

*In the Matter of Certain Wearable Electronic Devices  
with ECG Functionality and Components Thereof*  
*Investigation No. 337-TA-1266*

**Collin Stultz, M.D., Ph.D**

March 31, 2022

RDX-0003.1

## Education



**Dr. Collin Stultz**

*M.D., Ph.D*



- **Harvard College**

- Bachelor's degree in Mathematics and Philosophy
- *magna cum laude*



- **Harvard Medical School**

- Doctor of Medicine (Harvard-MIT Division of Health Sciences and Technology)
- *magna cum laude*



- **Harvard University**

- Ph.D. in Biophysics



- **Brigham & Women's Hospital**

- Intern and Resident, Department of Medicine



- **Brigham & Women's Hospital**

- Cardiology Fellow, Division of Cardiology

RX-309  
RDX-0003.2

# Practicing Cardiologist / Professor of Engineering MIT, Harvard



**Dr. Collin Stultz**

*M.D., Ph.D*



**VA** U.S. Department  
of Veterans Affairs



MASSACHUSETTS  
GENERAL HOSPITAL



Massachusetts  
Institute of  
Technology



HARVARD-MIT  
HEALTH SCIENCES AND TECHNOLOGY



Boston University  
School of Medicine

- Nearly 20 years as a board-certified cardiologist
  - Veteran's Affairs Hospital
    - 2003-2017 (~ 15 years)
  - Massachusetts General Hospital
    - 2017-present (~ 5 years)
- Nearly 20 years teaching undergraduate and graduate students
- Nina T. and Robert H. Rubin endowed Professor of Medical Engineering and Science and a Professor of Electrical Engineering and Computer Science
- Faculty member in Harvard-MIT Division of Health Sciences and Technology
- Previous work as Adjunct Associate Professor of Medicine, Boston University Medical School

RX-309  
RDX-0003.3


# Teach Students How to Acquire ECG Data, Interpret Data

6.03 - Spring 2017

Goals: You will derive the RR time series of an ECG signal that is 23.5 hours long. From these data you will compute both time domain and frequency domain metrics to assess this patient's risk of adverse outcomes.

1. Prelab (1pt)  
This prelab must be you work in groups

Recall the classic form of



Note the "names" of the but instead we will work

In the previous problem obtained by compute the corresponding RR interval intervals for a given ECG

The RR time series cont cardiovascular system, developing a "feel" for how seem "lame" but it is act are calculated.

Roughly estimate the RR series you need to speci each tracing, assume th

Lab 3 6.03 - Spring 2017

Goals: You will record your own ECG and examine it in the time and frequency domains. We will then apply filtering to remove noise and interference from the signal and explore how these filters affect our ability to make inferences about your heart rate.

1. Prelab  
There is no prelab assignment for this lab.

2. Getting Started

2.1 Log in

As with the other 6.03 labs, do this lab with a partner (ideally 2 people/group).

- Log into the EE Lab Windows machines:  
Username: admin  
Password: 34248CDE\*0
- Using Chrome (not Firefox, Internet Explorer, etc.), use the "student03" certificate to open up the MITx page for Lab 1. Do not install your own personal certificate.
- Open up the queue:  
<https://h03.scripts.mit.edu/queue/index.py>
- Log in with your Kerberos and 6.03 queue password. Make sure to log into the queue within 15 minutes of lab start time as it will close at that time.

2.2 Start Matlab

Start Matlab. Let's first clean up the system. At the Matlab prompt, type

This will delete residual files from prior users.

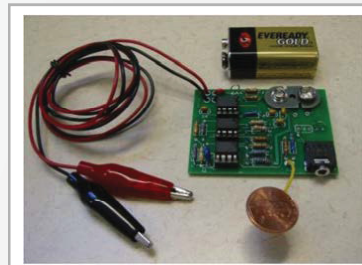
You will need the following files for this lab:

```
ecg503v1.m             idealP.m
```

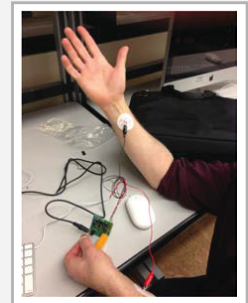
In addition, the following MATLAB commands may be useful for this lab:

```
findpeaks    semilogy    plot        save        zeros  
fit          fft           linspace    length
```

1



Electrocardiogram Circuit



## 4. Generate RR time series for two patients

Several metrics have been developed to identify patients at high risk of death based on the RR time series. The first metrics were made to work on the time domain signals alone.

The basic idea is that no-one has an RR time series that is constant in time. Our heart rates naturally fluctuate throughout the course of a day. When we get excited our heart rate increases and when we go to sleep our heart rate slows down. The heart rate itself is controlled (in part) by the *sympathetic* and *parasympathetic* nervous systems. Stimulation of the sympathetic nervous system causes the heart rate to increase (i.e., the RR interval decreases) and parasympathetic stimulation causes the heart rate to decrease (i.e., the RR interval increases).

Therefore, over any given period of time, one would expect there to be some spread in the distribution of RR intervals.

RDX-0003.4

# Teach Students How to Calculate HRV from PPG Signals

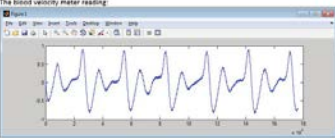
MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
6.S02 Introduction to Biomedical Signal Analysis  
Laboratory No. 1

Objective

1. Introduction to Pulse Oximetry and Blood Velocity Profiles

2. Blood Flow Velocity Profile

The blood velocity meter reading:



3. Laboratory: Basic Analysis of Your Blood Velocity Profile

You will work in groups of two. You and your partner will use one of the 6.S02 lab Macintosh desktop workstations running MATLAB in Windows. We use MATLAB under Windows for most of this lab as well.

The BVM setup is shown below:

PICTURE

## 1. Introduction to Pulse Oximetry and Blood Velocity Profiles

### Task 2:

Compute your average heart rate. To do this you will need to write a program that will allow you to identify the positions of the R waves. This is called segmentation. Feel free to use the built-in Matlab function "findpeaks".

Once you have the total number of beats, divide by the total time to get the average heart rate.

### Task 3:

Now compute the instantaneous heart rate time series for your data.

### Task 4:

Calculate the average instantaneous heart rate and use this to compute the average heart rate.

### Task 5:

Record your BV for 30seconds, while you simultaneously hold your breath. (If you can't hold for 30s then just hold it for as long as you can.)

Make a plot of your heart rate as a function of time.

RDX-0003.5

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

## LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

## FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

## E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.