

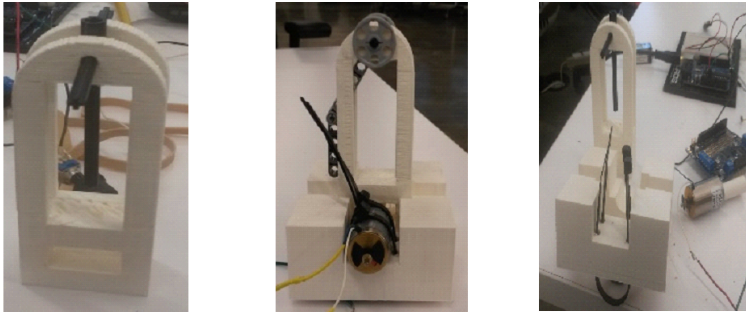
## Vertically Driven Inverted Pendulum

Teachers: Dr. Gregor Winkel, Mentor: Dr. Joo H Kim, Research Collaborator: Carlos Gonzalez and William Peng

### Research

**Title:** Vertically Driven Inverted Pendulum

To better understand, simulate, and optimize the walking of a biped robot, Dr. Winkel modeled and constructed an inverted pendulum. By studying the inverted pendulum in an unstable equilibrium (upright position), he investigated methods of stabilizing the pendulum. He built a 3D-printed inverted double-pendulum (see Figure 3) and connected it to an electric motor. He actuated the pendulum at frequencies higher than its natural frequency to achieve and demonstrate stability in an upright position. He examined data based on Mathieu's equation and concluded that the stability of the designed pendulum was reasonably close to theoretically predicted data.

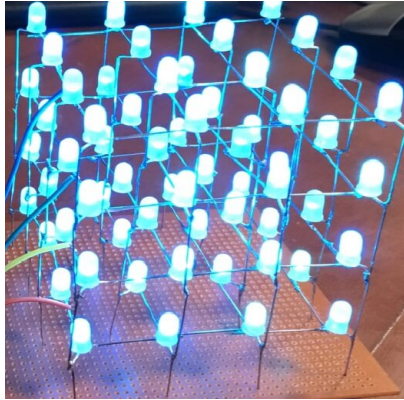


**Figure:** Vertically driven inverted pendulum

### Lesson Plan

**Title:** Building a 3 x 3 x 3 LED cube operated by an Arduino

An LED cube is an interesting way to introduce high school students to Arduino programming since it uses blinking LED's that are appealing to students. Moreover, soldering the LEDs together provides a practical experience with electronics to students. LED cubes of large sizes are becoming increasingly popular. At tech fairs they are often used to present 3D video animations or light pattern formations. To build the LED cube, we will use a cardboard template and press holes into them to have a template to build the three layers. The positive poles of the cube are all connected. The same for the negative poles of the LEDs. The cube will be connected to the Arduino via a transistor to act as an electronic switch. Each layer will be connected to its assigned Arduino digital pin. Each column will also be connected to its assigned Arduino digital pin. The program will be simple by setting certain Arduino digital pins to high and low, the LEDs will be turned on and off. Starting with novice, long, and complex programs, students will eventually learn more efficient programming methods.



**Figure: A representative image of an LED cube**