Vehicle Dynamics – Theme 4: Stopping

| Factsheet 4b |

Newton's laws

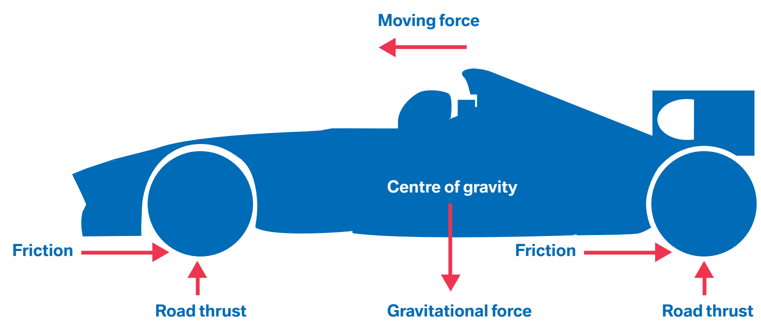
The movement of vehicles can be explained by Newton's laws:

1. **If an object moves in a straight line with a steady velocity and no other force acts on it, the object will continue to move in the same direction at the same velocity**. On Earth this is difficult to achieve because there are always a number of forces such as gravity, friction and air resistance acting on an object. Friction and air resistance are opposite forces to the moving force of a car.

2. **If you apply a force (F) to an object it is proportional to the mass (m) of the object and the acceleration (a) the object experiences F = m x a**. This means that, for example, the acceleration of a car depends on the mass of the car and the size of force applied. This means the smaller the mass the greater the acceleration. In return, the braking force depends on the mass too – the greater the mass the greater the force, and therefore the impact, on the tyres for example.

3. **Action equals reaction**. This means that every force has an opposite force of the same size. That is partly why cars dig themselves into the ground if the ground is soft.

Forces are measured in Newtons (N). One Newton is the force needed to accelerate one kilogram of mass at the rate of one metre per second.



The centre of gravity force pushes the car downwards, the street holds the car up, this means the thrust of the road keeps the car up. These opposite arrows (thrust at the back and front and force of gravity) add up to the same size. But, it is not only the thrust from the road that keeps the car up, it is also the air thrust created through the movement of the car. The movement force is equal to the friction force as long as the car is moving at a steady velocity.

Braking and accelerating

When a car brakes, the friction force increases and the movement force becomes smaller. At this point the friction force is greater and the forces are not balanced anymore. The opposite happens as the car accelerates.

The braking force of a car is measured in g's. **1g is the total braking force needed to equal the weight of the car.**

A big g becomes dangerous for the stability of the car. Whilst the car is braking, its centre tries to keep it moving but the brakes are pushing the car into the ground at the same time. This means that the thrust at the front of the car becomes bigger and the thrust at the back of the car becomes smaller. This can destabilise the car and makes it move forward as well as rotating it. That is why sudden braking can result in the car falling on its nose or spinning. The front tyres experience a greater pushing down force than the back tyres. This can change the direction of the movement and cause the car to spin. You can see this often on the race track.

If the difference between the forces in the rear and those in front becomes too big, the back may lift off the road and the car turn over as the back is braking slower than the front and tries to overtake the front of the car. The force of gravity cannot counteract the thrust force anymore. This happens sometimes on motorways when fast cars try to stay clear of an accident in front of them – if they brake too fast they will fall on top of them and a 'pile up' occurs, which can result in fatalities. It also happens sometimes on the race track, but the drivers are better protected and the cars are designed to withstand 'tumbling over'.