Lesson 18: Car Crash Safety!

Teachers' notes

The lesson may be spread over two sessions

Starter: Introduction to crumple zones as safety devices:

How Do Crumple Zones Work?

Crumple zones are deliberate weak spots that engineers have placed in the structure of a car. This sounds a bit weird but there are sound and simple principles behind the approach.

By placing the weak spots in strategic locations, the metal work of a car can be made to collapse in a controlled manner. This creates two mechanisms by which the energy from an impact can be managed:

1. In deforming the metal work of the car, some of the energy from the impact gets transferred into heat. This reduces the amount of energy left to damage the passenger area.
2. Since the collapse is controlled, energy from the impact can be directed away from the passenger area. In most designs, force from the impact is channelled to areas such as the floor, bulkhead, sills, roof and bonnet.

Force On The Passenger

To understand how crumple zones affect passengers, consider a car crashing head-on into a stationary concrete wall. Before the crash, the car and its passengers move together at the same speed. If the car has a rigid body, an impact will cause both the car and passengers to come to a stop in a split second.

It is this rapid deceleration that causes injuries and fatalities in a car crash. The force acting on the passengers is given by Newton's 2nd law:

$$\text{Force} = \text{mass} \times \text{acceleration}$$

or

$$\text{Force} = \text{mass} \times \frac{\Delta \text{velocity}}{\Delta \text{time}}$$

As the stopping time is only a split second, the force on the passengers is very high.

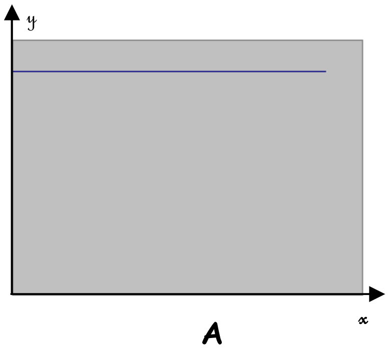
Cars with crumple zones, however, do not have a rigid body. You can think of them as a spring being compressed against a wall. Although the front bumper of the car immediately becomes stationary, it takes some time for the metal work to collapse. This allows the middle and rear of the car to continue in motion for a short time.

Since the stopping time is increased, the acceleration is decreased and so the force acting on the passengers is reduced greatly.

Starter:
Reading graphs (5 – 10 mins)
Students are asked to describe what a series of simple graphs show.

For lower ability students the teacher could add some X and Y axis labels (e.g. distance and time, or comedy ones like number of drinks and visits to the toilet). The teacher could lead a group discussion.

For higher ability students the teacher could ask them to apply their own labels for the X and Y axes and decide what the graph is saying.



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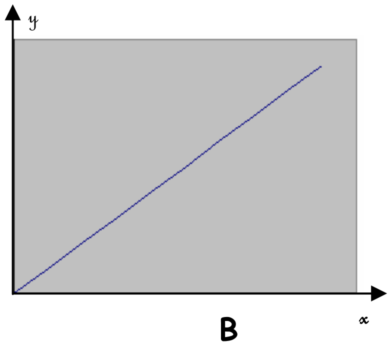

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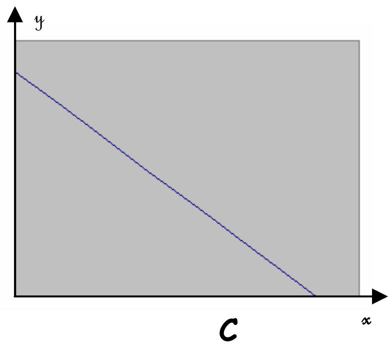

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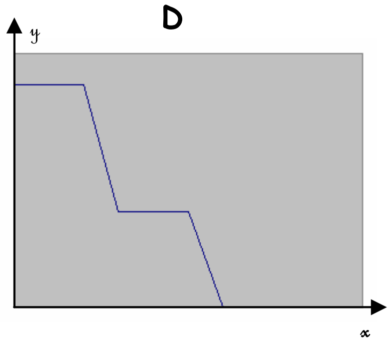

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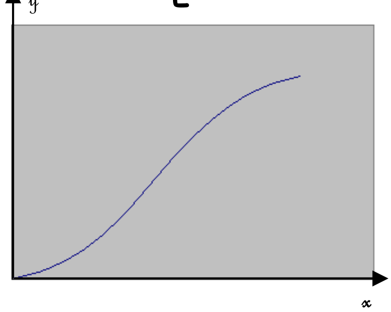

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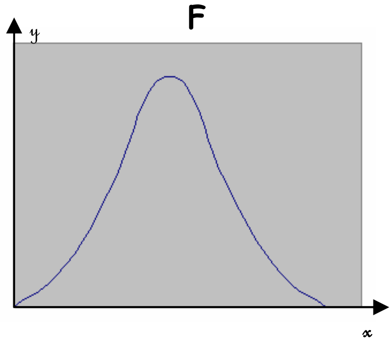

Extra points to be drawn from the graphs could include what the gradient of the line could mean, and what the difference in gradient could imply.

Looking at collisions (10 – 15 mins)

F = m x a

Students are reminded of the equation. The teacher could explain the effects of an object's mass and acceleration on the forces it experiences (e.g. large masses lead to lower accelerations. The object requires a larger force to maintain its acceleration. Large accelerations require large forces, etc…)

The main point from this part of the lesson is for the students to understand the idea that large accelerations or decelerations lead to large forces.

This can be illustrated by imagining an F1 racing car and the forces the driver experiences as he accelerates, or by using the case of a fighter pilot. (Large G-forces caused by large accelerations.)

Questions on F = m x a, to help consolidate?

1) **A force of 1000N is applied to push a mass of 500kg. How quickly does it accelerate?**
2) **A force of 3000N acts on a car to make it accelerate by 1.5m/s^2. How heavy is the car?**
3) **A car accelerates at a rate of 5m/s^2. If it weighs 500kg how much driving force is the engine applying?**
4) **A force of 10N is applied by a boy while lifting a 20kg mass. How much does it accelerate by?**