



## Vehicle Dynamics – Theme 4: Stopping

### Factsheet 4a

### About friction

Friction is a force that resists motion, in a direction opposite to the direction of travel. It is caused when two different surfaces are in contact with each other. This contact makes materials rub against each other, causes deformation and also creates an attraction between the molecules of the two surfaces which makes them want to 'stick' together.

All surfaces, even those that appear to be smooth, when examined under the microscope are uneven and rough with lots of bumps, cracks and crevices. This roughness helps make friction work. The rougher the surface, the higher the friction.

**Deformation** - materials deform when under pressure, especially soft ones. Just think how a rug or carpet deforms when we stand on it. Tyres also deform under the weight of the vehicle and the people in it and become flatter – this increases the friction between the two surfaces.

There are two main types of friction: **static** and **kinetic**. Static friction is resistance to motion of an object that is not moving. Kinetic friction is resistance on a moving object. Kinetic friction can be either **sliding** or **rolling**.

Static friction is usually greater than kinetic friction – that is why it is so difficult to make a heavy object move but when it starts moving, it gets easier.

Most of the friction on a sliding object is caused by the roughness of the two surfaces.

Rolling friction is usually much less than sliding friction but it can vary a lot depending on the material of the wheel and the surface it rolls on to. For example, if the wheel and the rolling surface are made of metal, similar to rail tracks, the friction will be minimal; if the wheel is made of rubber (as in tyres), there will be more friction, mainly due to the 'stickiness' of the surfaces.

In general, it is much easier to roll a round object than try to slide a flat one. When a wheel rolls, there is only friction at the point of contact with the ground. Deformation of the surfaces in contact as well as molecular 'stickiness' all combine to create the rolling friction.

# The right formula

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As no surfaces are totally hard, there is always some deformation happening, even though it may not always be visible to the eye. In the example of the tyre and the road surface, the tyre deformation is quite visible while the road's is not (think however of road wear and tear – it would not happen if there was no deformation). If the car travels on soft ground or sand, then the deformation on those surfaces is visible (that is why tyres can get stuck on soft ground).

### Friction equation

The equation to describe the resisting force of friction is:  **$F_r = u \times W$**

Friction equals the coefficient of friction multiplied by the force applied (in this case the force is the weight of the object).

It is interesting to note that the equation is independent of the area of contact.

The coefficient is a function of the weight, the elasticity of the materials and the static friction between the materials.