UNIT 5·6 Gravity

context

Rock climbers appear to defy gravity. Climbers push down on handholds and footholds to advance up the rock. By maintaining a balanced position, climbers can remain stable regardless of their weight. An upward frictional force on the hands and shoes opposes gravity and allows the climbers to move upwards. Gravity is that unseen quantity that is always trying to pull you down.

Gravity

Gravity is the rate of acceleration at which objects fall. It seems logical that heavier objects should fall faster than lighter ones but Galileo found that the acceleration due to gravity is the same for all similarly shaped objects. Newton later discovered that the acceleration due to gravity depends on the mass of the planet you are on and the distance you are from the centre of the planet, but not on the mass of the falling object.

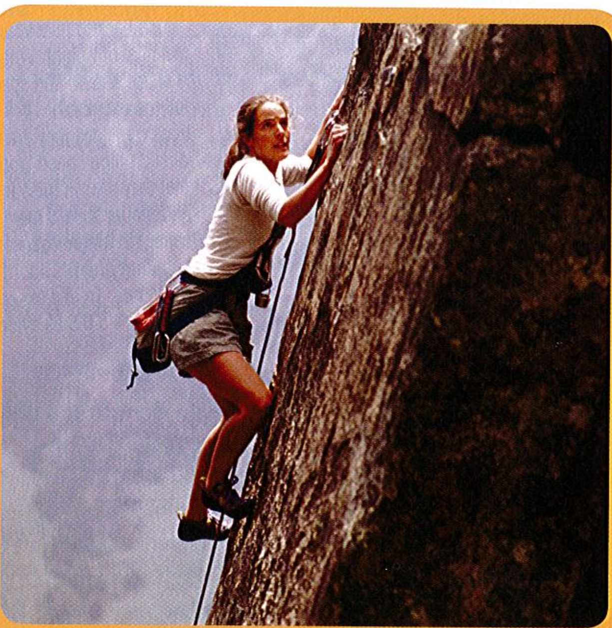

Fig 5.6.1 The rock climber's weight force is balanced only by her hand grip on the rocks and the friction of her boots.

On the Earth's surface the acceleration of all objects is 9.8 m/s^2. This means that the speed of a falling object increases about 10 m/s every second of its fall. This value is for objects falling in a vacuum. In air, acceleration will be slightly less.

An object pushes air out of its way as it falls. The air pushes back with an equal, upward force called **air resistance**. The more the air resistance, the lower the acceleration of the fall.

Weight

The force on a mass that is caused by gravity is called **weight**. It is the force that pulls objects down to the surface of a planet. Weight depends on the mass of the object and the acceleration due to the gravity of the planet itself. You can write this as:

weight = mass × acceleration due to gravity

or $w = mg$

Terminal velocity

Air resistance increases as speed increases—the faster you are falling, the more the resistance. Eventually it balances weight, and so the total force acting is zero. There can be no more acceleration and the object falls at a constant speed, called its **terminal velocity**. All objects have a terminal velocity, but its value will depend on the shape and size of the object. A sheet of paper has high air resistance and a low terminal velocity, while the same paper crumpled has lower air resistance and will reach higher speeds.

Science Focus

g-forces

Our weight often seems to increase because of inertia and **g-force** is used to describe this. Normally you only feel 1 g (i.e. normal gravity, g). If you experience 2 g, then you are being pushed into your seat twice as much as normal. The body responds, squashing muscles and bones.

Formula 1 drivers experience forces of up to 5 g when cornering: neck muscles strain to hold in place a head five times 'heavier' than normal and blood is 'pushed' sideways. Blood flow to the edges of the eye is disrupted, causing peripheral (side) vision to deteriorate, distorting perspective and making it difficult to judge distances.

If an aircraft suddenly increases altitude, blood moves down to the feet and away from the brain. At 8 g to 9 g this reduced blood supply to the brain will cause blackouts.

Prac 1 p. 172
Prac 2 p. 173
DYO