MAYOR OF LONDON

THE LONDON CURRICULUM

PHYSICS KEY STAGE 3

LONDON'S DRIVING FORCES

UCL Institute of Education

THE LONDON CURRICULUM

PLACING LONDON AT THE HEART OF LEARNING

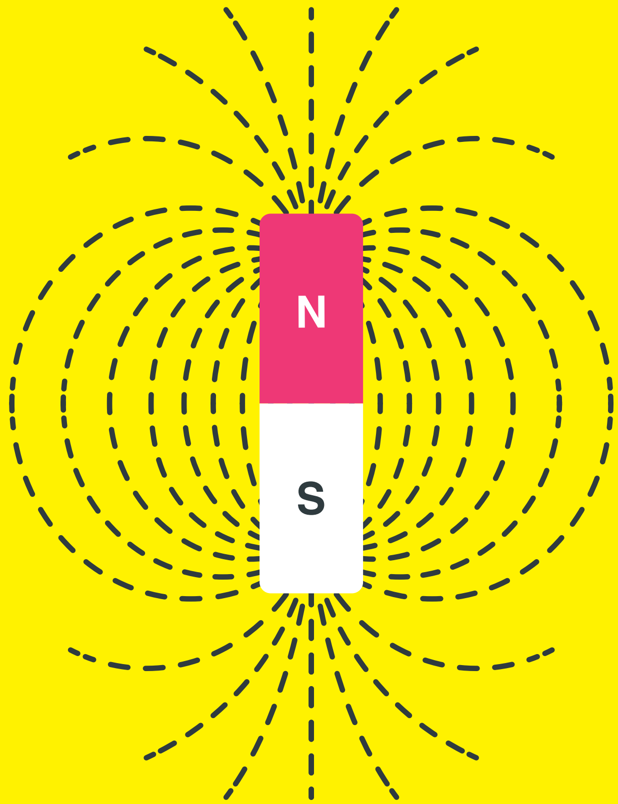
The capital is the home of innovations, events, institutions and great works that have extended the scope of every subject on the school curriculum. London lends itself to learning unlike anywhere else in the world. The London Curriculum aims to bring the national curriculum to life inspired by the city, its people, places and heritage.

To find out about the full range of free resources and events available to London secondary schools at key stage 3 please go to www.london.gov.uk/london-curriculum.

STEM in the London Curriculum

London provides numerous historical and contemporary cutting edge examples of scientists, engineers and mathematicians who have worked in their fields to create innovative solutions to problems throughout the world. Population growth, trade, communication, transport, health, food, water supply and many other aspects of life in London have driven technology-based innovations. London Curriculum science, maths, design & technology teaching resources aim to support teachers in helping their students to:

- **DISCOVER** the application of their subject knowledge to the life of the city.
- **EXPLORE** their neighbourhood and key sites around London, learning outside the classroom to see and understand how STEM subjects have shaped many aspects of the city.
- **CONNECT** their learning inside and outside the classroom, analysing situations and using their subject knowledge to create and present solutions.



CONTENTS

KEEPING LONDONERS HEALTHY OVERVIEW

UNIT AIMS AND OBJECTIVES

London is ever expanding and with many people having to travel to school, to work or just to visit any of London's visitor attractions it is important that London can keep on the move.

London is connected with its expansive road, rail and London Underground tube network that transports millions of people each day. This unit looks at how forces and energy, big ideas in physics, play a major role in London's transport network. Students will use modern information systems to measure average speeds for journeys around the capital. They will investigate forces acting on vehicles and the energy used to make vehicles move, with a focus on how energy efficiency is a vital issue in large conurbations like London. Finally students will explore the factors involved in safely travelling in London.

Opportunities are suggested for students to collect data on a local level as well as taking their investigations further at key London institutions such as the Science Museum and the Crystal.

CONDUCTING A RISK ASSESSMENT

For learning outside the classroom

It is the responsibility of each institution, delegated to the class teacher, to make risk assessments for a given class and a given location. Guidance can be found through the membership organisation CLEAPSS for all school science.
www.cleapss.org.uk

More general guidance on risk assessment for school trips can be found here:
www.atl.org.uk/health-and-safety/off-site-trips/risk-assessment-school-trips.asp

For practical work

A general guide for health and safety guidance and risk assessment of practical work can be found here:
www.nuffieldfoundation.org/standard-health-safety-guidance

If any additional specific guidance is necessary for particular practicals, this will be found within the instructions for each practical.

KEY STAGE 3 NATIONAL CURRICULUM

Calculation of fuel uses and costs in the domestic context

- comparing amounts of energy transferred (J, kJ, kW hour)
- fuels and energy resources

Energy changes and transfers

- other processes that involve energy transfer: changing motion, dropping an object, completing an electrical circuit, stretching a spring, metabolism of food, burning fuels

Changes in systems

- energy as a quantity that can be quantified and calculated; the total energy has the same value before and after a change
- comparing the starting with the final conditions of a system and describing increases and decreases in the amounts of energy associated with movements, temperatures, changes in positions in a field, in elastic distortions and in chemical compositions

Motion and forces describing motion

- speed and the quantitative relationship between average speed, distance and time (speed = distance ÷ time)
- the representation of a journey on a distance-time graph
- relative motion: trains and cars passing one another

Forces

- using force arrows in diagrams, adding forces in one dimension, balanced and unbalanced forces
- forces: associated with deforming objects; stretching and squashing – springs; with rubbing and friction between surfaces, with pushing things out of the way; resistance to motion of air and water

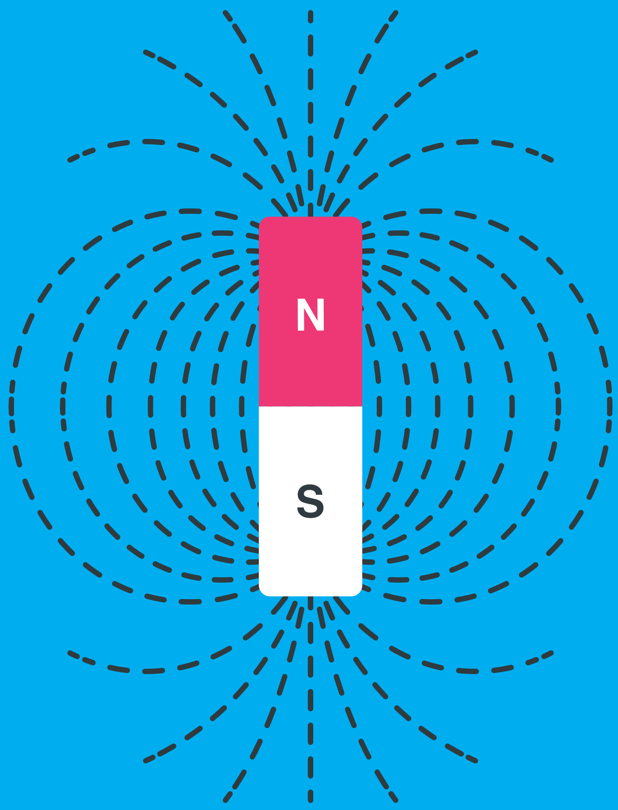
Forces and motion

- forces being needed to cause objects to stop or start moving, or to change their speed or direction of motion (qualitative only)

DISCOVER

Using typical journeys across London, students compare times of travel for different modes of transport and compare the average speeds of different vehicles, using different forms of representation for this data. This links to issues of congestion and the relative ease of traversing the city by using different modes of transport such as public transport and bicycles instead of cars.

The issue of conserving energy will then be explored relating to the various sources of energy used by vehicles as well as the importance of their design to improve their energy efficiency. Students will compare the efficiencies of new vehicles with greener technologies. Finally the students use the ideas learned about speed, forces and energy to investigate issues relating to safety when travelling in London, including the importance of safe speed limits.



LESSON 1
HOW FAST IS LONDON?

THE BIG IDEA

LStudents will use data from different websites to calculate the average speeds for various types of transport and represent these in graphic form to be able to see the relationship between the equation for speed and the slope of a distance time graph.

They will begin to discover the concept of relative motion between two bodies moving along the same axis initially.

LEARNING OUTCOMES

Could be able to describe the relative motion of two vehicles travelling along a road or on railway lines.

Should be able to draw and interpret distance time graphs for journeys on public transport in London.

Must learn the equation for average speed and can use the units for speed (m/s), distance (m) and time (s) and apply it to different modes of transport.

RESOURCES

Resource 1.1: Image of a speed camera

Resource 1.2: Relative motion questions

LESSON 1
HOW FAST IS LONDON?

YOU WILL ALSO NEED

- Wind-up toys
- Graph paper
- Stop watches
- Video of Usain Bolt's 100m win at London 2012 Olympics: **youtube.com/watch?v=o-urnlaJpOA**
- Google Maps: **google.co.uk/maps**
- Transport for London website: **tfl.gov.uk**

LANGUAGE AND NUMERACY

Keywords:

- Average speed
- Velocity
- Distance

Numeracy skills:

- Calculation of speed, distance and time and using the correct units for each variable

LESSON 1: HOW FAST IS LONDON?

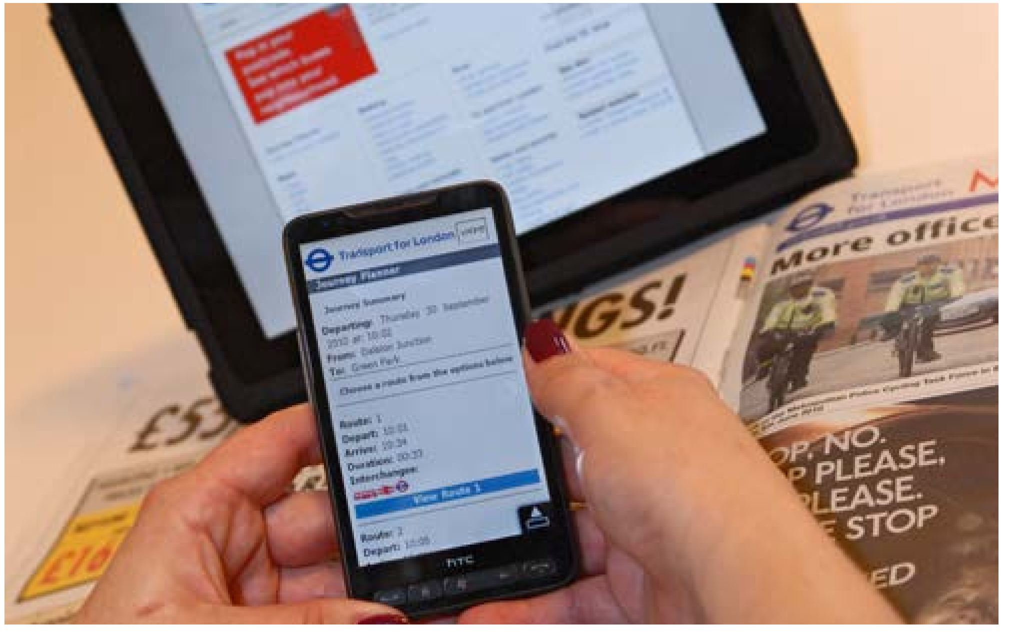
SETTING THE SCENE

Students have a good knowledge of transport in London and will regularly travel on various modes of transport between their homes and school or to go shopping or socialising. Depending on where they live in London, students will have access to different forms of public transport.

Students are also adept at discovering the quickest ways to travel where they want to go and are used to interacting with the countdown system for buses and trains as well as using websites such as Google Maps to find out the location of a venue and an optimum route to reach their destination.

Students will use data from different websites to calculate the average speeds for various types of transport and represent these in graphic form to be able to see the relationship between the equation for speed and the slope of a distance time graph.

By using wind-up toys they can represent the toys' different speeds graphically too and begin to discover the concept of relative motion between two bodies moving along the same axis initially.



© Transport for London

LESSON 1: HOW FAST IS LONDON?

ACTIVITIES

STARTER

Students are shown Resource 1.1: Image of a speed camera (page 11) and are asked to discuss how it operates in relation to cars and the lines on the road. Students can also watch a video of Usain Bolt's 100m win at the London 2012 Olympics and discuss his speed and motion at different stages throughout the race, e.g. at the start he accelerates (speeds up) and towards the end he slows down slightly after reaching a top speed. They then discuss the concept of average speed of Usain Bolt's run.

MAIN 1

Students use Google Maps to find the distance and journey time between two London Underground stations for driving and walking. They can use the TFL website to find the time of travel between the same stations. Using the distance and time information they calculate the average speed for each method of transport.

Differentiation

The students are given the average speed for a bicycle and need to rearrange the equation for average speed to calculate the time taken.

MAIN 2

The data of speeds are used to plot a distance time graph for all the modes of transport from Main 1 on the same axes. Students relate the steepness of each line with the speeds to find a relationship.

Differentiation

Students can measure the gradient of each line to work out the average speed for each mode of transport.

Differentiation

Provide worksheets with axes already drawn on.

MAIN 3

Students race wind up toys to see which one is the fastest, calculate the average speeds and draw a distance time graph plotting the graphs for each toy on the same axes. This will also show how stationary objects are represented on a distance time graph.

Differentiation

Provide worksheets with axes already drawn on.

MAIN 4

Students use a 20 metre length to model relative motion. Students work in threes to demonstrate and calculate speeds relating to relative motion using three scenarios:

1. Two students walk at the same pace for ten metres side by side whilst the third student measures the time taken. They calculate the relative speed by dividing the difference in distance between the two students (zero metres) by the time taken.
2. One student remains stationary whilst the other walks for ten metres. They calculate the relative speed by dividing the difference in distance between the two students (ten metres) by the time taken.
3. The students walk in opposite directions for ten metres and calculate the relative speed by dividing the difference in distance between the two students (20 metres) by the time taken.

Students relate their results to experiences in cars or on trains where vehicles travelling at high speeds appear to pass one another slowly when travelling in the same direction and quickly when travelling in opposite directions.

Students complete Resource 1.2 Relative motion questions (page 12).

Plenary

Students discuss how average speed cameras differ from instantaneous speed cameras and what this means for how motorists drive on busy main roads. Students can also discuss why bus lanes reduce the time taken when travelling by bus and the importance of restricting the types of vehicles that use bus lanes and how they may promote greater use of public transport.

Assessment opportunities

- Revisiting learning outcomes and success criteria
- Targeted questions
- Confidence checks (traffic lights)
- Prior knowledge check
- Assessment of homework task
- Relative motion questions

Homework ideas

Students plot a distance time graph for a person travelling from their home to a popular London tourist attraction by car and also by public transport and compare the graphs they have drawn. Information for the journeys may be obtained by using information from the TfL website and Google Maps.

LESSON 1: HOW FAST IS LONDON?

RESOURCE 1.1: IMAGE OF A SPEED CAMERA

GATSO SPEED CAMERA

LESSON 1: HOW FAST IS LONDON?

RESOURCE 1.2: RELATIVE MOTION QUESTIONS

Question 1

Mary gets on a Jubilee Line train at Wembley Park traveling south towards Kilburn.

Her friend Vishal gets on a Metropolitan Line train at the same time heading south to Finchley Road.

The trains depart the station at the same time. Mary can see Vishal. If both trains are travelling at the same speed, explain what she sees.

Answer to 1

Question 2

Mohammed is in a car travelling west at 20mph along Oxford street.

Damini is on a bus travelling east at 20mph along Oxford Street.

Mohammed and Damini pass each other travelling in opposite directions. From Mohammed's point of view, how fast is Damini travelling?

Answer to 2

LESSON 2
STOP STARTING LONDON

THE BIG IDEA

Students can model congestion on London's busy roads and discover how traffic jams sometimes occur due to the stop start nature of traffic.

Students will use their prior learning and focus on the forces acting on vehicles and passengers in vehicles as they travel around London.

LEARNING OUTCOMES

Could be able to describe the forces acting on objects changing direction.

Should be able to calculate resultant forces.

Must be able to describe the nature of the forces acting on vehicles when they are speeding up, travelling at a constant speed and decelerating.

RESOURCES

Resource 2.1: Representing motion using force arrows

Resource 2.2: Sample dance routine

Resource 2.3: Resultant forces

YOU WILL ALSO NEED

Video of phantom traffic jams:
youtube.com/watch?v=Suugn-p5C1M

LESSON 2
STOP STARTING LONDON

LANGUAGE AND NUMERACY

Key words:

- Balanced forces
- Unbalanced forces
- Acceleration
- Constant speed
- Deceleration
- Resultant force

Numeracy skills:

- Calculation of resultant forces by adding forces together using the convention that when the forces are in opposing directions one will be negative relative to the other.

LESSON 2: STOP STARTING LONDON

SETTING THE SCENE

London, like many world cities, suffers from congestion on the roads on a daily basis. Schemes like Transport for London's bicycle hire scheme play a part in reducing the amount of traffic on the road and London's network of train and tube services also alleviate the number of vehicles on the road.

No matter what vehicle is used, there are forces involved in making vehicles start and stop. The driver of a London Underground tube waiting at a station will close its doors and then use the controls to make the tube move due to a forward force that is applied that makes the whole train move out of the station. People on the tube will feel the effects of the force, particularly if they are standing up. When arriving into a station, the brakes are applied and the force due to the brakes makes the train come to a stop. Passengers feel the effects of the force too.

Students will use their knowledge about forces to explain how they affect the motion of vehicles and the passengers in the vehicles and how safety measures in cars and buses such as seat belts are necessary for keeping passengers safe.

LESSON 2: STOP STARTING LONDON

ACTIVITIES

STARTER

Students are asked to consider what the issues are of having so many cars on the road and how people could be encouraged to use more public transport by considering, for example, the use of bus lanes, the number of people that can travel on buses and trains etc. This builds on what the students have learned from the previous lesson.

MAIN 1

Students are asked to move in a circular path at the same speed whilst initially being equally spaced apart. Eventually, some students will slow down and create congestion in the circular path that can be used to model a traffic jam on a road or a motorway. They then watch a video on phantom traffic jams:

youtube.com/watch?v=Suugn-p5C1M

Highlight the phenomena and discuss the impact this has on peoples' journey times around London. Students discuss how vehicles on the road reduce their speed when there is congestion and consider the forces acting on the vehicle to slow it down.

MAIN 2

Students discuss a tube journey they have been on and consider what happens to a person standing up when the tube is moving. Students use force arrows to represent images of vehicles that are accelerating, travelling at a steady speed and decelerating (Resource 2.1: Representing motion using force arrows, page 18). Special attention must be paid to misconceptions of:

- Balanced forces representing a stationary vehicle.
- A greater resistive/retarding force representing a reversing vehicle.

Differentiation

Students consider the forces acting on people in a vehicle that is travelling around a bend and use force arrows to represent these. This can lead onto a discussion about passengers in cars and buses needing to wear their seat belts in case a vehicle comes to a sudden stop and the need for lower speed limits in built up areas. Students also consider how different road surfaces and conditions affect friction between wheels and the road when stopping a vehicle.

MAIN 3

Students watch a music video of people dancing and create a dance routine of force arrows for other students to dance to. An example has been given (Resource 2.2: Sample dance routine, page 22).

Differentiation

Students design a dance routine and the students dancing must quickly calculate the resultant force of two forces.

Students use Resource 2.3: Resultant forces (page 23) to calculate resultant forces on objects in one plane.

Differentiation

Students calculate resultant forces on objects in two planes.

Plenary

Students write a paragraph about a person standing on a tube as they make a journey travelling on a train between two stations and the forces they experience due to the motion of the train. They relate the idea of the person moving when the tube moves out of and into a station to the unbalanced forces acting on the person and the constant speed between stations to the balanced forces with zero resultant force.

Differentiation

Students draw the forces acting on a person standing on a tube as it leaves the station, as it travels at a constant speed between stations and as it enters a station to stop.

Assessment opportunities

- Revisiting learning outcomes and success criteria
- Targeted questions
- Confidence checks (traffic lights)
- Prior knowledge check
- Assessment of homework task

Homework ideas

Students consider how cars and public transport are designed with safety features such as seat belts, air bags, rounded corners and emergency exits and how they link with the concepts of forces to make travelling safer.

LESSON 2: STOP STARTING LONDON

RESOURCE 2.1: REPRESENTING MOTION USING FORCE ARROWS

Use force arrows to represent this bus accelerating.

If you associate values in Newtons for your force arrows, can you calculate the resultant force in each case.

Be careful: a negative resultant force does not mean that a vehicle is reversing!

LESSON 2: STOP STARTING LONDON

RESOURCE 2.1: REPRESENTING MOTION USING FORCE ARROWS CONTINUED

Use force arrows to represent this bus travelling at a constant speed.

If you associate values in Newtons for your force arrows, can you calculate the resultant force in each case.

Be careful: a negative resultant force does not mean that a vehicle is reversing!

LESSON 2: STOP STARTING LONDON

RESOURCE 2.1: REPRESENTING MOTION USING FORCE ARROWS CONTINUED

Use force arrows to represent this bus decelerating.

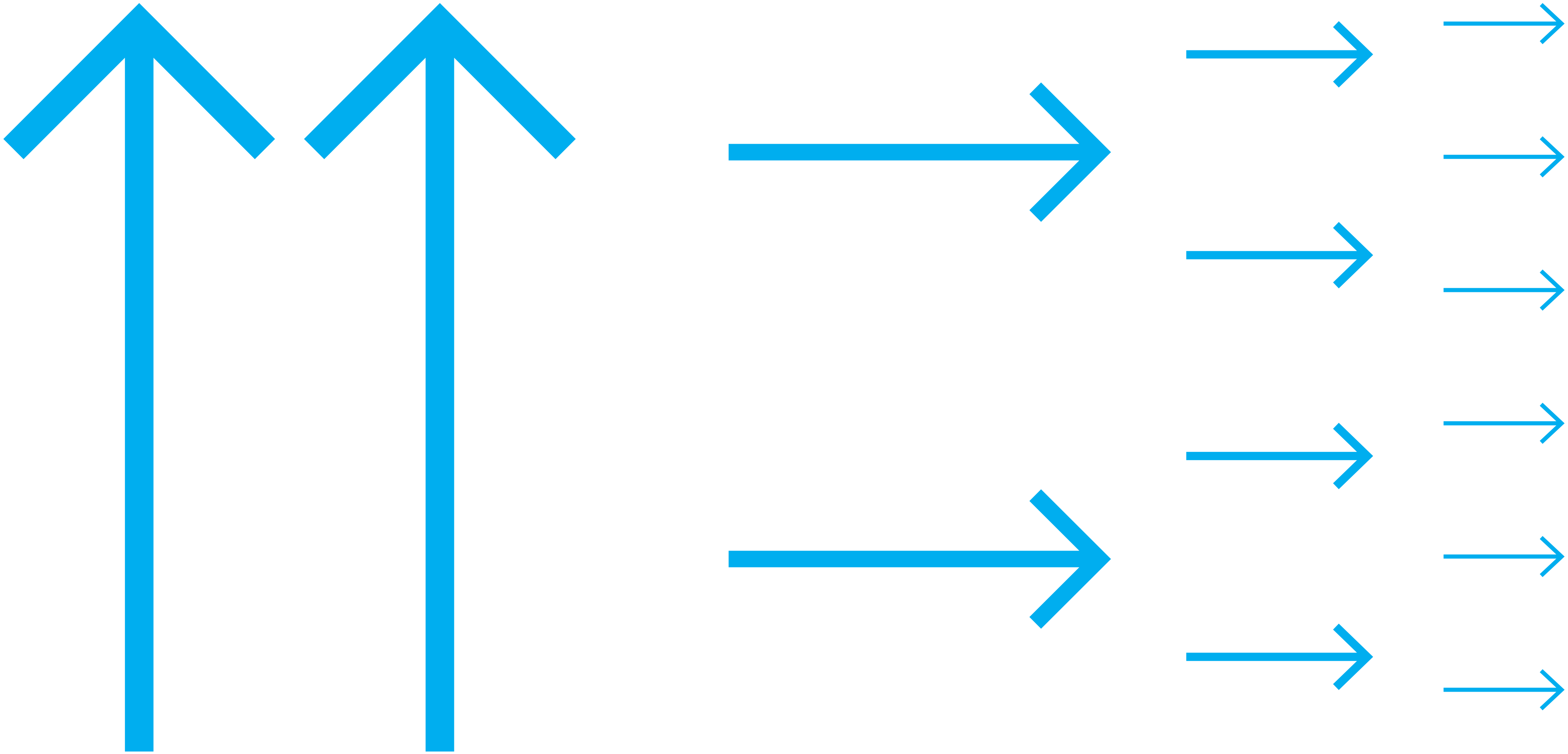
If you associate values in Newtons for your force arrows, can you calculate the resultant force in each case.

Be careful: a negative resultant force does not mean that a vehicle is reversing!

LESSON 2: STOP STARTING LONDON

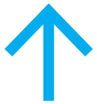
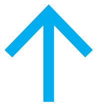
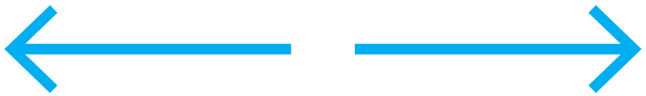
RESOURCE 2.1: REPRESENTING MOTION USING FORCE ARROWS CONTINUED

Force arrows



LESSON 2: STOP STARTING LONDON

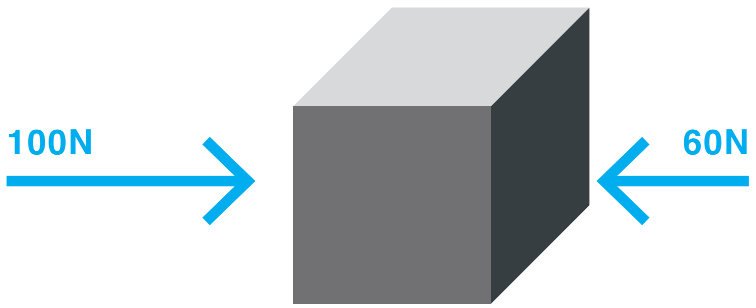
RESOURCE 2.2: SAMPLE DANCE ROUTINE

STEP NUMBER	FORCE ARROW	INSTRUCTION
1		Step left
2		Step right
3		Step forward
4		Step back
5		Step left
6		Step diagonally back right
7		Step forward
8		Don't move

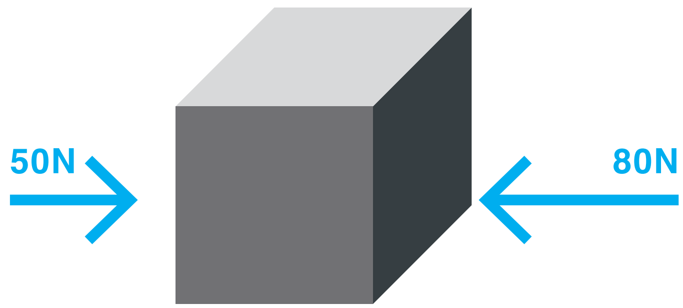
LESSON 2: STOP STARTING LONDON

RESOURCE 2.3: RESULTANT FORCES

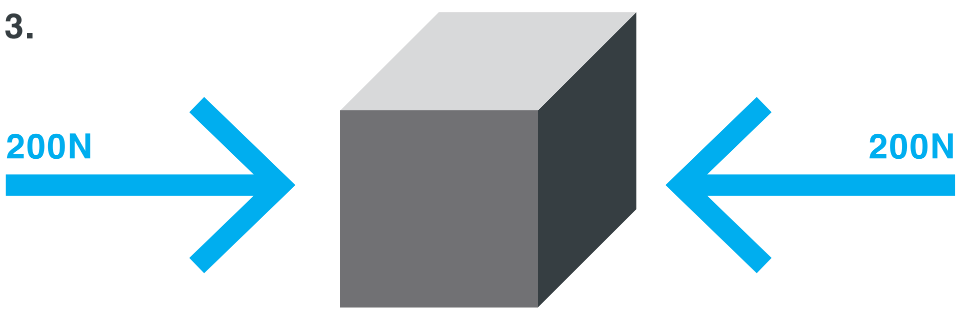
1.



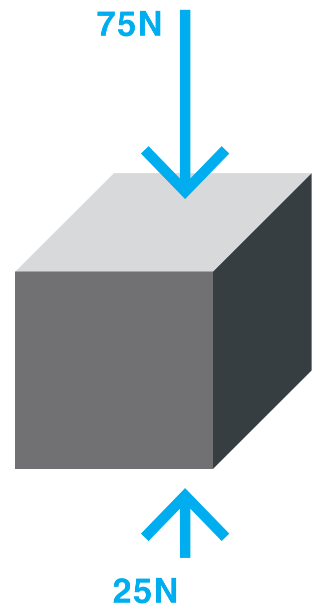
2.



3.



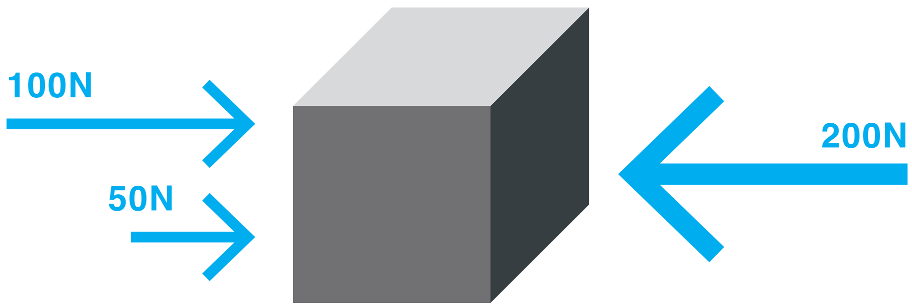
4.



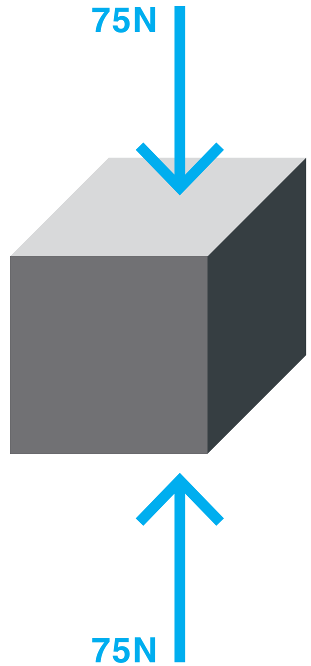
LESSON 2: STOP STARTING LONDON

RESOURCE 2.3: RESULTANT FORCES CONTINUED

5.

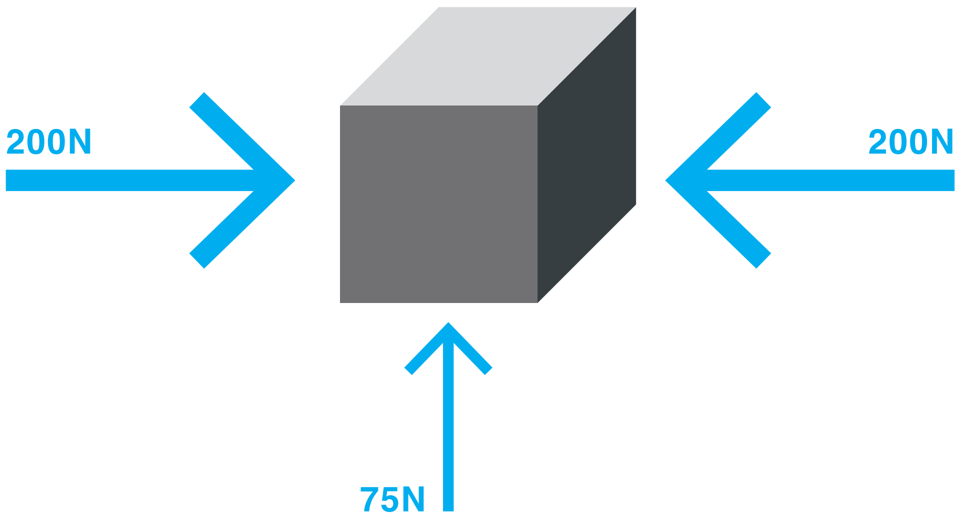


6.



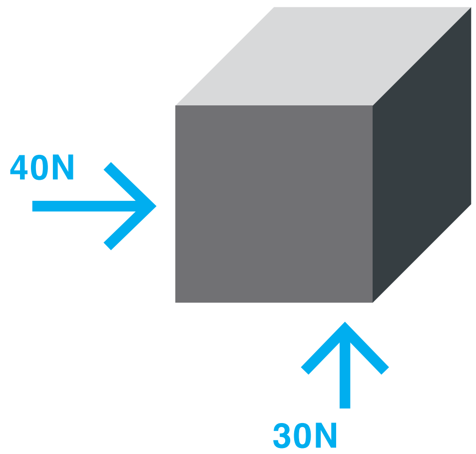
7.

Extension



8.

Extension



LESSON 3
KEEPING LONDON MOVING

THE BIG IDEA

Where does the energy come from to keep London moving? Students can represent simple energy transfers (Sankey Diagrams) relating to change in motion for different modes of transport and different types of fuel in London.

Using examples from London's transport, students can explain how an increase in aerodynamics corresponds to increased energy efficiency and reduced energy and fuel consumption and use a Sankey diagram to represent this.

National Wind tunnel network:

nwtf.ac.uk/html/index.html

LEARNING OUTCOMES

Could be able to calculate energy efficiency for different modes of transport.

Should be able to explain the importance of streamlined design to prevent wasted energy and improve energy efficiency.

Must be able to describe the different sources of energy for different modes of transport and discuss how waste energy can be reduced.

RESOURCES

Resource 3.1: Sankey diagrams for London Underground tube

Resource 3.2: Table template for time of flight investigation

Resource 3.3: Aerodynamic vehicle images

Resource 3.4: Sankey diagram calculations

LESSON 3
KEEPING LONDON MOVING

YOU WILL ALSO NEED

- A4 sheet of paper
- Metre ruler
- Timer
- Graph paper
- Video of bullet trains: **youtube.com/watch?v=VdFD2hy7kFM**
- Video of maglev vehicles: **youtube.com/watch?v=PTo-krTSZBA**

LANGUAGE AND NUMERACY

Key words:

- Surface area
- Energy efficiency
- Aerodynamic
- Sankey diagram

Numeracy skills:

- Calculate useful energy or wasted energy when given the total energy
- Calculation of energy efficiency as a percentage using the equation

LESSON 3: KEEPING LONDON MOVING

SETTING THE SCENE

Pollution, emissions and air quality are key issues to many people living in and visiting London. There is a lot of concern about the limited supplies of non-renewable fuels and their adverse impact on the environment. New energy technologies are being used in private electric cars, hybrid buses and hydrogen fuel cell vehicles. Many large vehicles are aerodynamically designed to improve their energy efficiency to ultimately reduce their emissions.

Students will have the opportunity to investigate the energy transfers involved in various transport methods and the importance of improving their energy efficiency.

LESSON 3: KEEPING LONDON MOVING

ACTIVITIES

STARTER

Students race wind-up toys along a one metre straight path. They then discuss how a wind-up toy gets its energy and why it doesn't just keep on moving. They then discuss what happens to the energy in the spring when the toy is left to move (considering the wasted energy of sound and some heat). They are asked to consider the energy transfers in a road vehicle.

MAIN 1

The students are asked to discuss how a London Underground tube, a DLR train or a London Tram gets its energy to be able to move. They are asked to consider what happens to the energy (how it is transferred) and how this might be represented on a diagram before being shown a Sankey diagram showing useful and wasted energy for a tube (Resource: 3.1 Sankey Diagrams, for London Underground tube, page 30).

They then discuss where the energy comes from for cars, bicycles and buses (including hybrid buses, hydrogen fuel cell buses and the new, more energy efficient Routemaster buses). Students then draw Sankey diagrams for a different mode of transport and compare them to see which they think is the most efficient.

MAIN 2

Students are asked to consider where the energy for electric vehicles comes from in answer to the statement that "Electric cars are greener than petrol engine cars". Students can debate the statements in groups.

MAIN 3

Students measure the time it takes for a piece of A4 paper to reach the table surface from a 50 cm height and recorded in an appropriate table. This is done three times to produce an average time of fall value. The investigation is repeated for as many times that the paper can be folded in half. A graph of results is drawn to show how the time decreases as the surface area decreases, thus the speed increases. This can lead to a discussion about how less energy is lost due to resistive forces when a moving object is streamlined.

Differentiation

Use Resource 3.2: Table template for time of flight investigation (page 31).

MAIN 4

Students look at images of a Routemaster bus, a Javelin train and a heavy goods vehicle (HGV) (Resource 3.3: Aerodynamic vehicle images, page 32) and discuss their design in terms of their shape and the speeds that they would travel at and how they are designed to reduce air resistance to be more energy efficient. The students can use results from their investigation in Main 2 to relate their ideas about surface area and kinetic energy.

Students discuss the importance of vehicles being energy efficient to improve air quality in London by reducing the amount of harmful pollution as well as reducing the reliance on non-renewable energy sources.

Plenary

Students watch a video about bullet trains in Japan:

youtube.com/watch?v=VdFD2hy7kFM

and maglev vehicles:

youtube.com/watch?v=PTo-krTSZBA.

Students discuss the importance of reducing resistive forces for high-speed travel and how this can improve energy efficiency.

Assessment opportunities

- Revisiting learning outcomes and success criteria
- Targeted questions
- Confidence checks (traffic lights)
- Prior knowledge check
- Assessment of homework task

Homework ideas

Students complete calculations for energy efficiency using Sankey diagrams (Resource 3.4: Sankey diagram calculations, page 33).

LESSON 3: KEEPING LONDON MOVING

RESOURCE 3.1: SANKEY DIAGRAM FOR A LONDON UNDERGROUND TUBE

$$\text{ENERGY EFFICIENCY} = \frac{\text{USEFUL ENERGY TRANSFERRED}}{\text{TOTAL ENERGY USED}}$$

$$60\% = \frac{60}{100}$$

LESSON 3: KEEPING LONDON MOVING

RESOURCE 3.2: TABLE TEMPLATE FOR TIMING OF FLIGHT INVESTIGATION

SURFACE AREA OF A4 SHEET	1ST TIMING (S)	2ND TIMING (S)	3RD TIMING (S)	AVERAGE TIMING (S)
Full (1 – no folds)				
Half (1/2 – one folds)				
Quarter (1/4 – two folds)				
Eighth (1/8 – three folds)				
Sixteenth (1/16 – four folds)				
Thirty-second (1/32 – five folds)				
Sixty-forth (1/64 – six folds)				

LESSON 3: KEEPING LONDON MOVING

RESOURCE 3.3: AERODYNAMIC VEHICLES

ROUTEMASTER BUS
© Transport for London

HEAVY GOODS VEHICLE (HGV)
© CC 2.0

JAVELIN TRAIN
© Matt Buck CC 2.0

LESSON 3: KEEPING LONDON MOVING

RESOURCE 3.4: SANKEY DIAGRAM CALCULATIONS

An old London black cab is found to have only 20% of the total energy transferred as useful kinetic energy and 15% is transferred as waste sound energy.

How much energy is wasted as heat?

Use the graph opposite to draw a Sankey diagram for the old London black cab. Label the arrows with:

- total input energy
- useful output energy transferred as kinetic energy
- wasted output energy transferred as heat
- wasted output energy transferred as sound

LESSON 3: KEEPING LONDON MOVING

RESOURCE 3.4: SANKEY DIAGRAM CALCULATIONS CONTINUED

A brand new London black cab transfers 45% of the total input energy to kinetic energy and 50% is transfered as wasted heat energy.

How much energy is wasted as sound?

Use the graph opposite to draw a sankey diagram for the new London black cab.

Using the formula calculate the energy efficiency for the old and new London black cabs.

Explain why there is a difference between the old and new London black cabs.

LESSON 4
TRAVELLING SAFELY IN LONDON

THE BIG IDEA

London Greenways are safe routes for Londoners to walk and cycle to reduce congestion and pollution and improve peoples' health. Students will investigate factors of safety when riding a bicycle particularly when riding on roads along with other traffic. Ideas about safe speed limits and road surfaces will be investigated to highlight the importance of safety on London's roads for all its users.

LEARNING OUTCOMES

Could be able to describe how different surfaces improve safety at crossings due to increase in frictional force.

Should be able to explain how cycle super highways and traffic lights are designed for safer cycling in London.

Must be able to describe the safety measures required for cycling on the roads.

RESOURCES

Resource 4.1: Colliding objects

YOU WILL ALSO NEED

Health impacts of cars in London

Greater London Authority, September 2015
www.london.gov.uk/sites/default/files/health_impact_of_cars_in_london-sept_2015_final.pdf

LESSON 4
TRAVELLING SAFELY IN LONDON

YOU WILL ALSO NEED

- You will also need
- Modelling clay/eggs
- Foam
- Newspaper
- Steel balls
- Ramp
- Modelling clay to stop steel balls
- Ruler to measure impact of steel balls on modelling clay
- Datasheet with car journey facts about London
- Laptops/ipads with access to TfL website: **tfl.gov.uk**
- Rubber soled shoe
- Different materials to represent surfaces for friction investigation
- Newtonmeter
- London Greenways: **sustrans.org.uk/blog/finding-adventure-london%E2%80%99s-greenways**

LANGUAGE

Key words:

- Congestion
- Pollution

LESSON 4: TRAVELLING SAFELY IN LONDON

SETTING THE SCENE

Cycling safety in London depends on necessary safety precautions such as wearing a helmet and ensuring you are visible whilst riding your bike. It is also vital that you are aware of and observe the rules of the road. Before venturing on the road with your bike it is useful to complete a cycle safety course. London Greenways exist for cyclists and walkers to experience the city with a reduced amount of traffic, making it safer as well as helping to reduce congestion and pollution.

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LESSON 4: TRAVELLING SAFELY IN LONDON

ACTIVITIES

STARTER

The importance of wearing a helmet when cycling is demonstrated by dropping two identical pieces of modelling clay (or eggs) from the same height onto the floor. One of the pieces of modelling clay is surrounded by a protective layer (e.g. foam) to prevent it from deforming as much as the unprotected piece of clay. Students discuss the differences in the impacts in relation to wearing a helmet when cycling.

MAIN 1

Students investigate how the impact of steel balls travelling down a ramp into a wall of modelling clay changes in relation to the ball's speed. This models how accidents occuring at high speeds due to vehicles having greater kinetic energy may lead to more damage on impact (Resource 4.1: Colliding objects, page 40). The deeper the impact of the ball on the modelling clay, the greater the energy which corresponds to a higher speed due to the ramp being inclined at a steeper angle.

MAIN 2

Students analyse how cars have an impact on health in London with reference to *Health impacts of cars in London.*

www.london.gov.uk/sites/default/files/health_impact_of_cars_in_london-sept_2015_final.pdf

They discuss the issues raised and identify solutions to create an information leaflet that could be used by the school.

MAIN 3

Students use the TfL website to investigate how bus and cycle lanes and traffic lights are used to make cycling safer in London.

MAIN 4

Students design an investigation to see how different surfaces affect the motion of objects moving on the surface. They can use a rubber-soled shoe to represent a tyre and a Newton meter to measure the force of moving the shoe across different surfaces. Students discuss their results in relation to different road surfaces, particularly focussing on the higher friction surfaces at Zebra and Pedestrian crossings. This leads to a discussion about how different weather conditions affect safety on the roads.

Plenary

Students discuss the benefits and risks of cycling in London and measures taken to limit accidents.

Assessment opportunities

- Revisiting learning outcomes and success criteria
- Targeted questions
- Confidence checks (traffic lights)
- Prior knowledge check
- Assessment of homework task

Homework ideas

Students produce a leaflet to promote cycling highlighting critical safety features and the benefits cycling brings to London's transport network.

LESSON 4: TRAVELLING SAFELY IN LONDON

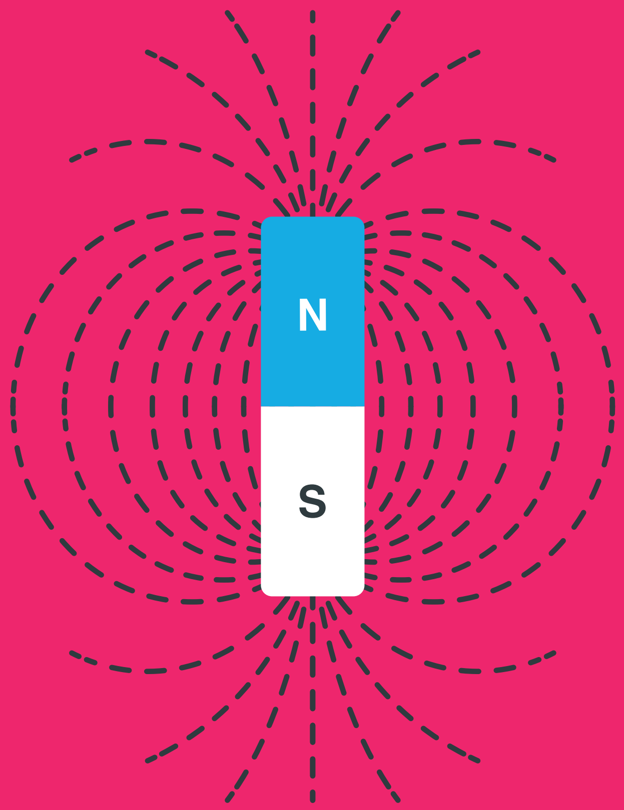
RESOURCE 4.1: COLLIDING OBJECTS

HEIGHT OF RAMP END (CM)	DEPTH OF COLLISION 1 (CM)	DEPTH OF COLLISION 2 (CM)	DEPTH OF COLLISION 3 (CM)	AVERAGE DEPTH OF COLLISION 4 (CM)

EXPLORE

The explore section suggests possible educational visits for students to learn more about the physics behind London's transport network. This includes a data collection project regarding the use and frequency of transport locally at different times of the day. They can explore the local public transport links in their area too.

Visits to museums such as the London Transport Museum and the Science Museum will enable students to explore some of the history and future of transport in London and around the world. A visit to the Crystal will expose the students to ideas about the sustainable development of London's infrastructure.



EXPLORE
LONDON'S TRANSPORT

THE BIG IDEA

London has evolved into one of the world's great cities. As more people are attracted to London it is important that its infrastructure develops to cater for its change in size as well as getting its population to think about issues relating to sustainability when they make local journeys.

LEARNING OBJECTIVES

Could: argue the importance of sustainability in relation to the planet's energy resources

Should: be able to describe the evolution of London's transport infrastructure with some speculation on how it will continue to evolve

Must: collect and analyse data about road use around their school at different times of the day.

EXPLORE

OPTION 1: LOCAL TRANSPORT SURVEY

Students can monitor the types of transport used in their local vicinity outside of their school by collecting and analysing data of the local traffic. Students can also investigate differences in traffic volumes at different times of the day and make connections with London refuelled, the London Curriculum chemistry unit, relating to congestion and pollution.

Students can compare their area with others by using the London Bus tracker where they are able to monitor different bus routes:

traintimes.org.uk/map/london-buses/#73

This can lead to discussions as to what technology is used to do this, how useful it is for Londoners and those visiting the city and reasons for the frequency of use of some bus routes.

EXPLORE

OPTION 2: VISIT TO A TRANSPORT EXHIBITION

London Transport Museum

Covent Garden Piazza, WC2E 7BB

020 7565 7298
bookings@ltmuseum.co.uk

London Transport Museum explores the story of London and its transport system over the last 200 years, highlighting the powerful link between transport and the growth of modern London, culture and society since 1800. As well as exploring the past, the Museum looks at present-day transport developments and concepts for urban transportation in the future.

www.ltmuseum.co.uk/learning/schools

Science Museum

Exhibition Rd, SW7 2DD

0870 870 4868

At the Science Museum the two most relevant galleries to visit are 'Making the Modern World' to explore the history and development of transport and the 'Engineering your future' gallery, which allows students to model transport engineering challenges through the use of interactive games.

The Science Museum has a teacher resource pack for the 'Engineering your future' gallery:

www.sciencemuseum.org.uk/visitmuseum/Plan_your_visit/exhibitions/engineer_your_future

The Crystal

One Siemens Brothers Way, E16 1GB

0207 055 6400
education@thecrystal.org

Students could be taken to The Crystal sustainable development hub where they can explore the idea of sustainable development. In particular they could visit the 'Keep Moving' zone to explore the increased need for efficient transport infrastructure in London. Students can discover and reflect in the significance of green transport choices, integrated traffic solutions and e-mobility.

www.thecrystal.org

THE CRYSTAL
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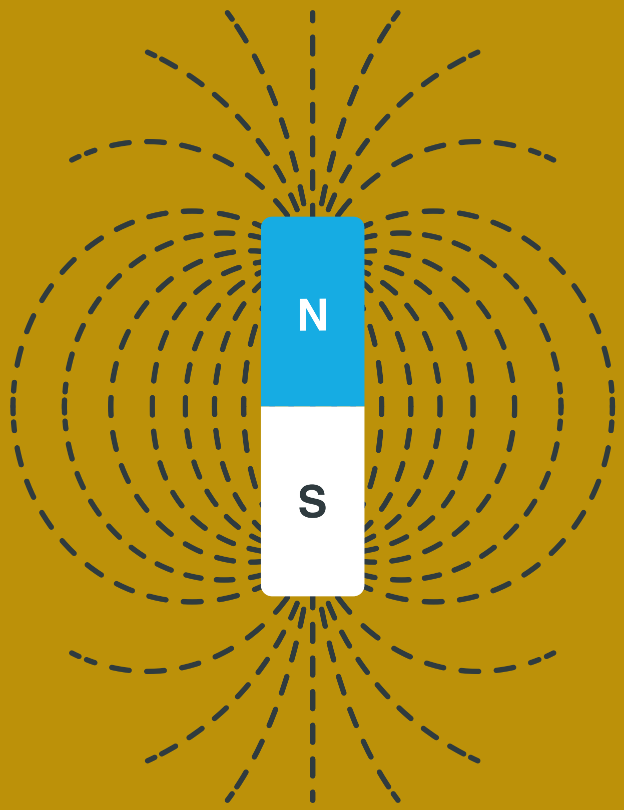
CONNECT

London continues to see new innovations in transport design, including research into driverless cars at the O2 Arena in Greenwich.

Despite all the innovations transport still depends on the humble wheel and has to overcome the frictional limitations that goes with its use. In this final section, students research new types of high speed transport and design a new vehicle, giving information about its use, location and route.

Inviting a design engineer into the classroom would allow students real world insight into the process of creating a newly designed vehicle.



LESSON 6
TRANSPORTING LONDON TO THE FUTURE

BIG IDEA

London relies on continual innovation in transportation as its population and increases. New technologies are necessary to improve the travelling experience for Londoners in terms of speed, safety and reduced negative environmental impact. Students will design their London transportation of the future utilising ideas they have learned in the previous Discover and Explore sessions of this unit.

LEARNING OBJECTIVES

Could be able to quantify the energy efficiency of their vehicles.

Should be able to explain how their futuristic vehicle will be energy efficient and reduce levels of pollution.

Must be able to design a futuristic vehicle that meets agreed criteria.

RESOURCES

Resource 6.1: Design template

YOU WILL ALSO NEED

Paper and colouring pens for designs

Video of bullet trains:

youtube.com/watch?v=VdFD2hy7kFM

Video of DLR:

youtube.com/watch?v=TrLRLHpxr-8

Video of driverless cars:

youtube.com/watch?v=tiwVMrTLUWg

LESSON 6
TRANSPORTING LONDON TO THE FUTURE

LANGUAGE AND NUMERACY

Key words:

- Average speed
- Distance
- Streamlined
- Futuristic
- Ecological

Numeracy skills:

- Calculation of energy efficiency using efficiency = useful energy/total energy.

LESSON 6: TRANSPORTING LONDON TO THE FUTURE

SETTING THE SCENE

Transport in London is constantly changing and evolving as it caters for a growing population and attempts to reduce the emissions produced by London vehicles. Future projects include more cycle highways with their own traffic control and Crossrail. New technologies allow for once polluting buses and heavy goods vehicles to reduce their carbon emissions. At the O2 Arena there are now driverless vehicles to transport people around the complex. The Dockland's Light Railway has had driverless trains for decades and technologies are advancing that allow for driverless cars to be able to travel on public roads.

As London continues to expand and develop, students are tasked with looking to the future to develop transportation for a modern conurbation like London. Technologies from across the world could be used to develop London's transportation links to make them faster and more energy efficient and at the same time tempt more people to leave their cars at home and use public transport.

LESSON 6: TRANSPORTING LONDON TO THE FUTURE

ACTIVITIES

STARTER

Students are shown videos of bullet trains, the DLR and driverless car projects as examples of innovations in transport and technology.

MAIN 1

Students use available resources to design a London transport vehicle of the future after agreeing criteria for their vehicles, e.g. materials, what speeds it will travel at, energy source, number of people it can carry etc. Students will present their vehicles to the rest of the class. Ideas of speed, energy and energy efficiency, forces and safety should be implemented in their designs building on what they have learned throughout the module.

Plenary

A review of the module by way of presentations of their futuristic transportation.

Assessment opportunities

- Revisiting learning outcomes and success criteria
- Targeted questions
- Confidence checks (traffic lights)
- Prior knowledge check

Homework ideas

Students create a powerpoint presentation about how they went about designing their futuristic London vehicle and the benefits it has relating to the environment, energy consumption and passenger safety.

LESSON 6: TRANSPORTING LONDON TO THE FUTURE

RESOURCE 6.1: DESIGN TEMPLATE

Type of energy source required.

Why have you chosen this energy source?

Will your vehicle travel on road, rail, other?

What distances will your vehicle travel?

How fast will your vehicle travel?

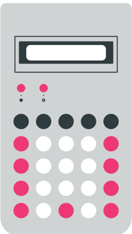
How many passengers will your vehicle hold?

How will you ensure that it is safe for its passengers and other vehicles?

What impact will it have on the environment?

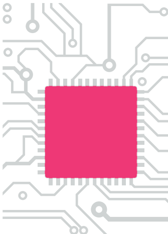
LINKS TO OTHER LONDON CURRICULUM SUBJECTS

London's Driving forces is part of London on the Move, a set of London Curriculum teaching resources that explore the application of STEM subject in the transport systems of the city.



MATHS

London on the move
This unit is part of a set of three exploring the science and technology that keeps London's transport moving.



COMPUTING

The Connected city examines the role computing plays in keeping journeys on the road network in particular reliable and safe.

CREDITS

The GLA would like to thank the following organisations for their contribution:

Our collaborators on the London Curriculum

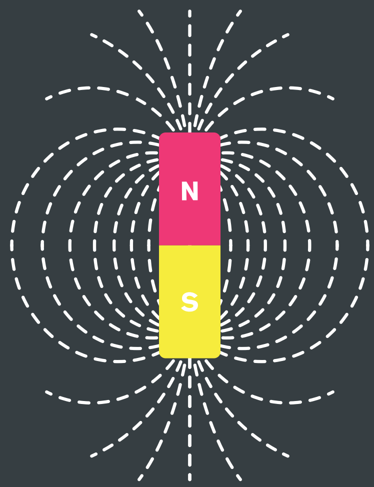
MUSEUM OF LONDON

UCL Institute of Education

Design **www.thirteen.co.uk**

Greater London Authority
City Hall
The Queen's Walk
London SE1 2AA

www.london.gov.uk
enquiries 020 7983 4100
minicom 020 7983 4458



‘The idea of using London as a teaching resource has never been explored much before, so both students and teachers are excited about it’

Key stage 3 teacher

‘It makes me feel proud to be a Londoner’

Key stage 3 student