What’s New in Core Motion

Session 705

Anil Kandangath Engineer
Gabrielle Badie Engineer
1 Core Motion on Apple Watch
1. Core Motion on Apple Watch

2. Pedometer
1. Core Motion on Apple Watch
2. Pedometer
3. Altimeter
1. Core Motion on Apple Watch
2. Pedometer
3. Altimeter
4. Motion awareness
Past Sessions

On Apple Developer

Motion Tracking with the Core Motion Framework

Understanding Core Motion
Motion Sensing
Motion Sensing

APPLICATION PROCESSOR

- Accelerometer
- Gyroscope
- Magnetometer
Motion Sensing

APPLICATION PROCESSOR - iPhone 5S

MOTION COPROCESSOR

- Accelerometer
- Gyroscope
- Magnetometer

Apple M7
Motion Sensing

APPLICATION PROCESSOR

MOTION COPROCESSOR

- iPhone 6 / 6+
  - Accelerometer
  - Gyroscope
  - Magnetometer
Motion Sensing

APPLICATION PROCESSOR

MOTION COPROCESSOR

iPhone 6 / 6+

Accelerometer
Gyroscope
Magnetometer
Altimeter
Motion Sensing

- Accelerometer
- Gyroscope
- Magnetometer
- Altimeter
Motion Sensing

- Accelerometer
- Gyroscope
- Magnetometer
- Altimeter

Sensor Data
Device Motion

Motion Activity
Pedometer
Motion Sensing

- Accelerometer
- Gyroscope
- Magnetometer
- Altimeter

Sensor Data
Device Motion
Motion Activity
Pedometer
Raw Pressure
Altitude Changes
Motion Sensing

- Accelerometer
- Gyroscope
- Magnetometer
- Altimeter

Sensor Data
- Device Motion
- Motion Activity
- Pedometer
- Raw Pressure
- Altitude Changes
- Flights of Stairs
Motion Sensing

- Accelerometer
- Altimeter

Motion Activity
- Pedometer
- Flights of Stairs
Apple Watch
Apple Watch
Motion sensing

MOTION COPROCESSOR

[Image of Apple logo]
Apple Watch
Motion sensing

MOTION COPROCESSOR + Motion Activity Pedometer = 24
Apple Watch
Motion sensing

MOTION COPROCESSOR

+ 

Motion Activity Pedometer

Motion Activity Pedometer Sensor Data
Apple Watch
Motion sensing
Apple Watch

Motion sensing

Most Core Motion APIs are available on watchOS
Core Motion APIs behave similarly on iOS and watchOS
Apple Watch
Motion sensing

Most Core Motion APIs are available on watchOS
Core Motion APIs behave similarly on iOS and watchOS

<table>
<thead>
<tr>
<th>Raw Sensors</th>
<th>iOS</th>
<th>watchOS</th>
<th>(Accelerometer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device Motion</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Pedometer</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Motion Activity</td>
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Apple Watch Motion Activity
Apple Watch Motion Activity
### Apple Watch Motion Activity States

<table>
<thead>
<tr>
<th>Activity</th>
<th>iPhone 5S</th>
<th>iPhone 6/6+</th>
<th>Apple Watch</th>
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<tbody>
<tr>
<td>Walking</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>Running</td>
<td>✔</td>
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<td>Cycling</td>
<td>✔</td>
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<tr>
<td>Automotive</td>
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<tr>
<td>Stationary</td>
<td>✔</td>
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</table>
Apple Watch Accelerometer

Available through CMAccelerometer
Apple Watch Accelerometer

Available through CMAccelerometer

Challenges
Apple Watch Accelerometer

Available through **CMAccelerometer**

**Challenges**
- Limited processing time
Apple Watch Accelerometer

Available through **CMAccelerometer**

**Challenges**

- Limited processing time
- Screen may turn off due to user motion
Apple Watch Accelerometer

Available through `CMAccelerometer`

**Challenges**
- Limited processing time
- Screen may turn off due to user motion

**Best Practices**
Apple Watch Accelerometer

Available through `CMAccelerometer`

Challenges

- Limited processing time
- Screen may turn off due to user motion

Best Practices

- Expect data only when app is on screen
Apple Watch Accelerometer

Available through **CMAccelerometer**

**Challenges**
- Limited processing time
- Screen may turn off due to user motion

**Best Practices**
- Expect data only when app is on screen
- Be prepared for task to be suspended
Apple Watch Accelerometer

Available through `CMAccelerometer`

Challenges
- Limited processing time
- Screen may turn off due to user motion

Best Practices
- Expect data only when app is on screen
- Be prepared for task to be suspended

`NSProcessInfo.h`  
`performExpiringActivityWithReason(_:usingBlock:)`
Historical Accelerometer
Historical Accelerometer
Historical Accelerometer

Collect continuous data for long durations
Historical Accelerometer

Collect continuous data for long durations
Even when app is not running
Historical Accelerometer

Collect continuous data for long durations
Even when app is not running
Enable custom data analysis
Apple Watch Historical Accelerometer

CMSensorRecorder
Apple Watch Historical Accelerometer

CMSensorRecorder

Apps can initiate historical data recording
Apple Watch Historical Accelerometer

CMSensorRecorder

Apps can initiate historical data recording

Accelerometer recorded at 50Hz
Apple Watch Historical Accelerometer

CMSensorRecorder

Apps can initiate historical data recording

Accelerometer recorded at 50Hz

Data can be queried up to three days
Apple Watch Historical Accelerometer
Start recording
Apple Watch Historical Accelerometer

Start recording

```swift
CMSensorRecorder
recordAccelerometerFor(duration:)
```

Start Recording
Apple Watch Historical Accelerometer
Access data

Start Recording
Apple Watch Historical Accelerometer

Access data

Start Recording

Device Sleeps
Apple Watch Historical Accelerometer

Access data

Start Recording

Device Sleeps

App Starts
Apple Watch Historical Accelerometer

Access data

- Start Recording
- Device Sleeps
- App Starts
- Query
Apple Watch Historical Accelerometer

Access data

```swift
CMSensorRecorder
accelerometerDataFrom(_:, to:) -> CMSensorDataList
```

- **Device Sleeps**
- **App Starts**
- **Start Recording**
- **Query**
Apple Watch Historical Accelerometer

Access data

CMSensorRecorder

accelerometerDataFrom(_:to:) -> CMSensorDataList

Start Recording

Device Sleeps

Query

App Starts
Apple Watch Historical Accelerometer
Access data

CMSensorRecorder
accelerometerDataFrom(_:to:) -> CMSensorDataList

- Start Recording
- Query
- Historical Data
- Device Sleeps
- App Starts
Apple Watch CMSensorRecorder

Access data
Apple Watch CMSensorRecorder
Access data

CMSensorRecorder

CMSensorDataList → CMRecordedAccelerometerData

Start Recording
Query
Historical Data

Device Sleeps
App Starts
Apple Watch CMSensorRecorder

Access data

CMSensorRecorder

CMSensorDataList → CMRecordedAccelerometerData

NSProcessInfo.h

performExpiringActivityWithReason(_:usingBlock:)

Start Recording

Query

Historical Data

Device Sleeps

App Starts
Apple Watch CMSensorRecorder

<table>
<thead>
<tr>
<th><strong>CMRecordedAccelerometerData</strong></th>
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<tbody>
<tr>
<td>startDate</td>
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<tr>
<td>timestamp</td>
</tr>
<tr>
<td>acceleration</td>
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CMSensorRecorder
Consider power and performance
Consider power and performance
Large data dumps will take time to process
Consider power and performance
Large data dumps will take time to process

Best Practices
CMSensorRecorder

Consider power and performance
Large data dumps will take time to process

Best Practices
• Record/Query minimum duration required
Consider power and performance
Large data dumps will take time to process

Best Practices
• Record/Query minimum duration required
• Know your sensor rate requirements
Consider power and performance
Large data dumps will take time to process

**Best Practices**

- Record/Query minimum duration required
- Know your sensor rate requirements
- Decimate data to reduce processing time
Apple Watch Summary

Motion Activity, Pedometer, and Accelerometer

Historical Accelerometer

Introducing WatchKit for watchOS 2

Presidio	Tuesday 10:00AM
Pedometer
Pedometer

Steps

Distance
Steps and Distance

Recap

<table>
<thead>
<tr>
<th>CMPedometerData</th>
</tr>
</thead>
<tbody>
<tr>
<td>numberOfSteps</td>
</tr>
<tr>
<td>distance</td>
</tr>
</tbody>
</table>
Steps and Distance

Recap

Consistent performance

<table>
<thead>
<tr>
<th>CMPedometerData</th>
</tr>
</thead>
<tbody>
<tr>
<td>numberOfSteps</td>
</tr>
<tr>
<td>distance</td>
</tr>
</tbody>
</table>
Steps and Distance

Recap

Consistent performance

• Across body locations

```
CMPedometerData
  numberOfSteps
  distance
```
Steps and Distance

Recap

Consistent performance
• Across body locations
• For varying pace
Steps and Distance

Recap

Consistent performance
- Across body locations
- For varying pace
Adapts to user over time

CMPedometerData

- numberOfSteps
- distance
Steps and Distance

Recap

Consistent performance
• Across body locations
• For varying pace

Adapts to user over time

Uses GPS when available

CMPedometerData

numberOfSteps
distance
Steps and Distance

GPS-Fusion
Steps and Distance

GPS-Fusion
Steps and Distance

GPS-Fusion
Pedometer

Steps

Distance
Pedometer

Steps

Distance

Floor Counting
Floor Counting

CMPedometerData

- numberOfSteps
- distance
- floorsAscended
- floorsDescended
### Floor Counting

<table>
<thead>
<tr>
<th>CMPedometerData</th>
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</thead>
<tbody>
<tr>
<td>numberOfSteps</td>
<td></td>
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<td>distance</td>
<td></td>
</tr>
<tr>
<td>floorsAscended</td>
<td></td>
</tr>
<tr>
<td>floorsDescended</td>
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</tbody>
</table>

Earn your floors
Floor Counting
Floor Counting

Requirements
Floor Counting

Requirements

• Minimum ascend rate
Floor Counting

Requirements

• Minimum ascend rate
• Steps
Floor Counting

Requirements

• Minimum ascend rate
• Steps

Implications
Floor Counting

Requirements

• Minimum ascend rate
• Steps

Implications

• May award floors for steep hills
Floor Counting

Requirements
• Minimum ascend rate
• Steps

Implications
• May award floors for steep hills
• Will not award floors for elevators/escalators
Pedometer

Steps

Distance

Floor Counting
Pedometer

Steps

Distance

Floor Counting

Pace
### CMPedometerData

<table>
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<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>numberOfSteps</td>
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<tr>
<td>distance</td>
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<tr>
<td>floorsAscended</td>
</tr>
<tr>
<td>floorsDescended</td>
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<tr>
<td>currentPace</td>
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</table>
Pace

**CMPedometerData**

<table>
<thead>
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<th>Field</th>
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<tbody>
<tr>
<td>numberOfSteps</td>
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<tr>
<td>distance</td>
</tr>
<tr>
<td>floorsAscended</td>
</tr>
<tr>
<td>floorsDescended</td>
</tr>
<tr>
<td>currentPace</td>
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</tbody>
</table>

Instantaneous Pace
## CMPedometerData

<table>
<thead>
<tr>
<th>Variable</th>
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<tbody>
<tr>
<td>numberOfSteps</td>
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<tr>
<td>distance</td>
</tr>
<tr>
<td>floorsAscended</td>
</tr>
<tr>
<td>floorsDescended</td>
</tr>
<tr>
<td>currentPace</td>
</tr>
</tbody>
</table>

### Instantaneous Pace

Provided in time/distance units (s/m)
### Pace

**CMPedometerData**

- `numberOfSteps`
- `distance`
- `floorsAscended`
- `floorsDescended`
- `currentPace`

**Instantaneous Pace**

Provided in time/distance units (s/m)
**Pace**

<table>
<thead>
<tr>
<th>CMPedometerData</th>
</tr>
</thead>
<tbody>
<tr>
<td>numberOfSteps</td>
</tr>
<tr>
<td>distance</td>
</tr>
<tr>
<td>floorsAscended</td>
</tr>
<tr>
<td>floorsDescended</td>
</tr>
<tr>
<td>currentPace</td>
</tr>
</tbody>
</table>

**Instantaneous Pace**

Provided in time/distance units (s/m)

Available for live pedometer updates
Pace
Challenges
Pace
Challenges
Smoothness
Pace
Challenges

Smoothness
Responsiveness
Pedometer

Steps  Distance  Floor Counting  Pace
Pedometer

Steps  Distance  Floor Counting  Pace  Cadence
# Cadence

<table>
<thead>
<tr>
<th>CMPedometerData</th>
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</thead>
<tbody>
<tr>
<td>numberOfSteps</td>
</tr>
<tr>
<td>distance</td>
</tr>
<tr>
<td>floorsAscended</td>
</tr>
<tr>
<td>floorsDescended</td>
</tr>
<tr>
<td>currentPace</td>
</tr>
<tr>
<td>cadence</td>
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</tbody>
</table>
Cadence

Rate of steps taken

<table>
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<tr>
<th>CMPedometerData</th>
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<tbody>
<tr>
<td>numberOfRows</td>
</tr>
<tr>
<td>distance</td>
</tr>
<tr>
<td>floorsAscended</td>
</tr>
<tr>
<td>floorsDescended</td>
</tr>
<tr>
<td>currentPace</td>
</tr>
<tr>
<td>cadence</td>
</tr>
</tbody>
</table>
# Pedometer

## Availability

<table>
<thead>
<tr>
<th>Feature</th>
<th>iPhone 5S</th>
<th>iPhone 6/6+</th>
<th>Apple Watch</th>
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</thead>
<tbody>
<tr>
<td>Steps</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Distance</td>
<td>✔️</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Floor Counting</td>
<td>✔️</td>
<td>✔️</td>
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<tr>
<td>Pace</td>
<td>✔️</td>
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<td>✔️</td>
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<tr>
<td>Cadence</td>
<td>✔️</td>
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</table>
Pressure
Pressure

Using this sensor

CMAltimeter
Pressure

Using this sensor

CMAltimeter

Pressure (kPa)
Relative Altitude (m)
Pressure
Relative Altitude

\[ \delta_1 = 0 \]
Pressure

Relative Altitude

Relative to first altitude sample

\[ \delta_1 = 0 \]

\[ \delta_2 \]

\[ \delta_3 \]
Pressure

Relative Altitude

Relative to first altitude sample
First sample reports zero altitude
Relative Altitude

Usage
Relative Altitude

Usage

Use for floor-scale changes, not body-scale
Relative Altitude

Usage

Use for floor-scale changes, not body-scale

Challenging Situations
Relative Altitude

Usage

Use for floor-scale changes, not body-scale

Challenging Situations

- Weather changes over long durations
Relative Altitude

Usage

Use for floor-scale changes, not body-scale

Challenging Situations

- Weather changes over long durations
- Rigid sealed cases
Relative Altitude

API

CMAltimeter

```
startRelativeAltitudeUpdatesToQueue(_:, withHandler:)
```
Relative Altitude

API

CMAltimeter

```swift
startRelativeAltitudeUpdatesToQueue(_: withHandler:)
```

└── CMAltitudeData
    └── pressure
    └── relativeAltitude
Relative Altitude

API

CMAltimeter

startRelativeAltitudeUpdatesToQueue(_: withHandler:)

CMAltitudeData

- pressure
- relativeAltitude

Request

Altimeter Data
Relative Altitude

API

CMAltimeter

```
startRelativeAltitudeUpdatesToQueue(_: withHandler:)
```

CMAltitudeData

- pressure
- relativeAltitude

Request

Sample 1

Altimeter Data

Approx 2.6s
Relative Altitude

API

**CMAAltimeter**

```swift
startRelativeAltitudeUpdatesToQueue(_: withHandler:)
```

**CMAltitudeData**

- pressure
- relativeAltitude

**Request**

- Sample 1: Approx 2.6s
- Sample 2: Approx 1.3s
- Sample 3

Altimeter Data
Access to Apple Watch accelerometer data
Summary

Access to Apple Watch accelerometer data
Historical accelerometer data
Summary

Access to Apple Watch accelerometer data
Historical accelerometer data
GPS-fusion in Pedometer
Summary

- Access to Apple Watch accelerometer data
- Historical accelerometer data
- GPS-fusion in Pedometer
- Pace and Cadence
Motion Awareness

Gabrielle Badie
Engineer
Sample App Concept
Music player
Sample App Concept

Music player

Detect
Sample App Concept
Music player

Detect

Engage
Sample App Concept

Music player

Detect

Engage

Reflect

12 mi

730 mi total
### Automotive

<table>
<thead>
<tr>
<th>Start Date</th>
<th>May 29, 2015, 4:30:00 PM</th>
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<tbody>
<tr>
<td>End Date</td>
<td>May 29, 2015, 5:33:07 PM</td>
</tr>
<tr>
<td>Duration</td>
<td>1h 1min 1s</td>
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### Walking

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<tr>
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<tbody>
<tr>
<td>End Date</td>
<td>May 29, 2015, 4:06:11 PM</td>
</tr>
<tr>
<td>Duration</td>
<td>0h 2min 15s</td>
</tr>
<tr>
<td>Pace Per Mile</td>
<td>6th 42min 4s</td>
</tr>
<tr>
<td>Distance (Miles)</td>
<td>0.00565033</td>
</tr>
<tr>
<td>Distance (Meters)</td>
<td>9</td>
</tr>
<tr>
<td>Number of Steps</td>
<td>9</td>
</tr>
<tr>
<td>Floors Ascended</td>
<td>0</td>
</tr>
<tr>
<td>Floors Descended</td>
<td>0</td>
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</table>

### Reflect
Detect

Activity updates

Pedometer updates
Engage

Walking and running
Engage
Walking and running

Pace and Cadence changes (Pedometer)
Altitude updates
Reflect

Context and summary

<table>
<thead>
<tr>
<th>Activity</th>
<th>Start Date</th>
<th>End Date</th>
<th>Duration</th>
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</thead>
<tbody>
<tr>
<td>AUTOMOTIVE</td>
<td>May 28, 2015, 4:38:00 PM</td>
<td>May 28, 2015, 5:53:07 PM</td>
<td>1h 15m 7s</td>
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<tr>
<td>WALKING</td>
<td>May 28, 2015, 4:03:56 PM</td>
<td>May 28, 2015, 4:05:11 PM</td>
<td>0h 2m 15s</td>
</tr>
<tr>
<td></td>
<td>Pace Per Mile: 7.1</td>
<td>Pace Per Mile: 7.1</td>
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<td></td>
<td>Distance (Miles): 0.0055923</td>
<td>Distance (Meters): 9</td>
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<tr>
<td></td>
<td>Number of Steps: 9</td>
<td>Floors Ascended: 0</td>
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<tr>
<td></td>
<td>Floors Descended: 0</td>
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<tr>
<td>WALKING</td>
<td>Start Date: May 28, 2015, 4:47:00 AM</td>
<td>End Date: May 28, 2015, 4:49:00 AM</td>
<td>0h 2m 0s</td>
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</table>
Reflect

Context and summary

Historical Activity query

Historical Pedometer query
More Information

Technical Support
Apple Developer Forums
http://developer.apple.com/forums

General Inquiries
Craig Keithley, Technologies Evangelist
keithley@apple.com
# Related Sessions

<table>
<thead>
<tr>
<th>Session</th>
<th>Location</th>
<th>Date/Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>What’s New in HealthKit</td>
<td>Pacific Heights</td>
<td>Tuesday 11:00AM</td>
</tr>
<tr>
<td>What’s New in Cocoa Touch</td>
<td>Presidio</td>
<td>Tuesday 2:30PM</td>
</tr>
<tr>
<td>What's New in Core Location</td>
<td>Pacific Heights</td>
<td>Thursday 1:30PM</td>
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<tr>
<td>Labs</td>
<td>Core Motion Lab</td>
<td>Frameworks Lab A</td>
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