Student 3: Low Merit

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Physics Internal 2.2

In 2015, Nigel Latta posed the question: *"If you crash your car, are you better off in a small, modern, 5-star safety rated car or something big and solid?"*

Nigel Latta Blows Stuff Up Series 1/Episode 4: Car Collisions

www.tvnz.co.nz/ondemand/nigel-latta-blows-stuff-up/10-05-2015/series-1-episode-4

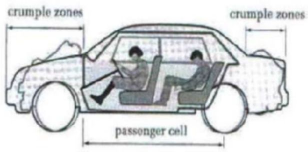
In this report, I will explain the physics ideas of velocity, Newton's Laws and the law of conservation of energy. I will link them to the situation of car collisions and explain why they are important in this situation.

Sir Isaac Newton discovered three laws that define mechanics.

The First Law:

An object maintains constant velocity (including being stationary) unless acted upon by an external net force.

This is related to car collisions because if the car is moving at 100 km/hr the passengers in the car are also moving at this speed. This means that if the car collides with something and becomes stationary or decreases its speed the passengers in the car will continue to travel at 100 km/hr until acted upon by external force.



This could be them colliding with something in the car like the windscreen or the seatbelt catching. During a collision, the passengers won't be sharing the same motion state as the car. When a seat belt is not used, the passenger will tend to continue with their state of motion. This law also links to what happens inside the human body during a crash. Once the body has stopped moving all the internal organs continue moving which can cause organs such as the brain to be damaged and sometimes cause fatal injuries such as brain bleeds. This shows that Newton's first Law is important in the situation of car collisions because it shows that if the car doesn't have seat belts and other safety mechanisms the passengers in the vehicle can be seriously harmed. (1)

The Second Law:

If an object experiences an external net force, it will accelerate such that F_{net}= m a.

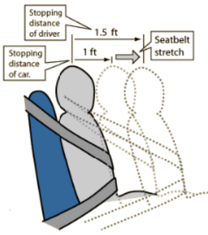
What this means is that when an object is accelerating it is dependent on two things - the objects net force, and its mass. This law is related to the situation of car collisions because the greater that mass of the car the greater force it takes to accelerate and if the mass of the car stays constant, acceleration increase as the force does. You can calculate the force using the equation F_{net}= m a. For example, if a 1000 kg car accelerates at 0.5m/s/s its force would be 500N (1000 x 0.5).

This links to the situation of car collisions because when two cars are accelerating toward each other the severity of the crash would be dependent on the force of the vehicles and the force is dependent on the mass and acceleration of the car therefore the greater the force of the car the higher chance of fatal injuries to the passengers. In other words, it states that the force that is applied in the collision is proportional to mass of impacting cars. This means that the bigger the force of impacting cars, the bigger the force applied, which implies greater damage. The passengers in the car with the greater mass *should* be better off because it will have a greater force against the other vehicle but because a smaller modern car has safety features this is not always the case.

The equation of force goes as follows F=ma and a=v/t therefore F=mv/t.

This is relevant because the crumple zone allows more time to be allotted because of its 'crumpling' feature thereby decreasing the force affecting the body of the car and by having a smaller force the car will induce less destruction and decrease the severity of the collision effect towards the passengers. (2)

In terms of collision time, a greater time/stopping distance in the crash will also result in a lower force i.e. *impulse = FΔt.*



From example car crash scenario with car stopping in one foot distance from a speed of 30 mi/hr.

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Impulse is the rate of change in momentum.The force acting on the car is inversely proportional to the change in time therefore an increase in time will decrease the force acting on the car and this explains how the crumple zone is effective in reducing the severity of damage to the passengers. ②

The Third Law:

Any action force has an equal and opposite reaction.

In a car crash Newton's third Law is shown because as the cars collide (actions force) there is an equal and opposite reaction which is the force sent through the cars **in the opposite direction pushing the front of the car backwards and causing** damage to the vehicle. This law is important to the situation of car crashes because the force that is sent backwards can completely crush the car if there are no safety features such as crumple zones and the greater the force of the vehicle the greater the reaction force therefore the faster you go the bigger chance of injury. Injuries such as whiplash are also an example of Newton's third law.

The Law of conservation of energy

The Law of conservation of energy states that energy cannot be created nor destroyed only transformed into another type of energy.

In relation to a car crash when the car is travelling it has kinetic energy using the COE law we know that if the car was in a collision the kinetic energy of the vehicle couldn't be lost nor destroyed only transformed into another kind of energy. This raises the question of what happens to the kinetic energy once the cars have collided? As explained before the energy can be transformed into other energy such as heat and sound energy. Crumple zones is a safety feature of modern cars that are designed to minimize the damage to the passenger's box of the car (behind the windscreen).

Crumple zones in the front of the vehicles minimize damage to the car by absorbing the kinetic energy as stated in Nigel Latta's experiment. COE is important to a collision between two vehicles because the passengers are better off in a vehicle with safety features such as crumple zones that absorb the kinetic energy. ③

The equation of $V_{average}$= change in distance/change in time can be used to calculate the average speed or velocity. This means that the average speed of an object is calculated by its change in distance over the change in time. We can make the automatic assumption that the faster you are travelling in your vehicle the more damage there will be to your car. This relates to the situation of a car collision because the higher the velocity the more force resulting in more destruction of the vehicle.

In the documentary, the smaller more modern car is a 2013 Toyota Yaris. The Yaris has safety features such as:

- Safety belts that act as the external force to stop the body from moving
- Airbags to stop the passenger hitting the dash board
- Crumple zones to absorb the energy of the car so that the passenger box is unaffected.

In conclusion, the answer to Nigel Latta's question of which vehicle would you be better off in I think you would be better in a modern five-star rating car. I can confirm this through the Physics ideas of Newton's Laws, The Law of Conservation of energy and Velocity. Safety features such as crumple zones, airbags and safety belts minimize the damage to the passengers therefore the mass of the car is defeated by science and technology.

References:

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