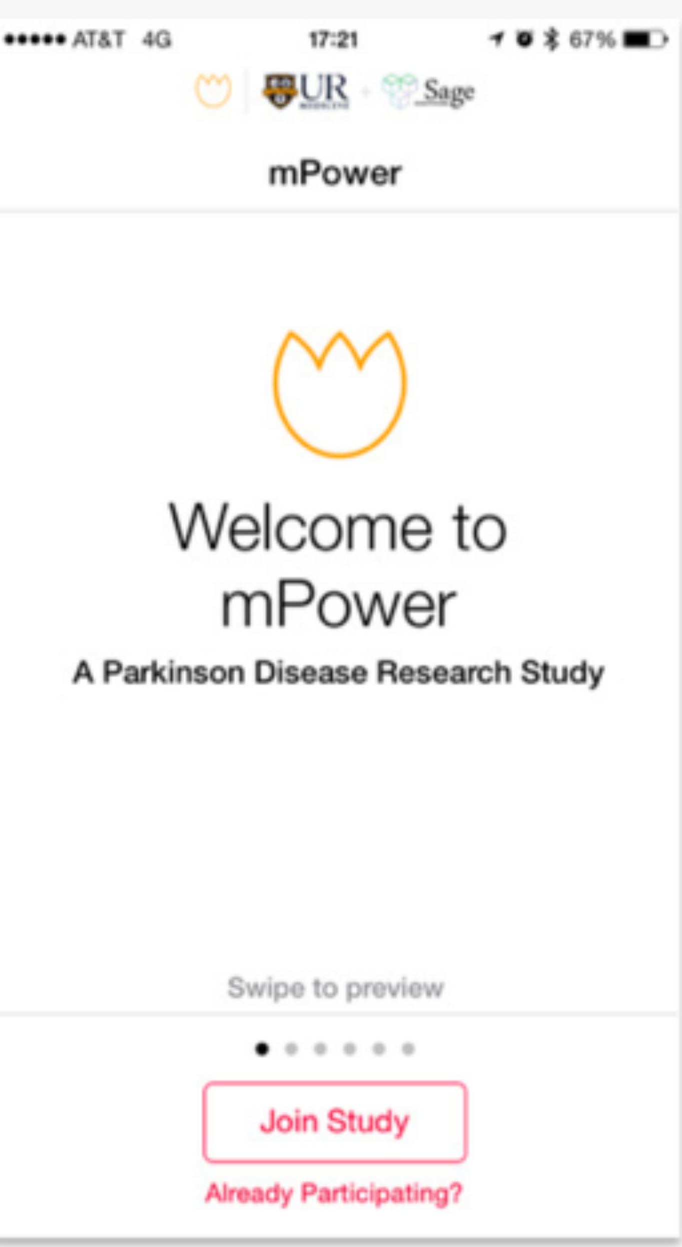
```
CMDeviceMotion *deviceMotion

deviceMotion.gravity
deviceMotion.userAcceleration

CMAcceleration gravity, CMAcceleration userAcceleration

gravity.x;
gravity.y;
gravity.z;

userAcceleration.x;
userAcceleration.y;
userAcceleration.z;
```

user movement

access through a different field!



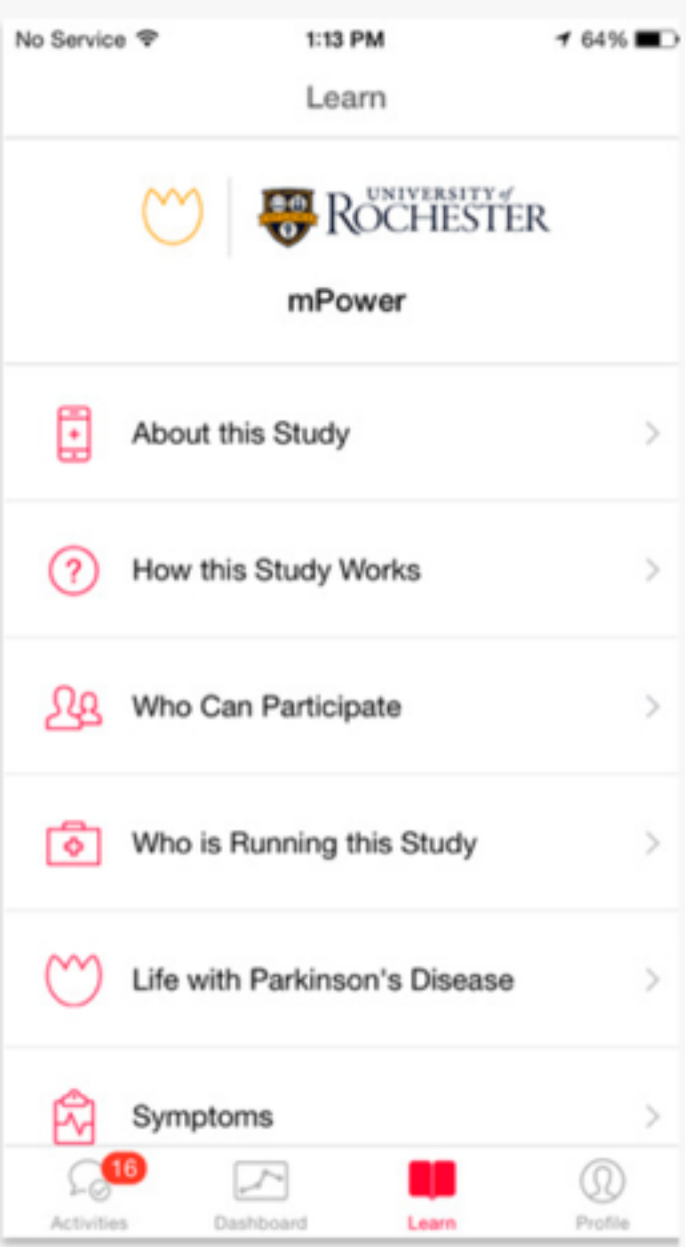
a cool example



mPower

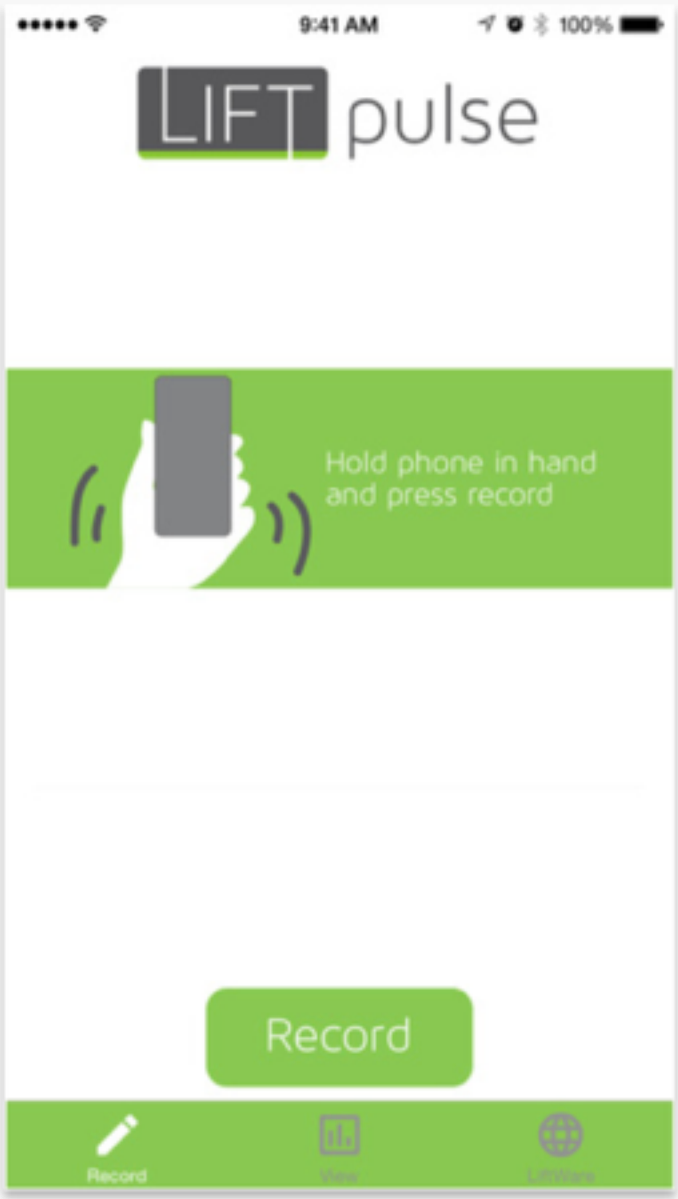
Welcome to mPower

A Parkinson Disease Research Study

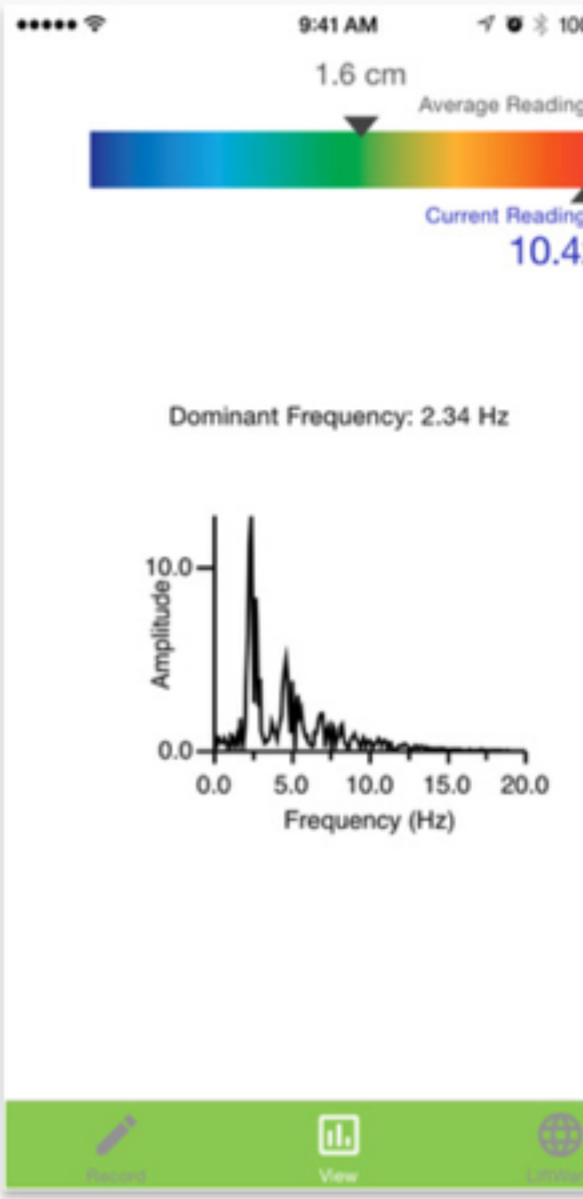


mPower

- About this Study
- How this Study Works
- Who Can Participate
- Who is Running this Study
- Life with Parkinson's Disease
- Symptoms



Hold phone in hand and press record



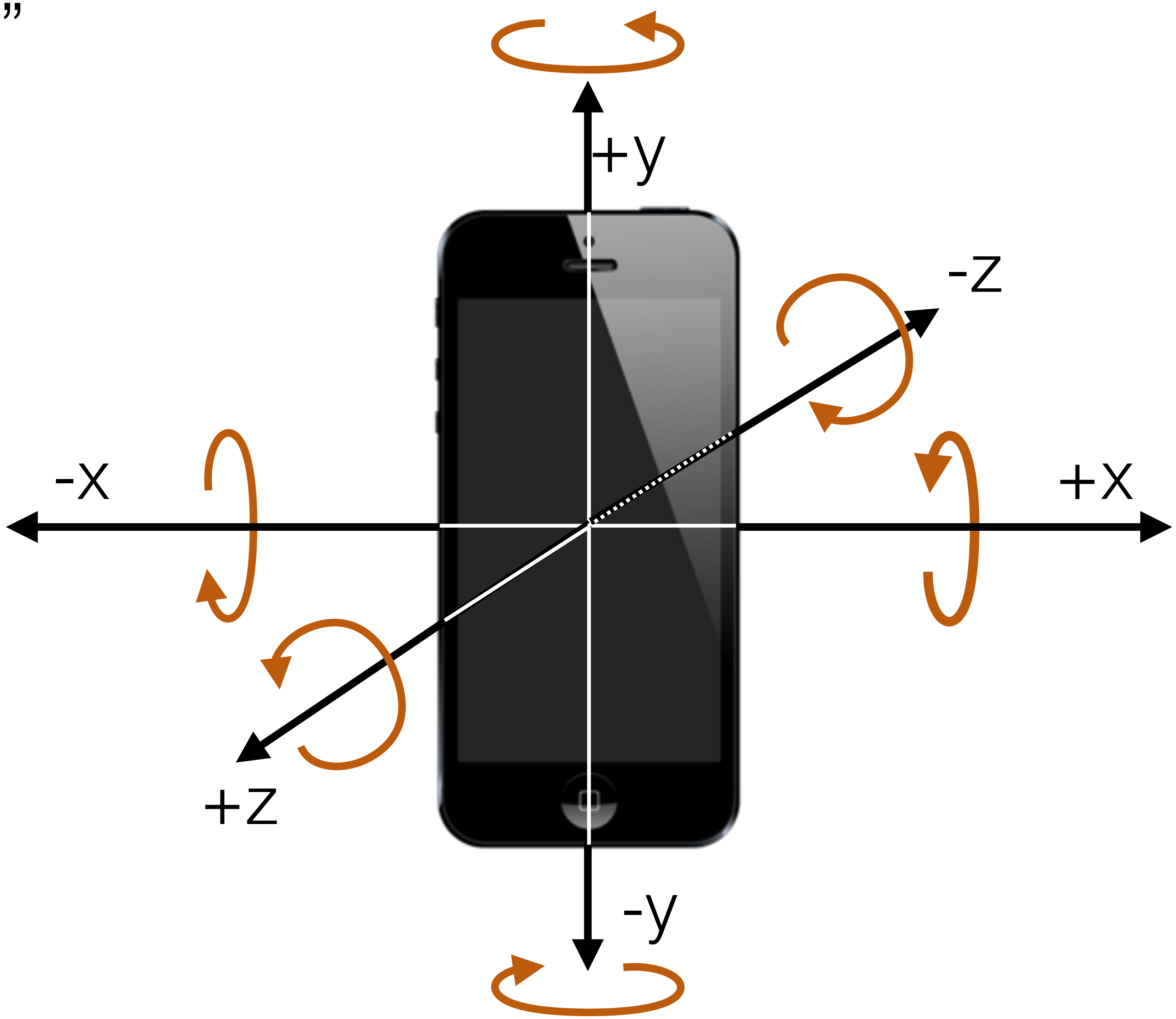
gyroscope

- measures the rate of rotation of the device
- MEMs device
  - essentially a microscopic, vibrating plate that resists motion

so it knows force in any rotating direction

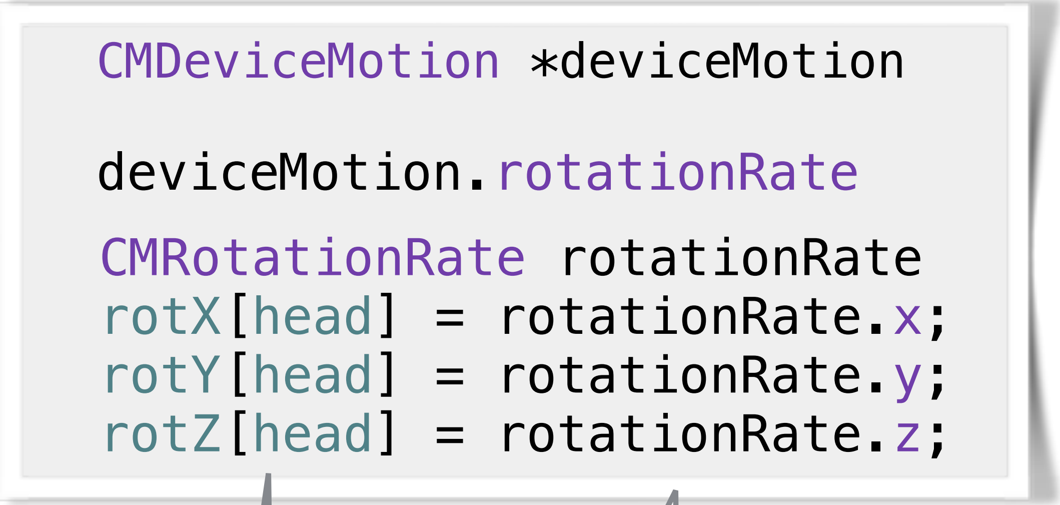
gyroscope

- the “right hand rule”



accessing the gyro

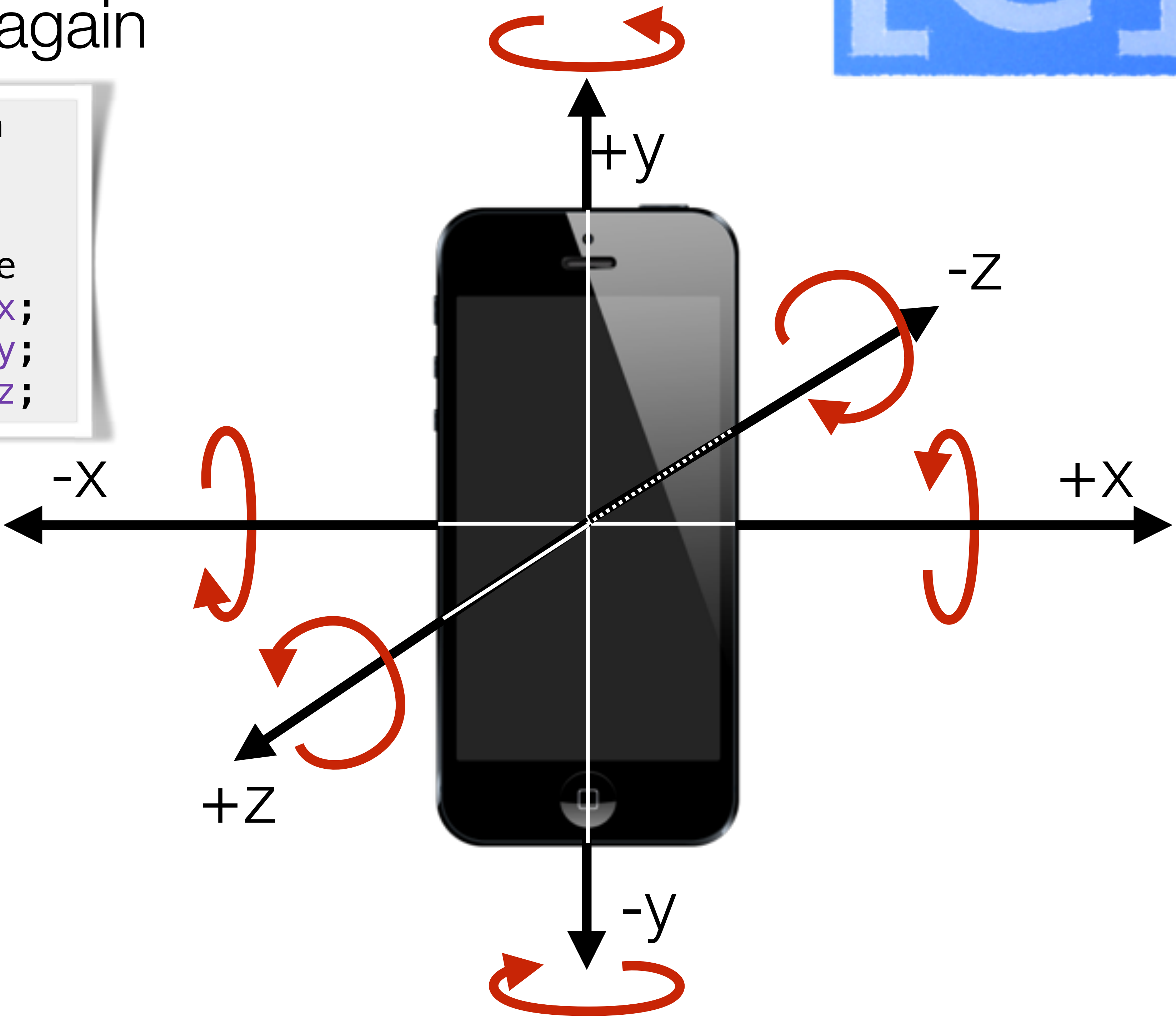
- use device motion again



```
CMDeviceMotion *deviceMotion

deviceMotion.rotationRate

CMRotationRate rotationRate
rotX[head] = rotationRate.x;
rotY[head] = rotationRate.y;
rotZ[head] = rotationRate.z;
```

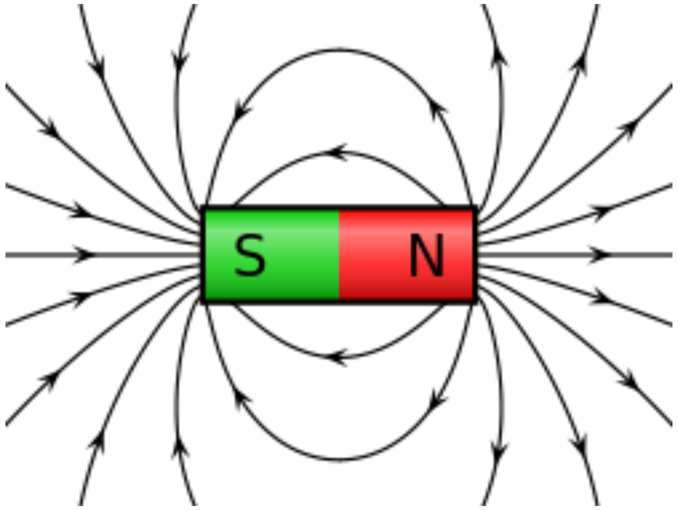
measures **rate** of motion

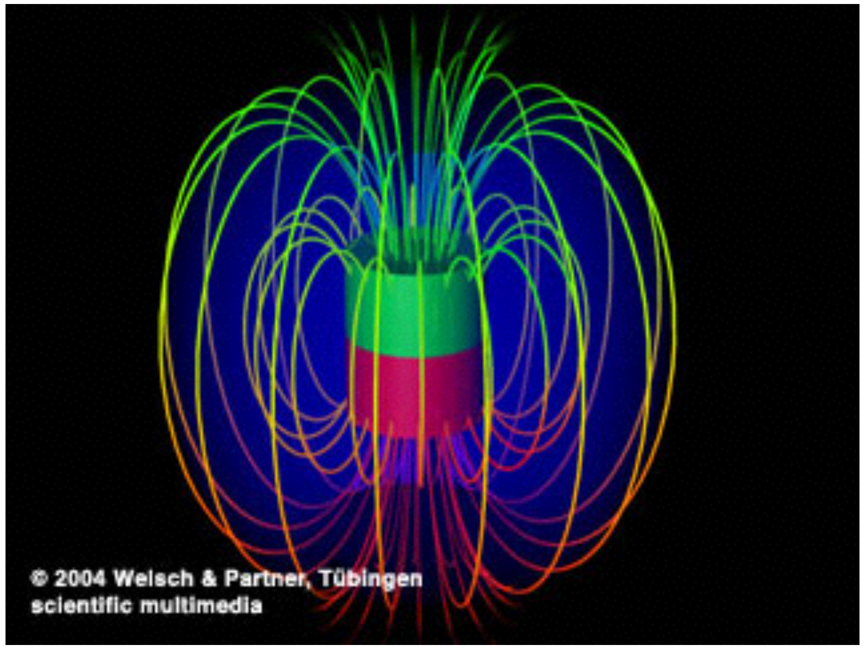
in this example, saves it to array



magnetometers

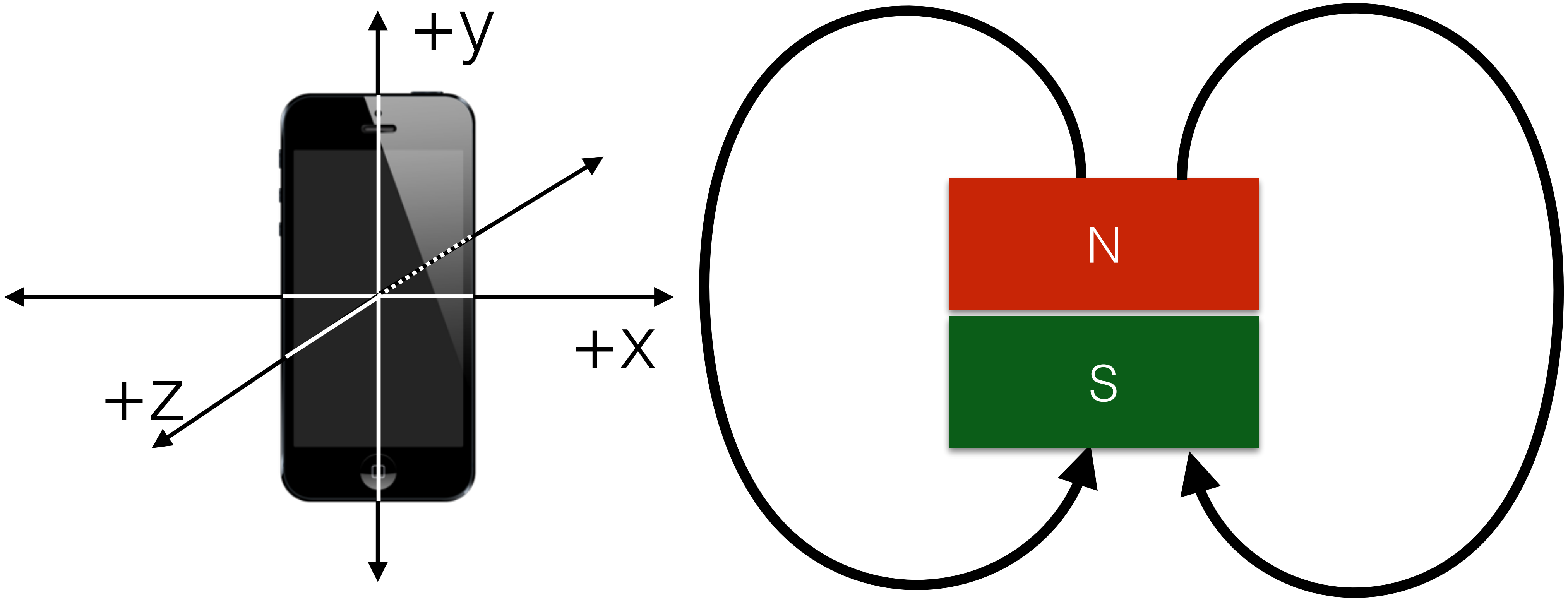
- measure magnetic fields
- magnets are measured in tesla (T)
  - **how**: essentially, there is a tight coupling between electricity flow and magnetic fields
- earth's magnetic field varies, but is around 50 uT
- iPhone can measure up to 1T with a resolution of about 8uT
- magnetic fields have direction!





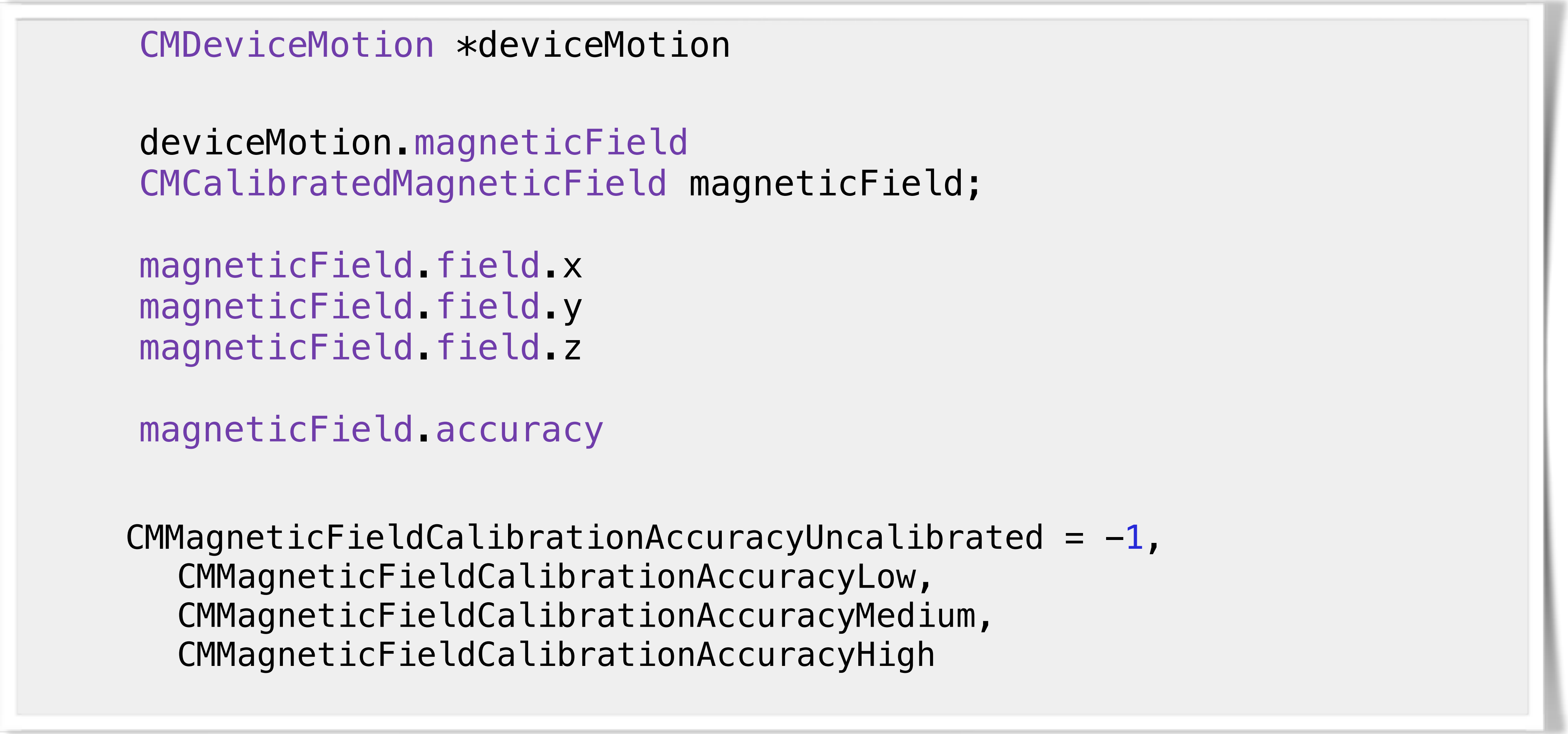
magnetic fields

- measure magnetic field along axis, towards “south”



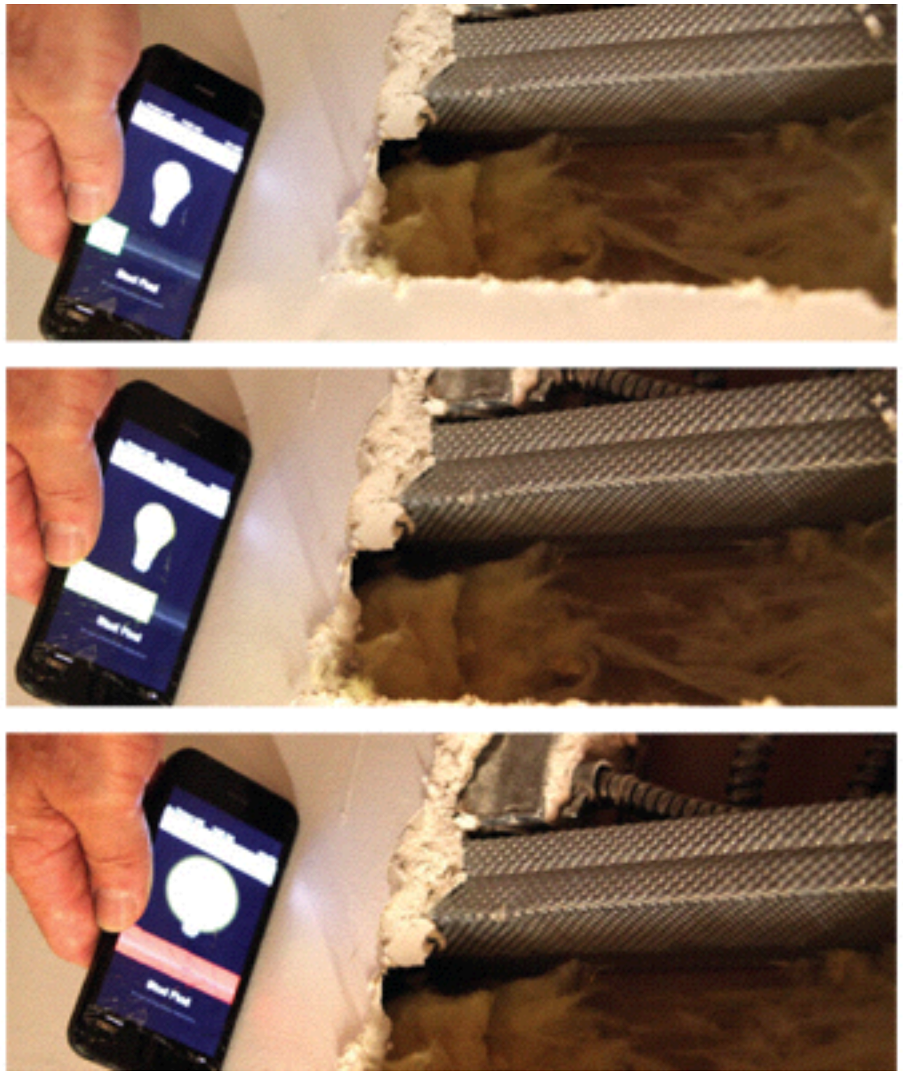
but iPhone has magnetic bias

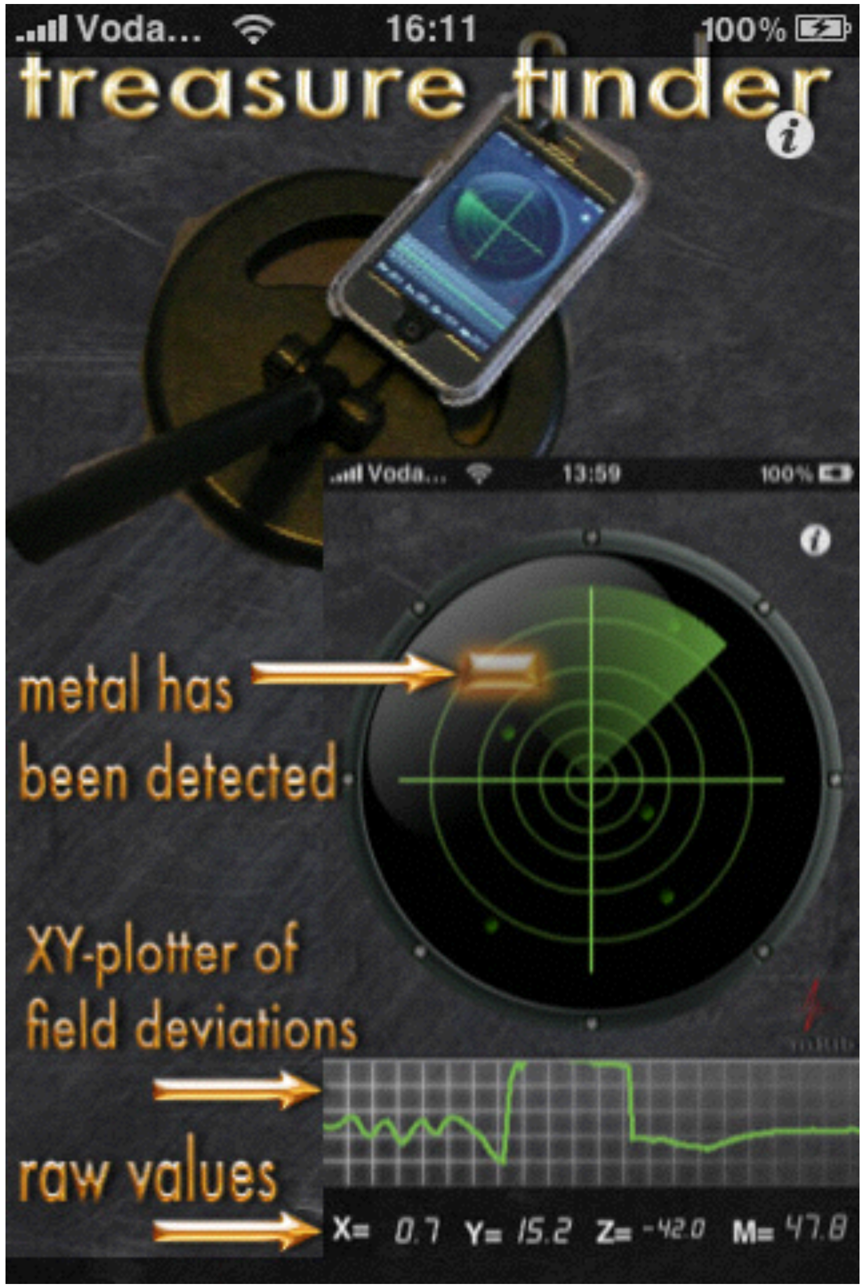
- the phone uses electricity and therefore is a magnet
    - good thing Apple subtracts that out for us!



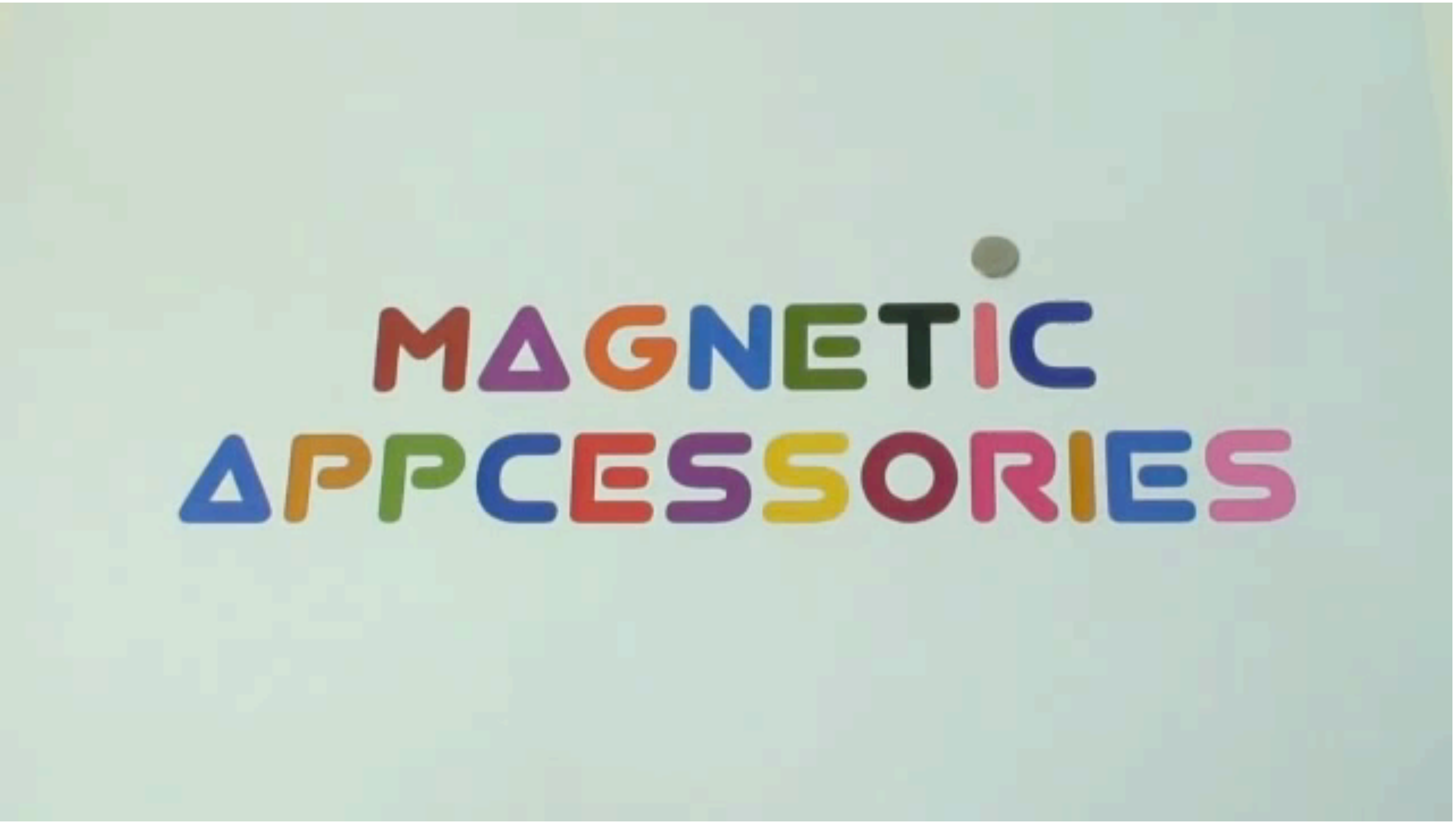
```
CMDeviceMotion *deviceMotion


deviceMotion.magneticField
CMCalibratedMagneticField magneticField;

magneticField.field.x
magneticField.field.y
magneticField.field.z

magneticField.accuracy


CMMagneticFieldCalibrationAccuracyUncalibrated = -1,
    CMMagneticFieldCalibrationAccuracyLow,
    CMMagneticFieldCalibrationAccuracyMedium,
    CMMagneticFieldCalibrationAccuracyHigh
```

a cool example



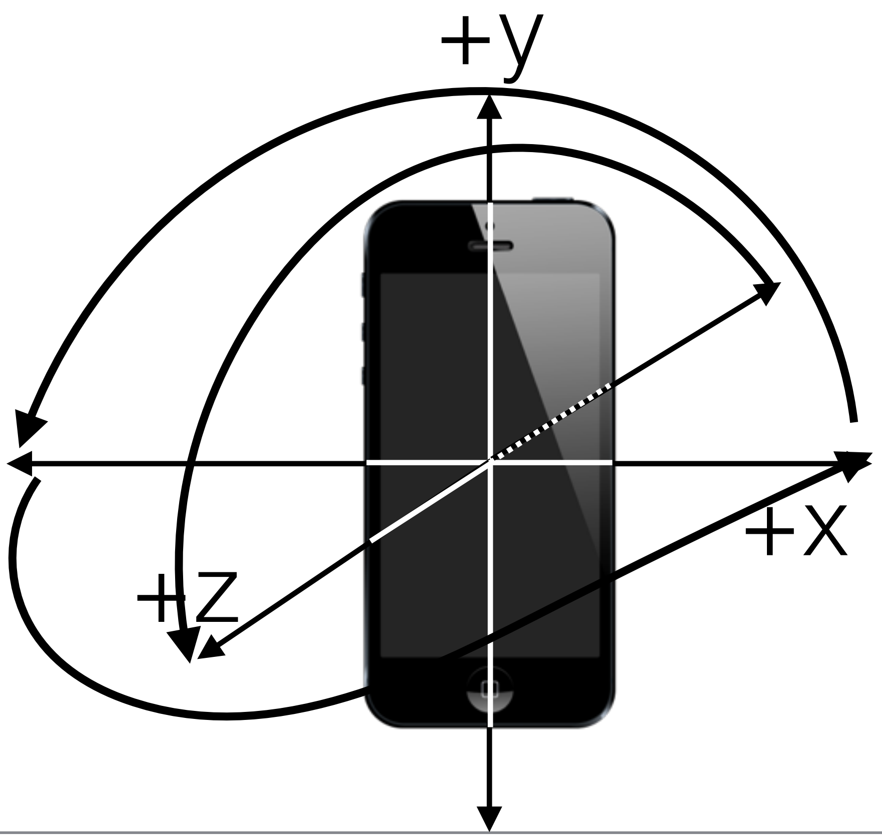


a cool example



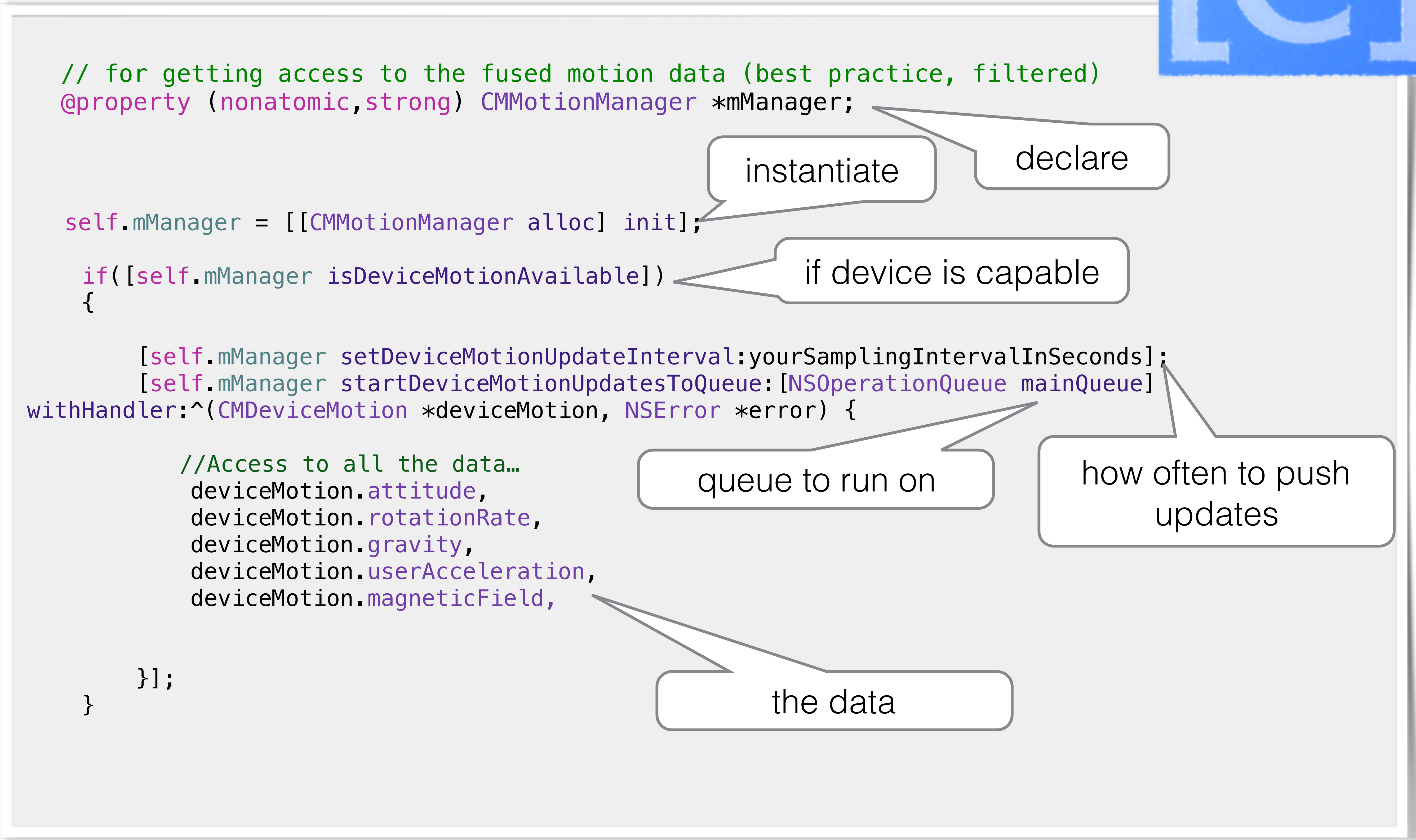
attitude

- attitude is roll, pitch, and yaw (position)
- these are "fused" measures of the device from
  - the magnetometer (used as a compass)
  - gyroscope (used for detecting quick rotations)
  - accelerometer (used for smoothing out the gyro)



yaw in x/y plane
pitch in y/z plane
roll in x/z plane

getting updates



```
// for getting access to the fused motion data (best practice, filtered)
@property (nonatomic,strong) CMMotionManager *mManager;



self.mManager = [[CMMotionManager alloc] init];

 if([self.mManager isDeviceMotionAvailable])
 {

     [self.mManager setDeviceMotionUpdateInterval:yourSamplingIntervalInSeconds];
     [self.mManager startDeviceMotionUpdatesToQueue:[NSOperationQueue mainQueue]
withHandler:^(CMDeviceMotion *deviceMotion, NSError *error) {

        //Access to all the data…
         deviceMotion.attitude,
         deviceMotion.rotationRate,
         deviceMotion.gravity,
         deviceMotion.userAcceleration,
         deviceMotion.magneticField,


     }];
 }
```

declare

instantiate

if device is capable

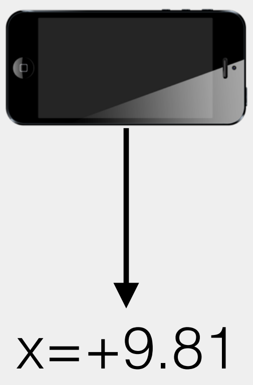
how often to push updates

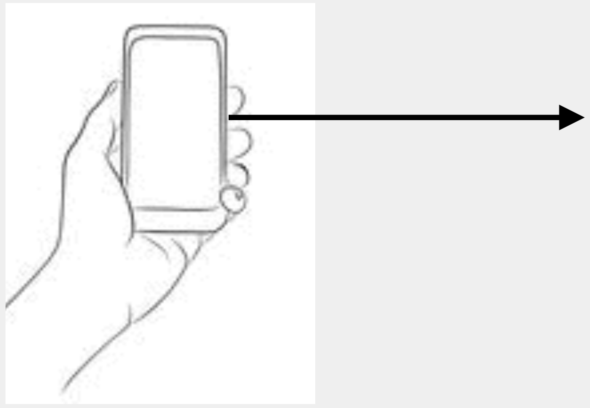
queue to run on

the data

summary

```
CMDeviceMotion *deviceMotion

deviceMotion.gravity
deviceMotion.userAcceleration

CMAcceleration gravity,
CMAcceleration userAcceleration

gravity.x;
gravity.y;
gravity.z;

userAcceleration.x;
userAcceleration.y;
userAcceleration.z;
```

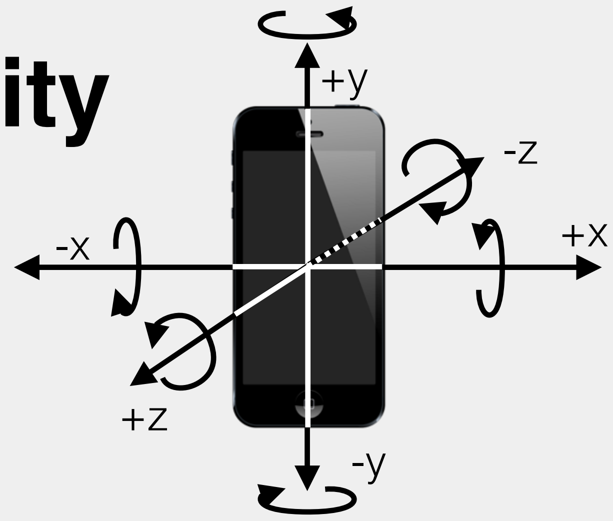




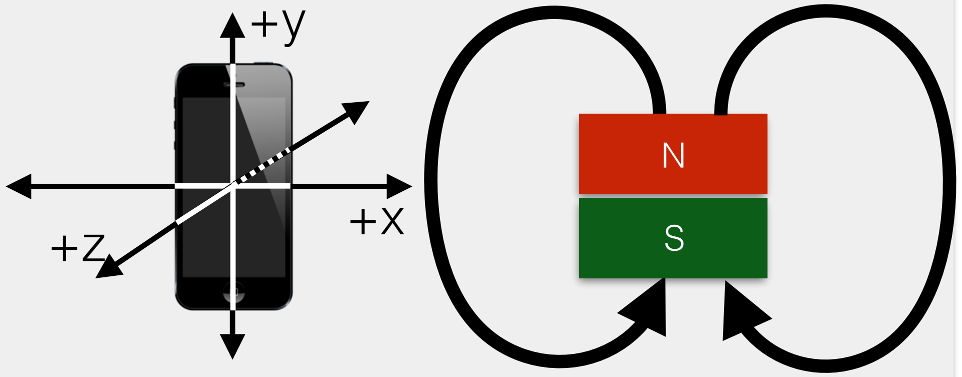
acceleration

rotation velocity

```
deviceMotion.rotationRate
CMRotationRate rotationRate
rotX[head] = rotationRate.x;
rotY[head] = rotationRate.y;
rotZ[head] = rotationRate.z;
```

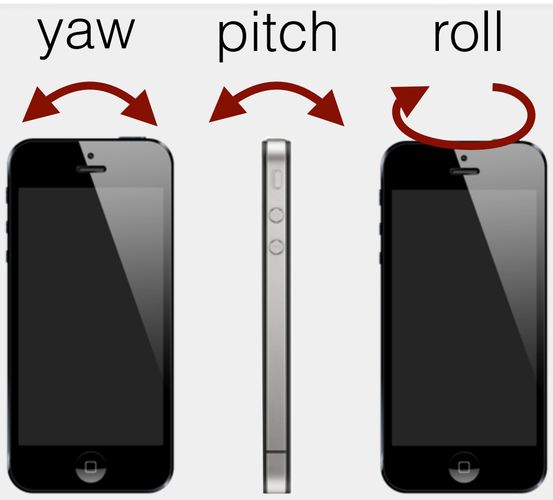


```
deviceMotion.magneticField
CMCalibratedMagneticField magneticField;

magneticField.field.x
magneticField.field.y
magneticField.field.z

magneticField.accuracy
```



magnetic field

```
deviceMotion.attitude

CMAttitude* attitude

attitude.roll;
attitude.pitch;
attitude.yaw;
```



device position

device motion demo

- lets build something
  - to start: take that gravity!

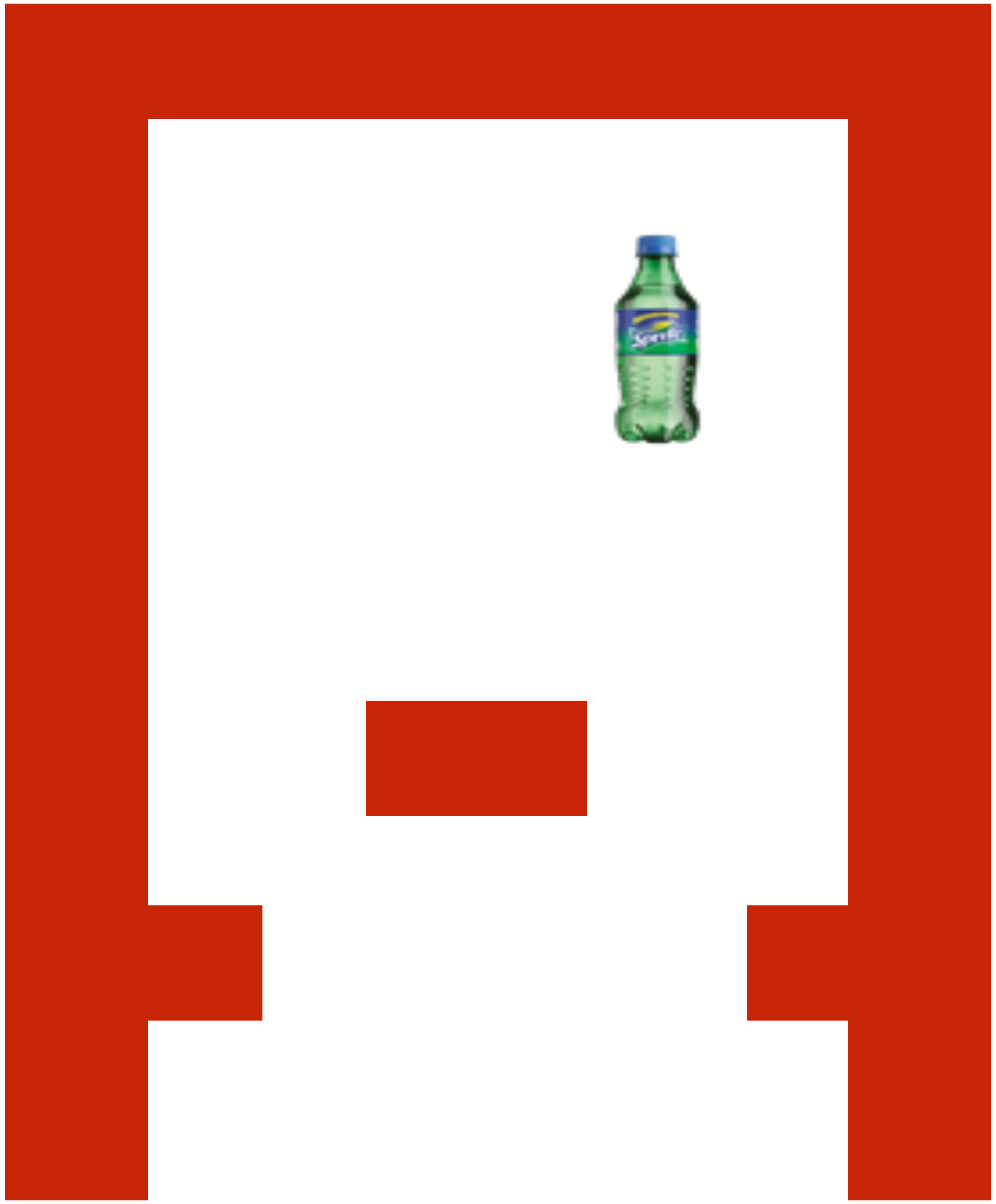
something more?

- how about a 3D physics engine?
  - Enter SceneKit
- 2D Physics? Enter SpriteKit:
  - SK abbreviated
  - real time physics engine for game applications
  - …and 2D games in general

SpriteKit

- setup game scene
- create sprites
  - color/texture
  - physical properties
    - mass
    - restitution
    - friction
    - awesomeness (not really)
- physics updated at 60 Hz

SpriteKit



create “blocks”

create “sides/top”

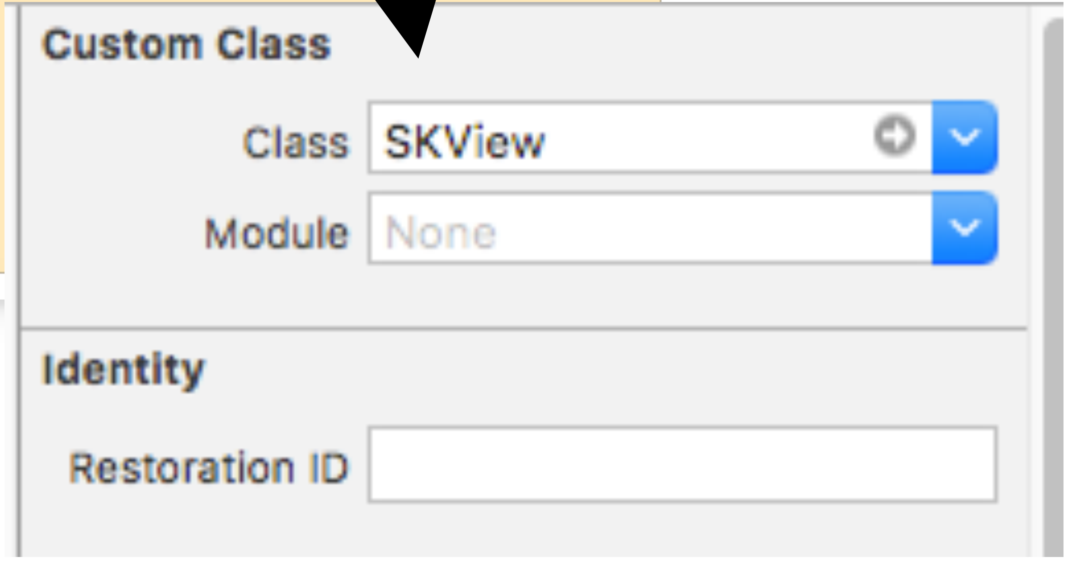
create “bouncy” sprite

make actual gravity
== game gravity

user must move phone
to keep sprite bouncing
on target

setup view controller

```
class GameViewController: UIViewController {


    override func viewDidLoad() {
        super.viewDidLoad()

        //setup game scene
        let scene = GameScene(size: view.bounds.size)
        let skView = view as! SKView // must be an SKView
        skView.showsFPS = true
        skView.showsNodeCount = true
        skView.ignoresSiblingOrder = true
        scene.scaleMode = .ResizeFill
        skView.presentScene(scene)
    }
}
```



Custom Class

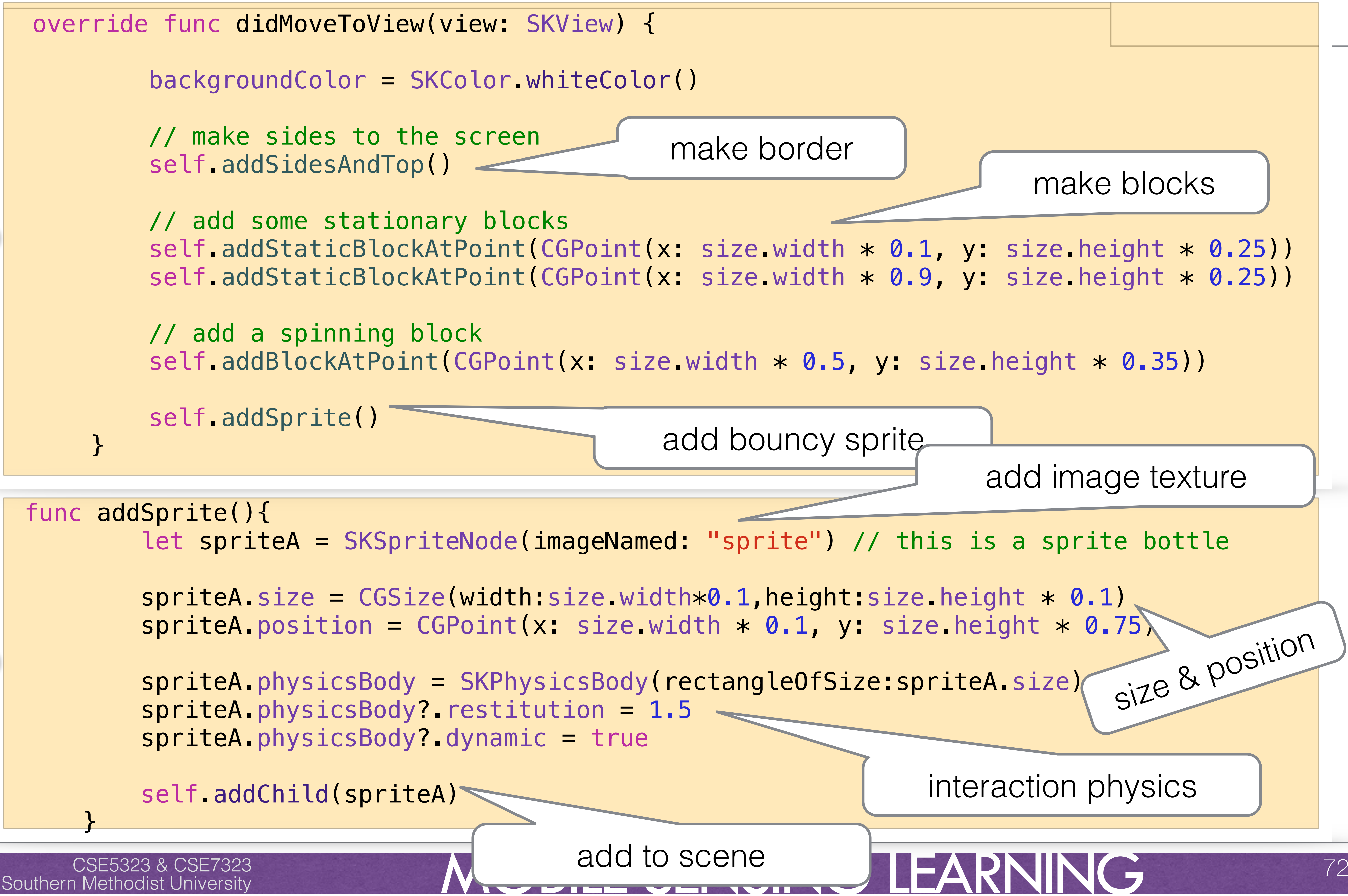
Class: SKView

Module: None

Identity

Restoration ID:

build sprites (in GameScene)



```
override func didMoveToView(view: SKView) {

        backgroundColor = SKColor.whiteColor()

        // make sides to the screen
        self.addSidesAndTop()

        // add some stationary blocks
        self.addStaticBlockAtPoint(CGPoint(x: size.width * 0.1, y: size.height * 0.25))
        self.addStaticBlockAtPoint(CGPoint(x: size.width * 0.9, y: size.height * 0.25))

        // add a spinning block
        self.addBlockAtPoint(CGPoint(x: size.width * 0.5, y: size.height * 0.35))

        self.addSprite()
    }
```

```
func addSprite(){
        let spriteA = SKSpriteNode(imageNamed: "sprite") // this is a sprite bottle

        spriteA.size = CGSize(width:size.width*0.1,height:size.height * 0.1)
        spriteA.position = CGPoint(x: size.width * 0.1, y: size.height * 0.75)

        spriteA.physicsBody = SKPhysicsBody(rectangleOfSize:spriteA.size)
        spriteA.physicsBody?.restitution = 1.5
        spriteA.physicsBody?.dynamic = true

        self.addChild(spriteA)
    }
```

make border

make blocks

add bouncy sprite

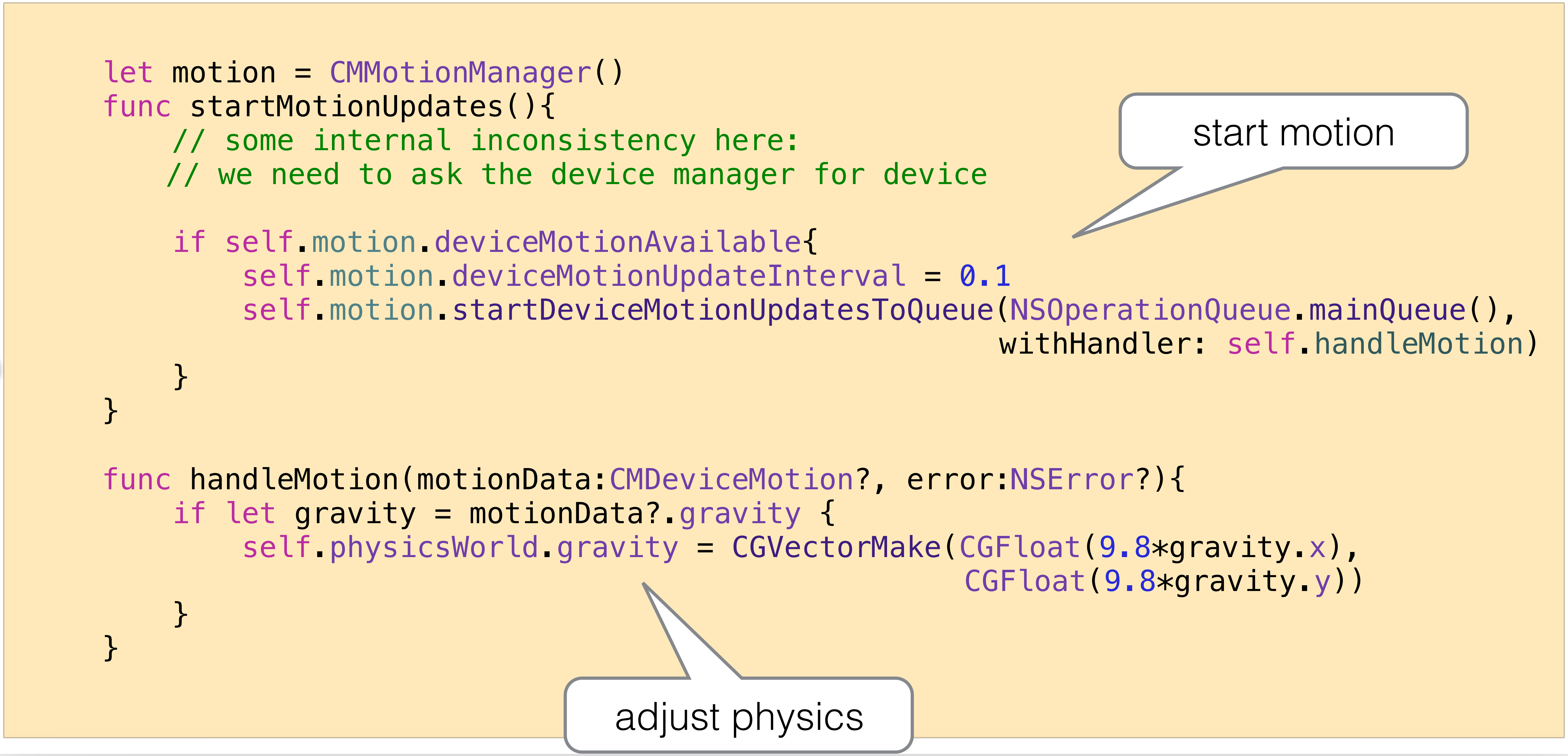
add image texture

size & position

interaction physics

add to scene

set gravity



```
let motion = CMMotionManager()
func startMotionUpdates(){
    // some internal inconsistency here:
   // we need to ask the device manager for device

    if self.motion.deviceMotionAvailable{
        self.motion.deviceMotionUpdateInterval = 0.1
        self.motion.startDeviceMotionUpdatesToQueue(NSOperationQueue.mainQueue(),
                                            withHandler: self.handleMotion)
    }
}

func handleMotion(motionData:CMDeviceMotion?, error:NSError?){
    if let gravity = motionData?.gravity {
        self.physicsWorld.gravity = CGVectorMake(CGFloat(9.8*gravity.x),
                                              CGFloat(9.8*gravity.y))
    }
}
```

start motion

adjust physics

device motion demo 2

- lemon lime bounce
- pre-made demo

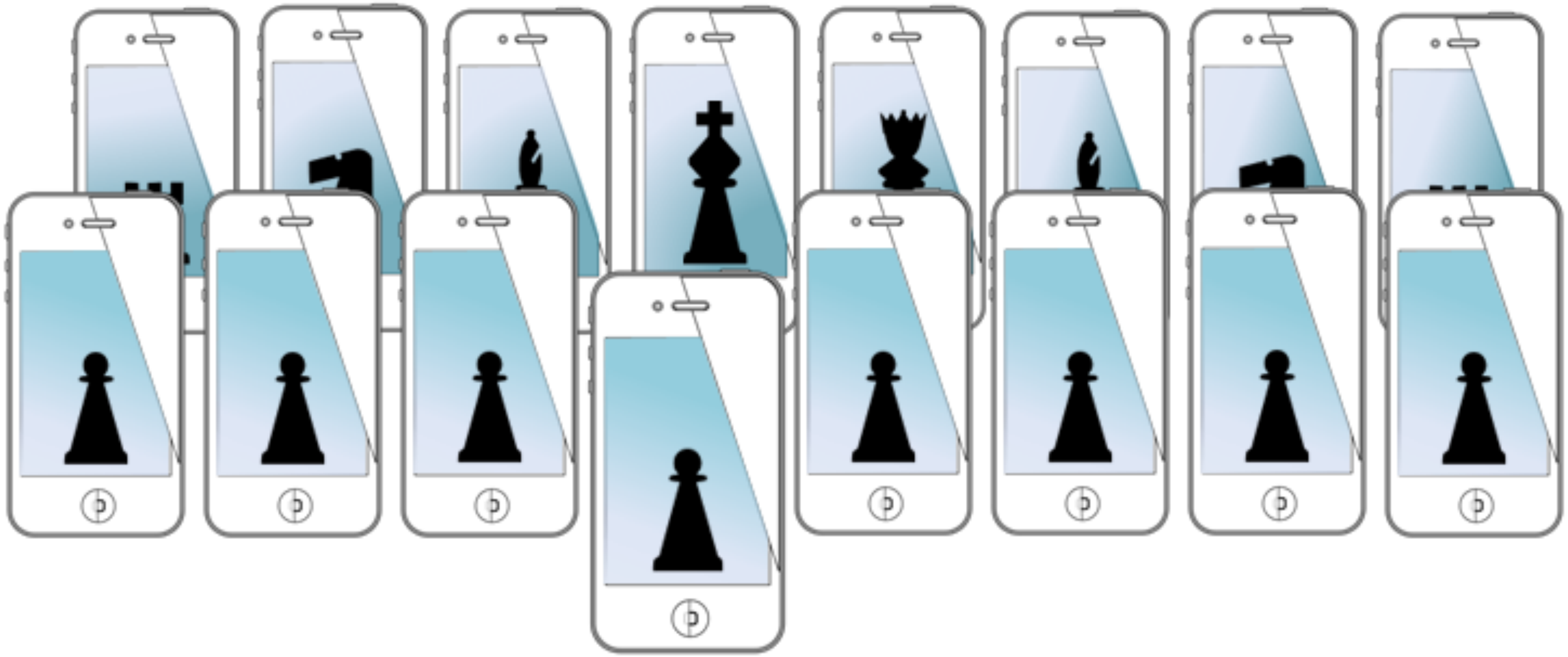
the end of motion…

- before moving on…
- one week lab next time…
- assignment posted

for next time…

- Image processing!

MOBILE SENSING LEARNING



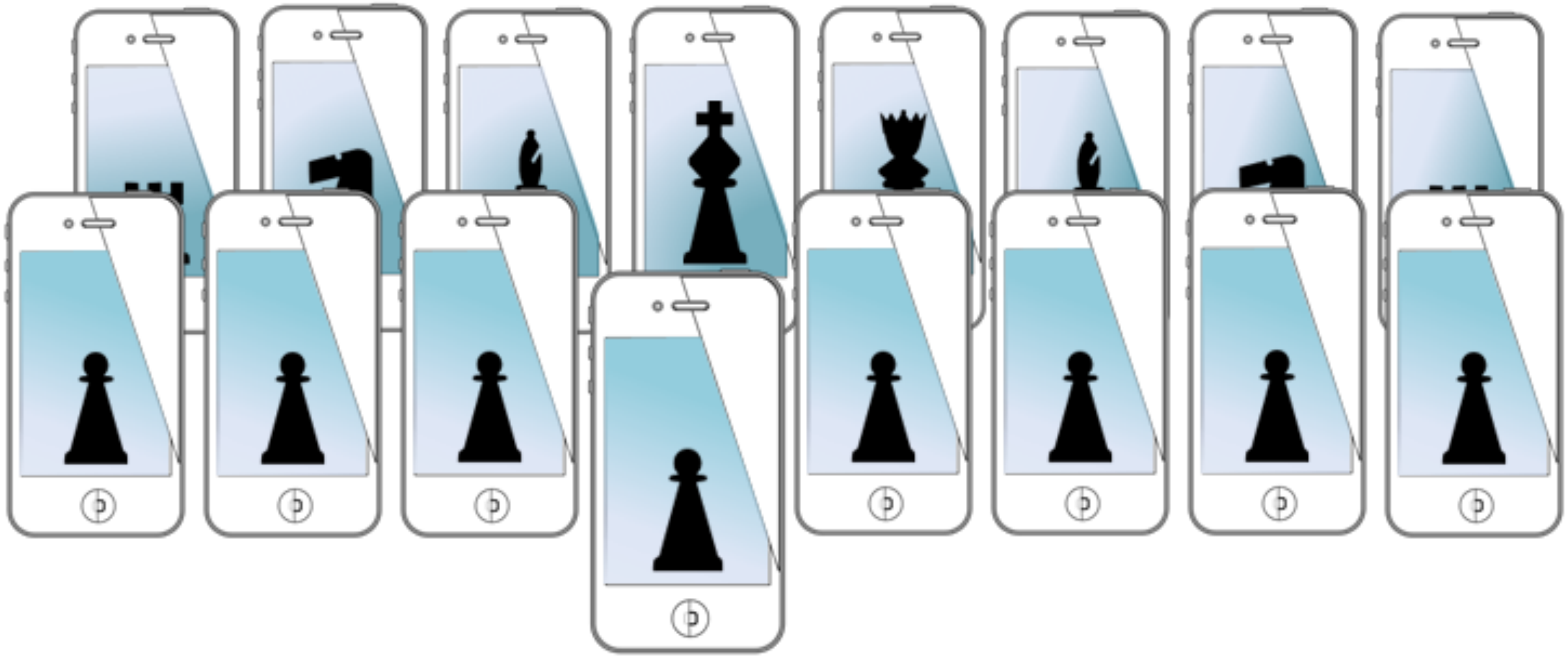
CSE5323 & 7323

Mobile Sensing and Learning

week 5 lecture b: activity, pedometers, and motion sensing

Eric C. Larson, Lyle School of Engineering,
Computer Science and Engineering, Southern Methodist University

MOBILE SENSING LEARNING



CSE5323 & 7323

Mobile Sensing and Learning

Supplemental Slides: vector trajectory and profiling

Eric C. Larson, Lyle School of Engineering,
Computer Science and Engineering, Southern Methodist University

supplemental slides

- vector trajectory

phone trajectory

- what direction is the phone (user) headed?
- direction could be:
  - cardinal {N, S, E, W}

    GPS and magnetometer
  - altitude {sea level, +30 feet, etc.}

    GPS
  - relative altitude {up, down}

    motion sensors
  - relative trajectory {left, right, straight}

    motion sensors
- how should we sense each of these?

up/down movement

- questions:
  - are we accelerating?
  - in what direction are we accelerating?
  - are we accelerating opposite of gravity?

which way is gravity?

vectors

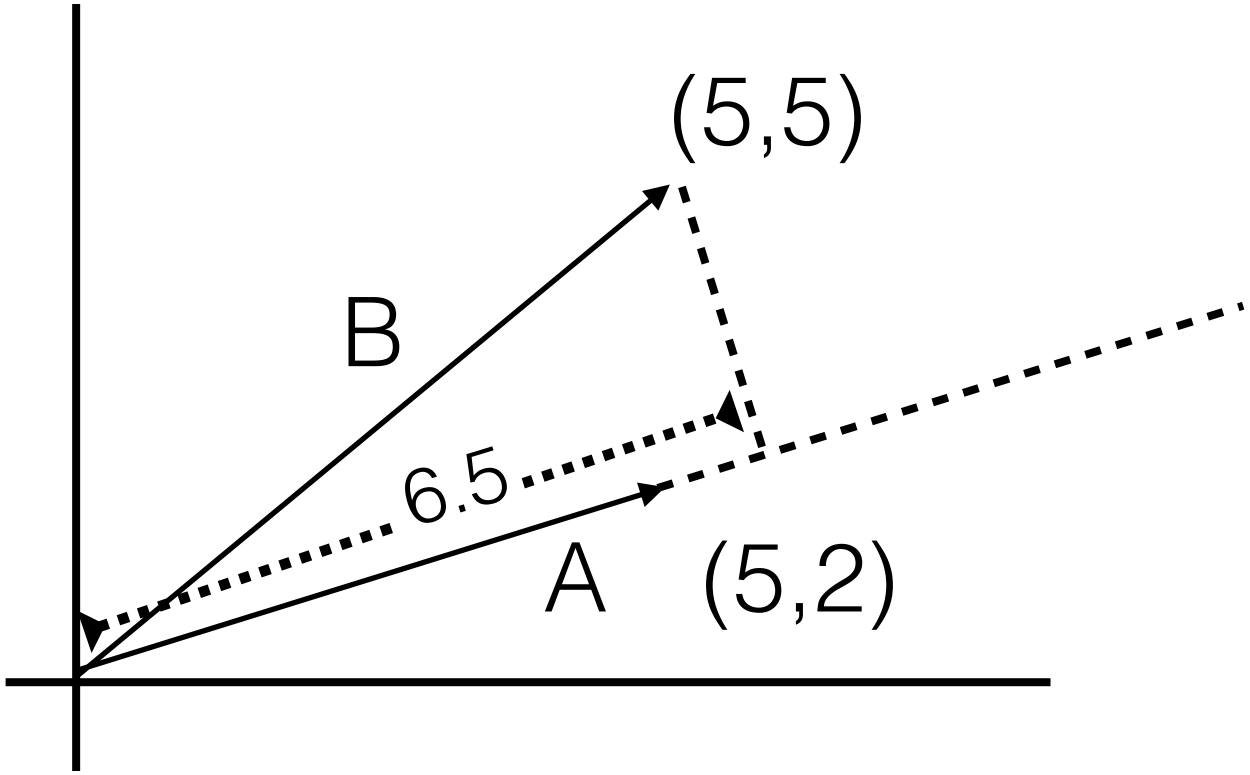
```
deviceMotion.gravity.{x,y,z}
```

which way is the phone accelerating?

```
deviceMotion.userAcceleration.{x,y,z}
```

vector direction

- how much of one vector is in the direction of another?
- projections



$$\frac{A \bullet B}{|A|}$$

$$\frac{(5,5)\bullet(5,2)}{|(5,2)|}$$

$$\frac{5*5+5*2}{\sqrt{(5^2+2^2)}} = 35/\sqrt{29}$$

$$\sim 6.5$$

vector direction

- acceleration of the user towards or away from gravity?

```
CMAcceleration gravity, CMAcceleration userAccel

float dotProduct =
  gravity.x*userAccel.x + gravity.y*userAccel.y + gravity.z*userAccel.z;

float normDotProd =
  dotProduct / (gravity.x*gravity.x + gravity.y*gravity.y + gravity.z*gravity.z);
```

positive acceleration is speeding up
negative acceleration is slowing down

vector acceleration demo

- don’t drop it!

profiling demo

- using the instruments panel in Xcode
  - memory leaks
  - general efficiency
  - excellent integration with iOS