8.4 Moving About

Contextual Outline

Increased access to transport is a feature of today's society. Most people access some form of transport for travel to and from school or work and for leisure outings at weekends or on holidays. When describing journeys that they may have taken in buses or trains, they usually do so in terms of time or their starting point and their destination. When describing trips they may have taken in planes or cars, they normally use the time it takes, distance covered or the speed of the vehicle as their reference points. While distance, time and speed are fundamental to the understanding of kinematics and dynamics, very few people consider a trip in terms of energy, force or the momentum associated with the vehicle, even at low or moderate speeds.

The faster a vehicle is travelling, the further it will go before it is able to stop when subject to a constant retarding force. Major damage can be done to other vehicles and to the human body in collisions, even at low speeds. This is because during a collision some or all of the vehicle's kinetic energy is dissipated through the vehicle and the object with which it collides. Further, the materials from which vehicles are constructed do not deform or bend as easily as the human body. Technological advances and systematic study of vehicle crashes have increased understanding of the interactions involved, the potential resultant damage and possible ways of reducing the effects of collisions. There are many safety devices now installed in or on vehicles, including seat belts and air bags. Modern road design takes into account ways in which vehicles can be forced to reduce their speed.

This module increases students' understanding of the nature and practice of physics and the implications of physics for society and the environment.

Assumed Knowledge

Domain: knowledge and understanding:

Refer to the *Science Years 7–10 Syllabus* for the following:

5.6.2a) describe qualitatively the relationship between force, mass and acceleration

5.6.2b) explain qualitatively the relationship between distance, speed and time

5.6.2c) relate qualitatively acceleration to change in speed and/or direction as a result of a net force

5.6.2d) analyse qualitatively common situations involving motion in terms of Newton's Laws.

	Students learn to:	*Students:*
1. Vehicles do not typically travel at a constant speed	▪ identify that a typical journey involves speed changes ▪ distinguish between the instantaneous and average speed of vehicles and other bodies ▪ distinguish between scalar and vector quantities in equations ▪ compare instantaneous and average speed with instantaneous and average velocity ▪ define average velocity as: $v_{av} = \frac{\Delta r}{\Delta t}$	▪ plan, choose equipment or resources for, and perform a first-hand investigation to measure the average speed of an object or a vehicle ▪ solve problems and analyse information using the formula : $v_{av} = \frac{\Delta r}{\Delta t}$ where r = displacement ▪ present information graphically of: – displacement vs time – velocity vs time for objects with uniform and non-uniform linear velocity

	Students learn to:	*Students:*
2. An analysis of the external forces on vehicles helps to understand the effects of acceleration and deceleration	▪ describe the motion of one body relative to another ▪ identify the usefulness of using vector diagrams to assist solving problems ▪ explain the need for a net external force to act in order to change the velocity of an object ▪ describe the actions that must be taken for a vehicle to change direction, speed up and slow down ▪ describe the typical effects of external forces on bodies including: – friction between surfaces – air resistance ▪ define average acceleration as: $$a_{av} = \frac{\Delta v}{\Delta t}$$ therefore $$a_{av} = \frac{v - u}{t}$$ ▪ define the terms 'mass' and 'weight' with reference to the effects of gravity ▪ outline the forces involved in causing a change in the velocity of a vehicle when: – coasting with no pressure on the accelerator – pressing on the accelerator – pressing on the brakes – passing over an icy patch on the road – climbing and descending hills – following a curve in the road ▪ interpret Newton's Second Law of Motion and relate it to the equation: $$\sum F = ma$$ ▪ identify the net force in a wide variety of situations involving modes of transport and explain the consequences of the application of that net force in terms of Newton's Second Law of Motion	▪ analyse the effects of external forces operating on a vehicle ▪ gather first-hand information about different situations where acceleration is positive or negative ▪ plan, choose equipment or resources for and perform a first-hand investigation to demonstrate vector addition and subtraction ▪ solve problems using vector diagrams to determine resultant velocity, acceleration and force ▪ plan, choose equipment or resources and perform first-hand investigations to gather data and use available evidence to show the relationship between force, mass and acceleration using suitable apparatus ▪ solve problems and analyse information using: $$\sum F = ma$$ for a range of situations involving modes of transport ▪ solve problems and analyse information involving $$F = \frac{mv^2}{r}$$ for vehicles travelling around curves

	Students learn to:	*Students:*
3. Moving vehicles have kinetic energy and energy transformations are an important aspect in understanding motion	▪ identify that a moving object possesses kinetic energy and that work done on that object can increase that energy ▪ describe the energy transformations that occur in collisions ▪ define the law of conservation of energy	▪ solve problems and analyse information to determine the kinetic energy of a vehicle and the work done using the formulae: $E_k = \frac{1}{2}mv^2$ and $W = Fs$ ▪ analyse information to trace the energy transfers and transformation in collisions leading to irreversible distortions
4. Change of momentum relates to the forces acting on the vehicle or the driver	▪ define momentum as: $p = mv$ ▪ define impulse as the product of force and time ▪ explain why momentum is conserved in collisions in terms of Newton's Third Law of motion	▪ solve problems and analyse secondary data using: $p = mv$ and $Impulse = Ft$ ▪ perform first-hand investigations to gather data and analyse the change in momentum during collisions ▪ solve problems that apply the principle of conservation of momentum to qualitatively and quantitatively describe the collision of a moving vehicle with: – a stationary vehicle – an immoveable object – another vehicle moving in the opposite direction – another vehicle moving in the same direction

	Students learn to:	*Students:*
5. Safety devices are utilised to reduce the effects of changing momentum	▪ define the inertia of a vehicle as its tendency to remain in uniform motion or at rest ▪ discuss reasons why Newton's First Law of Motion is not apparent in many real world situations ▪ assess the reasons for the introduction of low speed zones in built-up areas and the addition of air bags and crumple zones to vehicles with respect to the concepts of impulse and momentum ▪ evaluate the effectiveness of some safety features of motor vehicles	▪ gather and process first-hand data and/or secondary information to analyse the potential danger presented by loose objects in a vehicle ▪ identify data sources, gather, process, analyse, present secondary information and use the available evidence to assess benefits of technologies for avoiding or reducing the effect of a collision