Y10 Forces, Momentum and Energy

Force and Momentum

The relationship between momentum **p**, mass **m** and velocity **v** is:

$$p = m v$$

In a closed system the total momentum before an event is equal to the total momentum after the event. This is called conservation of momentum.

You may be required to complete calculations involving two objects. Examples of events are collisions and explosions.

The relationship between force **F**, change in momentum Δp and time **t** is:

$$F = \Delta p / t$$

You should be able to use this relationship to explain safety features such as air bags, seat belts, gymnasium crash mats, cushioned surfaces for playgrounds and cycle helmets.

Terminal Velocity

The relationship between weight **W**, mass **m** and gravitational field strength (acceleration of free fall) **g** is:

$$W = m g$$

You will not be expected to know the value of g.

The faster an object moves through a fluid the greater the frictional force which acts on it.

An object falling through a fluid will initially accelerate due to the force of gravity. Eventually the resultant force will be zero and the object will move at its terminal velocity (steady speed).

You should understand why the use of a parachute reduces the parachutist's terminal velocity.

You should be able to draw and interpret velocity–time graphs for objects that reach terminal velocity, including a consideration of the forces acting on the object.

Forces and Braking

When a vehicle travels at a steady speed the resistive forces balance the driving force.

You should realise that most of the resistive force is caused by air resistance.

The greater the speed of a vehicle the greater the braking force needed to stop it in a certain distance. You should understand that for a given braking force, the greater the speed, the greater the stopping distance.

The stopping distance of a vehicle is the sum of the distance the vehicle travels during the driver's reaction time (thinking distance) and the distance it travels under the braking force (braking distance).

A driver's reaction time can be affected by tiredness, drugs and alcohol. You should appreciate that distractions may affect a driver's ability to react.

When the brakes of a vehicle are applied, work done by the friction force between the brakes and the wheel reduces the kinetic energy of the vehicle and the temperature of the brakes increases.

A vehicle's braking distance can be affected by adverse road and weather conditions and poor condition of the vehicle. You should understand that 'adverse road conditions' includes wet or icy conditions. Poor condition of the car is limited to the car's brakes or tyres.

Forces and Elasticity

A force acting on an object may cause a change in the shape of the object.

An object behaves elastically if it returns to its original shape when the force is removed.

A force applied to an elastic object such as a spring will result in the object stretching and storing elastic potential energy.

For an object behaving elastically, the extension is directly proportional to the force applied, provided that the limit of proportionality is not exceeded.

The relationship between the force **F** and the extension **e** is:

$$F = k\,e$$

where **k** is a constant.

Energy, Work and Power

Work is done when a force causes an object to move through a distance.

The relationship between work done **W**, force **F** and distance **d** moved in the direction of the force is:

$$W = F\,d$$

Energy is transferred when work is done.

You should be able to discuss the transfer of kinetic energy in particular situations, for example shuttle re-entry into the atmosphere or meteorites burning up in the atmosphere and braking systems on vehicles.

The relationship between power **P**, work done or energy transferred **W** and time **t** is:

$$P = W / t$$

The relationship between gravitational potential energy E_p, mass **m**, gravitational field strength (acceleration of free fall) g and height h is:

$$E_p = m\,g\,h$$

You should understand that when an object is raised vertically work is done against the gravitational force and the object gains gravitational potential energy.

The relationship between kinetic energy E_k, mass **m** and speed **v** is:

$$E_k = 1/2\,m\,v^2$$

You should understand that an object of double the mass of another object travelling with the same speed will have double the kinetic energy. An object travelling at double the speed of another object with the same mass will have four times the kinetic energy. You should be able to apply this idea in the context of road safety.