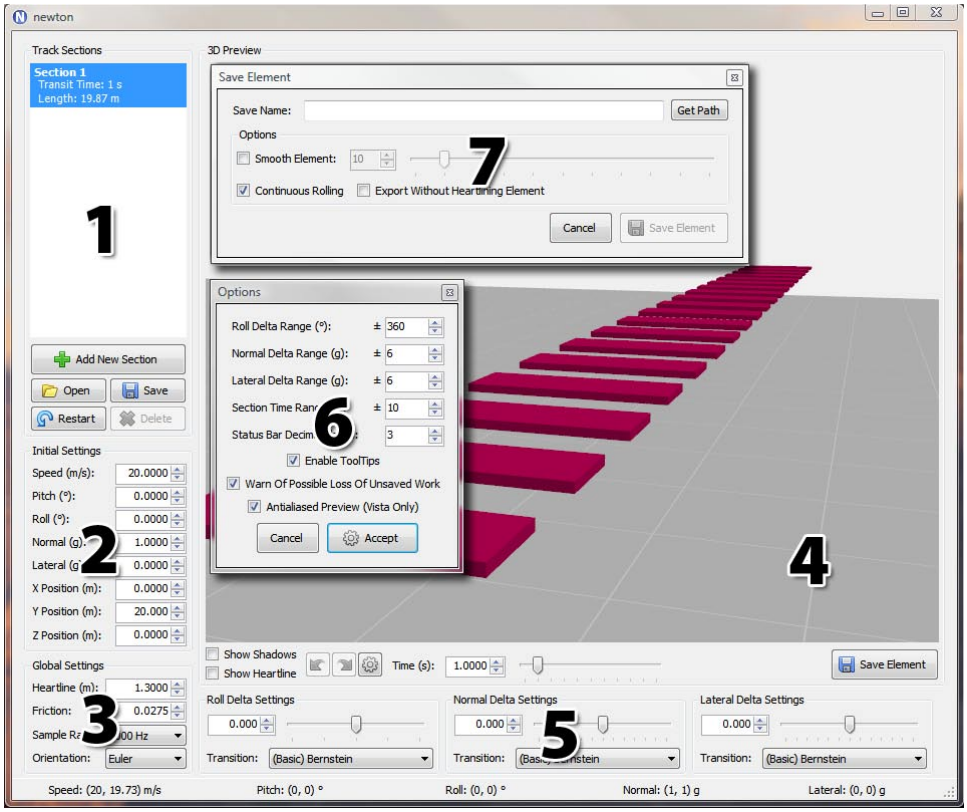
newton (nü´-tən) *n*. The Standard International unit of force required to cause a one kilogram mass to accelerate by one meter per second per second; abbreviated N.



1. TRACK SECTIONS

A track element is composed of multiple sections, with each section containing a set of parameters that defines its shape. This group contains several controls that allow you to add, delete, and switch between sections. Note that the delete button will work only if the currently selected section is also the last one. You can also save your work so you can open it at a future time; newton saves the force/roll profile files with the extension ".newt."

2. INITIAL SETTINGS

Here, you set the input parameters for your element. If the element is a continuation of another, you should set the speed (*in meters per second*), pitch, roll, normal, and lateral values to match the end of the previous element. The X, Y, and Z positions are provided merely for convenience—they have no effect on the final element once you import it into the NoLimits editor.

3. GLOBAL SETTINGS

These settings remain constant throughout the entire element. The first is the heartline; if you hover the mouse cursor over this control, newton will display a tooltip that suggests values for various coaster styles.

You should set the coefficient of friction to a value appropriate to the type of coaster you are trying to create. The default value of 0.0275 is a good starting point for steel coasters; wooden ones will have a substantially lower coefficient (less than 0.02).

The sampling rate determines the time step for the algorithm that newton uses to calculate the track. For example, a value of 100 Hz means that newton calculates the position of the track every 1/100 of a second. The larger the sampling rate, the more accurate the track, but the longer it takes to calculate. The default value of 1000 Hz is more than accurate enough in just about every reasonable case.

You have two choices for the way newton handles the orientation of the coasters. The default (and simpler, more

intuitive) method uses Euler angles. However, the Euler method suffers from gimbal lock, which means the element will behave unpredictably if you try to roll the track while the pitch is near vertical. The second method uses quaternions, which avoids this issue but is a bit more difficult to use (see section 5). In general, you should stick with the Euler method *unless* you are making a looping coaster.

4. 3D PREVIEW

The viewport displays the results of the calculation. Right-click anywhere in the viewport to engage/disengage the camera. While engaged, the camera will pivot upon mouse movement; the "W," "S," "A," and "D" keys will cause it to move forward, backward, left, and right, respectively. You can also move forward by pressing and holding the left mouse button. Holding the "Shift" key while doing any of the latter will cause the camera to move more quickly.

Below the viewport is a series of controls, the most important of which determines the length (in seconds) of the currently selected track. Another control (or, rather, a pair of buttons) provides undo/redo capability. This allows you to undo (and then redo) up to ten previous states of the currently selected section. Due to newton's efficient algorithm, it's easy to generate dozens of changes in a fraction of second using the various sliders. In order to prevent the saturation of newton's undo buffer, the transient intermediate states aren't saved. What this basically means is that there is a short (less than a second) time interval between making a change and being able to undo that change.

Two checkboxes control what the viewport displays. One toggles shadows (which are helpful in estimating height above ground), the other heartline fins (so you can see the relationship between the track and the defining heartline). Both of these options will negatively impact frame rates on slower systems, though.

The options button invokes a panel (6 in the figure) where you can adjust various program settings that newton will remember between sessions. The numerical controls allow you to adjust the range of the roll, normal and lateral force, and time sliders. You can also change the number of decimal places the status bar values show, enable/disable the tooltips, whether newton reminds you to save your work when you quit, and antialiasing in the viewport. The latter only works in Vista (in XP, antialiasing is always disabled), and turning this off will improve frame rates on low-end systems.

The "Save Element" button calls the save panel (7 in the figure) and allows you to save your work in a NoLimits compatible element file. Note that this is a one way process—newton can't open NoLimits elements. You can also adjust several options when saving an element. First, you should almost always use continuous rolling (it is on by default). If you plan on linking a newton generated element with those produced by other programs (such as Elementary), it's probably best to check the "Export Without Heartlining Element" option, then heartline the entire track using AHG. Finally, you also can optionally smooth the element to varying degrees, although newton tends to produce very smooth elements without this setting (which is why, along with the adverse distortions smoothing may introduce into the element, this is disabled by default). Smoothing is ignored if your sampling rate is larger than 1000 Hz, since the smoothing process is counter-productive to the (presumably desired) higher accuracy afforded by the higher rates.

5. ROLL/FORCE PROFILES

These three group boxes are used to shape the track. They all affect their respective parameters, but otherwise behave identically. Each contains a numerical control and slider to adjust the amount of change of the corresponding parameter in the selected section, as well as a drop down control to choose the transition shape. The transitions are grouped according to kind, and are arranged within each group from most gradual to steepest. It's best to experiment yourself to see which one produces the desired result.

Below this area is a status bar that displays the speed, pitch, roll, and force values at the beginning and end of the selected section, formatted in the following way: Parameter Name: (beginning value, end value) unit. The roll and

pitch values are, by necessity, given in the Euler representation. This is why, if you are using quaternions for the orientation, the change in roll in the status bar does not always reflect what you would expect due to the change in roll from the slider. In fact, quaternions do not treat yaw, pitch, and roll angles as separate rotations, which will undoubtedly make quaternions more difficult to use for many people. For example, while adjusting the normal force of a section using the Euler method, only the pitch will change, since the pitch and roll are "decoupled" from each other. The same is not true (in general) using the quaternion method.

Occasionally, you might come across a situation where the output speed reads "NaN," usually when attempting to build an inversion. This means that the coaster is not going fast enough to be able to complete the section at the normal force that you have specified. With a non-zero heartline, there is a minimum speed that the coaster must be traveling at in order to achieve the desired force at the heartline position. newton will prevent any attempts at adding new sections until the output speed no longer reads "NaN;" this is most easily accomplished by reducing the normal force.

HINTS & TIPS

Right-clicking on a slider will return it to its default value (1.0 for the time slider, 0.0 for the delta sliders).

Shift-right-clicking on a delta slider will adjust the slider so that its corresponding parameter will return to its default value at the end of the section (e.g., if a section starts with a normal force of 2.2 g, a shift-right-click on the normal force slider will set it to –1.2 g, so the normal force at the end of the section will be its default value of 1.0 g). Note—this doesn't work very well with the roll slider if "Quaternion" is selected for the orientation.

Stay away from the "(basic) linear" and "(special)" transitions unless you know what you are doing. The latter can be used to span a single transition across two adjacent sections, *but it should only be used if the two sections have identical transit times*.

You can make the camera move diagonally by holding down the two appropriate keys.

You can improve the frame rate of the 3D viewport by disabling shadows and heartline, disabling antialiasing (in Vista), and resizing newton to make the viewport smaller. You can also set the sampling rate to 100 Hz to speed up the calculation.

If you intend to link elements (newton generated or otherwise) together, it's best to begin/end each element at an inflection point to prevent small bumps at the joint.

To convert from miles/hour to m/s, *multiply* by 0.447. To convert from m/s to miles/hour, *divide* by 0.447.

To convert from km/hour to m/s, *divide* by 3.6. To convert from m/s to km/hour, *multiply* by 3.6.