The project's purpose was to design and fabricate an apparatus to be used in current and future UTD Physics labs to facilitate teaching the concepts of friction to students. Applications to real-world examples and the incorporation of tactile feedback were among the necessary parameters for any potential solutions. Overall, the team developed, through a series of several prototypes and testing with students, an acceptable apparatus that incorporated the desired parameters, and will be available for implementation and small scale production runs immediately. Additionally, the final solution managed to incorporate some of the stretch goals for the project, including partial fabrication with 3D printing technology – for easy, replicatable parts. An accompanying laboratory manual for operation and requisite experimentation has been produced as well, with the potential to be changed as needed as new experiments are developed or required for the apparatus.

### Abstract

The University of Texas at Dallas – Department of Physics
MECH 4382 Spring - Summer 2015

### Force Sensor and Sample Holder

- Easily integrates with multiple types of materials for testing
- 3D printed parts

### Full Prototype View

- Incorporation of tactile feedback
- Durable and sturdy

### Requirements & Constraints

1. **Experimental Procedures and Development**
   - Safety
   - Labs developed to be completed in a reasonable amount of time (1-2 class periods for students)
   - User friendly procedures
   - Connection to lecture components of class
   - Connection to real-world problems/examples

2. **Devices manufacturing**
   - Durable - (resistance to rusting/oxidation and deformation)
   - Sturdy
   - Easy and quick maintenance
   - User friendly
   - Easy and cost effective to replicate
   - Incorporation of tactile feedback
   - Easily integrates with multiple types of materials for testing
   - Inclusion of complete instructions for assembly and maintenance
   - Easily accessible lists of and costs of sources for replacement parts
   - Easy to understand detailed apparatus drawings including all parts needed
   - Integration with current software for recording experimental data
   - Incorporation of 3D printed parts

### Technical Details

**Sponsoring Company:**
The University of Texas at Dallas - Physics Department

**Title:**
Real World Physics - Friction

**Department Receiving Service:**
Introductory Mechanics Friction Lab

**Scope of Deliverables:**
Apparatus and accompanying lab procedures for friction labs

**Overall Budget and Cost:**
$2000

**Intended Beneficiaries:**
Students taking Physics Lab courses at UTD

**Faculty Advisor:**
Dr. Orlando Auciello; Department of Material Science and Engineering

**Industry Sponsor:**
David Taylor; Lab Manager

### BOM and Overall Costs

<table>
<thead>
<tr>
<th>Item #</th>
<th>Component Name</th>
<th>Price</th>
<th>Cost</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1 - 1/8” Ball Bearing</td>
<td>$0.04</td>
<td>$0.04</td>
<td>4</td>
<td>$0.16</td>
</tr>
<tr>
<td>2.</td>
<td>1 - 3/8” 1/4”-20 Screw Cap</td>
<td>$5.57</td>
<td>$0.57</td>
<td>10</td>
<td>$5.57</td>
</tr>
<tr>
<td>3.</td>
<td>1 - 1/8” 1/4”-20 Screw Cap</td>
<td>$0.40</td>
<td>$0.40</td>
<td>10</td>
<td>$4.00</td>
</tr>
<tr>
<td>4.</td>
<td>1/4” - 20 Hex Nut</td>
<td>$0.05</td>
<td>$0.05</td>
<td>100</td>
<td>$5.00</td>
</tr>
<tr>
<td>5.</td>
<td>1/4” Hexagon Flange Washer</td>
<td>$0.08</td>
<td>$0.08</td>
<td>10</td>
<td>$0.80</td>
</tr>
<tr>
<td>6.</td>
<td>Base</td>
<td>$1.35</td>
<td>$1.35</td>
<td>10</td>
<td>$13.50</td>
</tr>
<tr>
<td>7.</td>
<td>300.00 x 10.00</td>
<td>$0.60</td>
<td>$0.60</td>
<td>10</td>
<td>$6.00</td>
</tr>
<tr>
<td>8.</td>
<td>Drive Shaft</td>
<td>$1.50</td>
<td>$1.50</td>
<td>10</td>
<td>$15.00</td>
</tr>
<tr>
<td>9.</td>
<td>Frame</td>
<td>$0.25</td>
<td>$0.25</td>
<td>10</td>
<td>$2.50</td>
</tr>
<tr>
<td>10.</td>
<td>Rod</td>
<td>$0.30</td>
<td>$0.30</td>
<td>20</td>
<td>$6.00</td>
</tr>
<tr>
<td>11.</td>
<td>Leveling Mount</td>
<td>$1.83</td>
<td>$1.83</td>
<td>4</td>
<td>$7.32</td>
</tr>
<tr>
<td>12.</td>
<td>Pulley</td>
<td>$0.05</td>
<td>$0.05</td>
<td>2</td>
<td>$0.10</td>
</tr>
<tr>
<td>13.</td>
<td>1/4” 10-32 Screw</td>
<td>$0.34</td>
<td>$0.34</td>
<td>2</td>
<td>$0.68</td>
</tr>
<tr>
<td>14.</td>
<td>1/4” 10-32 Screw</td>
<td>$0.34</td>
<td>$0.34</td>
<td>2</td>
<td>$0.68</td>
</tr>
<tr>
<td>15.</td>
<td>1/4” 10-24 Screw</td>
<td>$0.69</td>
<td>$0.69</td>
<td>10</td>
<td>$6.90</td>
</tr>
<tr>
<td>16.</td>
<td>1/2” 10-24 Screw</td>
<td>$0.48</td>
<td>$0.48</td>
<td>10</td>
<td>$4.80</td>
</tr>
<tr>
<td>17.</td>
<td>1/2” 1/4”-20 Screw Cap</td>
<td>$5.40</td>
<td>$0.40</td>
<td>10</td>
<td>$5.40</td>
</tr>
<tr>
<td>18.</td>
<td>1/2” 1/4”-20 Screw Cap</td>
<td>$0.48</td>
<td>$0.48</td>
<td>10</td>
<td>$4.80</td>
</tr>
<tr>
<td>19.</td>
<td>1/2” 1/8” Dowel Pin</td>
<td>$0.80</td>
<td>$0.80</td>
<td>10</td>
<td>$8.00</td>
</tr>
<tr>
<td>20.</td>
<td>1/2” 1/4” 1/4”-20 Screw (Flat Head)</td>
<td>$0.26</td>
<td>$0.26</td>
<td>10</td>
<td>$2.60</td>
</tr>
<tr>
<td>21.</td>
<td>1/2” 1/4” 1/4”-20 Screw (Flat Head)</td>
<td>$0.40</td>
<td>$0.40</td>
<td>10</td>
<td>$4.00</td>
</tr>
<tr>
<td>22.</td>
<td>Force Sensor</td>
<td>$0.99</td>
<td>$0.99</td>
<td>10</td>
<td>$9.90</td>
</tr>
<tr>
<td>23.</td>
<td>Force Sensor Motor</td>
<td>$0.99</td>
<td>$0.99</td>
<td>10</td>
<td>$9.90</td>
</tr>
<tr>
<td>24.</td>
<td>Sample Holder Bottom</td>
<td>$0.30</td>
<td>$0.30</td>
<td>10</td>
<td>$3.00</td>
</tr>
<tr>
<td>25.</td>
<td>Sample Holder Bottom</td>
<td>$0.30</td>
<td>$0.30</td>
<td>10</td>
<td>$3.00</td>
</tr>
<tr>
<td>26.</td>
<td>Sample Holder Top Box</td>
<td>$0.30</td>
<td>$0.30</td>
<td>10</td>
<td>$3.00</td>
</tr>
<tr>
<td>27.</td>
<td>Sample Holder Top Rod</td>
<td>$0.30</td>
<td>$0.30</td>
<td>10</td>
<td>$3.00</td>
</tr>
</tbody>
</table>

- **Dual Range Force Sensor**
  - 1/2” 1/4”-20 Screw Cap
  - Price: $6.89 per 10
  - Cost: $0.69
  - Quantity: 10
  - Total: $6.90

- **Force Sensor Mount**
  - Price: $1.00
  - Cost: $1.00
  - Quantity: 10
  - Total: $10.00

- **Rotary Motion Sensor**
  - Price: $15.00
  - Cost: $15.00
  - Quantity: 10
  - Total: $150.00

### Data Acquisition

**Three Types of Samples – 500g**

- Silicone Rubber
- Cork
- Felt

**Silicone Rubber 100g to 700g**

- 100g
- 700g

### Acknowledgments

UTD Dept. of Physics; David Taylor; Dr. Orlando Auciello;
Peter Neidblaski - printing; Julie Carver - classroom development