

## Normal Force-o-meter Lab

### Teacher's Guide

#### Topic:

Newton's Laws of Motion

#### The following information is provided to the student:

**Question:**

How can Hooke's law be used to construct a normal force-o-meter and how can the normal force-o-meter be used to analyze a simulated free fall ride?

**Purpose:**

To use Hooke's law and a simple spring system to create and calibrate a normal force-o-meter (erroneously referred to as an accelerometer) and to use it to analyze a simulated free fall ride.

A complete lab write-up includes a Title, a Purpose, a Data section, and a Conclusion/Discussion of Results. The Data section should include a diagram of your constructed normal force-o-meter; the various markings should be shown and labeled (0•mg, 1•mg, 2•mg, etc.). Data should be recorded for a simulated free fall ride (the Mini Drop); values of  $F_{\text{norm}}$  should be recorded: (a) during the constant speed ride to the top of the tower, (b) at the stationary position at the top of the tower, (c) during the free fall stage, and (d) during the braking state at the bottom of the tower. Values of  $F_{\text{norm}}$  should be combined with an FBD to calculate the  $F_{\text{net}}$  and acceleration values; all work should be shown. The Conclusion/Discussion should explain how the stretch of the spring on the constructed normal force-o-meter allows one to determine the acceleration.

#### Materials Required:

Vertical accelerometer kit

#### Description of Procedure:

Students build the *accelerometer* (really a normal force-o-meter; see note below) and use Hooke's law to calibrate it. Directions which accompany the commercially-supplied kits can be followed. Once constructed and calibrated, students use it to measure the normal force acting on their body when at rest, when falling from a chair or lab table, and when contacting the floor and slowing down.

#### Alternative Materials and Procedure:

With some effort (perhaps more than one would want to exert), one might save a few dollars by acquiring the raw materials - springs, plastic tube, fishing sinkers, caps for tubes (or something comparable), narrow tape strings - and using them in place of the commercially distributed kits.

#### Safety Concern:

There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated. Special caution should be taken by students as they step off of elevated positions like lab tables and seat tops. Both ceilings and floors are capable of applying hurtful forces ( $F_{\text{hurt}}$ ).

**Suggestions, Precautions, Notes:**

1. [Pasco Scientific](#) is one of a handful of suppliers that sells amusement park physics kits (**ME-9426A**). The vertical accelerometers are used in this lab.
2. The so-called accelerometers are really normal force-o-meters. The accelerations are actually determined from the normal force. However, some manipulation is required in instances in which the rider is upside down and the seat pushes down with a normal force. Under all instances, the device measures the amount of normal force relative to the weight of the user. That is, the device technically measures normal force in units of “m•g”.
3. Remind students of the importance of safety when climbing on and stepping off of chairs and lab tables. Monitor students and intervene when safety becomes forgotten.
4. Save the normal force-o-meters for a field trip to the amusement park.

**Auxiliary Materials:**

None

**Scoring Rubric:**

<b>NL13. Normal Force-o-meter Lab</b>	<b>Score</b>
____ The normal force-o-meter was carefully and successfully constructed. ____ Included, labeled and organized all parts of the lab report. ____ Data section includes collected data for the four different locations of the simulated free fall ride. Free-body diagrams (with clearly labeled force types) are used to calculate the net force and acceleration for each of the four locations; work is clearly shown and labeled; calculations are accurate. ____ Conclusion/Discussion thoroughly and accurately describes how the stretch of the spring on the constructed normal force-o-meter allows one to determine the acceleration. Discussion reveals a high level of understanding.	____/____

**Connections to The Physics Classroom Tutorial:**

The following readings are a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/Class/newtlaws/u2l3a.cfm>

<http://www.physicsclassroom.com/Class/newtlaws/u2l3c.cfm>

<http://www.physicsclassroom.com/Class/newtlaws/u2l3d.cfm>

**Connections to Minds on Physics Internet Modules:**

Sublevel 9 of the Newton’s Law module is a suitable accompaniment to this lab:

<http://www.physicsclassroom.com/mop/module.cfm>