Edexcel Additional Science

Physics P2

Topic 9 — As Fast as You Can!

Forces between interacting bodies act in pairs. An understanding of motion and the ability to measure it enables us to send astronauts to the Moon and design exciting rides at theme parks. A resultant force can change the motion of an object. If the motion of a vehicle changes abruptly, passengers may be protected from serious injury by crumple zones or other safety measures, for example airbags. The resultant force on a falling object in a liquid or gas may gradually decrease to zero, at this point the falling object travels at terminal velocity.

While studying this topic there are opportunities for students to collect, analyse and present data using ICT equipment by working with others in a safe manner.

Have you ever wondered?

- Do the experiences of bungee jumping, parachuting and free-fall all feel the same?
- Could you manage the acceleration to be a good Formula 1 driver?
- Did you realise how much you know of the laws of physics if you skate, snowboard or play flight simulators?
- How does a Jetski work?
- What is the chance of you being injured in a high-speed outdoor activity?
- People have survived a fall from 20,000 feet — how?
- How closely can you drive behind another moving car?
- Which make of car is the safest?

Learning objectives

- The motion of moving objects can be measured.
- Forces can affect the motion of an object.
- The speed of falling objects usually change as they fall.
- Vehicles and theme park rides have safety features to protect passengers from injury.

Glossary

acceleration gradient resistance terminal velocity
action magnitude resultant force vector
collision momentum speed velocity
displacement reaction stopping distance weight

Students will be assessed on their ability to:

- explain that velocity is speed in a given direction and is a vector quantity
- define acceleration in terms of a change in velocity (this can mean change in magnitude and/or direction) and the time taken for the change
- draw and interpret velocity-time graphs and determine acceleration from the gradient of the graph
- use the equation: average velocity = displacement/time $v = s/t$
- use the equation: acceleration = change in velocity/time $a = (v - u)/t$
- explain that if the resultant force acting on a body is zero, it will remain at rest or continue to move at the same speed in the same direction
- explain that if the resultant force acting on a body is not zero, it will accelerate in the direction of the resultant force
- calculate a resultant force using a range of forces (limited to the resultant of forces acting along a line) including resistive forces
- use the equation: force = mass · acceleration $F = ma$

- explain that when two bodies interact, the forces they exert on each other are equal in size and opposite in direction and that these are known as action and reaction forces
- draw and interpret a free-body force diagram P2 9.11
- describe how data about forces can be collected and incorporated into spreadsheet software for use in modeling ‘what if’ situations
- explain that falling objects are acted on by a downward force (weight) and an upward force (air resistance) and that at the start of the fall the forces are unbalanced and the object accelerates
- **describe the increase in resistance with an increase in speed for a falling object and explain how this can lead to terminal velocity**
- explain that the stopping distance of a vehicle depends on the speed of travel
- describe the effect of factors such as driver’s reaction time and the condition of the vehicle and road, on stopping distance
- **calculate the momentum of an object using the equation: momentum = mass · velocity**
- **describe and explain measures designed to reduce the rate of change of momentum of fragile objects, eg passengers in theme park rides and eggs in cardboard packaging**
- evaluate the effectiveness of safety technology when traveling, when provided with appropriate data, for example, safety belts/harnesses, crumple zones and airbags to reduce injury
- demonstrate understanding of the different ways of expressing the size of a risk
- demonstrate understanding of the factors that influence people’s willingness to accept risks, for example, the degree of familiarity, whether it is imposed or voluntary, effects of adrenaline rush.

Topic 10 — Roller Coasters and Relativity

This topic builds on the concepts presented in Topic 9. A resultant force can make an object move in a circular path. Work, energy and power are fundamental concepts that have applications in many branches of science and everyday life. When energy is converted (eg in electrical, potential or kinetic) the conversion process will not be 100% efficient; however the total amount of energy in the system is conserved. This topic will explore the social benefits that science can bring when energy is used to do useful work, although it can also raise environmental issues arising from processes that involve energy transformation. The economic issues of converting energy from one form to another will also be raised within this topic.

Have you ever wondered?

- If you could design a roller coaster ride, what would it look like?
- Where does the power come from to make a theme park ride accelerate faster than a space shuttle?
- How do you make the biggest water splash?
- Can you say why theme park rides are addictive?
- Which parts of the ride make you feel sick?
- Can spaceships fly across galaxies at warp speed (faster than light)?
- How did Einstein come up with the most famous idea in physics — the theory of relativity?

Learning objectives

- How theme park rides work.
- For an object to move in a circular path a force must act on it.
- Energy can be converted from one form into another but it cannot be made or destroyed.
- New scientific theories are not always derived through experimental methods.

Glossary

acceleration electrical energy mass speed
conservation of
energy

energy transfer potential energy velocity
constant speed force power voltage
current gravitational potential
energy
theory of relativity work done
distance kinetic energy resultant force

Students will be assessed on their ability to:

- use the relationship: change in potential energy = mass · gravitational field strength · change
- in height PE = m · g · h
- use the relationship: kinetic energy = ½ · mass · (velocity)^2 KE = ½ mv^2
- use the equation: electrical energy = voltage · current · time E = V · I · t
- explain that work done is equal to energy transferred P2 10.4
- use the equation: power = work done/time taken P = W/t
- use the equation: work done = force · distance moved in the direction of the force W = F · s
- demonstrate understanding of and apply the principle of conservation of energy, for example, gravitational potential energy, kinetic energy and other forms of energy
- describe a roller coaster or other ride, in terms of speed, acceleration, force and energy
- **explain that an object moving in a circle at constant speed is accelerating**
- **explain the resultant force acting on an object which is moving in a circle causes this acceleration**
- **recall that this force is directed to the centre of the circle** P2 10.11
- recognise that some theories do not emerge from experimental data, but require creative imagination such as thought experiments, eg Einstein’s theory of relativity
- discuss the fact that some scientists are often reluctant to accept new theories, such as Einstein’s relativity, when they overturn long-established explanations
- **explain that Einstein’s theory of relativity is believed because it led to predictions which were tested successfully in different situations, for example, atomic clocks and cosmic rays.**

Topic 11 — Putting Radiation to Use

Radioactivity has many important applications in the modern world including treating malignant tumours, domestic smoke alarms, sterilisation of medical equipment, preserving food and dating materials. This topic provides an introduction to radioactivity. It enables students to find out about different types of radiation and their origins, examine their properties and explore their applications. The topic also provides an opportunity to discuss how scientific ideas change over time by considering the risks associated with radioactive sources. The benefits and environmental effects of using radiation can be debated.

Have you ever wondered?

- Irradiating food makes it last longer, so why won't the supermarkets sell it?
- Radioactivity destroys cancers, but does it leave a patient radioactive afterwards?
- How do we know things like 'Woolly mammoths died out 10,000 years ago', which is
- before humans learned to write?
- Why do some people wear radioactive watches that shine in the dark?
- What makes the 'Northern Lights' the most colourful sight on Earth?
- Could a low dose of radiation actually be good for you?
- Do you get a dangerous dose of cosmic rays if you fly often?

Learning objectives

- Atoms are made from particles that can be combined in different ways to produce isotopes, some of which are unstable.
- There are different types of ionising radiations that have different properties.
- The activity of a radioactive source can be measured and used in practical situations.
- Radioactivity has useful applications in everyday life and medicine.

Glossary

alpha particle electron mutation radioactivity
atom gamma ray neutron radon gas
atomic mass half-life nucleus sterilisation
atomic proton number ionising radiation mass nucleon number X-rays
background radiation isotope proton
beta particle magnetic field radioactive dating

Students will be assessed on their ability to:

- describe uses of radioactivity, for example, in household fire (smoke) alarms, in treating food so it keeps longer
- compare the properties of X-rays and gamma rays including their ionising abilities, production and detection
- describe uses of radioactivity in medical applications for both diagnosis and treatment for patients and also for sterilisation of equipment
- describe the nature of alpha, beta and gamma radiation and compare their abilities to penetrate and to ionise
- describe the structure of an atom in terms of protons, neutrons and electrons and describe particular nuclei using symbols in the format: X_{mp}
- **use the terms atomic (proton) number and mass (nucleon) number to explain the structure of isotopes**
- **recall that alpha and beta particles and gamma rays are ionizing radiations emitted from unstable nuclei in a random process**
- describe how the activity of a radioactive source decreases over a period of time
- use the concept of half-life to carry out simple calculations including graphical representations
- explain how graphical representations of half-life can be made using suitable software, and compare this to traditional methods of creating graphical representation

- demonstrate understanding that scientific conclusion, such as those from radioactive dating, often carry significant uncertainties
- describe how scientific ideas change over time, eg the risks associated with radioactive sources
- **recall the origin of background radiation from Earth and space** P2 11.13
- **explain what is meant by background radiation and explain how regional variations within the UK are caused in particular by radon gas**
- describe the dangers of ionising radiation in terms of tissue damage and possible mutations and relate this to the precautions taken while carrying out demonstrations at school
- **explain how the Earth's atmosphere and magnetic field protects it from radiation from space.**

Topic 12 — Power of the Atom

Nuclear energy provides an important economic basis for the production of electricity in the modern world, although the waste products from the process are extremely dangerous. Nuclear reactions provide the energy for stars, some submarines and nuclear weapons. Applications of nuclear energy raise ethical, social, economic and environmental issues that can be debated during the study of this topic. Students could use secondary data sources for this debate to help them draw conclusions. Students will have the opportunity to understand the chain reaction and how this may be controlled in a nuclear reactor to produce electricity. Electricity, or more precisely electric current, is the movement of charged particles. Students will study the two different types of charges and how the movement of

electrons can cause strange phenomena, including shocks and lightning. Although static charge can cause hazards, for example when fuelling aircraft, it can also be used in technological applications such as photocopiers and laser printers.

Have you ever wondered?

- What does E = mc2 really mean?
- How easy is it to build an atom bomb?
- Should we switch to nuclear power to stop global warming, as it doesn't produce greenhouse gases?
- Is it safe to bury nuclear waste underground in the UK?
- Two scientists claimed they could make a nuclear power station in a test tube. Are they crazy?
- Your teacher can create lightning bolts and make objects levitate — is this magic or physics?
- What should you do if you're in the countryside when lightning strikes?

Learning objectives

- Nuclear power stations use chain reactions to produce electricity.
- The Sun produces its energy using nuclear fusion.
- The movement of charged particles forms an electric current.
- Static charges have useful applications but they can also create hazards.

Glossary

attraction electrical energy insulation radioactive
chain reaction electrostatic nucleus repulsion
decay series fission neutron thermal energy
daughter nucleus fusion nuclear reactor

Students will be assessed on their ability to:

- demonstrate understanding of how scientific theories are used to make predictions
- explain the principle of a nuclear chain reaction
- describe the fission of U-235 to produce two daughter nuclei and two or more neutrons
- **describe a simple decay series starting from the daughter products of U-235**
- explain how a chain reaction can be used for both peaceful and destructive purposes
- explain how the chain reaction is controlled in a nuclear reactor
- evaluate the benefits and drawbacks of nuclear power for generating electricity, for example, carbon dioxide emissions, risks, public perception, waste disposal and safety issues
- describe the environmental and social impact of a nuclear power station on a locality
- describe how thermal energy from the chain reaction is transferred to electrical energy in a nuclear power station
- explain that the products of nuclear fission are radioactive and discuss the long-term possibilities for storage/disposal of nuclear waste
- **demonstrate understanding that nuclear fusion requires extremely high temperatures and densities, and relate this to the difficulty of making a practical and economic form of power**

- **describe how fusion differs from fission and recognise it as the energy source for stars**
- demonstrate understanding that new scientific theories, such as 'cold fusion', are not accepted until they have been validated by the scientific community
- explain common electrostatic phenomena in terms of the movement of electrons, for example, shocks from car doors, charges on synthetic fibres, dust on television screens and lightning
- demonstrate understanding that like charges repel and unlike charges attract
- explain how insulating and insulated materials can be charged by contact by the transfer of electrons
- describe some of the potential dangers of electrostatic charges, such as fuelling aircraft, and describe some of the uses of electrostatic charges, such as fingerprinting and laser printing.