

EDITORIAL

The Physics of the Seat-Belt

By W.E. Alnaser *

The media in Bahrain is very concerned nowadays in introducing the advantage of using the seat-belt. For physicists the advantage of the seat-belt is clear as the Sirius star in the night sky. The following facts have been extracted from the application of the momentum and impulse^{1,2} theory may be very important to remember.

The calculation shows that nearly 86% of the serious injuries can be avoided by using the seat-belt. This can be demonstrated from the following example.

A driver who neglects the seat-belt and drives his car at a speed of 36km/h. If this driver collides with a tree, his head (assumed weighing 5kg) will hit the windscreen in 0.002 seconds. Assuming that the contact area between the forehead and the windscreen in one square inch, then the force transferred to the driver's head will be 25,000 Newton (i.e. equivalent to the force resulted from the weight of 2.5 tonnes). Furthermore, the force per unit area on the body will be equal to 41,830,000 Newton (i.e. equivalent to the force resulted from the weight of 4,183 tonnes). However, if this driver was wearing the seat-belt during the collision, his head would have prevented him from hitting the windscreen and only the trunk would have collided with the seat-belt. Assuming that the area of the collision is one square feet and the time of collision (between the trunk and the seat-belt) is 0.2 seconds, then the average force on the body will be 3,500 Newton (instead of 25,000 Newton, where the driver was not using the seat-belt) which is equivalent to the force resulted from a weight of 350kg (0.35 tonnes). This means that the seat-belt reduces the force on the body by 86%. The force per unit area in this situation will be 35,000 Newton (instead of 41,830,000 Newton) which is equivalent to the weight of 3.5 tonnes.

The laws of physics show that the major damage occurs when the driver is not wearing the seat-belt and driving with a high speed. The speed in particular is a damaging factor. This is because when the driver doubles his speed the resulting kinetic energy increases by four times. For example, when driving the car at a speed of 100km/h the driver will retain an energy of 38,580 Joules (equivalent to the energy resulted from the fall of nearly four tonnes object from a height of one meter !!). However, this energy will be reduced to 9645 Joules (equivalent to the fall of nearly four tonnes object from a height of 24cm) while driving with a speed of 50km/h. This fact shows that it is impossible for any passenger to restrain his child by surrounding the child's waist by his hand. A child weighing 10kg in a car moving at a speed of 100km/h will retain a kinetic energy of 3858 Joules which is equivalent to the energy produced from the fall of one tonne from a height of 40cm. This energy is impossible to overcome by human. In addition, the hand will be freezed during the collision which make the holding situation out of control. Let us visualize what would happen to a driver in less than a second if he collided with an object when he was driving at a speed of 80km/h without wearing his seat-belt.

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In 0.1 second: The car's front bumper and grille-work collapse.

In 0.2 second: The bonnet crumples and smashes into the windscreen; spinning rear wheels leave the ground; the grille and radiator disintegrate; the body continues to move forward at 80km/h; the legs ramrod straight snap at the knee joints.

In 0.3 second: The body is now off the seat; broken knees are pressing against the dashboard; the frame of the steering wheel begins to bend under the vice-like grip; the chest is now above the steering column.

In 0.4 second: The front 60cms of the car is demolished, but the rear end is still travelling at 70km/h, the rear rises like a bucking horse.

In 0.5 second: The fear-frozen hands bend the steering column into an almost vertical position; force of gravity impales the driver to the steering wheel shaft; jagged steel punctures lungs and intercostal arteries; blood surges into his lungs.

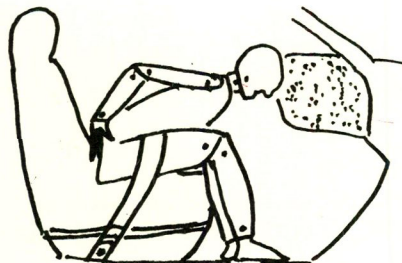
In 0.6 second: The brake pedal sheers off at the floor-boards; the chassis bends in the middle; the head smashes through the windscreen; the rear of the car begins its downward fall.

In 0.7 second: The entire writhing body of the car is forced out of shape; hinges tear; doors spring open; in one last convulsion, the seat rams forward, pinning you against the cruel steel of the steering shaft; blood flows from the mouth, head and body; shock freezes the heart; the driver now is dead.

Finally, statistics show that most drivers' journeys consist of short round-town trips. This is the time when many accidents occur and is also the period during which many people do not wear a seat-belt. Therefore, one should always use a seat-belt in order not to leave himself more exposed to injury.

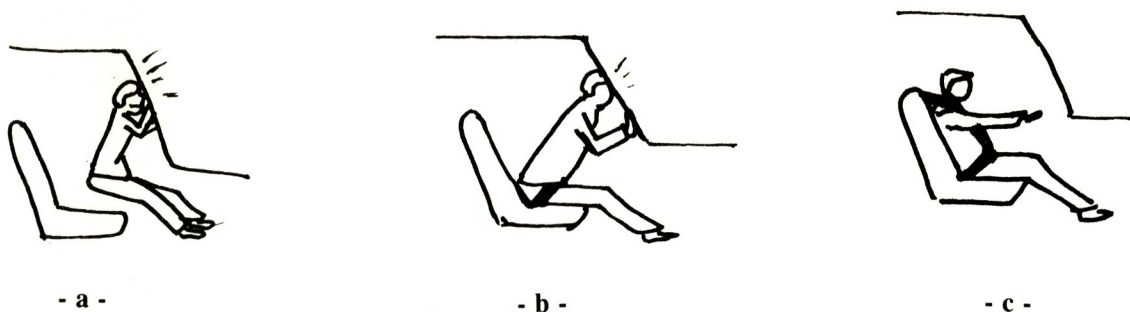
Doctors, university staff and other educated groups should set an example for the others by wearing the seat-belt publicly and regularly, not only that, to preach for it.

FIGURE 1



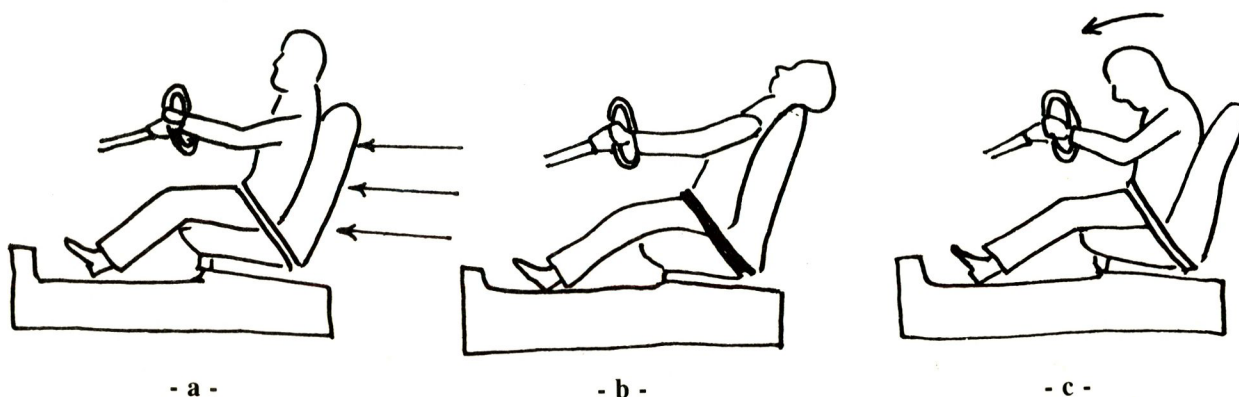
Advantage of padded dashboard. Upon impact, the padding allows the head of the passenger to deliver a force to the dashboard over a longer period of time, thus reducing the impulse the dashboard will be subjected to. Consequently, the force the dash delivers to the passenger's head will be reduced.

FIGURE 2




The safety of the seat-belt. (a) When the trunk is not restraint it flies off upon collision. (b) When only the lap is restraint the forehead hits the windscreen. (c) When both the shoulder and the lap are restraint, maximum protection during collision is provided.

FIGURE 3




Whiplash injury. (a) The trunk of a person sitting in an automobile struck from behind is accelerated forward due to the forces acting through the seat. (b) The inertia of the head causes it to stay in place while the trunk of the body moves forward, leading to severe stretching in the neck region. (c) A moment later the head is accelerated forward.



عزيزي السائق،
إن حزام الأمان أداة فعالة ولم يوضع في سيارتك من باب العبث، بل من أجل سلامتك وعائلتك. وقد ينقذك من موت محقق أو إصابات جسيمة بليغة.

Dear driver,
The Safety belt in your car is not for show but for protection of yourself and your family. Its use may save you a serious injury or even life in case of an accident. Please use it.



REFERENCES

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