ECE4011/ECE 4012 Project Summary

Project Title	Emory Sleep Patient Monitor
Team Members (names and majors)	Isabel Anderson (EE)
	Mauricio Builes Zapata (EE)
	Alan Grusy (CompE)
	Xavier Williams (CompE)
Advisor / Section	Whit Smith
Semester	Year/Semester Circle: Either **Final (ECE4012)**
Project Abstract (250-300 words)	The Dream Team designed a Restless Leg Syndrome monitoring system for a more convenient and cost-effective way of detecting the disease in comparison with traditional methods. Restless Leg Syndrome is a sleep disorder characterized by periodic limb movements that incapacitate and deteriorate a person's sleep. In order to properly diagnose the disorder, a patient is sent to a sleep clinic where they are monitored by sleep clinicians while connected to different data collecting apparatuses to characterize their pathology. As expected, this creates discomfort in the patient which in itself affects their sleep and is costly and inefficient for both the doctors and the patient. With these constraints in mind and in conjunction with Emory's Sleep Center, The Dream Team designed and prototyped a lightweight, power efficient and wireless device to record leg movements for a week's time in the comfort of their own house. The outcome of the team's work was an embedded solution that took advantage of wireless power transfer protocols, an accelerometer for motion recording, an antenna for Bluetooth data transfer in a 2.5 inch x 2 inch printed circuit board weighing less than 40 grams. The device is controlled by TI's CC2650 microcontroller unit, an ultra-low power consumption device with the added benefit of integrated Bluetooth functionality. Furthermore, the team designed and demonstrated a graphical user interface for the visualization of the collected data with the ability to annotate and classify time periods as per observations gathered from visits to the sleep clinic. In total, the cost per device totaled around USD $80, a small fraction of money in comparison to what going to a sleep center would be.

Project Title	Emory Sleep Patient Monitor

List **codes** and **standards** that significantly affect your project. Briefly describe how they influenced your design.	• I2C is used to attach low speed peripherals to microcontrollers.
	  ○ I2C was used to interface the LIS3DH Accelerometer with the CC2650.
	• Bluetooth Wireless Technology Standard: Communication standard that operates at 2.4GHz bandwidth. Necessary for obtaining the data from the monitoring device into a computer for interfacing and data processing.
	  ○ Affected our device design by requiring a 2.4 GHz antenna. This resulted in an copper trace inverted F antenna being included to the PCB design.
	• Qi Wireless standard: Inductive charging standard being used in the smartphone industry. It is a powerful standard to have due to extensive documentation and proven viability. Will be used due to the monitoring device's necessity to be a fully enclosed product [4].
	  ○ Was visible in the team's design by the inclusion of a female microUSB port as well as the external inductor coil acting as a power receiver, soldered to the device for demonstration. A Samsung charging base was used to prove charging.
	• The IEEE P360 Standard on wearable technology is a current working project by the Wearable Working Group that outlines basic safety and suitableness to wear wearable devices. It provides with technical requirements such as battery duration and optimization that help provide for guidelines in the project's technical considerations.
	• FCC regulations on class B devices: No radio interference is allowed to happen within a 10 meter radius. Given that the microcontroller and the Bluetooth module are commercially bought, they are already compliant with all necessary regulations.

List at least two significant **realistic design constraints** that applied to your project. Briefly describe how they affected your design.	Size: The device must be worn all night for potentially weeks at a time. Thus the size of the device needs to be minimal to ensure patient comfort. Battery Life: The device needs to last 1 week on a charge, so the patient can dump their sleep data during a weekly visit. This will create constraints on the size of the device and the amount of processes the embedded devices will be running. Thus the embedded devices will need to only collect data on movement and not continuously.
Briefly explain two **significant trade-offs** considered in your	Significant trade-offs arise from the need to make a comfortable and lightweight device and have a long lasting battery to be able to withstand extended periods of time collecting data without interruptions.

design, including options considered and the solution chosen.	Tradeoff 1: Battery Size The team had to select between a large external battery to the designed printed circuit board, and a smaller battery with a lower charge capacity. The selection affected the weight, longevity and size of the teams device. Considering the low power consumption of the components placed on the printed circuit board, the team opted to pick an RJD2032 rechargable battery of 85mAh. This allowed for the battery to be placed directly on the board therefore minimizing size Tradeoff 2: Ease of development vs low power consumption When selecting the microcontroller unit for the device's operation, the team had to select between TI's CC2650 with ultra low power consumption, robust and powerful microcontrollers or a pyBoard running microPython, with a larger footprint and less than ideal power consumption. The biggest advantage of the pyBoard was its ease of development, as it could be programmed in Python. However, the team opted for the CC2650, given that it's small footprint and integrated Bluetooth stack made the hardware integration easier. As further discussed in the Project's Final Report, this posed problems in the development on the firmware given the product's lack of supporting material due to its novelty.
Briefly describe the **computing aspects** of your projects, specifically identifying **hardware-software** tradeoffs, interfaces, and/or interactions. *Complete if applicable; required if team includes CmpE majors.*	There are two computing interfaces in the project. There is an embedded device that will collect data. There is a computer program that will receive the data when the embedded device is within range. The computer program will display the results in a GUI. The embedded device was supposed to have multiple interfaces, including an accelerometer, micro SD card, bluetooth and wireless charging. The accelerometer that was picked had a low power consumption and could be configured to to certain power level based on application specifics. The micro SD card was not able to be interface because the team did not have enough time to finish writing an SD card driver. The wireless charging went untested because the rechargeable batteries that were ordered did not arrive before the expo. The team looked through the documentation for the bluetooth part of the project but did not have enough time to implement them. The wireless charging would have been implemented while the device was transferring the data to the computer. The computer program will collect all of the data and display it in a GUI via document upload.