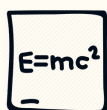


SEAT BELT USE

ACTIVITY 1

SUBJECT



Physics

OBJECTIVES

- Realize the importance of seat belt use
- Understand the dangers of non use of seat belt



LAB ACTIVITY

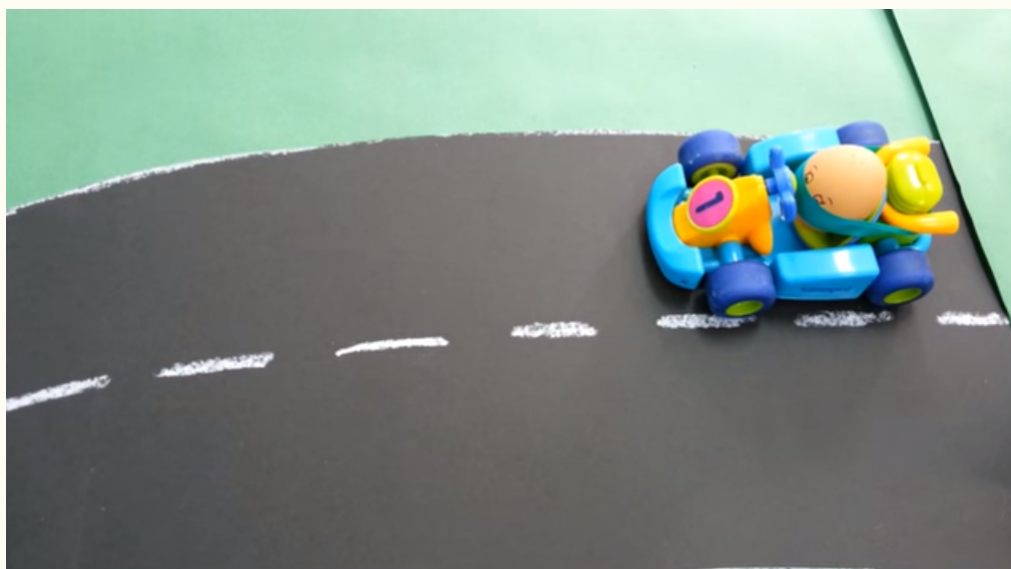
MATERIAL

- ✓ YouTube Video “Epi al volante”

link: <https://www.youtube.com/watch?v=awgDQaWSZLI>

ACTIVITY OUTLINE

Students watch the video “Epi al volante” on Youtube and reproduce it at the lab. The experiment consists of putting an egg or a doll in a car with a rubber band simulating the belt and hit the car to a wall. Then the students will repeat the same exercise without the band. This way you can check that the egg or doll without wearing the band will fall and the one with the rubber won't. Once the experiment is completed they will make a document explaining the conclusions of the experiment.



DISCUSSION - REFLECTION

With the conclusions obtained from the experiment students will create an awareness campaign that will be published on school TV so that everyone can see it and benefit. The name of the campaign will be:

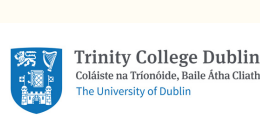
"Why taking risks when the action is so simple?"

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SEAT BELT USE

ACTIVITY 2

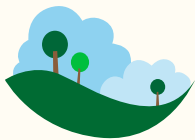
SUBJECT



Physics

OBJECTIVES

- Simulate a head-on collision that is quite comparable to a car crash at a speed of about 20 km/h.
- Understand the forces acting on the human body during a car crash.
- Realise the importance of seat belt use.



OUTDOOR ACTIVITY



Figure 1. "Impact" or "belt sledge" simulator

MATERIAL

- ✓ Impact simulator

The impact simulator or "Belt Sledge" (fig. 1), which you can use in road safety centers, simulates a frontal collision at low speed. You can find it at ÖAMTC road safety centers (Austria), RSI "Panos Mylonas" Mobile NEST (Greece), Motor Transport Institute (Poland)

ACTIVITY OUTLINE

Students using the simulator feel the forces that already occur at this comparatively low speed. Belts can save lives - the impact simulator demonstrates how important it is to fasten your seat belt in the car. The student sits, of course with fastened seat belts, on a car seat, which is mounted movable on an inclined plane. After going down the inclined plane the student bounces on a bar and is stopped in a fraction of a second. Let the student guess how much he/she thinks that the speed of the belt sledge was during the "crash". The force he/she feels corresponds to a real car accident with about 7-30km/h.

DISCUSSION - REFLECTION

The belt is an indispensable lifesaver. Each participant recognises the effects of an accident at a significantly higher speed and that in such a case, without the correct seat belt, there is little chance of a positive outcome.

The participants become aware of the risk they take in "beltless" driving. The impact simulator demonstrates the importance of buckling. The safety awareness of pupils is clearly promoted.

Link this scenario with activity number 3 in order to understand the forces acting on a sledge on an inclined plane

CREDITS

The scenario, as well as activities 3 and 4, are based on the project "Fahrphysik erleben" (which means to experience driving physics), which was developed in cooperation of experienced teachers of physics (namely Mr. Ableidinger, Mr. Binder, Mr. Geißler, Mr. Hofmann, Mr. Macho, Mr. Matschnig, Mr. Lohr and Mr. Woltron), of experts of ÖAMTC (the Austrian automobile club with roadside assistance service) and of the school authority of Lower Austria. You can download the script developed in the framework of this project (4 parts, in German) with the link:

<https://ag4physik.wordpress.com/2018/02/28/fahrphysik-erleben-3/#more-1242>

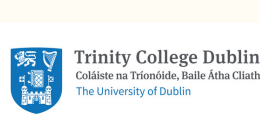
The aim of the initiative „Fahrphysik erleben“ was to integrate the practice and theory of driving safely with a car (brake path, reaction path, forces during driving, forces on tires, electronic assistance systems in a car etc) in teaching mechanics in physics.

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SEAT BELT USE

ACTIVITY 3

SUBJECT



Physics



Computer
Science

MATERIAL

- ✓ Smartphone or Tablet
- ✓ Desktop computer
- ✓ "phyphox" app for Android or iOS
- ✓ Worksheet software (MS Excel or similar)
- ✓ A mini cart & an inclined plane (see figure 1)

OBJECTIVES

- Simulate a head-on collision that is quite comparable to a car crash at a speed of about 20 km/h.
- Understand the forces acting on a car while moving.
- Realise the importance of seat belt use.

Smartphones and tablets are now part of everyday life for many students. Most of them have a large number of sensors: acceleration, gyroscope, magnetic field, microphone, camera, GPS, pressure, in the framework of this educational scenario the acceleration sensors will be used.



LAB ACTIVITY



Figure 1. Inclined plane with mobile phone and phyphox app with remote control

The app "phyphox" (Physikalisches Institut, RWTH Aachen Universität, <https://phyphox.org>) is free and available for Android & iOS. As phyphox can be controlled remotely from any device that is on the same network as the phone you can use this feature to display the measurements with a projector to pupils. After the experiment you can export the recorded data easily as xls file in order to open it with MS excel and analyse data with the functions of excel.

The following video is a short description of how to set up remote access with "phyphox" to remotely control your smartphone physics experiments. Discuss in the subject computer science issues which occur in open networks!

<https://youtu.be/mPUHCWypn9M>

ACTIVITY OUTLINE

Build an inclined plane in the physics lab (figure 1) and attach a mini cart with a smart phone with the app 'phyphox' installed. The smartphone is fixed with a tape on the mini cart and the app 'phyphox' is started. The mini cart rolls down the inclined plane and is stopped at the end of the plane by a bar. The app 'phyphox' records the acceleration and deceleration during the movement of the mini cart.

The student now has the task to measure deceleration of the impact of the mini cart on the bar. The friction of the mini cart on the inclined plane car should be neglected.

Because of the relationship $F = m \cdot a$ you can determine the force acting during the impact. You recognize that this corresponds to the effect of the multiple body weight - however only for the fraction of a second!

The mini cart (and also the impact simulator) is brought to a standstill in a very short time. With "real" delays during accidents significantly higher speeds are necessary for the realization of the detected forces! Formally, this means that the deceleration time t or the deceleration distance s are greater due to the crumple zone and the airbag of a car, resulting in smaller decelerations (and thus smaller forces).

This experiment shows which forces act on humans even at very low speeds. The little cart on the inclined plane simulates a head-on collision that is quite comparable to a car crash at a speed of about 20 km/h.

The following explains how to calculate the impact speed of the slide by means of an inclined plane:

\vec{F}_{HA} slope-down force

\vec{F}_G weight

\vec{F}_N normal force

h height

l length

b basis

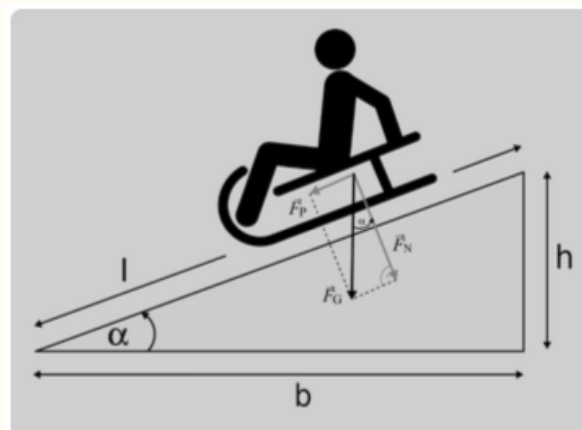


Figure 2: Sledge on inclined plane.

Figure 4 shows all those forces acting on a sled on an inclined plane:

ACTIVITY OUTLINE

The acceleration \vec{a} points in the direction of the slope-down force \vec{F}_{HA} , the gravity \vec{g} acts along the weight \vec{F}_G and the normal acceleration \vec{g}_{normal} is normal to the surface in the direction \vec{F}_N

The gravity \vec{g} can thus be considered as a result of the acceleration of the acceleration \vec{a} and the normal acceleration \vec{g}_{normal} . By the similarity of the triangles follows: $\frac{a}{g} = \frac{h}{l}$.

As result for a follows: $a = \frac{g \cdot h}{l}$

The speed can be calculated taking into account a constant acceleration as follows:

$v = a \cdot t$ and for $l = \frac{a \cdot t^2}{2}$; with $t = \sqrt{\frac{2 \cdot l}{a}}$ follows for the velocity v:

$$v = \sqrt{2 \cdot a \cdot l} = \sqrt{2 \cdot l \cdot \frac{g \cdot h}{l}} = \sqrt{2 \cdot g \cdot h}$$

Thus, for sliding on an inclined plane, there is no dependence of the final speed on the gradient, provided no friction and no air resistance are taken into account.




If the height is assumed to be 0.4 m, the root of g will be about 9 km/h for the final speed of the mini cart.

DISCUSSION - REFLECTION

- Discuss with students the impact of these forces to the human body.
- Link this activity with Seat Belt Use activity number 2 in order to experience these forces on their own bodies using a belt-sledge simulator.

A QUICK GUIDE TO THE THE "PHYPHOX" APP

After starting the app "phyphox" a selection of an experiment will appear and in most cases a warning appears. Then you have to select the desired experiment, in this case "acceleration without g" **. A total of 3 representations can be selected (graph, amount and simple).

The symbol  starts the recording immediately. Further settings are available with the 3-point menu : Time automatic - here you can set a delayed start of the measurement and the duration of the measurement. Export data - measured values as comma-separated values (CSV); Tab-delimited values and export as MS Excel (xls). If you want to create a new experiment press .

A dialogue appears where you can adjust further settings (title of the new experiment, sample rate and sensors for the experiment).

****NOTE:**

The acceleration sensors are so-called micro-electro-mechanical systems (MEMS), an acceleration sensor consists of a mass which is suspended by springs so that it is freely movable in one direction. If an accelerating force acts in this direction, the mass m is deflected by the distance x . The change of position will be measured and results in the acceleration. So these are not acceleration sensors but force sensors. This means that in the unaccelerated case (for example, a smartphone lies unmoved on a table) in the vertical direction a value of approximately $1g$ is measured. To avoid this effect start your experiment with „acceleration without g “! For measurements it should be noted that the sampling rate is limited to approximately 100 Hz depending on the smartphone.

When using the app with students, it should be noted that the term 'acceleration' is less clear for students than "speed" and "path".

CREDITS

This scenario, as well as activity 5, are based on the project “Fahrphysik erleben” (“to experience driving physics”), which was developed in cooperation of experienced teachers of physics (namely Mr. Ableidinger, Mr. Binder, Mr. Geißler, Mr. Hofmann, Mr. Macho, Mr. Matschnig, Mr. Lohr and Mr. Woltron), of experts of ÖAMTC (the Austrian automobile club with roadside assistance service) and of the school authority of Lower Austria. You can download the script developed in the framework of this project (4 parts, in German) with the link:

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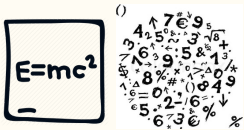


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SEAT BELT USE

ACTIVITY 4

SUBJECT



Physics Math

OBJECTIVES

- Realize the importance of seat belt use
- Understand the relation of speed, kinetic energy, force of impact, effect of seat belts
- Realize how seat belts and airbags can decrease the force of impact and to try to conceptualize this in terms of physics



IN CLASS ACTIVITY

MATERIAL

- Video

Check links below

ACTIVITY OUTLINE

Teacher shows a video or photo of a car crash and introduces and explains the various parameters of a car crash scenario to study. The basic scenario is a car traveling at 50 km/hr and driver and passengers in three cases with non-stretching seat belts (case 1), with stretching seat belts (case 2), without seat belts (case 3).



Figure 1: Selected small overlap front tests Video
(Insurance Institute for Highway Safety)

Crash Tests Video Resources or links

<https://mediaroom.iihs.org/b-roll?item=1634>
<https://mediaroom.iihs.org/b-roll?item=1562>
<https://mediaroom.iihs.org/b-roll?item=1640>
<https://mediaroom.iihs.org/b-roll?item=1791>
<https://mediaroom.iihs.org/b-roll?item=1577>

ACTIVITY OUTLINE

Students are instructed to utilize the work-energy principle and to calculate the force of impact experienced by driver or passenger in each case. They have to take into account that the assumed stopping distance in case 1 is about 30 cm, in case 2 about 45 cm, in case 3 about 10 cm or even less.

Case 1 – speed is 50 km/h, stopping distance of driver/passengers with non-stretching seat belts is 30 cm. In this case, the force on a person of mass 75 kg is about 22 kNt, and the deceleration about 30 g's. In other words, a person experiences an impact force 30 times its weight! A moderate amount of stretch in the seat belts will reduce the average impact force.

Case 2 – speed is 50 km/h, stopping distance of driver/passengers with stretching seat belts is 45 cm. A moderate amount of stretch in a seat belt harness can extend the stopping distance and reduce the average impact force on driver/passengers compared to a non-stretching harness. In this case, the force on a person of mass 75 kg is about 15 kNt, and the deceleration about 20 g's. In other words, a person experiences an impact force 20 times its weight.

Case 3 – speed is 50 km/h, stopping distance of driver/passengers without seat belts is 6 cm. With no seat belt to stop the person with the car, the person flies free (1st Newton's law – Law of Inertia) until stopped suddenly by impact on the steering column, windshield, etc. The stopping distance is estimated to be about one fifth of that with a seat belt, causing the average impact force to be about five times as great. In this case, the force on a person of mass 75 kg is about 110 kNt, and the deceleration about 150 g's! In other words, a person experiences an impact force 150 times its weight!

NOTE

It is essential that teacher explains and emphasizes that:

The work done to stop the driver is equal to the average impact force on the driver times the distance traveled in stopping. A crash which stops the car and driver must take away all its kinetic energy, and the work-energy principle then dictates that a shorter stopping distance increases the impact force. Equivalently, a longer stopping distance decreases the impact force.

The task of the seat belt is to stop driver or passengers with the car so that the stopping distance is probably 4 or 5 times greater than if there was no seat belt. A crash which stops the car and driver must take away all its kinetic energy, and the work-energy principle then dictates that a longer stopping distance decreases the impact force.

DISCUSSION - REFLECTION

Students present and comment on their results in each case. They also communicate misunderstandings they may have (e.g. if there is airbag in car then there is no need for wearing seat belt, right?). Students discuss and reflect on their findings and understandings. They discuss the implications of their findings in relation to wearing seat belts at all times and car speeds by all passengers. At this point they may also discuss that children seats with seat belts are also always necessary for the same reasons.

At the end, teacher and students clearly conclude that:

- Either a stretching or non-stretching seat belt reduces the impact force compared to no seat belt.
- All passengers should always wear seat belts.
- Airbag can provide extra safety but should not be used as justification for not wearing seat belt. While the driver or passenger with an airbag may experience the same average impact force as with a good seat belt, the airbag exerts an equal pressure on all points in contact with it. Thus, the same force is distributed over a larger area, reducing the maximum pressure on the body and so cushioning further the impact.
- There are no exceptions because these are the laws of Physics and Nature!

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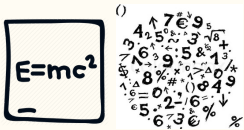


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SEAT BELT USE

ACTIVITY 5

SUBJECT



Physics Math

MATERIAL

- YouTube video "Importance of seat belt":
<https://youtu.be/M70yoV2ZizY>

OBJECTIVES

- Realize the importance of seat belt use
- Calculate the force on a safety belt during an accident!



IN CLASS ACTIVITY

ACTIVITY OUTLINE

Watch the YouTube video "Importance of seat belt" and calculate the force on a safety belt during an accident!

A. On the assumption you have no safety belt, calculate the amount of braking deceleration, if you want to catch at a full braking the speed of 50 km/h within 40 cm to the steering wheel with your arms.

As $v = 50/3,6 = 14 \text{ m/s}$ and $s = 0,4\text{m}$ you can use the formula $a = \frac{v^2}{2 \cdot s}$, which gives the result of $a = 245 \text{ m/s}^2$, which means about 25 times the body weight!



ACTIVITY OUTLINE

Considering the fact that you can catch one to two times your body weight with your arms, you can calculate the speed v which corresponds to this force: with an acceleration $a=10 \text{ m/s}^2$ and a braking distance of $s=0,4\text{m}$ you can use the formula $v = \sqrt{2 \cdot s \cdot a}$ and obtain $v = 2,8 \text{ m/s} = 10 \text{ km/h}$!

B. According to ECE regulation no. 16 the three-point belt with a width of at least 46 mm must be able to withstand a force of 9.800 N and have a tearing force of at least 14.700 N (source Wikipedia).

Now you can calculate the speed of the car before an impact so that the safety belt tears: assuming a mass of the driver of 80 kg you obtain with the first Newton's law $F = m \cdot a$ an acceleration of $a = F/m = 14.700/80 = 183,5 \text{ m/s}^2$

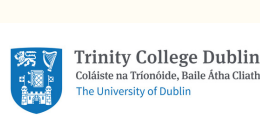
If you assume a crumple zone of the car of 1m you can calculate the impact speed to tear the safety belt: $= 19,3 \text{ m/s} = 69 \text{ km/h}$!

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SEAT BELT USE

ACTIVITY 6

SUBJECT



Physics Math Geography History Social Studies

MATERIAL

- Road fatalities in Austria diagram

OBJECTIVES

- Realise the importance of seat belt use.
- Link legislation and enforcement as well as technology with traffic safety.

ACTIVITY OUTLINE

Have a look at figure 1 and discuss the facts that contributed to the decrease of the number of traffic deaths in Austria.

Figure 1 shows the development of traffic deaths from 1960 to 2001 in Austria. Up to the year 1972 an increasing trend up to the maximum value of 2.948 traffic deaths is to be recognized. The oil crisis and, above all, the interaction of legislative measures and increasing safety technology in vehicle development lowered the number of traffic deaths.



IN CLASS ACTIVITY

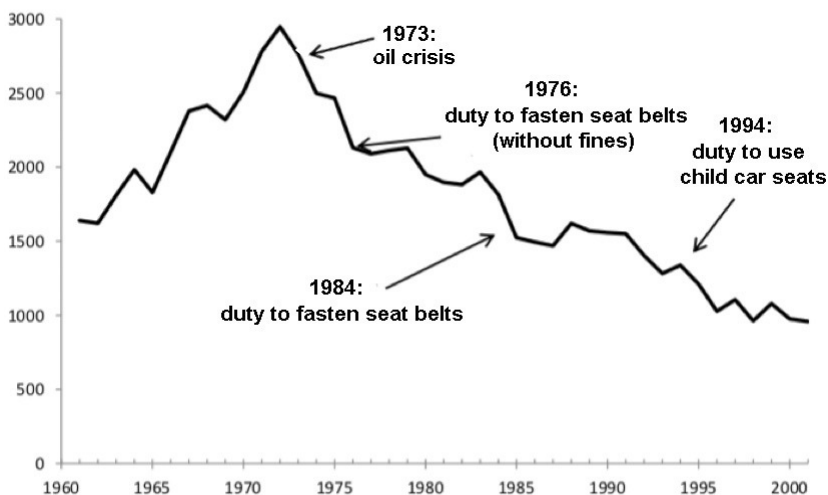


Figure 1. Road fatalities in Austria 1960-2001

Road Fatalities in Austria 2015 - 2017	
Year	Fatalities
2015	479
2016	432
2017	417

Source: OECD/ITF

Table 1. Road fatalities in Austria 2015-2017

DISCUSSION - REFLECTION

The number of road deaths in the last three years (2015-2017) varies between 479 to 417 victims (see table 1). So the value has further reduced from 1972 to today to one sixth.

That is not enough. Because about every eighth traffic death per year could still live if the person had been belted in the vehicle. The seat belt fixes the vehicle occupants in the event of an accident on the seat, so that they participate in the deceleration of the vehicle at an early stage and are not thrown out of the seat. Uncontrolled maximum forces are reduced. The intended elongation of the belt strap lengthens the deceleration path and further reduces the forces that occur.

Approximately 55% of the passengers in the rear area (rear seat area) avoid the use of the belt because they think that:

- Nothing will happen to them anyway
- They have forgotten to fasten
- They think they can brace themselves in the case of an accident.

At an impact speed of 50 km/h, the forces acting upon a person are about 30g, that means 30 times the own body weight. This can certainly no longer be braced with bare hands.

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