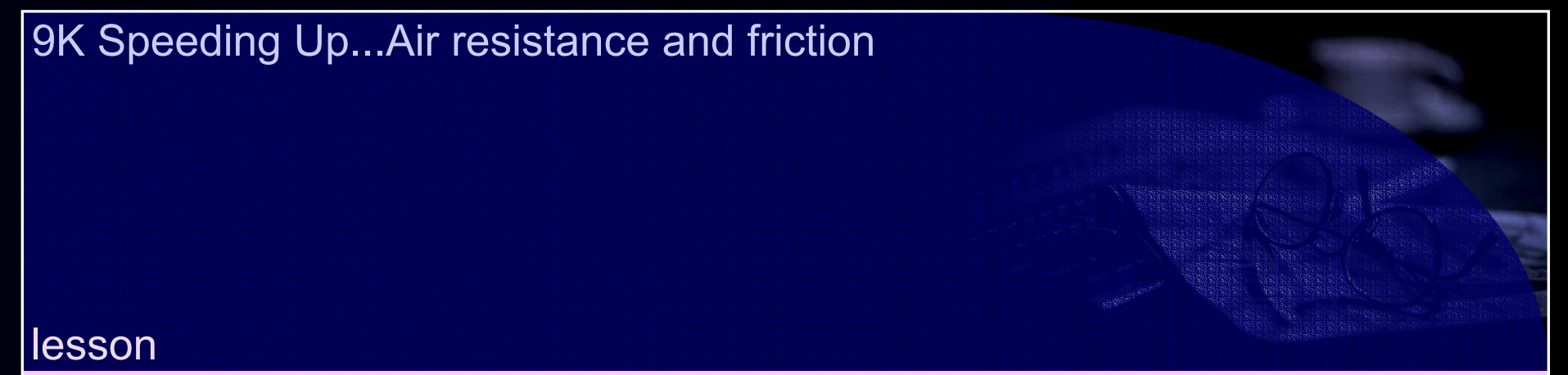
9K Speeding Up...Air resistance and friction



lesson

Science Interactive LTD. PO BOX 50764 LONDON NW6 9AT email: sales@science-interactive.co.uk web: www:science-interactive.co.uk

What is friction

Ordinary friction between objects can be thought of as arising from *surface roughness*. Although two objects can appear to have relatively smooth surfaces, under the microscope, their surfaces can be extremely rough or pitted. This unevenness causes friction between moving objects, for example an engine piston moving inside a cylinder. Friction causes heat to build up as an object's atoms or molecules gain kinetic energy. *Try this: rub your hands together...do they become warm ?*

Useful and unwanted friction:

	Example one	Example two	Example three	Example four
Diagram				
	Useful	Useful	Unwanted	Unwanted
	Friction between the brake plate and the disc slows the car down converting the car's kinetic energy into heat.	Friction between the climbing axe and the ice keeps the ice climber from falling to the ground.	Friction between the skier and the ice slows down the downhill skier. How can you make the skies faster ?	The friction between suitcase wheels and the ground slows down progress. *How do wheel bearings reduce friction ?*

What is air resistance

Ordinary *air resistance* is the force that acts against anything that moves through the atmosphere or air. Moving objects have to push past air molecules when they are moving forward. This force becomes larger in magnitude when an object increases its speed. It can be reduced by an object having a more aerodynamic shape, for example a sports car has a very low profile and a smooth pointed front. When the car travels at high speeds, air resistance is kept low. Streamlining also works when travelling through water.

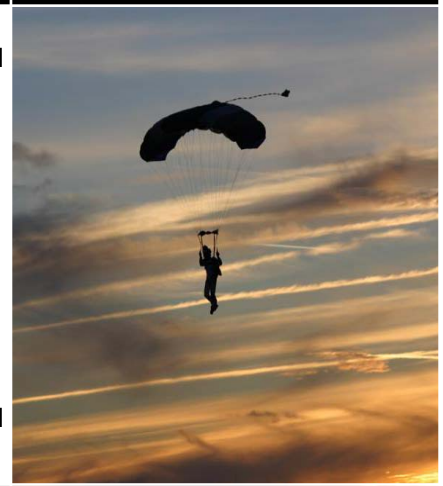
Air resistance and car design:

	Beetle (Top speed 200kmhr^{-1})	Porsche (Top speed 240kmhr^{-1})	4 x 4 (Top speed 170kmhr^{-1})
Diagram			
Notes	Overcoming air resistance at high speeds requires an aerodynamic shape. Sports cars are designed so that their shape allows air to flow over and around their body therefore reducing air resistance. This and the fact that they have large powerful engines allows them to achieve very high top speeds. *How can you say that the shape of the other two cars is related to their top speeds ?*		

Falling objects and air resistance

As an object falls through air, it usually encounters some degree of air resistance. Air resistance is the result of collisions of the object's leading surface with air molecules. The actual amount of air resistance encountered by the object is dependent upon a variety of factors. To keep the topic simple, it can be said that the two most common factors which have a direct effect upon the amount of air resistance are the *speed of the object* and the *cross sectional area of the object*. Therefore both increased speed and cross sectional area of a moving object results in an increased amount of air resistance.

Falling objects and air resistance:

	Start	Middle	End	Using parachutes
Diagram				
	At the start of the jump, the air resistance is low and the free faller accelerates downwards. As his speed increases, the air resistance increases, slowing his acceleration. Eventually the air resistance force will be equal and opposite to the downward force due to gravity. At this point the free faller's speed remains constant.			Parachutes have a large cross sectional profile which increases air resistance, therefore lowering your speed.

Falling objects and terminal velocity

Gravity on Earth causes all objects with a mass to fall and accelerate towards its surface. In practise, the Earth's atmosphere subjects all moving objects to air resistance. This is the upward push of atmospheric air molecules exerted on a falling object. It requires a large amount of energy to push the air molecules out of the way during free fall. Because of this special type of friction, a falling object like a human will reach, on average a final or *terminal velocity of about 50ms^{-1}*. Terminal velocity is where the forces of gravity pulling you downwards is equal and opposite, to the upward force of air resistance. *What is the difference between the terminal velocities of a human falling with and without a parachute ?*

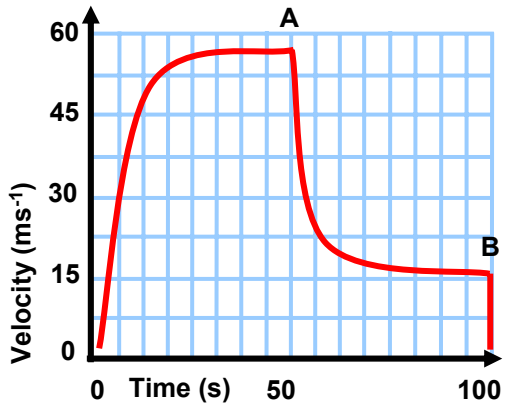
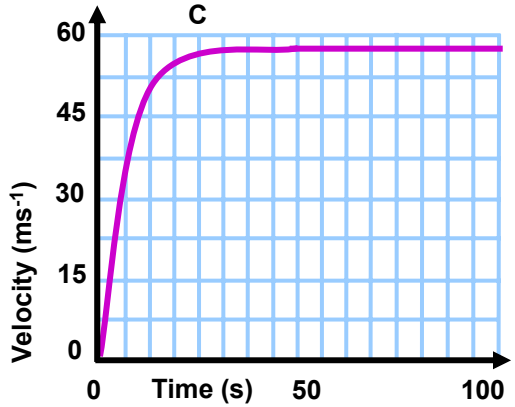
Terminal velocity:

	Free fall	Re-entry	Asteroids
Diagram			
Notes	Free falling, without a parachute, gravity accelerates you to Earth's surface reaching a terminal velocity of about 50ms^{-1}. This velocity is sufficient to kill you !	Spacecraft can travel an amazing 30,000 kmhr^{-1} on re-entry causing the tip of the craft to warm to 1600^{o}C. Without heat proofing the re-entry vessel would fail.	Meteors, lumps of space debris can travel at over 100,000 kmhr^{-1}, largely burning up because of heat caused by air resistance. Most meteors never reach the Earth's surface.

Understanding terminal velocity

Why does an object which is falling and encountering air resistance eventually reach *terminal velocity* ? As an object falls, it picks up speed. The increase in speed leads to an increase in the amount of air resistance. Eventually, the force of air resistance becomes large enough to balance the force of gravity. At this instant in time, the net force on the falling object is 0 Newtons, therefore the object stops accelerating and the objects velocity remains constant. The velocity at which this happens is called the 'terminal velocity.' *Which object would have a lower terminal velocity when falling through air, a 10g feather or a 10g coin ?*

Terminal velocity:

	Terminal velocity	Falling with parachute	Falling without parachute
Diagram			
Notes	Free falling, without a parachute, gravity accelerates you to Earth's surface reaching a terminal velocity of about 50ms^{-1}. Nothing beats the sensation of free falling !	Falling with parachute: Speed increases reaching terminal velocity at A, where parachute deployment reduces speed reaching a lower terminal velocity at B.	Falling without parachute: Speed increases reaching terminal velocity at C, where the force of air resistance becomes large enough to balance the force of gravity.