Car Travel Safety – your life is in your hands!

Overview

In this activity, students are engaged in the study of car collisions and the risk of traveling without seatbelt. Besides the design and test of a physical/mathematical model of this situation, students must idealize some experiments to test and improve the model they defined.

Goals

- Apply Newton's first and second Laws of movement;
- Conceive a simple physical / mathematical model related to real life situations;
- Explore TI-Nspire CX Lists & Spreadsheet, Data & Statistics and Vernier Dataquest™ functionalities in real-life contexts;
- Idealize and assemble data acquisition experiments, using sensors and interfaces;
- Raise awareness of road safety

Materials and Tools

Despite several other possibilities, the following materials and tools are suggested for this activity (1)

- TI-Nspire CX;
- TI-Nspire Lab Cradle;
- Dynamics Cart and Track System
- Motion detector / CBR2
- Dual-Range Force sensor;
- 25-g Accelerometer;
- Photogate

Activity / Background

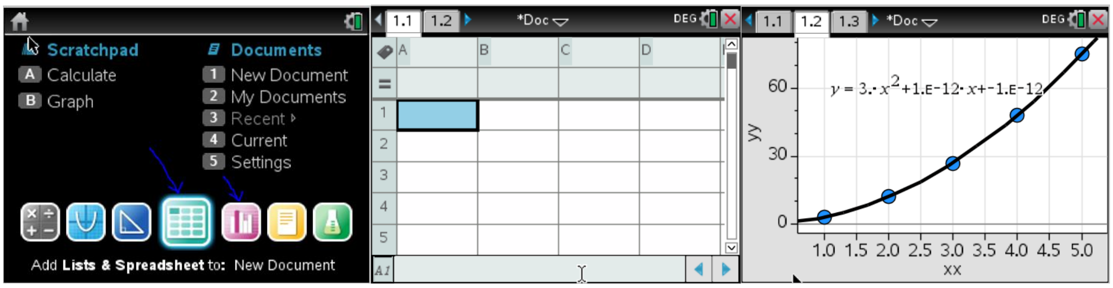
The situation of children traveling in a car without a seat belt or on an adult's lap is still very common today. In fact, there seems to be no clear perception of the enormous risk involved, since even at moderate traffic speeds, extreme force will be required to immobilize this passenger in the event of a collision, preventing it from being projected in the interior of the car or even out of it, leading to injuries that are often fatal.

Theoretical model

Using TI-Nspire technology, define a theoretical model that is capable of predicting the intensity of a passenger's holding force for different vehicle speeds before the crash.

Tips (for students):

- *In real life it is not always possible to know in advance all the variables of a given situation. Every day engineers from all over the world have to estimate unknown quantities in order to arrive at solutions that, although not exact, are good approximations to situations that may actually occur. This time, it is you who have to work to estimate all the physical magnitudes you do not know at the start (frictional forces, collision velocities, and so on…);*
- *You can use* Lists & Spreadsheet *and* Data & Statistics *functionalities of TI-Nspire CX to design and test your model;*



Background (for teachers)

Despite other possibilities, this situation can be modelled using Newton's second law and/or impulse / momentum considerations, as follows:

$$\Delta p = \int_{t1}^{t2} F(t)dt \qquad (1)$$

where p is the linear momentum , F is the force, t_1 and t_2 are the inicial and final times of the collision.

Regarding students expertise in mathematics and/or numerical integration, we can consider a constant force during collision (due to the extreme low duration) so that the above equation could assume a simplified version:

$$\Delta p = F * \Delta t \qquad (2)$$

As it is relatively difficult for students to estimate collision times, an alternative approach, using Torricelli's equation (3) may give easier solutions, as it involves the estimation of car deformation (assuming a collision with a rigid wall), instead of time collision estimations.

$$vf_x^2 = vi_x^2 + 2a_x\Delta x \qquad (3)$$

Where vf_x is the car's final velocity along the x axis (assuming constant acceleration), vi_x is the car's initial velocity along the x axis, a_x is the accelerations along the x axis, and Δx is the car's displacement.

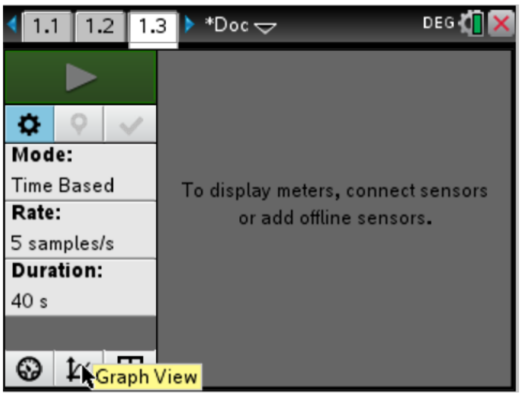
After the estimation of the acceleration experimented by a passenger during the collision, Newton's second Law will give the correspondent force necessary to restrain the passenger. This calculations can be performed in the Lists functionality of TI-Nspire CX.

Experimental setup

Idealize an experimental procedure capable of, at laboratory scale, verify the validity of the model that you defined. Given the possible differences, indicate some possibilities for the improvement of the model and /or minimization of deviations.

Tips (for student):

- *You can use TI-Technology to study car collisions in lab, using sensors connected to Lab-Cradle to measure and analyze car collisions in different situations. You can then extrapolate the situations studied in lab to the ones that occur in real streets every day.*



- *Be sure to discuss with your colleagues the limitations of this upper scale of your experimental data*.

Background (for teachers)

An option for the kind of experiment that could give reasonable estimations for the forces involved to immobilize a passenger in the event of a collision would consist in attaching a small metallic sphere to a force sensor (over an experiment car), while colliding it into a rigid wall (measuring velocities immediately before the collision, force and acceleration). Some variations in the sphere's mass and in the car's velocity should be tested. Students must be questioned about the need to vary the mass of the sphere as the acceleration is been measured for each experiment.

After collecting some data, it should be possible to adjust a curve to the experimental data, extrapolating it for real context situations (mass of the passenger and vehicle's speed). It should be taken into account the deformation (or not) of the car used during the tests, discussing what would be the influences in the maximum force necessary to restrain the passenger. It would be interesting to compare the magnitude of these forces with the weight of some (big) objects or animals familiar to the students.

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