Empiribox

Nurturing Future Scientists

# Forces, Magnetism & Space

## Scheme of Work

# Background to Forces, Simple Machines and Space

## **FORCES** (from Wikipedia bit.ly/Wiki-Forces)

In physics, a force is any influence that causes a free body to undergo an acceleration. Force can also be described by intuitive concepts such as a push or pull that can cause an object with mass to change its velocity (which includes to begin moving from a state of rest), i.e., to accelerate, or which can cause a flexible object to deform. A force has both magnitude and direction, making it a vector quantity. Newton's second law, ' F=ma', can be formulated to state that an object with a constant mass will accelerate in proportion to the net force acting upon and in inverse proportion to its mass, an approximation which breaks down near the speed of light. Newton's original formulation is exact, and does not break down: this version states that the net force acting upon an object is equal to the rate at which its momentum changes.

Related concepts to accelerating forces include thrust, increasing the velocity of the object, drag, decreasing the velocity of any object, and torque, causing changes in rotational speed about an axis. Forces which do not act uniformly on all parts of a body will also cause mechanical stresses, a technical term for influences which cause deformation of matter. While mechanical stress can remain embedded in a solid object, gradually deforming it, mechanical stress in a fluid determines changes in its pressure and volume.

Philosophers in antiquity used the concept afforce in the study of stationary and moving objects and simple machines, but thinkers such as Aristotle and Archimedes retained fundamental errors in understanding force, due to an incomplete understanding of the sometimes non-obvious force of friction, and a consequently inadequate view of the nature of natural motion. Most of the previous misunderstandings about motion and force were eventually corrected by Sir Isaac Newton; with his mathematical insight, he formulated laws of motion that remained unchanged for nearly three hundred years. By the early 20th century, Einstein developed a theory of relativity that correctly predicted the action of forces on objects with increasing moment near to the speed of light, and also provided insight into the forces produced by gravitation and inertia.

## **SIMPLE MACHINES** (From the Franklin Institute)

Simple machines are simple tools used to make work easier. Compound machines have two or more simple machines working together to make work easier. In science, work is defined as a force acting on an object to move it across a distance. Pushing, pulling, and lifting are common forms of work. Furniture movers do work when they move boxes. Gardeners do work when they pull weeds. Children do work when they go up and down on a see-saw. Machines make their work easier. The furniture movers use a ramp to slide boxes into a truck. The gardeners use a hand shovel to help break through the weeds. The children use a see-saw to go up and down. The ramp, the shovel, and the see-saw are simple machines.

If two or more simple machines work together as one, they form a compound machine. Most of the machines we use today are compound machines, created by combining several simple machines. Can you think of creative ways to combine simple machines to make work easier? Think about it.

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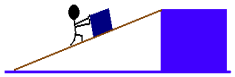
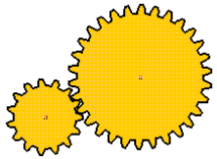
|---|---|
|  | **Inclined Plane**<br>A plane is a flat surface. For example, a smooth board is a plane. Now, if the plane is lying flat on the ground, it isn't likely to help you do work. However, when that plane is inclined, or slanted, it can help you move objects across distances. And, that's work! A common inclined plane is a ramp. Lifting a heavy box onto a loading dock is much easier if you slide the box up a ramp--a simple machine. |
|  | **Wedge**<br>Instead of using the smooth side of the inclined plane, you can also use the pointed edges to do other kinds of work. For example, you can use the edge to push things apart. Then, the inclined plane is a wedge. So, a wedge is actually a kind of inclined plane. An axe blade is a wedge. Think of the edge of the blade. It's the edge of a smooth slanted surface. That's a wedge! |
|  | **Screw**<br>Now, take an inclined plane and wrap it around a cylinder. Its sharp edge becomes another simple tool: the screw. Put a metal screw beside a ramp and it's kind of hard to see the similarities, but the screw is actually just another kind of inclined plane. Try this demonstration to help you visualize. How does the screw help you do work? Every turn of a metal screw helps you move a piece of metal through a wooden space. And, that's how we build things! |
|  | **Lever**<br>Try pulling a really stubborn weed out of the ground. You know a deep, persistent weed that seems to have taken over your flowerbed. Using just your bare hands, it might be difficult or even painful. With a tool, like a hand shovel, however, you should win the battle. Any tool that pries something loose is a lever. A lever is an arm that "pivots" (or turns) against a "fulcrum" (or point). Think of the claw end of a hammer that you use to pry nails loose. It's a lever. It's a curved arm that rests against a point on a surface. As you rotate the curved arm, it pries the nail loose from the surface. And that's hard work! |
|  | **Wheel and Axle**<br>The rotation of the lever against a point pries objects loose. That rotation motion can also do other kinds of work. Another kind of lever, the wheel and axle, moves objects across distances. The wheel, the round end, turns the axle, the cylindrical post, causing movement. On a wagon, for example, the bucket rests on top of the axle. As the wheel rotates the axle, the wagon moves. Now, place your pet dog in the bucket, and you can easily move him around the yard. On a truck, for example, the cargo hold rests on top of several axles. As the wheels rotate the axles, the truck moves. |
|  | **Pulley**<br>Instead of an axle, the wheel could also rotate a rope or cord. This variation of the wheel and axle is the pulley. In a pulley, a cord wraps around a wheel. As the wheel rotates, the cord moves in either direction. Now, attach a hook to the cord, and you can use the wheel's rotation to raise and lower objects. On a flagpole, for example, a rope is attached to a pulley. On the rope, there are usually two hooks. The cord rotates around the pulley and lowers the hooks where you can attach the flag. Then, rotate the cord and the flag raises high on the pole. |
|  | **Gears**<br>Gears are a common mechanical object used to change the rate of rotation of one shaft into a faster or slower rotation of a second shaft. As one cog rotates its teeth push the connecting cog in the opposite direction. A larger cog will push a smaller cog through more revolutions for each one turn of its own. The reverse happens when a smaller cog is the driver, using the larger cog to slow the motion. |

## **SPACE** (From Easy Science for Kids bit.ly/earth-orbits)

From the perspective of an Earthling, outer space is a zone that occurs about 100 kilometers (60 miles) above the planet, where there is no appreciable air to breathe or to scatter light. In that area, blue gives way to black because oxygen molecules are not in enough abundance to make the sky blue.

Further, space is a vacuum, meaning that sound cannot carry because molecules are not close enough together to transmit sound between them. That's not to say that space is empty, however. Gas, dust and other bits of matter float around "emptier" areas of the universe, while more crowded regions can host planets, stars and galaxies.

A solar system refers to a star and all the objects that travel in orbit around it. Our solar system consists of the sun - our star - eight planets and their natural satellites (such as our moon); dwarf planets; asteroids and comets. Our solar system is located in an outward spiral of the Milky Way galaxy.

In our solar system, the moon orbits around Earth. Earth – and the other planets – orbit around the Sun. The stars also orbit around the Sun. Have you ever wondered why the Earth, the other planets, the moons and the stars just don't go flying off on their own into space? What keeps them on their track?

The answer is gravitational forces. The Sun, as well as the planets, has a gravitational field that attracts smaller objects and holds them in place. But, you ask, why don't the planets fall into the Sun? When you point a magnet at a paper clip, the paper clip becomes attached to the magnet. Why don't the planets do the same thing?

The planets and stars travel on an elliptical path around the Sun, which keeps them from falling into the Sun. Here's a useful explanation from Cornell University. Say Superman threw a ball across the sky. The ball would go a long way, but eventually it would begin to fall. Because Superman threw it with such force, the ball would go all the way to the horizon, or the rounded edge of the Earth. Because the Earth is turning, the ball falls, but it never actually drops to the ground. It simply travels around the Earth. This is how orbit works. The moon orbits around the Earth, while the Earth orbits around the Sun.

## Famous Scientists whose work involved studies of Forces. Simple Machines and Space

| | Shortened web link (Type these) |
|---|---|
| Aristotle | bit.ly/Forces-Aristotle |
| Galileo Galilei | bit.ly/Forces-Galileo |
| Sir Isaac Newton | bit.ly/Forces-Newton |
| Albert Einstein | bit.ly/Forces-Einstein |

| Old QCA UNIT REFERENCES & LINKS for Useful Information and Ideas | Shortened web link (Type these) |
|---|---|
| **Forces** | |
| Old QCA KS2 Science Units | bit.ly/QCA-KS2-Science |
| Old QCA KS3 Science Units | bit.ly/QCA-KS3-Science |
| BBC Bitesize Science | bit.ly/BBC-Bitesize-Science |
| **Simple Machines** | |
| Science Buddies website on Levers | bit.ly/ScienceBuddies-Levers |
| Wonders of our World website on simple machines | bit.ly/WooW-Simple-Machines |
| Teach Engineering website – Levers that Lift | bit.ly/Levers-That-Lift |
| Aspire website with many forces lessons and animated investigations | bit.ly/Aspire-Investigation-Animations |
| **Space** | |
| Planets for Kids website | bit.ly/Planets-For-Kids |
| BBC Bitesize game to control the spin of the Earth and the moon | bit.ly/BBC-Earth-Moon-Play |
| Science Channel video about Jupiter | bit.ly/Jupiter-In-Detail |
| Science Kids website about the solar system and facts about the planets | bit.ly/ScienceKids-Planet-Facts |
| BBC Bitesize with most of what you need to teach the Earth in Space topic | bit.ly/BBC-Earth-And-Space |
| Videos aimed at KS3 but with some useful information and images | bit.ly/Teachers-TV-Videos |
| Woodlands Junior School website with science revision topics | bit.ly/Woodlands-Junior |
| The NASA website | bit.ly/NASA-Space-Science |
| Solar System Notes | bit.ly/Solar-System-Notes |

| FORCES KEY VOCABULARY | |
|---|---|
| Air resistance | Stretched |
| Apply | Surface area |
| Attract | Up thrust |
| Attraction | Weight |
| Balance | Sir Isaac Newton |
| Balanced forces | Albert Einstein |
| Brakes | Resistance |
| Buoyant | Resist |
| Buoyancy | Rate of fall |
| Compress | Repel |
| Compressed | Opposite |
| Dependent Variable | Oppose |
| Energy | Parachute |
| Equal and opposite | Scale |
| Exert | Lubricants |
| Extend | Mass |
| Floating | Up thrust |
| Force | Lever |
| Force or Newton meter | Pulley |
| Friction | Pivot |
| Galilee | Fulcrum |
| Gravity | Simple machines |
| Independent variable | Work |
| Springs | Mechanical advantage |
| Sinking | Inclined plane |

## FORCES KEY FACTS AND DEFINITIONS

**Force-** Forces are pushes and pulls. Examples of which are: pressure, friction, air resistance, gravity, upthrust, magnetic, repulsion, torque (twist).

**Force arrows-** These are arrows that are drawn on a picture to show both the direction and size of the forces acting on it.

**Gravity-** Gravity is the force every object that has mass exerts on every other object around it. The size of this gravitational force is directly proportional to mass i.e. Twice the mass= twice the gravity and inversely proportional to distance i.e. Twice the distance is half the gravity.

**Weight-** Weight is a FORCE caused by Gravity acting on Mass.

**Mass-** Mass is the amount of 'stuff' in an object. This 'stuff' is the sum total of atoms and molecules that make up every object.

**Friction** - Friction is the force that 'opposes' motion that occurs wherever there is movement between objects. See below the relationship between mass and force

**Inertia-** the resistance of any physical object to changes in its speed or direction.

**Air Resistance-** Resistance to movement caused by atoms and molecules of air colliding with objects moving through it.

**Up Thrust-** the upward force of both air and liquids on an object.

**Pressure-** the amount of force acting on a certain area.

**Simple machine-** any device like a pulley, lever or slope that makes work easier.

| | |
|---|---|
| 1Kg Mass | = 10N Force |
| 100g Mass | = 1N Force |
| 1g Mass | = 0.01N Force |

## Understanding the Assessment Focuses for Science

The AFs for science describe the key elements of performance.They are linked to the National Curriculum programmes of study and the level descriptions, and are designed give a detailed, analytic view of pupils' attainment across all the key stages and in all areas of science.

### AF1 Thinking scientifically

AF1 contains the main criteria related to how pupils work with scientific ideas, models and evidence to understand and handle knowledge of the subject. It includes criteria which recognise how scientific ideas and models develop through further evidence, recognising the tentative nature of science as a discipline.Pupils work with scientific ideas, models and evidence themselves to further their understanding, and recognise how scientific understanding as a whole develops in such a way.

### AF2 Understanding the applications and implications of science

The focus of AF2 is linking specific scientific ideas to particular applications and scientific and technological developments, and exploring how these developments can affect individuals, society and the world. It includes criteria related to the understanding of various issues surrounding developments, such as ethical or moral arguments, and also criteria related to the understanding of the factors that can influence the development of science and technology. In addition, there are criteria which relate to the application of science in roles or jobs.

### AF3 Communicating and collaborating in science

AF3 contains the main criteria related to how pupils construct and present evidence-based responses and arguments for particular audiences, drawing on appropriate scientific language, mathematics, and scientific conventions and terminology. It also contains the main criteria related to how pupils use and develop collaborative approaches to their own work, and understand and recognise the advantages of the collaborative work of scientists.

### AF4 Using investigative approaches

The focus of AF4 is how pupils ask questions, hypothesise, and develop appropriate and safe strategies and methodologies to collect scientific evidence, through experimental or other means.

### AFS Working critically with evidence

AFS involves criteria based on how pupils interpret and analyse data and other scientific evidence to identify outcomes and draw conclusions using scientific knowledge and understanding. It also considers their ability to evaluate evidence, recognise limitations and develop methodologies or other strategies to improve data or provide further evidence.

## APP (ASSESSING PUPIL PROGRESS)

| Assessment Foci | Opportunities for APP in this Unit | |
|---|---|---|
| | **Descriptors** | **Levels** |
| **AFl** Thinking scientifically | Can use the SC1 planning sheet to explain what question they are investigating | 2 |
| | Be able to draw the force fields around a simple bar magnet | 4 |
| | Using the particle model of materials to explain pressure in detail | 6 |
| **AF2** Understanding the applications and implications of science | Be able to explain how parachutes help save lives | 2 |
| | Explain some of the benefits of rockets in society | 4 |
| | Describe how the design of cars has changed to reduce friction | 6 |
| **AF3** Communicating and collaborating in science | Can distinguish between evidence and opinion in each of the investigations | 2 |
| | Can use force arrows when describing the forces on a parachute | 4 |
| | Explain why it is necessary for scientists to 'review' each other's work | 6 |
| **AF4** Using investigative approaches | Can complete the Sc1 Planning sheet with simple Variables identified | 2 |
| | Can suggest good examples of how to improve their experimental design | 6 |
| | State simply what their results from investigations appear to suggest | 2 |
| **AF5** Working critically with evidence | Base conclusions from their results in various formats e.g. line graphs | 4 |
| | Students can confidently say how their data was precise and accurate | 6 |

# FORCES, MAGNETISM AND SPACE SCHEME OF WORK

| Demonstration/ Investigation | Key Concepts / Key Questions | | |
|---|---|---|---|
| **Lessons 1 & 2:** Introduction to FORCES | | | |
| **Lesson 1: Teacher Demonstrations** | | **NC Knowledge** | **Working Scientifically** |
| **D1:** Gravity defying water<br>**D2:** Egg and conical flask<br>**D3:** Magdeburg Spheres | 1. Forces are pushes and pulls.<br>2. These are recorded using Force Arrows.<br>3. Force arrows can be used to show both SIZE and DIRECTION of forces.<br>4. Gas pressure causes Force due to millions of particles colliding with the particles of the walls of the container. The more particles colliding the greater the pressure. | 1. Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object. | 1. Introduce pupils to the process of '***planning***' a scientific investigation. Learning how to shape questions that they can test, be able to state clearly independent and dependent variables, make predictions and attempt to justify them, write out clear methods and equipment lists taking into consideration any associated risk. |
| **Lesson 2: Children's Investigations** | | | |
| **I1:** Effervescent film canister poppers | 1. Are all surfaces as easy to move over?<br>2. Does the volume of water in the canister affect the time to explosion? | 1. Identify the effects of air resistance, water resistance and friction, that act between moving surfaces. | 1. Outline a simple plan and make a prediction using independent and dependent variables. |

| **Lessons 3 & 4:** Introduction to FRICTION | | | |
|---|---|---|---|
| **Lesson 3: Teacher Demonstrations** | | **NC Knowledge** | **Working Scientifically** |
| **D1:** Silk scarf and beaker.<br>**D2:** Using Newton meters | 1. Friction is a force that OPPOSES motion between any two objects in contact.<br>2. Friction is caused by the physical and chemical contact between different surfaces.<br>3. Know Forces are measured in Newtons (N). | 1. Identify the effects of air resistance, water resistance and friction, that act between moving surfaces.<br>2. Compare how things move on different surfaces. | |
| **Lesson 4: Children's Investigations** | | | |
| **I1:** Balloon Car Racers | 1. A class competition focusing on minimising friction to see who can design a car that travels furthest or fastest and then decide why the winning car did so. | | 1. Review the investigative planning sequence and more specifically:<br>a. Developing the skill of being able to work as part of a team to build a simple machine - car.<br>b. Be able to test experimentally a range of different predictions using friction. |

| Lessons 5 & 6: Magnetism, Simple Machines, Levers, Pulleys & Gears | | | |
|---|---|---|---|
| **Lesson 5: Teacher Demonstrations** | | **NC Knowledge** | **Working Scientifically** |
| **D1:** Doors, Screwdrivers and scissors<br>**D2:** Pulleys<br>**D3:** Gears | 1. A lever is a simple mechanical machine that makes work easier- typical levers include, screwdrivers, scissors, doors and door handles, see-saws, tongs, fishing rods etc.<br>2. A lever works by moving a load about a fulcrum with effort.<br>3. Mass is the sum of all the atoms and molecules in every object.<br>4. A pulley is a simple machine with a wheel and a groove where a pulled rope changes the direction of the force and lifts the load.<br>5. Gears are toothed wheels that work together to change the direction of a force. | 1. Recognise that some mechanisms, including levers, pulleys and gears, allow a smaller force to have a greater effect. | |
| **Lesson 6: Children's Investigations** | | | |
| **D1:** Gauss gun<br>**I1:** Magnetic Circus | 1. What is a magnet?<br>2. Can you make a compass?<br>3. Are all magnetic fields the same?<br>4. Magnetism is a force emitted by magnets.<br>5. A magnetic field is the area of force around a magnet.<br>6. Magnets have two poles; a North and a South.<br>7. Like poles attract and unlike pole repel.<br>8. A compass is a simple device that works by moving. | 1. Notice that some forces need contact between two objects, but magnetic forces can act at a distance.<br>2. Describe magnets as having two poles.<br>3. Predict whether two magnets will attract or repel each other, depending on which poles are facing.<br>4. Compare and group together a variety of everyday materials on the basis of whether they are attracted to a magnet, and identify some magnetic materials. | 1. Review the investigative planning sequence and more specifically:<br>a. Develop the skill of conducting simple experiments to explore the barrier effects of different materials on magnetism.<br>b. Learn to identify problems and limitations of experiments.<br>c. Enhance their skill of being able to design their own simple experiments. |

| **Lessons 7 & 8:** Introduction to AIR and WATER RESISTANCE | | | |
|---|---|---|---|
| **Lesson 7: Teacher Demonstrations** | | **NC Knowledge** | **Working Scientifically** |
| **D1:** Floating bubbles in carbon dioxide<br>**D2:** Parachutes | 1. Air resistance is caused by the action of air particles colliding with anything moving through it.<br>2. The action of air or water particles resisting the movement of objects 'sinking' through them is UPTHRUST.<br>3. Does surface area affect the chances of an egg passenger surviving? | | 1. Pupils by week 7 / 8 should now be able to sketch out the complete Planning sequence of an investigation – this is a good lesson to allow them practice to 'sketch out' a plan once they have been given the context of parachutes and different shaped objects in liquids. |
| **Lesson 8: Children's Investigations** | | | |
| **I1:** Water Resistance | 1. Does surface area affect the ability of an object moving through air or water?<br>2. How does the results of this investigation affect the design of vehicles? | 1. Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object. | 1. Review the investigative planning sequence and more specifically:<br>a. Develop the skill of making and testing a prediction using parachutes & different shaped objects in water.<br>b. Develop the skill of making and recording observations precisely.<br>c. Appreciate some of the difficulties in carrying out experiments accurately and precisely.<br>d. Pupils by week 7 / 8 should now be able to sketch out the complete Planning sequence of an investigation. |

| **Lessons 9 & 10:** Rocket Science | | | |
|---|---|---|---|
| **Lesson 9: Teacher Demonstrations** | | **NC Knowledge** | **Working Scientifically** |
| **D1:** Crushed Can<br>**D2:** Hero's Engine | 1. Rockets fly because of action and reaction of the burning fuel pushing on the rocket.<br>2. Newton's 1st Law – A body remains at rest or moving in a straight line, until acted upon by a force.<br>3. Newton's 3rd Law- For every action there is an equal and opposite reaction. | | |
| **Lesson 10: Children's Investigations** | | | |
| **I1:** NASA Rocket | 1. How does the angle of trajectory affect the distance travelled? | | 1. Practice the skill of making a prediction.<br>2. Develop the skill of making scientific equipment.<br>3. Working collaboratively to generate reliable data.<br>4. Appreciate the limit of equipment for testing hypotheses. |

| **Lessons 11 & 12:** EARTH and SPACE | | | |
|---|---|---|---|
| **Lesson 11: Teacher Demonstrations** | | **NC Knowledge** | **Working Scientifically** |
| **D1:** Solar System | 1. Learn that the Earth and other planets are approximately spherical objects- not perfectly round, that rotate about their axis. | 1. Describe the movement of the Earth, and other planets, relative to the Sun in the solar system. | |
| **Lesson 12: Children's Investigations** | | | |
| **I12.1:** Earth & Phases of the Moon | 1. Gravity is a force that acts towards the centre of every object.<br>2. Pupils learn that the tilt of the Earth is why we have seasons.<br>3. Pupils realise that it is colder in winter because energy from the Sun reaching the Earth is spread out. | 1. Describe the movement of the Moon relative to the Earth.<br>2. Describe the Sun, Earth and Moon as approximately spherical bodies.<br>3. Use the idea of the Earth's rotation to explain day and night and the apparent movement of the sun across the sky. | 1. Asking relevant questions and using different types of scientific enquiries to answer them. |

| **End of Scheme of Work Practical Assessment Task** | | | |
|---|---|---|---|
| Assessment - Planning | | | |
| Investigating Paper Aeroplanes | Independently, in class or for homework plan and carry out an investigation. | 1. Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object.<br>2. Identify the effects of air resistance, water resistance and friction, that act between moving surfaces. | 1. Outline a simple plan and make a prediction using independent and dependent variables.<br>2. Develop the skill of making and recording observations precisely.<br>3. Start to appreciate some of the difficulties in carrying out experiments accurately and precisely. |