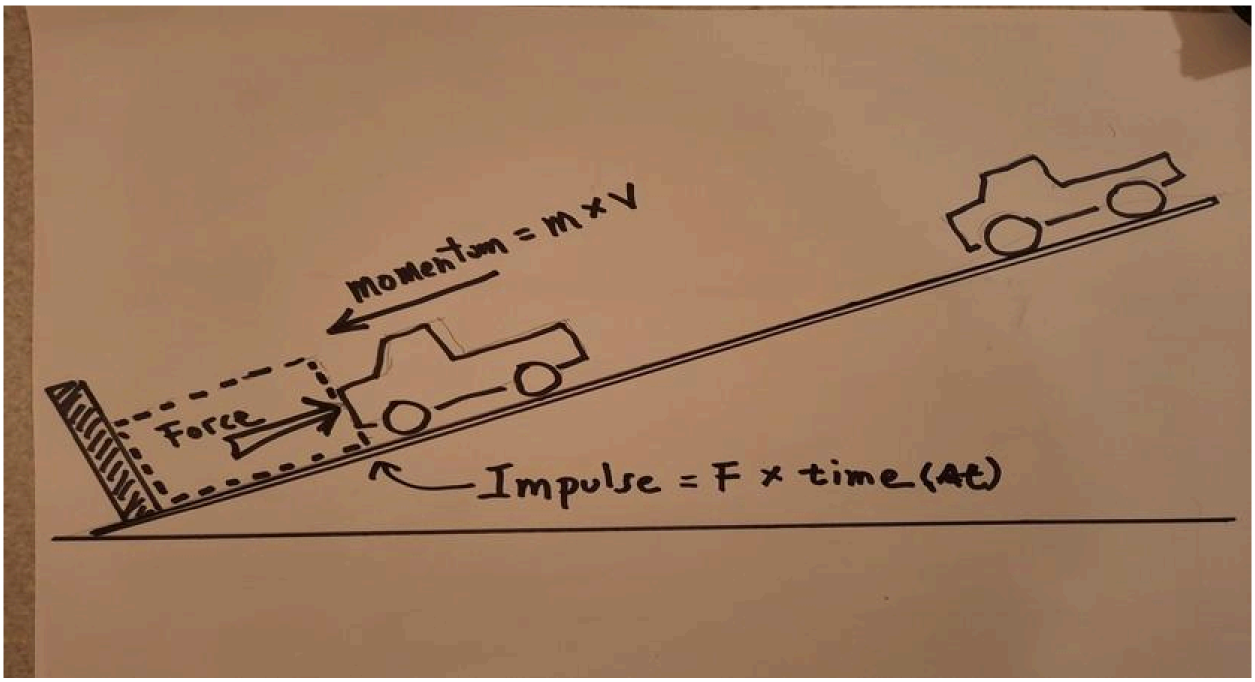
Activity: Crash Test Engineering (Ingénierie de barrière de sécurité)



Grade Level(s)	Timeframe
3-5, 5-7, 7-9, 9-12	90 - 180 min

ABSTRACT

This lesson examines how to design crash attenuating barriers by experimenting with a instrumented toy or cart rolling down a ramp which crashes into a barrier constructed by the students.

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Used with Grade 5, but suitable for higher levels, especially be adding complexity such as a internet reseach phase for design ideas, taking video of the crash, etc.

This is an in-class experimental lesson that uses a smart phone and an app such as Phyphox (free) or a device such as PocketLab to capture the acceleration data of the cart. The instrumentation of the test helps to give a laboratory atmosphere to the activity.

Minimum time is 90 minutes.

EXTRA MATERIALS

[004_2.pptx]

004_3.png

SUPPLIES AND EQUIPMENT

- Test cart: can be a block of wood with wheels attached, or something like a toy truck which can be weighted by adding washers or coins inside, for example. (weight makes experiment run better)
- Smart phone with Phyphox app: (Note that the smartphone from a prior upgrade and that is now sitting around doing nothing should be good enough for this and probabably preferred, as there is a risk of damaging the phone.) Alternative is to purchase a device like PocketLab (https://www.thepocketlab.com).
- Laptop and wireless router (optional): alternative might be to use classroom smartboard, perhaps.
- Ramp
- Crash barrier construction materials: Lesson can be effectively done using only newspaper and masking tape, but can be expanded to exploring many other materials

GETTING READY

Prior to the students constructing their barriers in teams, a brief presentation is given generally on how engineers work to make things safe, and then gets into the theory of the forces in a crash event, including momentum of moving objects, conservation of momemtum, impuses, etc.,. (pptx file included below).

From this they should learn that to have an effective barrier, that is to lower the force or acceleration, it should be “squishy”, but not too squishy, and have a long as possible “squish” zone. While not to give away the “answer”, example barriers made by the instructor (perhaps having intentional faults of what not to do, such as using weak and empty paper cylinders) can be tested as a demonstration to get the creative process started with the students.

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The slide show (in French) is very basic, and uses this opportunity to describe more generally, using examples, how in addition to crash barriers, engineers will design certain things to intentially“break” in a controlled way in order to enhance safety or functionality.

Note the slides on the nasal swab (which has a notched stem so it can be broken more easily) was designed in Winnipeg by the young and diverse team of engineers shown in the picture.

Also, the lightpost safety base is something designed and manufactured in Winnipeg

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The following Instructable gives a very comprehensive explaination of how the experiment is done using a PocketLab as a data logger.

https://www.instructables.com/PocketLab-Crash-Cushion-Activity/

While the Instructable uses a PocketLab device, this experiment can also be done using a smartphone fixed to the cart, where even older phones will work provided the Phyphox app can be installed. A limitation is the accelerometer of most phones does not read values above ~7 to 8 g’s. Thus, the reading will max out in tests above this threshold, but in actual practice I have found most students are eventually able to make barriers successful enough that the test results end up being in working range of the sensor. Also, the data sampling rate in the phone might be less than optimal for this application, so expect some variability or occasional odd readings in the results, but it should still be be good enough. A special script to run within Phyphox (referred to as an “experiment”) that formats the display to provide the relevant data for this experiment can be downloaded by using the attached QR code (TBD). (Code in Worksheets and Leader Instructions.)

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Running this Phyphox experiment on the app will show a live graph of the y-direction accleration output (this assumes the phone is fixed to the cart along the long axis) and a numeric display of maximum +/- acceleration values.

As described in the instructable, the students can run many tests of their barrier models, with each iteration changing variables of their design to see if they can reduce the crash forces (acceleration) further. Once set up, the data logging app is intuitive enough to use so that the students should be able to run the experiments themselves. The “timed run” feature of the app is used, which gives an audible countdown before it starts recording, signaling to the student when to release the cart. After the crash, the acceleration value shown on the screen is then recorded by the student. The students are then asked how they think the design might be improved based on what they observed, and time permitting, modify or build a new barrier for a next test. Tips can be provided about what to do to either increase or decrease the stiffness of the design, etc. Helpful, but not required, is to use the remote access function of the app so the data display on the phone can also be viewed on a laptop screen (or the classroom smartboard?), so other students can easily see.

Another example of this experiment, using another type of commercial data logger, is provided here:

https://www.mrwaynesclass.com/ProjectCrashBarrier/index.html