SCIENCE | BTEC LEVEL 2 | EDEXCEL

Teaching Pack

For BTEC First Award in Applied Science
Unit 6: Applications of Physical Science

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BTEC Next Generation

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Contents

Thank You for Choosing ZigZag Education ii
Teacher Feedback Opportunity iii
Terms and Conditions of Use iv
Teacher's Introduction 1
Lesson Plan 1: Investigate Motion: Speed and Velocity 4
Speed and Velocity Questions 7
Lesson Plan 2: Investigate Motion: Acceleration 10
Acceleration Questions 13
Lesson Plan 3: Investigate Motion: Conservation of Energy 18
Conservation of Energy Questions 22
Lesson Plan 4: Investigate Motion: Energy and Braking 25
Energy and Braking Questions 27
Assignment A: Velocity, Acceleration and Energy Transfers 29
Lesson Plan 5: Investigate Forces: Resultant Forces 32
Resultant Forces Questions 35
Lesson Plan 6: Investigate Forces: Forces and Work 37
Forces and Work Questions 39
Lesson Plan 7: Investigate Forces: Resistive Forces 41
Resistive Forces Questions 44
Assignment B: Investigate Forces 46
Lesson Plan 8: Investigate Waves: Reflection of Light and Sound 48
Reflection of Light and Sound Questions 51
Lesson Plan 9: Investigate Waves: Refraction of Light 53
Refraction of Light Questions 56
Lesson Plan 10: Investigate Waves: Lenses and the Eye 58
Lenses and the Eye Questions 61
Lesson Plan 11: Investigate Waves: Sound Waves 63
Sound Waves Questions 66
Assignment C: Light and Sound Waves 68
Lesson Plan 12: Investigate Electricity: Electric Circuits 70
Electric Circuits Questions 74
Lesson Plan 13: Investigate Electricity: Series and Parallel Circuits 76
Series and Parallel Circuits Questions 81
Lesson Plan 14: Investigate Electricity: Thermistors and LDRs 84
Thermistors and LDRs Questions 88
Assignment D: Electric Circuits, Thermistors and LDRs 91
Answers to Questions 93

Teacher's Introduction

This unit is taught over 30 guided learning hours (GLH). Teachers will have different approaches to the balance between teaching and working on assignments, as well as when they carry out assignment work. This scheme of work suggests splitting the time into 14 teacher-taught hours, ten assignment lessons and six spare lessons for additional assignment time to obtain missed assessment criteria and also catch-up time for students who have missed lessons or need extra support. For differentiation purposes, information that only distinction-level students need is marked in a boxes with a D symbol. 'Did you know' boxes are included to give students some fun or useful extra information about the topic – they do not need to know this information to complete their assignments.

This pack contains the following materials:

1. A single-page overview scheme of work
2. 14 lesson plans
3. Notes for each lesson covering all the learning aims between them
4. Questions in non-write-on and write-on format to reinforce learning, with answers
5. Assignments covering all the assessment criteria between them

This resource is designed to be flexible in the following ways:

- Proposed assignment tasks have been put into suggested slots after the relevant material has been covered.
- The assignments provided in this pack are designed to be independent of each other so that any one can be substituted if you have a preferred assignment from elsewhere.
- For each lesson there is a lesson plan followed by student notes and questions. Questions are then repeated provided in write-on format. You could use the material in one of the following ways:
    1. Use the notes to support your classroom teaching and then hand out either the non-write-on questions or the write-on questions at the end of the lesson (possibly for homework).
    2. Use the notes to supplement your own notes or the textbook and hand them out at the end of the lesson as a summary with the questions, so students can complete the questions using the notes as support.
    3. Just use the questions (either write-on or non-write-on as appropriate) at the end of the lesson and subsequently hand out the notes at revision time.

If using this resource for assessed work, then as with all BTEC assignments they must be **internally verified**. Also you must check suitability with the board* and follow the **important disclaimer notice below**.

* Note: Pearson BTEC / Edexcel currently offer a free Assignment Checking Service.

IMPORTANT DISCLAIMER REGARDING ASSESSMENT: if you choose to use the assignments in this resource for assessed work, it is your responsibility to internally verify them and to check with Edexcel that the material you use is suitable. This includes the requirement from September 2014 not to conduct 'interim assessment' within a Learning Aim. You should **not** use the material in this resource for actual assignments unless you have checked their suitability with Edexcel. The awarding body specifies the level of support that students can be given and you **must** check the level of support given in this pack is appropriate to meet these needs and as necessary **adjust and use the resource appropriately to meet these requirements**. Please check for the most up-to-date information from Edexcel at: ***http://www.edexcel.com/btec/Pages/default.aspx***. Note that relevant paperwork for practical work, such as observation sheets, should also be obtained from Edexcel. Assignment details and requirements from the awarding bodies sometimes change after their initial published requirements and so you must check that the resource material here is in line with the latest requirements **before use**.

Update (July 2014)
A new 'Important Disclaimer Regarding Assessment' has been added in the introduction.

Update: 2nd edition (February 2015)
Following changes to BTEC assessment rules which affect learners registered from 1st September 2014, this resource has been amended to meet these rules:

- Resubmission dates have been removed from all assignment briefs (pages 29, 46, 68, 91)

In addition, to meet current assessment rules, essential changes have been made, including:

- Assignment briefs each cover one Learning Aim in full. Therefore:
  - Assignments 1 and 2 have been merged and edited (pages 29, 30)
  - Assignments 4 and 5 have been merged and edited (page 68)
  - Assignments 6 and 7 have been merged and edited (page 91)
  - Teacher's Introduction and Suggested Scheme of Work have been amended accordingly (pages 1, 3)
- Text aimed at students does not refer to Level 1 tasks or criteria (pages 29, 30, 31, 46, 47, 68, 69, 91, 92)

Other amendments: assignments have been renamed to be consistent with the Learning Aims:

- Merged assignments 1 and 2 have been renamed Assignment A (page 29)
- Assignment 3 has been renamed Assignment B (page 46)
- Merged assignments 4 and 5 have been renamed Assignment C (page 68)
- Merged assignments 6 and 7 have been renamed Assignment D (page 91)

Suggested Scheme of Work

GLH	LP	Title
1	1	Investigate Motion: Speed and Velocity
2	2	Investigate Motion: Acceleration
3	3	Investigate Motion: Conservation of Energy
4	4	Investigate Motion: Energy and Braking
5–7		**Assignment A: Velocity, Acceleration and Energy Transfers*
8	5	Investigate Forces: Resultant Forces
9	6	Investigate Forces: Forces and W[illegible]
10	7	Investigate Forces: Resist[illegible]
11–13		**Assignment B: Investi[illegible]es*
14	8	Investi[illegible] Waves: Reflection of Light and Sound
15	9	[illegible]gate Waves: Refraction of Light
16	[illegible]	Investigate Waves: Lenses and the Eye
17	11	Investigate Waves: Sound Waves
18–19		**Assignment C: Light and Sound Waves*
20	12	Investigate Electricity: Electric Circuits
21	13	Investigate Electricity: Series and Parallel Circuits
22	14	Investigate Electricity: Thermistors and LDRs
23–24		**Assignment D: Electric Circuits, Thermistors and LDRs*
25–30		***Opportunity for catch-up and obtaining missing assignment cri*

Learning Aims Note
'All students should' aims are levelled at Level 1 and Pass students, **'most students should'** aims are levelled at Merit students and **'some students should'** aims are levelled at Distinction students.

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Lesson Plan 1: Investigate Motion: Speed

Learning Aims

All students should:	Measure distance for simple experiments. Calculate speed and velocity for simple experim Produce accurate graphs to represent uniform m
Most students should:	Interpret graphs to identify objects that are stati speed.
Some students should:	Calculate the gradient for distance–time graphs

Keywords: distance, displacement, speed, velocity, gradient

Starter

Review previous learning. Briefly recap speed, distance and time.

Main

1. Brief introduction to distance and displacement, and speed and
2. Introduction to distance–time graphs. On the board, draw a tab object's distance and time – students can plot a graph of these re
3. Review graphs and discuss. Explain what sort of motion is repre graph and explain that the gradient represents speed.
4. Further examples of distance–time graphs – students can calculate the calculate the object's speed.
5. Elicit answers to graph examples and discuss.
6. Air Track Experiment: Students use a rider on an air track to inv object travelling at (close to) uniform speed. Speed can be calcul distance travelled and the time taken. Actual speed values can b (optional).
7. Discuss results of air track experiment with students.
8. Answer Questions 1–7 from the pack.
9. Elicit answers with class discussion.

Plenary

Properties Checklist: Draw up a table of properties of distance, displaceme whether it has a direction, whether it has units of m/s, etc). Students must the table to show which properties apply to each.

Speed and Velocity

Distance and Displacement

Distance and displacement are both measured in metres (m) – but they are not t same. **Displacement** is the distance an object has travelled **in a given direction** – size and a direction. **Distance** only has a size.

For example, if a remote control car travels 5 metres north, then turns around an **distance** travelled is 5 m + 5 m = 10 m. But its **displacement** is zero, because it is from.

Speed and Velocity

Speed and v... y ... distance and displacement – **speed** just has a directio **given direc**... eed and velocity are both measured in metres per second (m/

The **speed** of an object is its rate of change of **distance** travelled:

$$\text{distance travelled (m)} = \text{speed (m/s)} \times \text{time (s)}$$

or

$$\text{speed (m/s)} = \frac{\text{distance travelled (m)}}{\text{time (s)}}$$

The **velocity** of an object is its rate of change of **displacement**:

$$\text{displacement (m)} = \text{velocity (m/s)} \times \text{time (s)}$$

or

$$\text{velocity (m/s)} = \frac{\text{displacement (m)}}{\text{time (s)}}$$

Worked example
A car is travelling along a straight flat road at a constant speed of 40 m/s. How m in 2 minutes?

2 minutes = (2 × 60) s = 120 s

$\text{distance travelled (m)} = \text{speed (m/s)} \times \text{time (s)}$ *= 40 ... 120 s = 4,800 m (or 4*

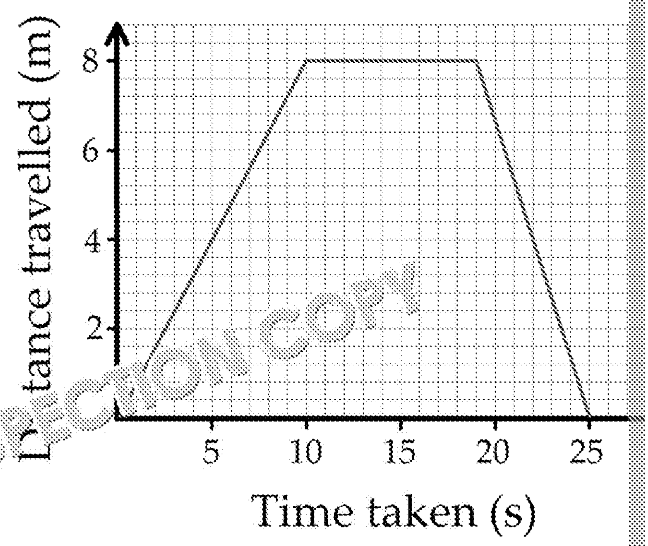
Did you know?
When a car travel... speed camera, the camera measures the time it tak white li... on the road.

The formula $\text{speed (m/s)} = \frac{\text{distance travelled (m)}}{\text{time (s)}}$ is used to work out how is travelling faster than the speed limit!)

Distances in simple experiments can be measured using a **ruler**, **metre rule** or **ta** measured using a **stopwatch**.

Distance–Time Graphs

The distance–time graph of a moving object can tell us a lot about the motion of



The graph shows the motion of a remote-control car.

The first 10 seconds of the graph show a **straight line** sloping upwards. This show travelled is increasing at a steady rate – so the car must be travelling at **constant**

A steeper line would show us that the car's distance was increasing more quickly speed. On the other hand, a less steep line would show us that the car was trave of the line on a graph is called the **gradient**.

- On a distance–time graph, the **gradient** of the line represents **speed**.

From the graph, we can see that in the first 10 seconds the car travell starting point at a steady rate. We can use this information to work o

$$\text{speed (m/s)} = \frac{\text{distance travelled (m)}}{\text{time taken (s)}}$$

So in the first part of this graph, the speed of th was 8 / 10 = 0.8 m

After 10 se th becomes flat. This shows that the car's distance from i therefore th must be **stationary** when the line is **flat**.

After 19 seconds, the line slopes downwards in a straight line and returns to zero returned back to its starting position, travelling at constant speed.

Speed and Velocity Questions

1. What is the difference between distance and displacement?

2. Copy and complete the phrases using some of the following words:

direction	*displacement*	*distance*	*gradient*	*h*
size	*speed*	*stationary*	*velocity*	

________ is speed in a given ________. It is the rate of change of _____ of change of ________. The ________ of a distance–time graph represe object must be ________.

3. An object travels at 5 m/s for 30 seconds. How far does it travel in this

4. In 100 seconds an object travelling at constant speed covers a distance during this time?

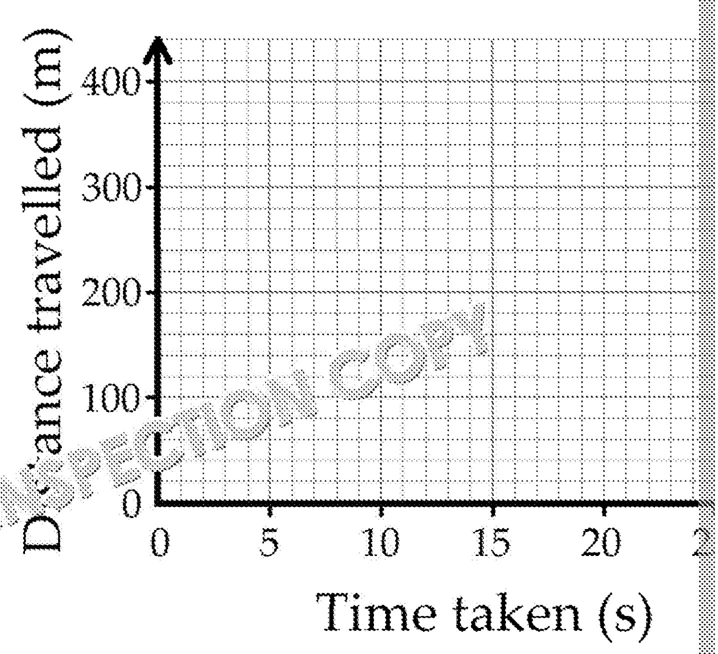
5. An object travels 80 m at a constant speed of 5 m/s. How long does it

6. In the distance–time graph on the information sheet, calculate the spe from 19 seconds onwards.

7. A car is timed travelling along a straight flat road. The results are sho

Time (s)	0	5	10	15	20
Distance (m)	0	40	160	280	340

   a) Copy and complete the graph below with the results.



   b) Calculate the speed of the car between 5 seconds and 15 seconds.
   c) Describe the motion of the car after 20 seconds.

Speed and Velocity Questions

1. What is the difference between distance and displacement?

....

....

2. Complete the phrases using some of the following words:

direction	*displacement*	*distance*	*gradient*	*h*
size	*speed*	*stationary*	*velocity*	

_______________ is spee[illegible]n _______________. It is the rate

_______[illegible]ereas speed is the rate of change of _______________

of a di[illegible]–time graph represents speed. If the line is flat, the object

3. An object travels at 5 m/s for 30 seconds. How far does it travel in this

....

....

4. In 100 seconds an object travelling at constant speed covers a distance during this time?

....

....

5. An object travels 80 m at a constant speed of 5 m/s. How long does it

....

....

6. In the distance–time graph on the in[illegible]sheet, calculate the spe from 19 seconds onwards.

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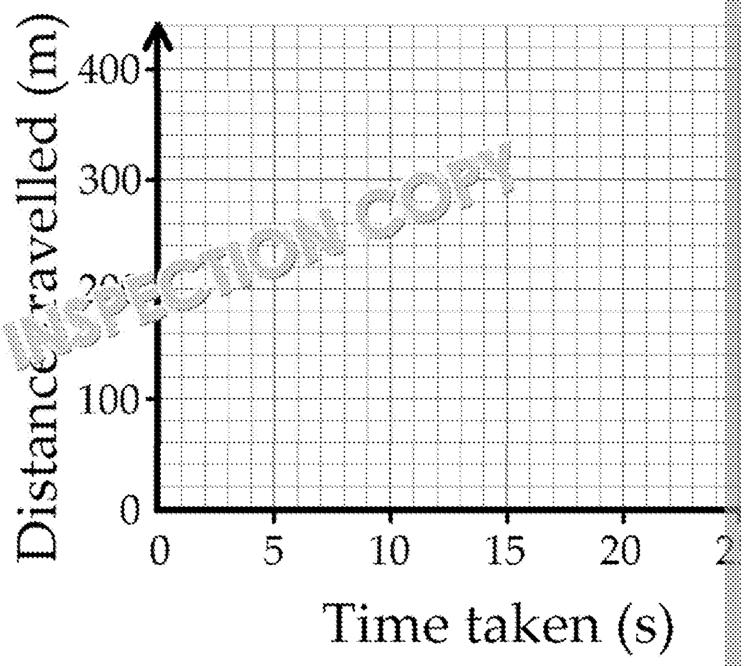
7. A car is timed travelling along a straight flat road. The results are sho

Time (s)	0	5	10	15	20
Distance (m)	0	40	160	280	340

a) Plot these results on the graph below.



b) Calculate the speed of the car between 5 seconds and 15 seconds.

....

....

c) Describe the motion of the car after 20 seconds.

....

....

Lesson Plan 2: Investigate Motion: Ac

Learning Aims

All students should:	Produce accurate graphs to represent uniform a primary data.
Most students should:	Interpret graphs to identify objects that are stati speed and moving with increasing or decreasin
Some students should:	Calculate the gradient and area of speed–time g

Keywords: acceleration, deceleration, velocity, gradient, area

Starter
Review of previous learning. Recap the differences between distance and velocity.

Main

1. Introduction to acceleration as rate of change of velocity. Explai down and changing direction all count as acceleration.
2. Introduction to units of acceleration and the equation for calcula example problems on the board for students to solve.
3. Elicit answers to examples during class discussion.
4. Introduction to velocity–time graphs. On the board, draw a tabl object's velocity and time – students can plot a graph of these re
5. Review graphs and discuss. Explain what sort of motion is repre graph and explain that the gradient represents acceleration and represents distance.
6. Trolley experiment: Students can set up a motion sensor or light measure the speed of a trolley at different points (i.e. near the to ramp), as well as timing the trolley between light gates. Hence, average acceleration down the ramp.
7. Discuss results of trolley experiment with students and what they wo graph and speed–time graphs of the trolley's motion to look like.
8. Answer Questions 1–4 from the pack.
9. Elicit answers during class discussion.

Plenary
Fastest finger first: students to work in small groups. Ask students a series and acceleration and the student that answers each question first gets to lo

Acceleration

When the velocity of an object changes, the object **accelerates**. If an object spee
direction, it is accelerating. The quicker the velocity of an object changes, the gre
velocity and displacement, acceleration has a size and direction.

Calculating Acceleration

The **acceleration** of an object is its **rate of change of velocity** – the amount that i
is calculated using the equation:

$$a = \frac{v-u}{t}$$

where: a is acceleration, in metres per second squared (m/s^2)
u is the initial velocity of the object, in metres per second (m/s)
v is the final velocity of the object, in metres per second (m/s)
t is time taken, in seconds (s)

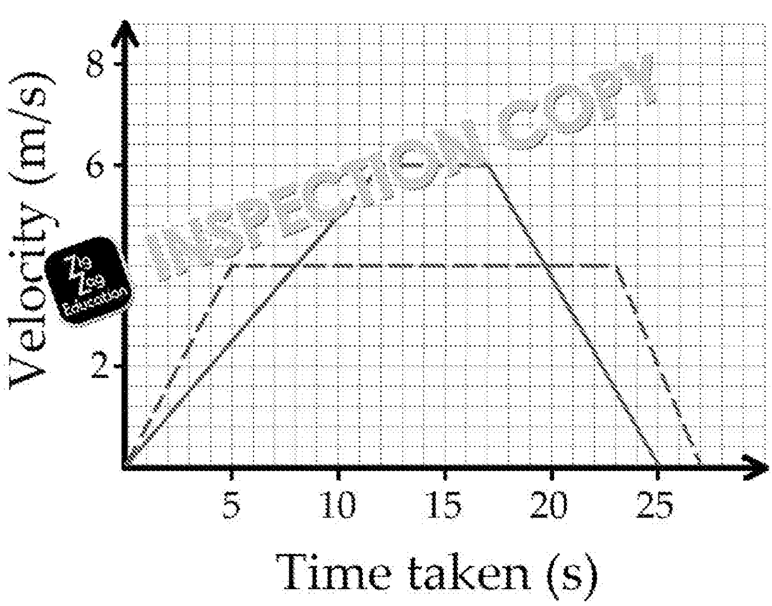
Worked example
A car accelerates from 10 m/s to 30 m/s over a period of 5 seconds. Calculate the

$a = \frac{v-u}{t}$ = *(30 – 10) / 5 = 20 / 5 = 4* m/s^2

Speed–Time Graphs

The features of a speed–time graph (or velocity–time graph) are similar to those
horizontal (flat) line shows that the object's **speed** is not changing, while a slope
speed is changing at a constant rate.

- On a speed–time graph or velocity–time graph, the **gradient** of the line repr
object.
NB: Speed–time graphs and velocity–time graphs are the same, except that
show negative velocity – like the one below.



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Using the acceleration equation, we can calculate that the dotted
first 5 seconds is:

$$a = \frac{v - u}{t} = (4 - 0) / 5 = 0.8 \text{ m/s}^2$$

After 5 seconds, the dotted line becomes flat. This means that the car's **velocity**
travelling at constant velocity.

After 23 seconds, the line slopes back do... ...ds ... zero. This shows that the ca
acceleration is negative).

D

We can also use a speed–time graph to find the total **distance** trave

When we multiply an object's velocity by the time taken, it gives th
travelled. So by finding the **area under the line** on a velocity–time
distance.

On a velocity–time graph, the **area** underneath the line represents t
object.

Tip: *break the total area up into triangles and rectangles and calculate the*
them up.
For a rectangle, the area is simply the base × height.
For a triangle, the area is $\frac{1}{2} \times$ *base × height.*

Acceleration Questions

1. Copy and complete the phrases using some of the following words:

accelerating	*acceleration*	*direction*	*distance*	*gr*
moving	*negative*	*positive*	*size*	*s*

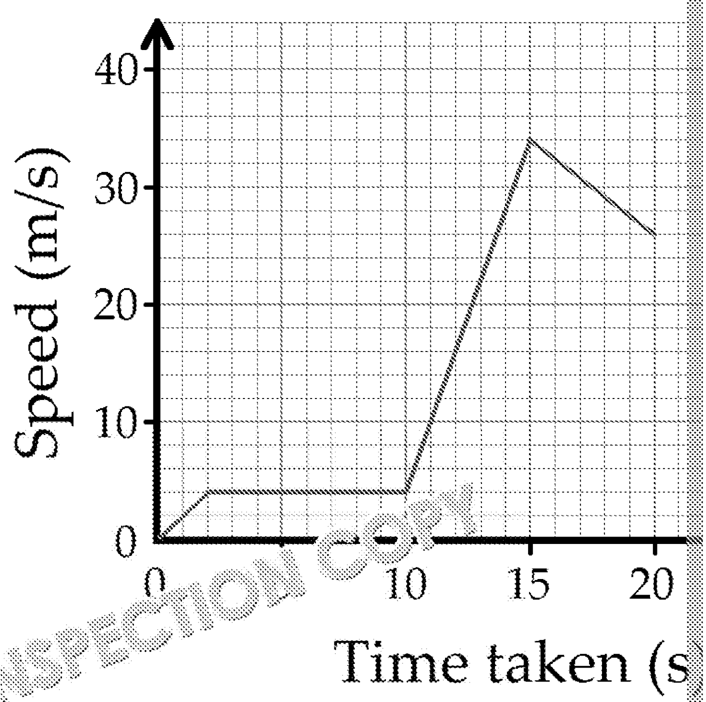
Acceleration is the rate of change of ________. An object is ________ if changes ________. If the acceleration of an object is ________, it can be

The ________ of a velocity–time graph represents ________ and the ar represents ________.

2. In the velocity–time graph on the information sheet, describe the mot
   a) in the first 12 seconds
   b) between 12 seconds and 17 seconds
   c) a[illegible] se[illegible]

3. In the velocity–time graph on the information sheet, calculate:
   a) the initial acceleration of the solid-line car, before it reaches const
   b) the deceleration of the dotted-line car after 23 seconds
   c) which car has travelled furthest?

4. The speed–time graph shows a rollercoaster in the first 20 seconds of i pulling the rollercoaster slowly up a slope.

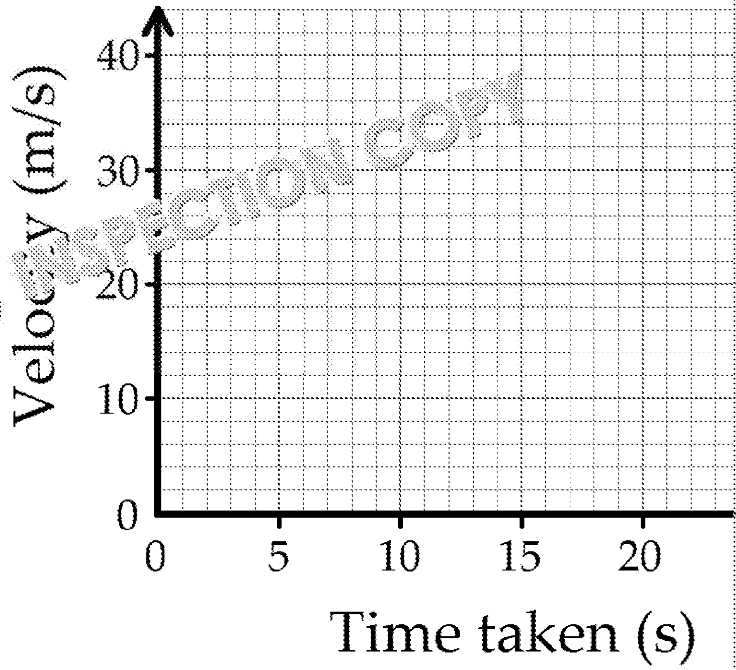


   a) Calculate the initial acceleration which starts the rollercoaster mo
   b) When do you think the rollercoaster reaches the top of the slope?
   c) Describe what the graph shows between 10 and 15 seconds. Wha is doing?
   d) Calculate the total distance travelled by the rollercoaster in the fir
   e) What is its average speed during this time?

5. A car is timed driving along a straight flat road and its velocity is reco
results are shown in the table.

Time (s)	0	5	10	15	20
Velocity (m/s)	0	16	32	32	30

a) Copy and complete the graph below with your results.



b) What is happening between 10 and 15 seconds?
c) Fully describe the motion of the car between 20 and 25 seconds.
d) Calculate the acceleration of the car in the first 10 seconds.
e) Calculate the distance the car has travelled.

Acceleration Questions

1. Complete the phrases using some of the following words:

accelerating	*acceleration*	*direction*	*distance*	*gr*
moving	*negative*	*positive*	*size*	*s*

Acceleration is the rate of change of ________________. An object is ___ up, slows down or changes ________________. If the acceleration of a can be described as deceleration.

The ________________ of a velocity–time graph represents ________ underneath the graph represents ________________.

2. In the velocity–time graph on the information sheet, describe the mot
   a) in the first 12 seconds

   ....

   b) between 12 seconds and 17 seconds

   ....

   c) after 17 seconds

   ....

3. In the velocity–time graph on the information sheet, calculate:
   a) the initial acceleration of the solid-line car, before it reaches const

   ....

   ....

   b) the deceleration of the dotted-line car after seconds

   ....

   ....

   c) w r has travelled furthest?

   ....

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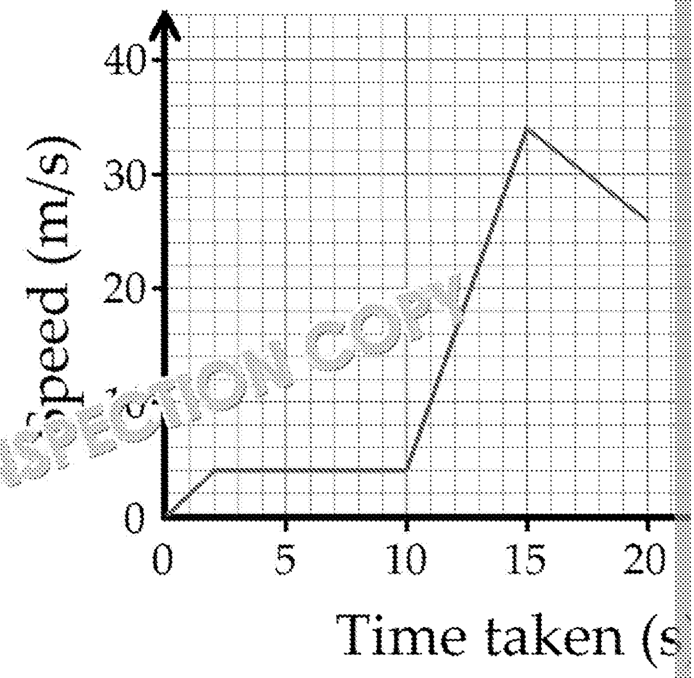
4. The speed–time graph shows a rollercoaster in the first 20 seconds of i pulling the rollercoaster slowly up a slope.



a) Calculate the initial acceleration which starts the rollercoaster mo

....

....

b) When do you think the rollercoaster reaches the top of the slope?

....

....

c) Describe what the graph shows between 10 and 15 seconds. Wha is doing?

....

....

d) Calculate the total distance travelled by the rollercoaster in the fir

....

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....

e) What is its average speed during this time?

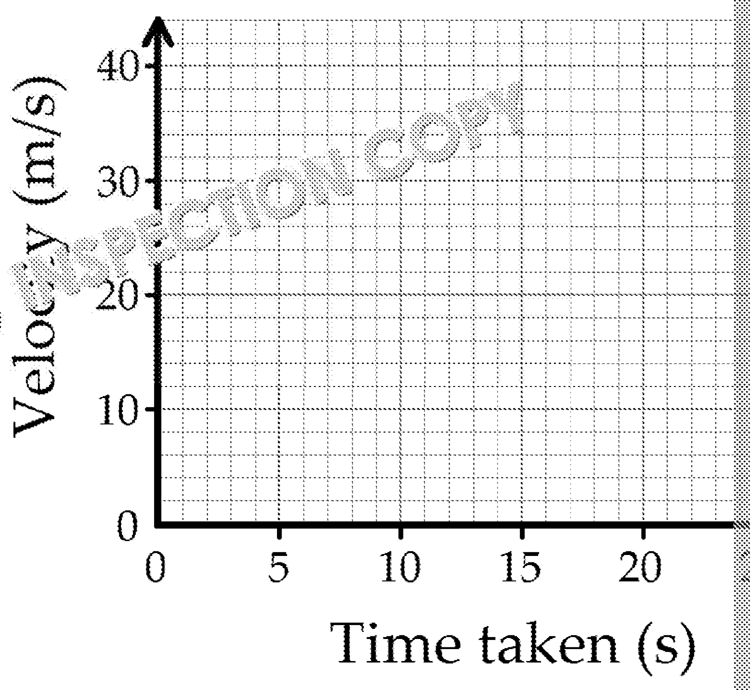
....

....

5. A car is timed driving along a straight flat road and its velocity is reco results are shown in the table.

Time (s)	0	5	10	15	20
Velocity (m/s)	0	16	32	32	30

a) Plot these results on the graph below.



b) What is happening between 10 and 15 seconds?

....

c) Fully describe the motion of the car between 20 and 25 seconds.

....

d) Calculate the acceleration of the car in the first 10 seconds.

....

....

e) Calculate the distance the car has travelled.

....

....

....

Lesson Plan 3: Investigate Motion: Conserv

Learning Aims

All students should:	Draw energy transformation diagrams for simp Describe the conservation of energy for simple e transformation diagrams.
Most students should:	Calculate kinetic energy and changes in gravita
Some students should:	Understand that as an object falls, gravitational into kinetic energy.

Keywords: energy, work, transfer, transformation, input, output, gravitation

Starter
Energy matching exercise. Students are given a list of appliances or proces
to its correct useful energy output.

Main
1. Review energy matching exercise and discuss.
2. Introduction to conservation of energy and equivalency of work
3. Explain the different types of energy and where they may be fou
4. Introduction to energy transformation diagrams. Write example can attempt their own energy transformation diagrams.
5. Explain how to calculate kinetic energy, using the worked exam
6. Explain how to calculate gravitational potential energy, using th pack. Explain how as an object falls, its gravitational potential e kinetic energy.
7. Falling object experiment: Students drop a piece of card from va gate to measure its speed before hitting the ground. Using the s the distance through which the card falls, they should be able to gravitational potential energy lost and the amount of kinetic ene two.
8. Discuss results from the falling object experiment with students. Use experiment to draw an energy transformation diagram for the experim
9. Answer Questions 1–6 from the pack.
10. Elicit answers during class discussion.

Plenary
Students work in pairs. Each student writes five questions (with answers)
One point is gained for every question they get correct; one point is lost fo
The winner is the one with the most points after all ten questions have bee

Conservation of Energy

Whenever two objects interact, **energy is always conserved**. Energy is never cre[illegible] **transferred** or **converted** into a different form.

When work is done on an object by a force, the amount of **energy transferred** to [illegible] amount of **work done** on the object:

$$\text{work done (J)} = \text{energy transferred (J)}$$

Work done and energy transferred are both measured in **joules** (J).

Worked example
A ball is sitting stationary on a de[illegible] work is done on the ball to make it be[illegible] was transferred to the ba[illegible]

$\text{work done (J)} = \text{energy transferred (J)}$, *so the ball has 50 J of energy*

The energy of an object which is moving is called ***kinetic energy****.*

Types of Energy

Energy is used and transferred in all sorts of different forms.

Type of energy	Description	
Electrical	Energy carried by a current through electrical circuits	Any applia[illegible] (TV, mobil[illegible]
Kinetic	Energy of movement	Anything [illegible] a skydiver [illegible]
Light/ electromagnetic	Energy of radiation of light (or other waves in the electromagnetic spectrum)	The Sun, a [illegible] oven
Potential (chemical, elastic, gravitational)	Stored energy with the potential to do work	Chemical: [illegible] Elastic: str[illegible] Gravitatio[illegible] above the [illegible]
Thermal/heat	Energy tr[illegible] heat from hot to [illegible]	Radiator, h[illegible]
[illegible]	Energy of vibrations which cause sound	Musical in[illegible]

All of these forms of energy can be transformed into another.

- For example, a **light bulb** is supplied with **electrical** energy which it then co[illegible] into **light** and **heat**.
- A sprinter converts the **chemical** energy in food into **kinetic** energy and som[illegible]

Energy Transformation Diagrams

When energy is transferred by a process, it can be converted from one form to a
For example, if a battery is connected to a light bulb in an electric circuit, the foll
place:

chemical energy stored in battery ⇒ **electrical energy** in circuit ⇒ **light**

Light is the only **useful** form of energy emitted by the bulb. Heat is just a by-product which is lost to the surroundings and so it is considered **wasted** energy.

Wasted energy is usually lost as heat or sound to the surroundings.

Sankey diagrams, like the one shown to the right, include all the different energy inputs and outputs of a process. Each arrow has a thickness which represents the proportion of each type of energy involved.

For example, if the diagram were describing a light bulb, the 'energy input' wou
mains or a battery.

The 'useful energy output' would be **light** energy to light up the room.

The 'wasted energy' would be **heat lost** to the surroundings.

Remember that **energy is always conserved** – so the **total energy output** of a pr
total energy input.

Kinetic Energy

Kinetic energy is the energy of movement – any moving object will possess kinet
energy an object has depends both on its **mass** and its **speed**. The faster an obje
energy it has.

Kinetic energy is calculated using the equation:

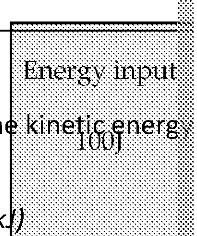
$$K.E. = \frac{1}{2} \times m \times v^2$$

where: $K.E.$ is kinetic energy, in joules (J)
m is mass, in kilograms (kg)
v is speed, in metres per second (m/s)

Worked example

A car of mass 1,500 kg is driving at a speed of 30 m/s. Calculate the kinetic energ

$K.E. = \frac{1}{2} \times m \times v^2$ = 0.5 × 1,500 kg × (30 m/s)^2 = 675,000 J (675 kJ)



Gravitational Potential Energy

Gravitational potential energy is the energy stored in any object in a gravitation
If work is done on an object to move it further out of the gravitational field, its g
increases.

If an object is allowed to fall in the gravitational field due to gravity, its gravitatio

NB: As an object falls due to gravity, it speeds up – its ***gravitational potentia*** *…* ***kinetic energy****.*

An object's change in gravitational potential energy is calcu[illegible]ed using the equat

$$P.E. = m \times g \times h$$

where: $P.E.$ is the ch[illegible] gravitational potential energy, in joules (J)
m [illegible] kilograms (kg)
g [illegible] acceleration due to gravity, in newtons per kilogram (N/kg)
h [illegible] the change in height, in metres (m)

On Earth, the acceleration due to gravity *g* is approximately **10 N/kg**.

Did you know?
When you are riding on a rollercoaster, the rollercoaster is converting energy between kinetic and gravitational potential energy as you go round the track.

The higher the rollercoaster gets the more gravitational potential energy it gains – this gravitational potential energy is then converted back into kinetic energy as the rollercoaster falls, which is the reason why you go so fast at the end of a vertical loop!

Worked example
A ball with a mass of 2 kg is dropped from a height of 1.8 m. Calculate its loss in g

$P.E. = m \times g \times h$ = 2 kg × 10 N/kg × 1.8 m = 36 J

If all the gravitational potential energy lost is converte[illegible] kinetic energy, calcu before it hits the ground.

$K.E. = P.E.$ = 36 J

$K.E. = \frac{1}{2} \times$ [illegible] $v^2 = \frac{2K.E.}{m}$ = (2 × 36) / 2 = 36; v = 6 m/s

Conservation of Energy Questions

1. Name the types of energy input and output for each of the following p
   a) an electric kettle boiling
   b) a cymbal being hit
   c) a desk lamp
   d) a skydiver falling

2. Copy and complete the phrases using some of the following words.

created	electricity	equal	heat	in
potential	surplus	transferred	useful	w

   Energy cannot be ________ or destroyed; it can only be ________ or co

   ________ of a process is always ________ to the total energy output.

   Energy processes transfer ________ energy, which is in the form we w

   ________ – usually as ________ or sound lost to the surroundings.

3. A stationary car has a mass of 2,000 kg. 900 kJ of work is done by the e energy is wasted, what is the speed of the car after this work is done?

4. A ball is stationary on a desk. 80 J of work is done on the ball to make
   a) How much useful energy is transferred to the ball?
   b) What do you think happens to the wasted energy?
   c) The ball moves off at 16 m/s. Calculate the mass of the ball.

5. A skydiver with a mass of 75 kg jumps out of a plane and falls 500 m b parachute.
   a) Calculate the gravitational potential energy lost by the skydiver b (g = 10 N/kg)
   b) Assuming all gravitational potential energy is transferred to kine calculate the speed of the skydiver just before the parachute open

6. **Group Activity:** In groups, discuss a wide range of appliances you ha what types of energy transfer are taking place when you use these ap

Conservation of Energy Questions

1. Name the types of energy input and output for each of the following p

   a) an electric kettle boiling

   Input ....

   Output ....

   b) a cymbal being hit

   Input ....

   Output ....

   c) a desk lamp

   Input ....

   O ....

   d) a skydiver falling

   Input ....

   Output ....

2. Complete the phrases using some of the following words.

created	*electricity*	*equal*	*heat*	*i*
potential	*surplus*	*transferred*	*useful*	*w*

Energy cannot be __________ or destroyed; it can only be __________

energy __________ of a process is always __________ to the total en

Energy processes transfer __________ energy, which is in the form w

also __________ – usually as __________ or sound lost to the surrou

3. A stationary car has a mass of 2,000 kg. 90 J of work is done by the e energy is wasted, what is the speed of the car after this work is done?

....

....

....

....

4. A ball is stationary on a desk. 80 J of work is done on the ball to make

   a) How much useful energy is transferred to the ball?

   ....

   b) What do you think happens to the wasted energy?

   ....

   c) The ball moves off at 16 m/s. Calculate the mass of the ball.

5. A skydiver with a mass of 75 kg jumps out of a plane and falls 500 m b
   parachute.

   a) Calculate the gravitational potential energy lost by the skydiver b
   (g = 10 N/kg)

   ....

   ....

   ....

   ....

   b) Assuming all gravitational potential energy is transferred to kine
   calculate the speed of the skydiver just before the parachute open

   ....

   ....

   ....

   ....

6. **Group Activity:** In groups, discuss a wide range of appliances you ha
   what types of energy transfer are taking place when you use these ap

Lesson Plan 4: Investigate Motion: Energy

Learning Aims

All students should:	Understand the concept of a vehicle's stopping d
Most students should:	Identify the factors affecting transportation and s
Some students should:	Explain how changes in energy will affect transp distances.

Keywords: brakes, kinetic energy, speed, sto[illegible] [illegible]istance, thinking dista

Starter

Review of [illegible] [illegible]ing. Recap 'work done = energy transferred'.

Main

1. Introduction to braking. Discuss with students the energy trans brakes.
2. Introduction to stopping distance, including safety implications
3. Discuss with students the different factors that may affect thinki
4. Discuss measures that could be taken to reduce stopping distan
5. Stopping distance experiment: Students roll a trolley or toy car d types of surface and measure the stopping distance once it has l students should comment on how the stopping distance is affec relate this to the stopping distances of vehicles under various ro
6. Discuss results of experiment with students.
7. Answer Questions 1–4 from the pack.
8. Elicit answers during class discussion.

Plenary

Stopping Factors List: Create a li[illegible] [illegible]a[illegible]rs which may affect the stoppin Students must sort the f[illegible] [illegible]ording to which part of the stopping dist distance, th[illegible] k[illegible] [illegible]ance, or both.

Energy and Braking

Braking

To stop a vehicle, the driver has to apply the brakes. The brakes do work against
decelerate.

D

When the brakes are applied, they provide a **frictional force** bet
wheel tyres. This frictional force does work to convert **kinetic** en
(and some **sound**), which is transferred to the brake pads, whee
energy increases the temperature of the brake pads and the whe
sometimes be heard as 'squealing' when the brakes are applied t

The greater the speed of the vehicle, the more kinetic energy it h
be done to stop the vehicle (or decelerate it by a given amount) c

Stopping Distance

The **stopping distance** of a vehicle is the shortest distance in which it can safely s
Stopping distance is very important for **road safety** – a shorter stopping distance
driver can stop their vehicle more quickly, so they are less likely to run into an un
hazard (e.g. a person crossing the road).

Stopping distance is made up of two different components:

- **thinking distance** – the distance the vehicle travels during the time it takes
driver to react
- **braking distance** – the distance the vehicle travels while the brakes are bein

The total stopping distance is the sum of these two components:

$$\text{stopping distance} = \text{thinking distance} + \text{braking dis}$$

Thinking distance and braking distance are each affected by a number of factors:

Thinking distance	Br
Alcohol and drugs – these slow down the reaction time of the driver, increasing the thinking distance. ***Tiredness*** will also slow down reactions, increasing the thinking distance.	***Road conditions*** – if th surface is poorly main more gently to avoid s braking distance.
Distractions in the car – like using a mobile phone, or fiddling with the car radio – can increase the thinking distance because the driver is not paying full attention to the road.	***Brake condition*** – if th they will not be as effe vehicle down. This inc
Visibility – fog, heavy rain and snow can make it harder for the driver to see what is ahead so their reaction time is likely to be affected. This increases the thinking distance.	***Tyre condition*** – if tyre they will not slow dow increases the braking
Speed – the faster a vehicle is travelling, the greater the thinking and braking dis travelling fast, the driver travels further while reacting to a situation, so the think takes more energy to stop the vehicle, so the braking distance will also be greate	

Energy and Braking Questions

1. Copy and complete the phrases using some of the following words (w
once):

braking	*chemical*	*distance*	*energy*	*e*
heat	*kinetic*	*mass*	*potential*	*s*
speed	*stopping*	*thinking*	*tyres*	

When a vehicle brakes, its ________ energy is converted into ________

________ a vehicle is travelling, the more ________ needs to be done t

________.

The ________ distance of a vehicle is the sum of the thinking distance a

Alcohol and drugs affect the ________ distance, while the condition o

brakes affect the ________ distance. The greater the ________ of a vehi

will be.

2. A vehicle is travelling at 30 m/s before the driver spots a hazard in the
   a) The driver takes 2 seconds to react to the hazard. Calculate the di
   this time.
   b) What is the name of this distance?
   c) The driver then applies the brakes – the vehicle travels a further 3
   complete stop. Calculate the total stopping distance of the vehicle
   d) State a precaution the driver could have taken which would have
   stopping distance.

3. List and explain three factors which affect a) thinking distance, b) bra

4. **Group Activity**: Prepare a group presentation on the different factors
stop over a greater distance. Do some group research on the energy ch
vehicle brakes and suggest how stopping distances can be reduced.

Energy and Braking Questions

1. Complete the phrases using some of the following words (words may

braking	*chemical*	*distance*	*energy*	*e*
heat	*kinetic*	*mass*	*potential*	*s*
speed	*stopping*	*thinking*	*tyres*	

When a vehicle brakes, its ___________ energy is converted into _____

energy. The ___________ a vehicle is travelling, the more ___________

over a certain ___________.

The ___________ distance of a [illegible] the sum of the thinking distan

Alcohol and drugs [illegible] ___________ distance, while the conditio

brake [illegible] the ___________ distance. The greater the ___________ o

distances will be.

2. A vehicle is travelling at 30 m/s before the driver spots a hazard in the
   a) The driver takes 2 seconds to react to the hazard. Calculate the di this time.

   ....

   b) What is the name of this distance?

   ....

   c) The driver then applies the brakes – the vehicle travels a further 3 complete stop. Calculate the total stopping distance of the vehicle

   ....

   d) State a precaution the driver could have taken which would have stopping distance.

   ....

3. List and explain three factors which affect a) thinking distance, b) bra
   a) 1 ....
   2 ....
   3 ....
   b) 1 ....
   2 ....
   3 ....

4. **Group Activity:** Prepare a group presentation on the different factors stop over a greater distance. Do some group research on the energy ch vehicle brakes and suggest how stopping distances can be reduced.

Assignment A: Velocity, Acceleration and Energy

Learner's name:		
Start date:	Deadline:	Da

Velocity, Acceleration and Energy Tra

Scenario

You have joined your school science club. The school open evening is coming up make some posters of experiments they have done. You task is to carry ou investigates speed and acceleration, and create showing your results about the subject.

Your science club is part to promote safer driving in local reside to produce awareness of the issue by explaining its scientific b transfer.

Task 1
Carry out one of the experiments you have studied during this unit and creat experiment you carried out.

You may find it helpful to split the poster into different sections, e.g. aims, ap discussion and conclusion.

1. Your poster should explain what you did, including how all your measur time) were taken. You should also explain what you can conclude from y *Remember to include units with your measurements.*

2. You should include a distance–time graph of your results.

3. You should also include a speed–time graph for examples of motion whe

4. Include calculations of speed/velocity from your distance and time data. *Show the formulae you use and remember to give units.*

5. Use your graphs to describe the type of motion that is occurring at each *You should be able to highlight parts of the graph which show when an obj constant speed, accelerating or decelerating.*

6. Use the gradients of your graphs to calcula and velocity and use speed-time graph to calculate the e velled.

Task 2

1. Describe the energy transfers that take place when a car brakes; illustrate energy transformation diagram. Provide a description of an experiment y investigating energy conservation (e.g. measuring K.E. and P.E. of a falling transformation diagram for this as well.

2. Describe the law of conservation of energy and describe how your energy represents it for your experiment.

3. Use the equation for kinetic energy to calculate the kinetic energy of a car the gravitational potential energy of a falling object is converted into kine calculations.
Show the formulae you use and remember to include all relevant units. The 1,500 kg, although you don't have to stick to this if you don't want to.

4. Explain how stopping distance is affected by the speed/kinetic energy of be addressed to reduce stopping distance.

Learner's name:	**Start Date:**

Learner's declaration:
I certify that the work submitted for this assignment is my own. I have clearly refe
work. I understand that false declaration is a form of malpractice.

Learner's Signature: Date:

Learner's comments for the assessor:

Teacher's/assessor's name:

Marking Criteria		
Task:	**Criteria**	**Learner must:**
1	**2A.P1**	Produce accurate graphs to represent uniform and non-uniform motion using primary data.
	2A.P2	Calculate speed and velocity for simple experiments.
	2A.M1	Interpret graphs to identify objects that are stationary, moving at constant speed and moving with increasing or decreasing spee
	2A.D1	Calculate the gradient for distance–time graphs and the gradie and area of speed–time graphs.
2	**2A.P3**	Describe the conservation of energy for simple experiments, including energy transformation diagrams.
	2A.M2	Calculate kinetic energy and changes in gravitational potential energy.
	2A.D2	Explain how changes in energy will affect transportation and stopping distances.

Deadline:

Summative feedback:

Date assessed:

Internal verifier's name:

Internal verifier's feedback:

Date:

If a learner has not met the Level 2 criteria, they can be assessed on the Level	
1A.1	Produce accurate graphs to represent uniform motion using primary data
1A.2	Measure distance for simple experiments.
1A.3	Draw energy transformation diagrams for simple experiments.

Lesson Plan 5: Investigate Forces: Resul

Learning Aims

All students should:	Identify the forces on objects. Describe the effects of balanced and unbalanced
Most students should:	Calculate the force on objects, in relation to thei application. Identify 'pairs' of forces that act on different obj forces are equal in size and opposite in directior
Some students should:	Explain the various forces involved, and their a of applications.

Keywords: force, weight, newtons, resultant, equilibrium, mass, accelerati

Starter

Review of previous learning. Discuss forces acting on an object at rest, e.g.

Main

1. Brief introduction to 'pairs' of forces (every action has an equal
2. Introduction to resultant forces, including implications of zero a a stationary or moving object.
3. Use free body force diagrams to allow students to calculate resu as a class.
4. Resultant force experiment: Students place a weight on a set of s meter onto the weight and slowly apply a lifting force to it. How newton meter relate to the reading on the scales? Draw a free bo experienced by the weight – does this explain the results?
5. Discuss results of resultant force experiment (including the free body Discuss how we can tell that the forces are balanced and what might l
6. Explain how weight is not the same as mass and demonstrate th
7. Introduction to $F = m \times a$, using worked example from the info for the students to solve themselves.
8. Elicit answers to problems during class discussion.
9. Answer Questions 1–5 from the pack.
10. Elicit answers during class discussion.

Plenary

True or false: Ask students a series of true or false statements about result move to either end of the room to vote.

Resultant Forces

A **force** is an interaction between two objects. If two objects collide, rest against
gravitational pull on each other, forces are acting between the two objects. Forc

One of the most important rules about forces is that **every action has an equal a**

- If a block is resting on a table, the **weight** of the block is acting downwards o opposite **normal reaction force** is exerted on the block by the table, in respo *NB: A normal reaction force from a surface always acts **in response to an ap***
- If a horse pulls a cart, the **pulling force** the horse exerts on the cart is match **pulling force** by the cart on the horse.

Most objects have more than one force acting on them at once. To simplify a pro forces with one **resultant force**, which has the same effect as all the forces comb

If all the forces on an object are **balanced**, the resultant force is **zero** and the obj

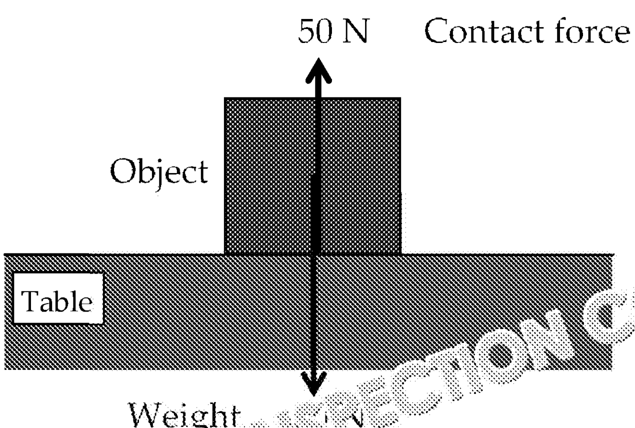
- If the object was stationary, then it will remain **stationary**.
- If the object was moving, then it will continue to move at a **constant speed**.

However, if the resultant force is **unbalanced**, the object will experience an **acce** resultant force.

- If the object was stationary, then it will begin to move in the direction of the
- If the object was moving and the resultant force acts in the direction of mov (accelerate).
- If the object was moving and the resultant force acts against the direction o down (decelerate).

Calculating the Resultant Force

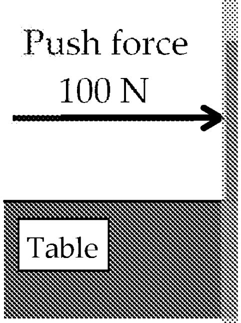
The resultant force is the sum of all the forces acting in one particular direction – opposite direction, it is subtracted.



The block shown on the the resultant force on it the weight of the block cancel each other out. It remains stationary – if it steady speed.

A force of 1[illegible] applied to the side of the block. The table generates a frictional force of 20 N in the opposite direction. The overall resultant force is in the direction of the push force and its size is 100 N – 20 N = 80 N.

This means the block accelerates in the direction of the push force.



NB: *These are **free body force diagrams**. It is always useful to draw a free bo question about forces.*

Weight

The **weight** of an object is the gravitational force that acts on it. It is measured in

Mass is the **quantity of matter** in an object and is measured in kilograms (kg). An no matter where it is.

Weight is different from mass. An object's weight varies depending on the **gravit** subjected to. The Earth's gravitational field strength is approximately **10 N/kg** on can vary depending on where you are.

Did you know?
Astronauts on the Moon feel incredibly light and are able to bounce around – th field strength of the Moon is only about one sixth of the Earth's. So the astrona weight on the Moon that they would be on the Earth! Although their weight is d Earth, it is important to remember that their mass remains the same wherever t

If we know the mass of an object, we can calculate its weight using:

$$W = m \times g$$

where: *W* is weight, in newtons (N)
m is mass, in kilograms (kg)
g is gravitational field strength, in newtons per kilogram (N/kg)

Forces and Motion

When a resultant force acts on an object, the object **accelerates** in the direction o

The resultant force is linked to the **mass** of the object and the **acceleration** cause

$$F = m \times a \qquad (\text{or } a = \frac{F}{m})$$

where: *F* is the resultant force acting on the object, in **newtons** (N)
m is the mass of the object, in kilograms (kg)
a is the acceleration of the object, in metres per second squared (m/s^2)

The *greater* the force, or the *smaller* the mass, the greater the acceleration.

Worked Example
A 2.5 kg block is at rest. A force is applied and the block accelerates to a speed of the size of the resultant force.

Acceleration a = (v – u) / t = 15 / 5 = 3 m/s²

$F = m \times a$ *= 2.5 kg × 3 m/s² = 7.5 N*

Resultant Forces Questions

1. Copy and complete the phrases using some of the following words.

acceleration	*drag*	*equilibrium*	*gravitational*	*f*
motion	*opposite*	*reaction*	*resultant*	*s*
weight				

Every action has an equal and ________ reaction. A body resting on a t

table, but experiences a ________ force from the table in response.

A ________ force is a single force with th sa e e fect as all the forces

zero, the object is in ____ ____ ________ it remains so, and if it is

constant __

A non- resultant ________ causes an ________ in the direction of t

2. A book with a weight of 5 N rests on a desk. Calculate the reaction for

3. A car of mass 1,000 kg begins to accelerate at a rate of 5 m/s^2. Calculat the car.

4. An object is travelling at a constant speed of 3 m/s. A resultant force o direction of motion. After 5 seconds the object's speed has increased t
   a) Assuming the acceleration is constant, calculate the acceleration o
   b) What is the mass of this object?

5. An object is falling through the air, accelerating at 8 m/s^2. Its mass is 4
   a) Calculate the resultant force acting on this object.
   b) Calculate the weight of the object (g = 10 N/kg).
   c) What is the size of the force acting against the object's motion?

6. **Group Activity:** Do some group research to investigate the effect of u accelerating mass – examples could include a sledge running down a h kicked through the air.

Resultant Forces Questions

1. Complete the phrases using some of the following words.

acceleration	*drag*	*equilibrium*	*gravitational*	*f*
motion	*opposite*	*reaction*	*resultant*	*s*
weight				

Every action has an equal and ______________ reaction. A body resti

______________ on the table, but experiences a ______________ forc

A ______________ force is a single force wi[illegible] same effect as all th

it is zero, the object is in ______________; if it is ______________ it re

continu[illegible]t c[illegible] ______________.

A non-zero resultant ______________ causes an ______________ in t

2. A book with a weight of 5 N rests on a desk. Calculate the reaction for

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3. A car of mass 1,000 kg begins to accelerate at a rate of 5 m/s^2. Calculat the car.

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   a) Assuming the acceleration is constant, calculate the acceleration o

   ....

   b) What is the mass of this object?

   ....

5. An object is falling through the air, accelerating a[illegible] m/s^2. Its mass is 4
   a) Calculate the resultant force acting o[illegible] object.

   ....

   b) Cal[illegible]te [illegible]ght of the object (g = 10 N/kg).

   ....

   c) What is the size of the force acting against the object's motion?

   ....

6. **Group Activity:** Do some group research to investigate the effect of u accelerating mass – examples could include a sledge running down a kicked through the air.

Lesson Plan 6: Investigate Forces: Forces

Learning Aims

All students should:	Describe work done in terms of forces moving t Calculate the work done by forces acting on obj
Most students should:	Identify applications of compressive and tensile
Some students should:	Understand that compressive and tensile forces stored as internal energy and can later be transf

Keywords: force, work, energy, distance, compressive, tensile, elastic

Starter

Introduction ... something which does work on (and therefore tr

Main

1. Brief introduction to forces and work (work done = energy trans
2. Calculation of work done by a force over a certain distance. Use information sheet to demonstrate.
3. Write example problems on the board for the students to solve, between work done and energy transferred.
4. Elicit answers to examples during class discussion.
5. Introduction to compressive and tensile forces, including examp
6. Answer Questions 1–3 from the pack.
7. Elicit answers during class discussion.

Plenary

Tensile Force Experiment: Students can investigate the elastic potent by extending it to different lengths and measuring how far it can fire plot a graph of distance extended against distance the projectile is fi relationship between the two and relate this to energy transfers.

Forces and Work

When a resultant force acts on an object, it does **work** to move that object. The w
to the **energy transferred** to the object.

For example, if a heavy load is lifted into the air, the force that lifts it against grav
work done by the force is equal to the **energy transferred** to the load – which is t
potential energy.

Work Done by a Force

When a force moves an object through a distance, it is doing **work** on the object.

The greater a force, and the further it moves an object, the more work is done by

We can calculate the work done by a force using the following equation:

$$W = F \times d$$

where: *W* is the work done by the force, in joules (J)
F is the force, in newtons (N)
d is the distance moved in the *direction of the force*, in metres (m)

Worked example

A crane lifts a 2,500 kg load to a height of 10 metres. How much work does the cr

The force exerted by the crane is equal to the weight of the load. F = m × g = 2,50

$W = F \times d$ *= 25,000 N × 10 m = 250,000 J (250 kJ)*

Compressive and Tensile Forces

A **compressive** force is one which does work to **squash** the shape of an object.

A **tensile** force is one which does work to **stretch** the shape of an object.

An **elastic** object stores the work done by a compressive or tensile force as **elastic potential energy**. When the force is removed, it can then use this energy to restore its original shape.

Examples of elastic objects include **rubber bands, squash balls, bungee cords** and **springs**.

Forces and Work Questions

1. Copy and complete the phrases using some of the following words.

compressive	*distance*	*elastic*	*elastic potential*	*e*
force	*work*	*restore*	*shrink*	*s*
velocity	*gravitational potential*			

When a ________ moves an object, it does ________ on the object. The

the ________, the more work is done.

A ________ force does work to squash the shape of an object; a ________

________ the shape of an object. ... object is ________, it stores this

which is then used to ________ its shape once the force is removed.

2. A weight lifter picks up a dumb-bell from the floor and lifts it 1.5 met bell has a mass of 20 kg.
   a) Calculate the change in gravitational potential energy of the dum
   b) How much work has the weight lifter done?
   c) The weight lifter drops the dumb-bell. If all the gravitational pote converted to kinetic energy during the fall, what is its speed just b

3. A slingshot has 30 J of work done on it to stretch it. The slingshot con force stretching the slingshot is removed.
   a) What is the name of the force that stretched the slingshot?
   b) What type of energy was stored in the slingshot while it was bein
   c) If all the energy is transferred to the rock as kinetic energy, calcul
   d) In practice, the rock would probably travel more slowly. Why do

Forces and Work Questions

1. Complete the phrases using some of the following words.

compressive	distance	elastic	elastic potential	e
force	work	restore	shrink	s
velocity	gravitational potential			

When a _______________ moves an object, it does _______________ or

force or the larger the _______________, the more work is done.

A _______________ force does work to squas[illegible] shape of an object;

work to _______________ the sh[illegible] n object. If the object is ______

_______________ _______________ energy, which is then used to ________

force [illegible]

2. A weight lifter picks up a dumb-bell from the floor and lifts it 1.5 met bell has a mass of 20 kg.
   a) Calculate the change in gravitational potential energy of the dum

   ....

   ....

   b) How much work has the weight lifter done?

   ....

   c) The weight lifter drops the dumb-bell. If all the gravitational pote converted to kinetic energy during the fall, what is its speed just b

   ....

   ....

3. A slingshot has 30 J of work done on it to stretch it. The slingshot con force stretching the slingshot is removed.
   a) What is the name of the force that stretched the slingshot?

   ....

   b) What type of energy was st[illegible] the slingshot while it was bein

   ....

   c) If [illegible] energy is transferred to the rock as kinetic energy, calcul

   ....

   ....

   d) In practice, the rock would probably travel more slowly. Why do

   ....

   ....

Lesson Plan 7: Investigate Forces: Resis

Learning Aims

All students should:	Identify friction forces and situations where the Describe how friction and normal reaction force an applied force.
Most students should:	Explain how friction and normal reaction forces an applied force.
Some students should:	Explain the various forces involved, and their a of applications.

Keywords: resistive force, friction, drag, ...e, air resistance, static, kinetic

Starter

Dem...tion of static and kinetic friction: Use a newton meter to p surfa... – demonstrate that up to a point the mass does not move an surface it is resting on (could also be used as a simple practical).

Main

1. Introduction to resistive forces and friction, including when the
2. Explanation of static and kinetic friction.
3. Discuss the example of a car beginning, continuing and ending various forces acting at different stages.
4. Students can fill in the labels on a free body force diagram of a car tra
5. Discuss the example of forces acting on a parachutist during the terminal velocity.
6. Discuss the case study of forces acting on a rocket at different st
7. Drag force experiment: Show that fluids of different viscosities drag force on a ball bearing / marble. Use about three fluids each wallpaper paste of different thicknesses). Students can use stop taken for a ball bearing to fall through ... depth of each fl force exerted on it.
8. Answer Que... ...rom the pack.
9. Elicit ...s during class discussion.

Plenary

Parachute experiment: Students design a parachute for a fixed mass see whose can keep the plasticine in the air the longest (could take a

Hydrogen rocket demonstration: Set up a hydrogen rocket to show t instruction in the YouTube video: **http://youtu.be/M_9vTsqp9D0**. A in class.

Resistive Forces

When an object is travelling at constant speed, the resultant force on the object i **driving force** causing the object to move is balanced by other forces which **oppo** known as **resistive forces**.

The most common form of resistive force is **friction**.

- Friction can occur between an object and a solid surface.
- It can also occur when an object moves through a fluid – more commonly kn
- The drag force on an object by the air is often referred to as **air resistance**.

Friction

Like the normal reaction f... acts against weight), friction only acts in re When a force ... to move something, friction will act against it – and match it. Th... own as **static friction**. Once this point has been exceeded, the friction still a... against the motion. This is known as **kinetic friction**.

Imagine pushing a heavy box across the ground. If at first you only apply a small this is because the frictional force is matching your applied force.

It is only when you increase your applied force to a point where it exceeds the fri start to move.

When a car accelerates fro **friction** and then **kinetic fr** force of the engine. The fri contact between the tyres

As the car accelerates, **air** against the driving force. H force is large enough to ov resistance, the car will con

The greater a vehicle's **speed**, the greater the air resistance will be that opposes and save fuel, some vehicles are more **streamlined** – this ... s more air to pass the overall air resistance is lower.

Car brakes work by applying a f... force between the brake pads and the w frictional force does w... the motion of the car – this work is transfer wheel tyres ... ngs. Kinetic friction and air resistance also do work aga because the ... force from the engine has been removed, the car decelerate

Did you know?
One of the reasons that racing cars can travel so fast is because they are ***stream*** ***ground****. This means that they experience much less air resistance than the avera*

Terminal Velocity

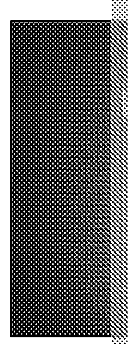
As a parachutist falls through the air, the weight of the parachutist is opposed by air **resistance** – a form of friction between the air and the parachutist.

The amount of air resistance acting on the parachutist is relatively small, but grows as the parachutist accelerates until it matches their weight. At this point the parachutist is in equilibrium, falling at a constant speed called **terminal velocity**.

Once the parachutist opens their parachute, the **area** over which the air resistance acts increases dramatically. This means the air resistance increases, so the parachutist **decelerates**. As their speed falls, air resistance decreases until once again it matches the weight of the parachutist. **Terminal velocity** is reached once again but this time it is much slower.

Case Study: Forces on a Rocket

A rocket experiences enormous forces in the processes of both launching and landing.



The driving force from a rocket comes from chemicals (such as hydrogen and oxygen) reacting to form a large amount of very hot expanding gas. The gas is channelled out through the rocket's exhaust, generating a **thrust force** (a reaction force opposing the downwards force of the expanding gas). The NASA Space Shuttle was capable of producing over 17 million newtons of thrust in total.

The thrust produced by a rocket is far greater than its weight and any air resistan
upwards until it reaches space. Some rockets aim to enter an orbit around the Ea
orbit to proceed on into outer space.

For a rocket orbiting the Earth, the only force acting on it is the Earth's gravity. Th
rocket is able to maintain a constant orbiting speed. Technically the rocket is in 'f
matches the curvature of the Earth, it does not fall closer to Earth unless it reduc

When a rocket returns to Earth, its weight is counteracted by air resistance so it
velocity. The NASA Space Shuttle was designed so that it was able to glide back t

D

How to explain the various forces involved in a variety of applicat

You should be able to name all the forces acting in the examples sho
situations too. When considering the forces that may be acting on an

- The motion of the object. Which force is making the object move
  acting opposite to this force?
- The weight of the object. The weight will usually be acting dow
  forces acting upwards to counteract this?

To estimate the size of the weight force acting, think about what the
$W = m \times g$. For estimating the size of a driving force, it can be useful

Resistive Forces Questions

1. Copy and complete the phrases using some of the following words.

air resistance	*causes*	*drag force*	*energy*	*f*
kinetic	*opposes*	*resistive*	*static*	*termin*

Friction is a ________ force which ________ motion. In fluids it is mor

________, and in air it is usually called ________.

Up to a point, friction matches the ________ applied to an object – this

Beyond this limit, ________ friction occurs.

A falling object reach________ when its ________ is balanced by res

2. What frictional forces and the normal reaction force have in comm causes them to act.

3. A parachutist of mass 75 kg opens his parachute, mass 25 kg, and falls
   a) What is the combined weight of the parachutist and parachute? (g
   b) What is the size of the air resistance force acting upwards on the p

4. What is the difference between static friction and kinetic friction? Exp object along a rough surface.

5. Explain why an object falling through a fluid will eventually reach ter

6. **Group Activity**: Discuss all the different forces which act on either a c stage of its motion. Which of these are resistive forces and what cause

7. **Group Activity**: Do some research into the various safety features tha Discuss, in terms of forces, how these safety features protect the passe

Resistive Forces Questions

1. Complete the phrases using some of the following words.

air resistance	causes	drag force	energy	f
kinetic	opposes	resistive	static	termin

Friction is a ___________ force which ___________ motion. In fluids it

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friction. Beyond this limit, _____ fr...on occurs.

A falling object r... ___________ when its ___________ is balanced

2. What ...tional forces and the normal reaction force have in comm causes them to act.

....

....

3. A parachutist of mass 75 kg opens his parachute, mass 25 kg, and falls
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7. **Group Activity**: Do some research into the various safety features tha Discuss, in terms of forces, how these safety features protect the passe

Learner's name:		
Start date:	Deadline:	Da

Investigate Forces

Scenario

You are employed at NASA and your initial duties include showing tourists aro
suggests that you prepare a presentation describing all the forces experienced
give visitors an insight into the physics of space travel.

Task

Prepare a slideshow presentation … e … es which act on a rocket. Some d
below for you to use.

Mass of rocket	
Overall acceleration when launching	15
Acceleration downwards due to gravity (all stages)	
Air resistance when launching and landing	5,0
Lift when landing	
Total height reached by the rocket	

Your presentation should include the following points.

1. Draw a free body force diagram of all the forces acting on a rocket during
   Earth, and as it returns to Earth.
   Point out at least two examples of balanced forces and two examples of unb
2. Out of these forces, highlight which of them are friction forces. Describe t
   situations that include friction forces.
3. Explain how a force does work as it moves the rocket through a certain d
   work that is being done at various points.
   Also include two other examples of when a force does work to move an obje
4. Use figures in the table to calculate the amount of work done to propel th
   atmosphere.
   Also calculate the work done for your two other examples, using estimates o
   distance travelled (you can research example values for these). Show the fo
   give units.
5. Explain the way in which resistive forces (i.e. friction and the normal reac
   You should use examples, e.g. pushing a heavy box, t… cribe how resistive
   force up to a certain point.
6. Explain how these resistive for… re …sed.
   Explain what your exam… el… s about when resistive forces act and wha
7. In term… he … of the rocket at different points, describe how forc
   unbala… fect motion.
8. Calculate the sizes of the forces involved during the flight of the rocket.
   Use the information in the table to help you calculate estimates of the force
   you use. Remember to include all relevant units.
9. Explain in detail the nature of all the forces acting, complete with calculat
   the flight of a rocket and for all the other examples you have included.
   Think about all the forces that could be acting at each stage and investigat
   their approximate sizes. At each stage, explain the effect that the combinat
   the objects.

Learner's name:	**Start Date:**
Learner's declaration: I certify that the work submitted for this assignment is my own. I have clearly refe work. I understand that false declaration is a form of malpractice. Learner's Signature: Date	
Learner's comments for the assessor:	

Teacher's/assessor's name:		
		Marking Criteria
Task:	**Cri[illegible]**	**L[illegible] must:**
1	2B.[illegible]	Describe the effects of balanced and unbalanced forces on obj
	2B.P5	Calculate the work done by forces acting on objects for simple experiments.
	2B.P6	Describe how friction and normal reaction forces are produced response to an applied force.
	2B.M3	Calculate the force on objects, in relation to their mass and acceleration for an application.
	2B.M4	Explain how friction and normal reaction forces are produced i response to an applied force.
	2B.D3	Explain the various forces involved, and their approximate sizes variety of applications.
Deadline:		
Summative feedback:		
Date assessed:		

Internal verifier's name:
Internal verifier's feedback: Date

If a learner has not met [illegible] criteria, they can be assessed on the Leve	
1B.4	Ide[illegible] the [illegible]n objects.
1B.5	De[illegible] work done in terms of force moving through a distance.
1B.6	Ide[illegible] friction forces and situations where they occur.

Lesson Plan 8: Investigate Waves: Reflection o

Learning Aims

All students should:	Describe, using diagrams, reflection of light in p applications. Describe how sound is reflected for simple appl
Most students should:	Describe how mirrors can affect rays of light. Draw diagrams to explain the reflection of light
Some students should:	Explain how reflection of light and sound can b

Keywords: reflection, mirror, conc... ...ex, plane, ray diagram, echo, u

Starter

Review of ...us learning. Ask students to contribute to class discussio about light, ...und and waves in general.

Main

1. Brief introduction to reflection of both light and sound.
2. Introduction to mirrors – discuss different basic shapes of mirro produced.
3. Introduction to ray diagrams. Draw a diagram of the image form explanation. It may aid the students' grasp of ray diagrams if th diagram themselves.
4. Explanation of how a periscope works.
5. Periscope experiment: Students should build their own basic pe box or carton, by cutting holes and fastening pieces of mirror ca Students can then use their periscopes to look over/around obst
6. Discuss applications in which mirrors are useful. Encourage cla
7. Introduction to echoes of sound, includi... ...ussion of its app from the information sheet to de...ns... ...e use of sonar.
8. Answer Questi... ...6 ...m the pack.
9. Elicit ...s during class discussion.

Plenary

Reflection experiment: Students use a light box and a plane mirror on reflection of a straight beam of light. With the lights dimmed, student fixed point on the plane mirror and sketch the path of the light on the and reflection can then be measured and compared.

Reflection of Light and Sound

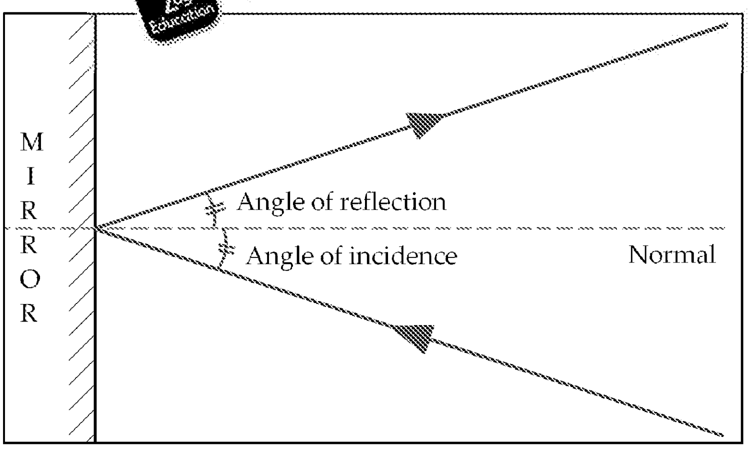
Light and sound both travel in **waves**. When a wave hits a boundary that it canno **reflected** in a new direction. Everything we see is visible because some light has eyes.

There are many applications where it can be useful to change the direction of lig **reflection**.

Mirrors

A **mirror** is a surface which is designed to reflect almost all the light that hits it. M inwards), **convex** (curved outwards) or **plane mirrors** (flat surfaces).

Light rays travel in straight lines. We can use straight lines on a **ray diagram** to re



Light hitting a reflected at ar measured rela imaginary line surface at the shown in the

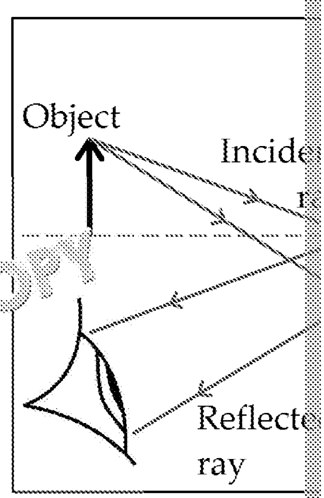
The angle at w is called the **a** The angle at w mirror is calle

The angle of incidence is always equal to the angle of reflection

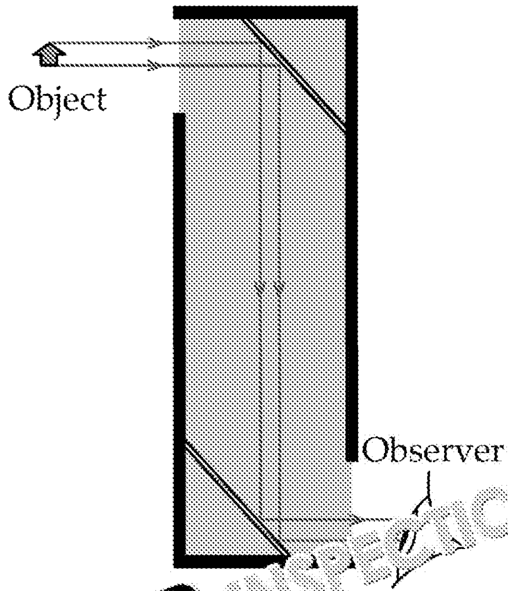
The image shown in a mirror is known as a **virtual image** – the light rays form the image in a way which makes it appear to come from behind the surface of the mirror, as shown in the diagram.

A plane mirror produces an **upright** image, as the diagram shows. Convex mirrors also display upright images, but images in concave mirrors are upside down (for example when you look into the concave side of a spoon).

The image in a mirror is **laterally inverted**. This means the left and right hand sides have been switched round – your left hand is your reflection's right hand and vice versa.



Virtual image g



Plane mirrors are used in **perisco**
provide an image of an object wh
For example, in a **submarine** a pe
above the surface of the water.

The diagram shows how two **pla**
simple periscope, to direct light r
corner and into the eye of the ob

D

Mirrors have many applications where they can show us views that
- **Rear-view mirrors** in cars give the driver a view of what is happ mirrors can be useful for this purpose because they provide a w can also distort the image, unlike plane mirrors which provide a
- Mirrors are also used at **road junctions** where a driver might no ahead. A convex mirror can provide a wide view of the junction showing whether another car is approaching.
- **Reflecting telescopes** use mirrors to focus an image of a distant are commonly used in astronomy, since they tend to be more ac **telescopes** which use lenses.

Echoes

An **echo** is a reflected sound wave. When you talk in a large room, you can some voice – these are sound waves from your mouth which have travelled across the

- Bats use echoes of **ultrasound** – sound waves above the range of human he their surroundings. The longer an echo from an obje... takes to return to the had to travel and so the further away the object is.
- Ships and submarines imitate this te...e by sending pulses of sound whi use of sound reflection is known as sonar.
- Ultrasound is also used in medical imaging, including prenatal scans of unb ultrasound ...ent boundaries are detected and put together to form patien

Worked example
A fishing ship uses sonar to detect a shoal of fish. The echo arrives back exactly 6 pulse. If the speed of sound in water is 1,500 m/s, how far away are the fish?

Distance = speed × time = 1,500 m/s × 6 s = 9,000 m. Therefore the sound wave h

*But this is the distance there **and** back – so the shoal is **half** this distance away –*

Reflection of Light and Sound Questions

1. Copy and complete the phrases using some of the following words.

concave	echo	incidence	light	pl
reflected	reflection	refracted	refraction	s
ultrasound				

________ travels in straight lines. When it is ________, the angle of ___

angle of reflection. A ________ mirror is a flat surface designed for ___

________ waves can also be reflected – this is known as an ________. B

their surroundings, while ships and submarines use it in a technique c

2. A group of students shine a beam of light at a mirror from different an which is reflected in a table. Copy the table below and fill in the m

Angle of incidence	Angle of reflection
30°	
	45°
90°	

3. The image shown in a plane mirror is **virtual**, **upright** and **laterally in**
   a) Explain what is meant by each of these terms.
   b) How would the image differ if the mirror were concave?

4. Describe three applications in which mirrors can be used to widen ou

5. A submarine detects a large obstacle in its path using sonar. There is a pulse being sent and the signal being returned. Given that the speed o how far away is the obstacle?

6. **Group Activity:** On a poster, draw a diagram of an object reflected in how the paths of the light rays form an image which appears to be be

Reflection of Light and Sound Questions

1. Complete the phrases using some of the following words.

concave	echo	incidence	light	p
reflected	reflection	refracted	refraction	s
ultrasound				

_______________ travels in straight lines. When it is _______________,

is always equal to the angle of reflection. A _______________ mirror is

_______________ of light.

_______________ waves can also be reflected ... known as an ___

___________ to detect their surro...s, while ships and submarines

_______________.

2. A gro... stu... shine a beam of light at a mirror from different an... which ... reflected in a table. Fill in the missing results for them.

Angle of incidence	Angle of reflection
30°	
	45°
90°	

3. The image shown in a plane mirror is **virtual**, **upright** and **laterally in**
   a) Explain what is meant by each of these terms.

   Virtual..

   Upright..

   Laterally inverted..

   b) How would the image differ if the mirror were concave?

   ....

4. Describe three applications in which mirrors can be used to widen ou

   1 ....

   ....

   2 ....

   ....

   3 ....

   ....

5. A subm... detects a large obstacle in its path using sonar. There is a pulse being sent and the signal being returned. Given that the speed o how far away is the obstacle?

   ....

   ....

6. **Group Activity:** On a poster, draw a diagram of an object reflected in how the paths of the light rays form an image which appears to be be

Lesson Plan 9: Investigate Waves: Refrac

Learning Aims

All students should:	Describe, using diagrams, reflection and refract applications.
Most students should:	Describe how lenses can affect rays of light.
Some students should:	Explain how reflection and refraction of light ca

Keywords: refraction, normal, total intern l r fle , critical angle, optic

Starter

Refr d ation (student participation): Place a coin at the stud ve one attempt each at stabbing it with a knitting needle. it!

Main

1. Introduction to refraction, including what causes it to occur.
2. Brief discussion of the use of refraction in corrective lenses (alth more detail in subsequent topics).
3. Explanation of total internal reflection in a glass prism – draw d sheet on the board to aid explanation.
4. Total Internal Reflection experiment: Students use a light box to glass semi-circular prism on a piece of paper. They can then ske and out of the prism, in order to investigate refraction and total
5. Discuss applications which make use of total internal reflection.
6. Answer Questions 1–4 from the pack.
7. Elicit answers during class discussion.

Plenary

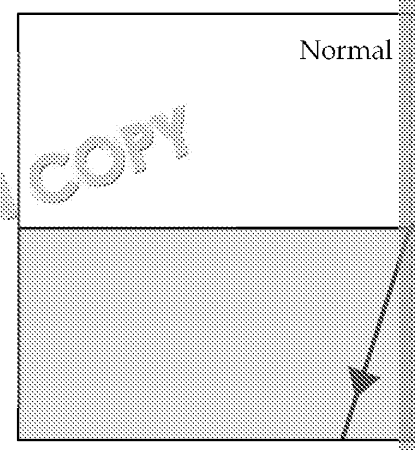
Fastest Finger First: Students w n s. Ask a series of questions abou reflection – the pair wh hand up first and answer correctly get t

Refraction of Light

When you put a straw in a glass of water, the straw appears to be in a different p
causing it to look 'broken'. This is an optical illusion caused by the **refraction** of li

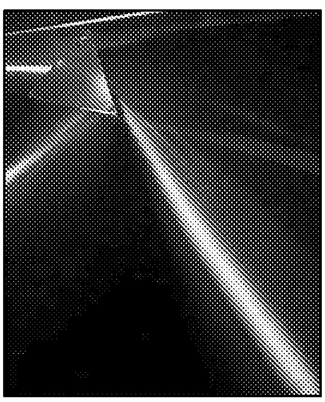
Refraction

Waves move through different media at different speeds. When a wave moves from one medium into another, its speed changes and this can also change the **direction** in which the wave is travelling.



The change in direction is called **refraction.** It will happen whenever a wave crosses a boundary between two materials of different densities – for example, a ray of light passing from air into water.

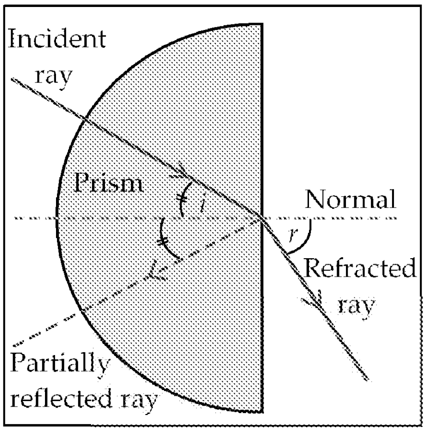
The only time a wave will *not* change direction is when it is travelling along the n
at exactly 90° to the boundary between the media. However, it will still change s



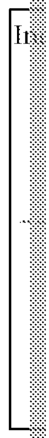
When a beam of white light enters a glass prism, a
light are refracted by different amounts. This splits
can see as they exit the prism. The effect can be se
prism.

Refraction is used in **corrective lenses** to improve
of light which would otherwise focus in the wrong
refraction corrects this so that objects appear mor
greater detail in the next section.

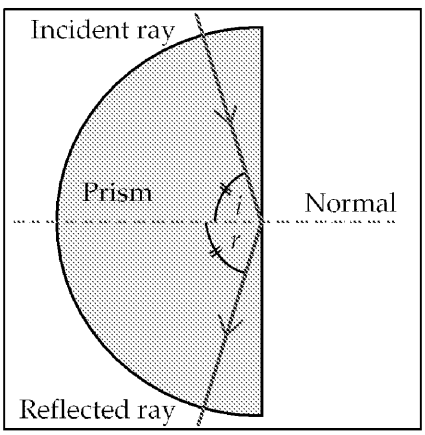
Total Internal Reflection



When a ray of light is refracted travelling fr
dense one (e.g. glass into air), then as well
a **partially reflected** ray. This reflects back
the normal rules of reflection (at an equal
of incidence.)



If we gradually increase the angle of incidence, eventually we find a point where the ray is refracted **along the boundary**. The angle of incidence where this occurs is known as the **critical angle**.



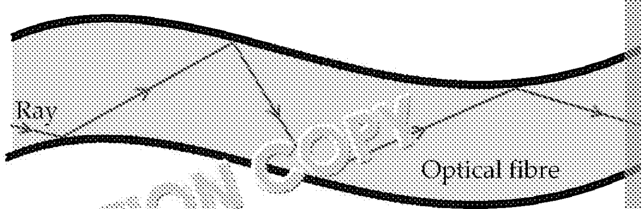
For angles of incidence greater than the cri
refracted – instead the ray is entirely **refle**
known as **total internal reflection.**

The angle of reflection is *always* equal to th

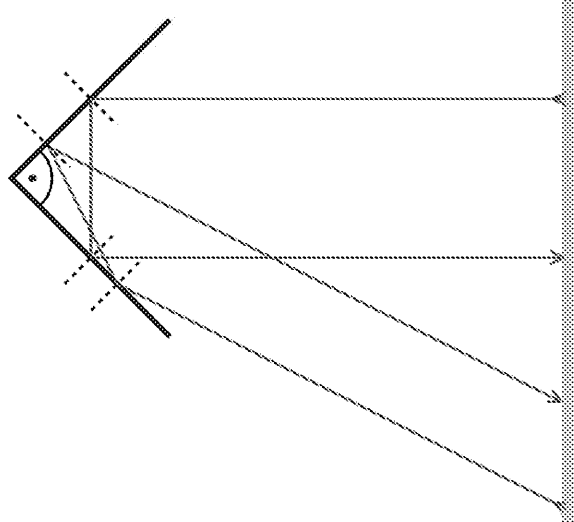
From this angle, the surface of the water acts as a mirror because of

Total internal reflection is useful because it is possible to reflect rays of light alon
known as **optical fibres** – without any of the light leaving the tube.

- Optical fibres can be used to send information, such as phone or internet co
- Optical fibres are used in **keyhole surgery** in medicine, to see inside parts of be difficult to operate on. One bundle of fibres provides light through a narr second bundle carries the reflected light back to be displayed on a monitor. what they are doing on the monitor.



Total internal reflection is also used in **road safety reflectors**, such as the ones at
of each reflector is a series of prisms, which are designed to reflect light b



Refraction of Light Questions

1. Copy and complete the phrases using some of the following words.

absorbed	*boundary*	*critical*	*denser*	*di*
less dense	*normal*	*reflected*	*reflection*	*ref*
total internal reflection				

_______ occurs when a wave passes from one medium into another.

the wave to change _______.

If the wave is passing from a _______ medium to a _______ one, it w

boundary up to a _______ angle where the whole wave is deflected a

angle, _______ occurs at the boundary.

2. When is the only time that a wave travelling across a boundary will n

3. Explain how total internal reflection can be useful a) in medicine, b) in

4. **Group Activity**: On a poster, present a series of diagrams which expla occurs. Describe a real-life application which uses this.

Refraction of Light Questions

1. Complete the phrases using some of the following words.

absorbed	*boundary*	*critical*	*denser*	*di*
less dense	*normal*	*reflected*	*reflection*	*ref*
total internal reflection				

_______________ occurs when a wave passes from one medium into a

causes the wave to change _______________.

If the wave is passing from a ________ ________ medium to a ________

_______________ at the boundary up to a _____________ angle wher

along the _______________. Beyond this angle, _______________ occu

2. When is the only time that a wave travelling across a boundary will n

....

....

3. Explain how total internal reflection can be useful a) in medicine, b) in

....

....

....

4. **Group Activity**: On a poster, present a series of diagrams which expla occurs. Describe a real-life application which uses this.

....

....

Lesson Plan 10: Investigate Waves: Lenses

Learning Aims

All students should:	Describe, using diagrams, the refraction of light
Most students should:	Describe how different types of optical lens can
Some students should:	Explain how the eye lens focuses light onto the can correct simple eye problems.

Keywords: lens, convex, concave, focus, shor sight, long sight, retina

Starter
Provide st s variety of lenses. Students can play around with t notice abo effects they cause.

Main
1. Introduction to lenses as devices designed for refraction of light concave lenses.

2. Use ray diagrams to demonstrate the functions of convex and co beneficial for students to copy these diagrams down themselves

3. Discuss ways in which a lens can be made more (or less) power

4. Explain how lenses are used to correct defects in vision, using d

5. Answer Questions 1–4 from the pack.

6. Elicit answers during class discussion.

Plenary
Light Focusing experiment: Students shine light from behind a simple form a silhouette on a 'screen' (sheet of white card or paper). They can image more into focus by placing a lens (or more than one) in between

Convex and Concave Lenses 'Splat': Students divide into two groups, each stands by the board. Teacher writes convex and concave on the board, rea which the answer is either convex or 'concave'. Students must advise the correct ans

Lenses and the Eye

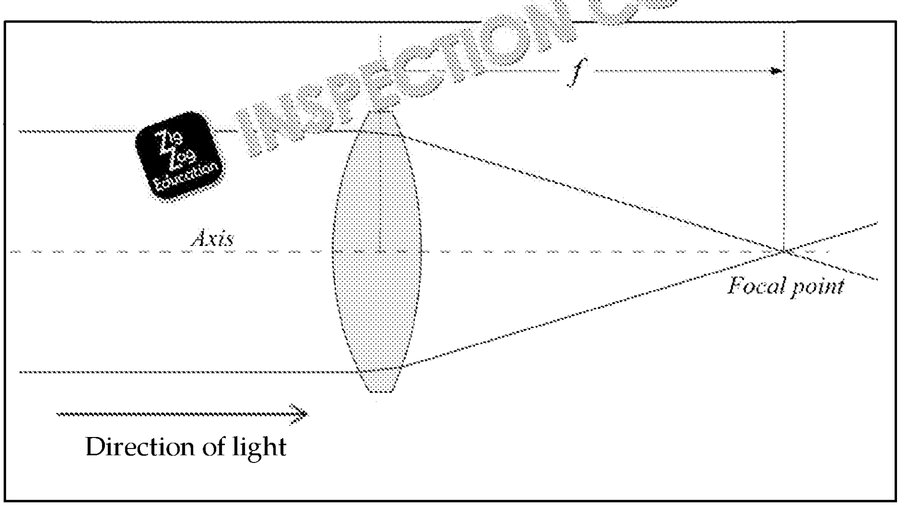
Lenses

A lens is a medium which **refracts** light to create an image. The purpose of a lens i
certain point to create a clearer image.

Our eyes already contain natural lenses which focus light rays for us. Lenses can a
vision or in devices such as magnifying glasses and cameras.

Types of lens

The two basic shapes of lens are **convex** (converging) and **concave** (diverging) len



Co
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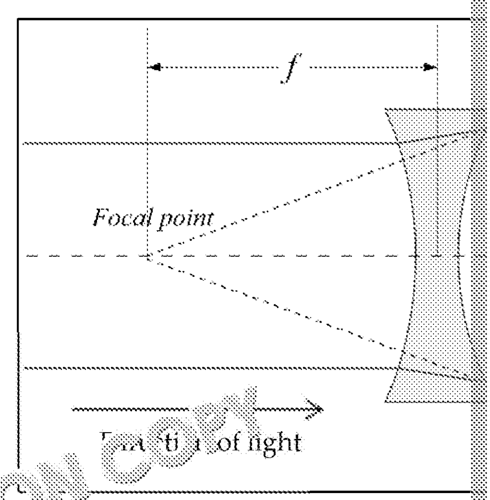
Convex lens

Concave lenses are designed to make parallel rays diverge away from each other, so that they appear to have come from a single point behind the lens. To do this, they have surfaces which curve inwards like the one shown.

Diverging lenses are primarily used to correct **short-sightedness**.



Concave l

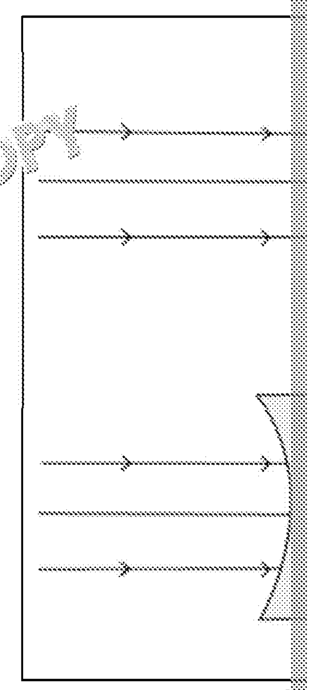
The **power** of a lens is the amount of refraction it causes; different lenses must b
for different ...ation. The power of a lens can be increased by using a **more re**
lens with a more **highly curved surface**.

> ***Did you know?***
> *When someone goes to the optician for a new pair of glasses, the optician is ab*
> *correct power by find out how much their eyes need refocusing.*

Correcting Vision

Our eyes work by using a **lens** to focus light onto the back of the eye (the **retina**) to our brain. However, sight defects are very common and are usually caused by front of or behind the retina so that the images we receive are out of focus. This is the wrong length, or because the lens is unable to focus an image in the correc

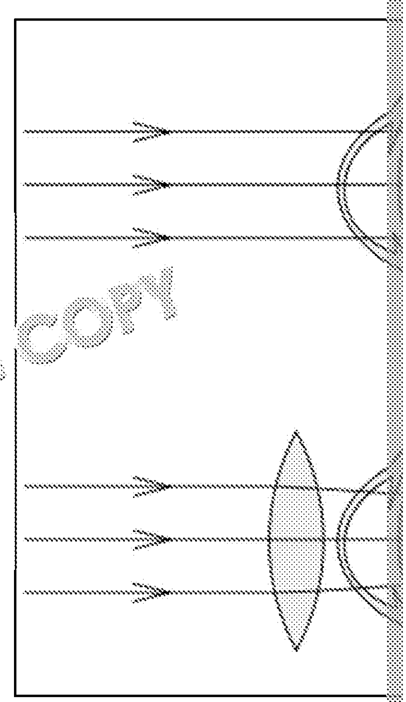
These defects can be easily corrected by placing a corrective lens in front of the e



Uncorrected

Short sight is caused by the eyeball being too long or the focusing power of the lens being too great. Images of **distant** objects are focused slightly in front of the retina, meaning the image detected at the retina is out of focus.

By placing a **concave** lens in front of the eye, the focusing power of the eye lens is slightly counteracted and images are focused slightly further back onto the retina.



Uncorrected e

Long sight is caused by the eyeball being too short, or the focusing power of the lens not being strong enough. Images of **close** objects are focused slightly behind the retina, meaning the image detected at the retina is out of focus.

By placing a **convex** lens in front of the eye, the light rays are converged slightly before reaching the eye, so the eye lens does not have to be as powerful. Images are focused slightly further forward onto the retina.

Lenses and the Eye Questions

1. Copy and complete the phrases using some of the following words.

concave	converge	convex	curved	d
long	reflective	refractive	short	

________ lenses refract parallel rays so that they converge. They are u

________ lenses refract parallel rays so that they ________ and are use

lens can be made more powerful by using a more ________ material, o

________.

2. What are the two possib[illegible] ca[illegible] of short sight?

3. Whic[illegible] pr[illegible]erties of a lens can you increase in order to increase th

4. Explain how different types of lens can be used to treat short sight an

Lenses and the Eye Questions

1. Complete the phrases using some of the following words.

concave	converge	convex	curved	d
long	reflective	refractive	short	

__________ lenses refract parallel rays so that they converge. They ar

sight. __________ lenses refract parallel rays so that they __________

__________ sight. A lens can be made more powerful by using a mor

making the shape more __________ .

2. What are the two [illegible] causes of short sight?

   1 ....

   2 ....

3. Which two properties of a lens can you increase in order to increase th

   1 ....

   2 ....

4. Explain how different types of lens can be used to treat short sight an

   Short sight ....

   ....

   ....

   ....

   ....

   Long sight ....

   ....

   ....

   ....

   ....

Lesson Plan 11: Investigate Waves: Sou

Learning Aims

All students should:	Describe the importance of a medium for the tra through a variety of substances for applications
Most students should:	Describe the propagation of sound waves, inclu rarefaction.
Some students should:	Explain how sound waves can be applied in eve

Keywords: sound, longitudinal, compression, rarefaction, wavelength, fre

Starter

Review of previous learning. Encourage class discussion on what students properties and waves.

Main

1. Introduction to sound waves and properties of longitudinal wa
2. Demonstration of longitudinal waves: Use a Slinky spring to de waves travel via compressions and rarefactions.
3. Explain concepts of wavelength, frequency and amplitude, and them.
4. Write example problems on the board for students to solve using this during class discussion.
5. Discuss why sound needs a medium through which to propaga quickly through solids and liquids than through air.
6. Yoghurt Pot Telephone experiment: Students can make a basic t pots by tying a string between the bases of the pots. By holding should be able to use the pots to hear each other across the class
7. Discuss applications of sound waves – including ones previousl Light and Sound'.
8. Answer Questions [illegible]-6 from the pack.
9. Elicit answers during class discussion.

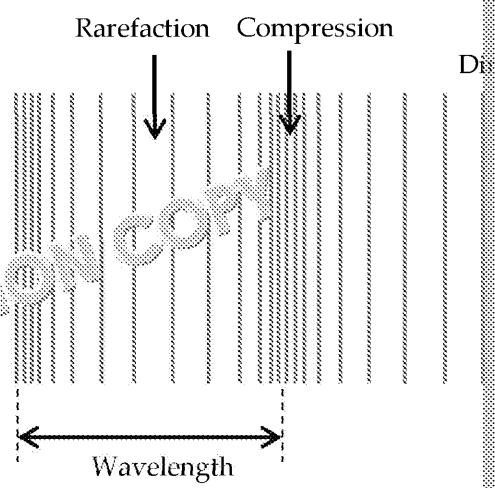
Plenary

Demonstration of pitch and frequency: Encourage students who play them into class (or borrow some from music dept. if not enough musi observe the effects of pitch and volume of a note on an oscilloscope.

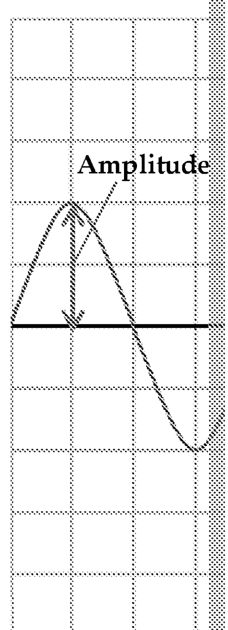
Sound Waves

Sound waves are waves which transfer sound energy by vibrating through a med
in our ears as sound. Sound waves cannot travel in a vacuum – they rely on a me
propagate), so that the vibrations can be passed from molecule to molecule.

Sound waves are **longitudinal** waves, which means they oscillate **parallel** to the direction of propagation. A longitudinal wave pushes the air together to form **compressions** and ... to form **rar**...**ns** along the direction of ...



A sound wave has wavelength, frequency and amplitude – but it is not easy to understand and describe amplitude when looking at a longitudinal wave diagram like the one above. However, if you play a sound into the microphone of an oscilloscope it will show it in the form of a **transverse** wave, like the one shown.



Now it is easier to look at the three elements of a sound wave: its **wavelength**, **fr**

- The **wavelength** of a wave is the distance between any point on a wave and
  example, the distance between two identical areas of compression or rarefa
  shown above.
- The **fr**...**y** of a wave is the number of wavele... that pass a certain point **per second**.
  The frequency of a sound wave determines the **pitch** of the sound. A sound
  produce a high sound, while one with low frequency will produce a lower on
- The **amplitude** of a wave is its **maximum displacement** from its undisturbed
  The amplitude of a sound wave determines how **loud** the sound is. A sound
  will produce a loud sound, while one with small amplitude will produce a qu

We can use the wavelength and frequency of a wave to calculate its speed:

$$v = f \times \lambda$$

where: v is the wave speed, in metres per second (m/s)
f is the frequency, in Hertz (Hz)
λ is the wavelength, in metres (m)

The medium through which sound travels affects the speed of the sound waves. through solids and liquids than through air. This is because the molecules in a so so they can pass the vibrations on more quickly.

For example, the speed of sound in water is about 5 times faster than in air. This **communications** and also allows sea creatures like whales to communicate quick

Sound travels faster through a brick wall than through air – but the sound we hea because the sound is partly reflected by the surface of the wall.

This partial reflection is useful in **ultrasound imaging**, where each reflection of a boundary is between different types of tissue.

Did you know?
Space is a vacuum, so sound waves cannot travel through it. If you tried to ma would hear it! Sound itself cannot be transmitted through space – it can only b electromagnetic radiation and converted back to sound waves by a receiver.

D

Sound waves are useful for a variety of applications. As discussed i Sound', sound waves are used for **ultrasound imaging** and **sonar** – used in the following applications:

- **Voice recognition** is used by police and forensics analysts to ide their voice. Each person's voice has a unique **frequency spectru** called a **speech signature**. The police can use computer software telephone call) to a person using their speech signature.
- Ultrasound can also be used to break up **kidney stones**. High-en directed at the kidney stone, causing it to vibrate strongly enoug fragments. These fragments are then small enough to exit the ki

Sound Waves Questions

1. Copy and complete the phrases using some of the following words.

amplitude	*compression*	*frequency*	*liquid*	*long*
rarefaction	*transverse*	*vacuum*	*wavelength*	

Sound waves are ________; they travel by creating areas of compressi

medium. Sound waves cannot travel in a _______.

The higher the ________ of a sound wave, the higher its volume. The h

the ________ of the sound.

2. A wave has a frequency of [illegible] Hz and a wavelength of 7 m. Calculate t

3. A sound wave travels through air at 340 m/s. If its wavelength is 17 cm
the wave.

4. If a sound wave has a very small amplitude but a high frequency, how

5. Sound travels almost five times faster through water than it does thro

6. Name four applications which use sound waves. For each one, explain
important role in the application.

Sound Waves Questions

1. Complete the phrases using some of the following words.

amplitude	*compression*	*frequency*	*liquid*	*long*
rarefaction	*transverse*	*vacuum*	*wavelength*	

Sound waves are ___________; they travel by creating areas of compre

through a medium. Sound waves cannot travel in a __________.

The higher the ___________ of a sound wave, th ... her its volume. T

higher the ___________ of the sou

2. A wave has a ... y of 50 Hz and a wavelength of 7 m. Calculate t

....

3. A sound wave travels through air at 340 m/s. If its wavelength is 17 cm the wave.

....

4. If a sound wave has a very small amplitude but a high frequency, how

....

5. Sound travels almost five times faster through water than it does thro

....

....

6. Name four applications which use sound waves. For each one, explai important role in the application.

1 ....

....

....

2 ....

....

....

3 ....

....

....

4 ....

....

....

Learner's name:		
Start date:	Deadline:	Da

Light and Sound Waves

Scenario

You are working at a science museum. You are asked to write an article for th medical applications of light via reflection, refraction and total internal reflecti

Your manager then asks you to contribute to an exhi o sound waves, by describes the medical applications that sound w ves e used for.

Task 1

Write an a n any medical applications of light.

1. For me pplications that use reflection, include a basic ray diagram o demonstrate how waves are reflected.
   Ultrasound imaging is a good example of a medical application which relie

2. For medical applications that use refraction or total internal reflection, sh and total internal reflection in a prism to aid your explanations of how th
   Optical fibres are a good example of a medical use of total internal reflecti

3. Describe the different ways in which lenses and mirrors can change the d
   Include mirrors and lenses which are both convex and concave in shape.

4. Relate these processes to their uses in additional medical applications, su provide.

Task 2

Your poster should include:

1. An explanation of how reflection of sound is used for techniques such as
   Relate the way sound is used for ultrasound imaging and sonar to the way

2. Discussion of how it is vital for sound waves to have a medium to travel t this in certain applications.
   Describe how the medium affects the way in which sound travels. Include e e.g. air, water, wall partitions, etc.

3. An explanation of the way in which sound w s p pagate.
   Refer to the fact that sound waves ar it d and travel via compres explanation.

4. An overall disc the benefits of sound waves for medical applicati they ar

Learner's name:	**Start Date:**

Learner's declaration:
I certify that the work submitted for this assignment is my own. I have clearly refer
work. I understand that false declaration is a form of malpractice.

Learner's Signature: Date:

Learner's comments for the assessor:

Teacher's/assessor's na

Marking Criteria		
Task:	**Criteria:**	**Learner must:**
1	**2C.P7**	Describe, using diagrams, reflection and refraction of light for simple applications.
	2C.M5	Describe how lenses and mirrors can affect rays of light.
	2C.D4	Explain how reflection and refraction of light can be used in applications.
2	**2C.P8**	Describe the importance of a medium for the transmission of so waves through a variety of substances for simple applications.
	2C.M6	Describe the propagation of sound waves, including compressio and rarefaction.
	2C.D5	Explain how sound waves can be applied in everyday uses.

Deadline:

Summative feedback:

Date assessed:

Internal verifier's name:

Internal verifier's feedback:

Date:

If a learner has not ... Level 2 criteria, they can be assessed on the Level	
1C.7	Des... using diagrams, reflection of light in plane mirrors for simple ap
1C.8	Desc... how sound is reflected for simple applications.

Lesson Plan 12: Investigate Electricity: Ele

Learning Aims

All students should:	Understand the meanings of common circuit sy Measure currents and voltages in electric circuit
Most students should:	Calculate resistances from measured currents a
Some students should:	Analyse an everyday life situation in which the is not constant.

Keywords: current, voltage, potential difference, resistance, ohmic, non-o

Starter
Review of previous learning. Provide students with a table containing all t know – students must fill in the name of the component each symbol repr

Main

1. Review table of circuit symbols and discuss.
2. Introduce 'new' circuit symbols – thermistor and LDR – and bri each of these components.
3. Discuss current, voltage and resistance (*this can be treated as revis Science unit 3 – Energy and Our Universe, but will help with the new*
4. Introduction to Ohm's law, and ohmic/non-ohmic conductors.
5. Introduction to current–voltage graphs, and comparison of grap wire/resistor and a filament bulb.
6. Current vs. Voltage experiment: Students investigate the effect t current through a) a resistor, b) a filament bulb, by controlling t power supply and using a voltmeter and ammeter to take readi respectively. Students then plot current–voltage graphs of the re relationships they find (i.e. ohmic or non-ohmic).
7. Answer Questions 1–3 from the pack.
8. Elicit answers during class discussion.

Plenary
Discuss results of current vs. voltage experiment with students. Discuss w do not obey Ohm's law.

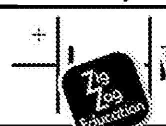
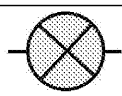
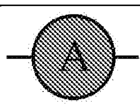
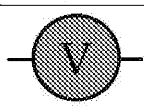
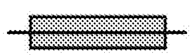
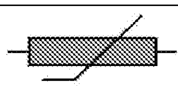
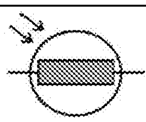
Electric Circuits

An **electric circuit** is a complete circuit of electrical components, connected by w
Current flows around the circuit when **voltage** from a power supply is provided.

Electric circuits can be represented in the form of **circuit diagrams**.

Circuit Symbols

The symbols shown below are some of the most important **circuit symbols** used components of the circuit. You will need to be familiar with these symbols so tha of your own.

Circuit Symbol	Name of Component	Function of
	**Battery**	Pushes charge around a c flows. Current always flow cell round to th
	**Switch**	Connects or disconnects t o
	**Filament lamp**	Emits light whe
	**Resistor**	Limits the current that flo circ
	**Ammeter**	Measures current flowing
	**Voltmeter**	Measures voltage ac
	**Fuse**	Melts and disconnects the a set a
	**Thermistor**	Varies resistance acco
	**LDR (light-dependent resistor)**	Varies resistance depe

Current

An electric current is a flow **of charge** around a complete circuit. Current will onl are **conductors** of electricity – most of these are metals. The current in a circuit p the circuit with electrical energy.

Current will only flow in a circuit if it is complete and has a power supply. If any p there is no voltage supplied to the circuit, the current around the entire circuit w

Current is measured in **amperes** (also called amps, A). The current at a particular using an **ammeter**. The ammeter is connected in **series** at the relevant point in th passing through it in amps (A) or milliamps (mA).

Voltage

The **voltage** across a component is the amount of electrical **energy transferred** t **charge** that passes through it. The higher the voltage, the more energy the comp

The voltage of a power supply is the **work done** by the power supply on **each un** around the circuit. The higher the voltage of the supply, the more energy it provi

Voltage is measured in **volts** (V). The voltage across one or more components in a **voltmeter**. The voltmeter is connected in **parallel** across a component and reads millivolts (mV).

In the UK, the mains power supply in our homes provides a voltage of 230 V.

Resistance

The amount of current that ... through a component depends on the **resista** greater the ... component, the less current is able to pass through it measured i... (Ω) or kilohms (k Ω).

For a given voltage, the higher the resistance, the smaller the current that flows. are all related by **Ohm's law**:

$$V = I \times R$$

where: *V* is voltage, in volts (V)
I is current, in amps (A)
R is resistance, in ohms (Ω)

NB: *This equation can be rearranged as* $I = \frac{V}{R}$ *, to find current, or* $R = \frac{V}{I}$ *,*

Did you know?
When an electrician wires up a circuit in a house, they have to make sure the ci a fire hazard. The more current that flows in a wire, the hotter the wire gets – s ***resistor*** *in the circuit to reduce the amount of current that flows.*

D

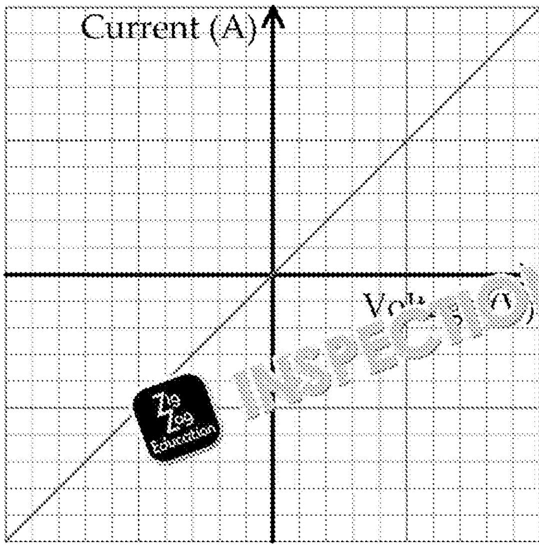
Ohm's law states that this relationship between voltage, current at **constant temperature**. Electrical components which follow th **conductors**.

However, not all components do follow this rule. For example, a ... at ... temperatures, but at higher temperatures its resist ... current through it does not rise at the same rate as the volta bulb is a **non-ohmic conductor**.

You can analyse an everyday example of a non-ohmic conducto taking measurements of current through it for different voltage current–voltage graph (as shown below). A non-ohmic conduct voltages, but the graph will change as the voltage increases.

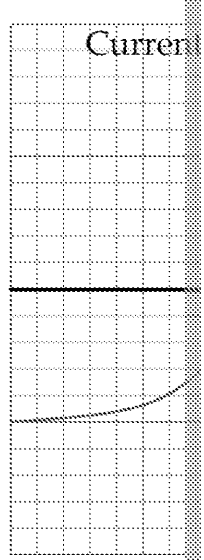
Current–Voltage Graphs

Current–voltage graphs show us how the current through a component varies wi
component.



A **wire** in an electric circuit is o
so the current–voltage graph i
proportional relationship, in a

A **resistor** is also ohmic at con
voltage graph also looks like th



At low currents, a **filament bulb** is roughly ohmic. However, we can see on the graph that as the voltage is increased, the graph starts to curve because current is not increasing at the same rate. A filament bulb is a **non-ohmic** conductor.

This is because as the current through the bulb rises, the **temperature** of the filament wire rises. As the temperature rises, its **resistance** also rises – restricting the amount of current that flows.

Electric Circuits Questions

1. Copy and complete the phrases using some of the following words (w
once).

current	*filament bulb*	*fuses*	*Hooke's*	*no*
Ohm's	*power*	*resistance*	*resistors*	*s*
voltmeter				

_______ law states that at constant ________, voltage and ________ ar

Components which obey this rule are called ________ conductors. Th

________.

Components which d... o... the rule are called ________ conducto

non-o... s ______ through it increases, because its temperature r

2. a) When a current of 2.7 A passes through a bulb, its resistance is 3 Ω
difference across the bulb.
   b) The current increases to 5 A; the potential difference across the bu
resistance of the bulb now?

3. Sketch the current–potential difference graphs of a) a resistor, b) a fila
whether the component is an ohmic or non-ohmic conductor, giving r

Electric Circuits Questions

1. Complete the phrases using some of the following words (words may

current	filament bulb	fuses	Hooke's	no
Ohm's	power	resistance	resistors	s
voltmeter				

__________ law states that at constant __________, voltage and ______

proportional. Components which obey this rule are called __________

wires and __________.

Components which do not obey the rule are called __________ condu

more ... through it increases, because its temp

__________ rises.

2. a) When a current of 2.7 A passes through a bulb, its resistance is 3 Ω difference across the bulb.

   ....

   b) The current increases to 5 A; the potential difference across the bu resistance of the bulb now?

   ....

3. Sketch the current–potential difference graphs of a) a resistor, b) a fila whether the component is an ohmic or non-ohmic conductor, giving r

   a) ....

   ....

   ....

   ....

   ....

   ....

   b) ....

   ....

   ....

   ....

   ....

   ....

Lesson Plan 13: Investigate Electricity: Series ar

Learning Aims

All students should:	Describe, using diagrams, how to build series ar Measure currents and voltages in series and par
Most students should:	Calculate resistances from measured currents ar
Some students should:	Use information about a parallel circuit to calcu through or resistance of a particular appliance.

Keywords: current, voltage, resistance, series, parallel

NB: The section 'Series and Parallel Circuits' is also covered in the Teaching Pack Unit 3 – Energy and Our Universe. The following section can be treated as revisi help students with the new concepts being introduced.

Starter

Review of previous work. Solve problems related to current, voltage and r discussion.

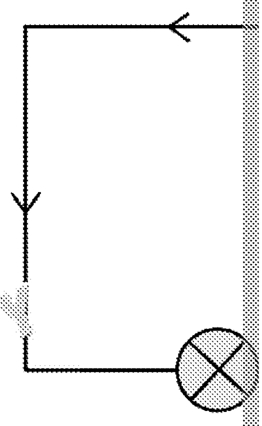
Main

1. Discuss rules of current, voltage and resistance in a series circui
2. Demonstration on the board using worked example in the pack. students to solve themselves.
3. Elicit answers to examples during class discussion.
4. Discuss rules of current, voltage and resistance in a parallel circ
5. Demonstration on the board again using worked example in the examples for the students to solve themselves.
6. Elicit answers to examples during class discussion.
7. Investigating series and parallel circuits: Students can set up cir ways of connecting two filament lamps and a resistor in a circui connecting in series and in parallel. In particular students shoul brightnesses of the bulbs when connecting them both in series a
8. Answer Questions 1–5 from the pack.
9. Elicit answers during class discussion.

Plenary

Properties Match: Create a list of properties of either series or parallel circ into the correct category.

Series Circuits



These two bulbs are connected in **series**.

In a **series circuit**, all the components are linked in a single 'loop'.

Series circuits have certain rules regarding voltage, current and resistance.

In a series circuit, the same current flows through each component.
The cell pushes the same amount of charge round the circuit each second – so th through each bulb per second. This means the current is the same in each bulb a circuit.

In a series circuit, the total voltage provided by the supply is shared between th
The voltage of the **cell** is the amount of energy it transfers to each unit of charge round the circuit, it transfers this energy to all the **components** in the circuit befo Therefore the total energy held by each unit of charge is **shared** between the com If one of the bulbs has a higher resistance, it will receive more of the energy and across it than the other bulb.

For cells connected in series, the total voltage is the sum of the voltage of each
If another cell were added to this circuit alongside the first one, each unit of char the first cell and then more energy from the next cell. The total amount of energy energy it receives from each individual cell. Therefore the total voltage is the sum cells.

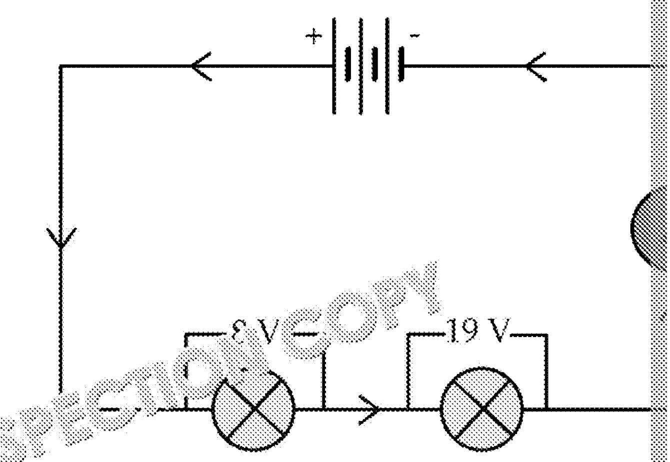
Resistance in Series Circuits

The total resistance of the circuit is the sum of the resistance of each compone

Resistance is calculated using $R = \frac{V}{I}$. Each bulb in the diagram has a **share** of th so they must also each have a **share** of the total resistance of the circuit.

Worked Example

An electrician sets up two bulbs in series with three identical cells as shown. The
measured as 8 V and 19 V as shown. Calculate the voltage supplied by *each* cell.



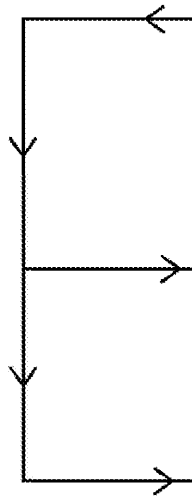
- *The total voltage provided by the supply is shared between the components.*
  be equal to the sum of the voltages of the bulbs. 8 V + 19 V = 27 V.
- *The 27 V voltage is provided by 3 cells – if they are all identical, then each ce*
  voltage – so 27 V / 3 = 9 V.

The ammeter gives a reading of 5 A. Calculate the resistance of each bulb.

- $R = \frac{V}{I}$. *We know the same current flows throughout a series circuit, so the*
  8 V / 5 A = 1.6 Ω. The resistance of the 19 V bulb is 19 V / 5 A = 3.8 Ω.

Parallel Circuits

These two bulbs have been connected to the power supply in **parallel**.



In a **parallel circuit**, different components lie on different **branches** of the circuit. The current in the circuit can travel down either branch.

Parallel circuits have certain rules regarding voltage, current and resistance – but they are different from the rules for series circuits.

NB: If two components lie on the same branch of a parallel circuit, those two components are still ***in series with each other****. The two components as a whole are in parallel with the rest of the circuit.*

In a parallel circuit, the voltage across each component in parallel is the same a
Each unit of charge still carries the same amount of energy, regardless of which r
above, each unit of charge will pass through exactly one bulb – none will pass th
energy transferred from each unit of charge is the same for each component in p

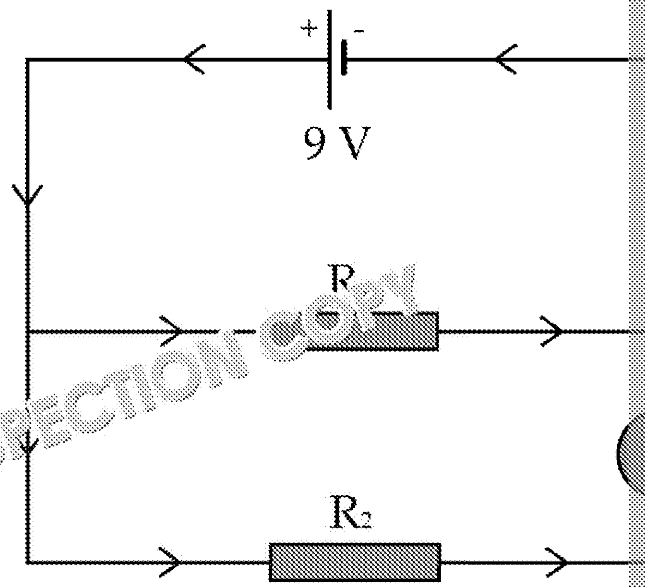
The total current throughout the circuit is the sum of the current through each
When the current reaches a junction, some will flow down one route and some w
Therefore the current is split between the two routes.
The amount of current that flows through each component depends on the **resis**
resistance of one bulb is higher than the other, more of the current will flow thro
resistance.

If the voltage of a parallel circuit and the resistance of a component are known, y will flow through that component using $I = \frac{V}{R}$.

Worked Example

Two resistors, R_1 and R_2, are set up in parallel with a 9 V power supply as show

The ammeter reads 5 A. Calculate the resistance of R_2.



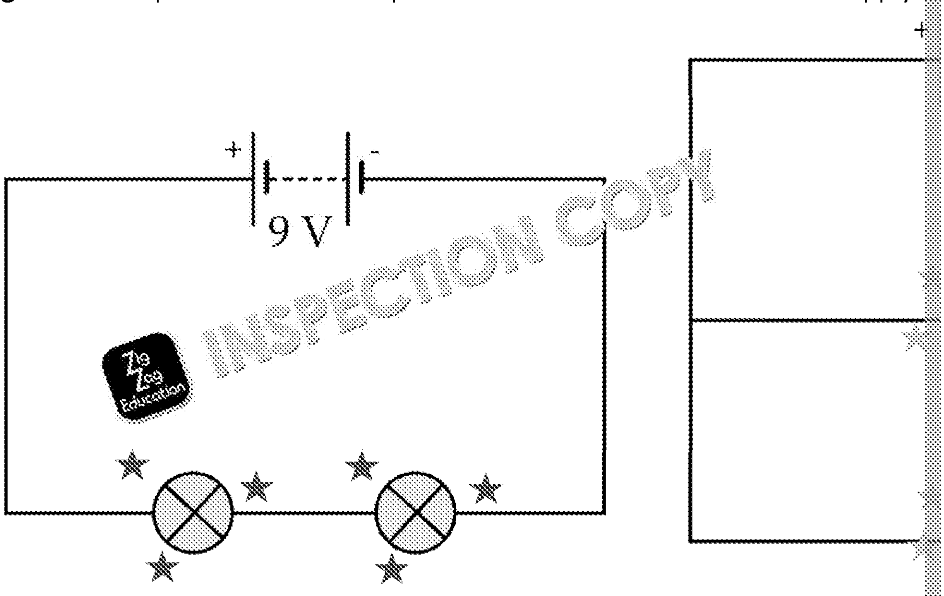
- $R = \frac{V}{I}$; *we know that voltage is the same across each component as the vo*

9 V / 5 A = 1.8 Ω.

R_1 has a resistance of 18 Ω. Calculate the current flowing throughout the ci

- *Calculate current through* R_1: $I = \frac{V}{R}$; *9 V / 18 Ω = 0.5 A.*
- *Current flowing throughout the circuit is the sum of the current through each* *5 A + 0.5 A = 5.5 A.*

In a parallel circuit, each component receives the same amount of voltage that it connected by itself in parallel. This means that a pair of filament lamps connecte **brighter** than a pair of filament lamps connected in series with the same supply.



Series and Parallel Circuits Questions

1. Copy and complete the phrases using some of the following words (w
once).

ammeter	*components*	*current*	*parallel*	*pow*
series	*voltage*	*wire*		

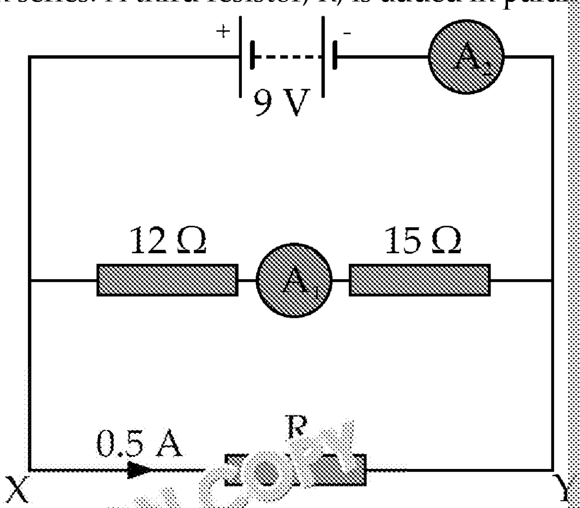
In a ________ circuit, the current is the same at any point. The ______
shared between the individual ________.

A ________ circuit has the same ________ across each branch of the cir
provided by the ________. The ________ in the circuit is divided betw
that flows in each di... depends on the ________ of the componen

2. Draw a circuit diagram of two resistors in series with two 9 V cells.
   a) What is the total voltage provided by the cells?
   b) One resistor has a resistance of 5 Ω; the other has a resistance of 7
   of the circuit?
   c) The current of the circuit is 1.5 A. Calculate the voltage across eac

3. Draw a circuit diagram of a bulb and a resistor each in parallel with a
   a) The resistance of the bulb is 16 Ω. Calculate the current through th
   b) The total current in the circuit is 3.75 A. Calculate the resistance o

4. Two resistors are set up in series. A third resistor, R, is added in paral



   a) i) Calculate the voltage between points X and Y.
   ii) The voltage across the 15 Ω resistor is 5 V. Calculate the volta
   b) i) Calculate the total resistance of the 12 Ω and 15 Ω resistors in
   ii) Calculate the current flowing through ammeter A_1.
   iii) Calculate the current flowing through ammeter A_2.
   c) Calculate the resistance of resistor R.

5. **Group Activity:** Draw your own circuit diagrams for certain simple a
how it is best to lay out the components (i.e. series or parallel).

Series and Parallel Circuits Questions

1. Complete the phrases using some of the following words (words may

ammeter	*components*	*current*	*parallel*	*pow*
series	*voltage*	*wire*		

In a _______________ circuit, the current is the same at any point. The

the _______________ is shared between the individual _______________

A _______________ circuit has the same _______________ across each

the amount provided by the _______________ _______________ i

between branches – the amo... ...ws in each direction depends o

components.

2. Draw ...it diagram of two resistors in series with two 9 V cells.

   a) What is the total voltage provided by the cells?

   ....

   b) One resistor has a resistance of 5 Ω; the other has a resistance of 7
   of the circuit?

   ....

   c) The current of the circuit is 1.5 A. Calculate the voltage across eac

   ....

   ....

3. Draw a circuit diagram of a bulb and a resistor each in parallel with a

   a) The resistance of the bulb is 16 Ω. Calculate the current through t

   ....

   b) The total current in the circuit is 3.75 A. Calculate the resistance o

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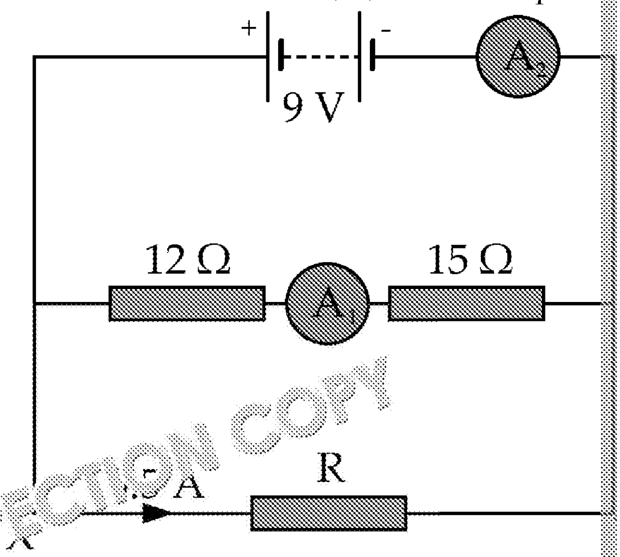
   ....

4. Two resistors are set up in series. A third resistor, R, is added in paral



a) i) Calculate the voltage between points X and Y.

....

ii) The voltage across the 15 Ω resistor is 5 V. Calculate the volta

....

b) i) Calculate the total resistance of the 12 Ω and 15 Ω resistors in

....

ii) Calculate the current flowing through ammeter A_1.

....

iii) Calculate the current flowing through ammeter A_2.

....

c) Calculate the resistance of resistor R.

....

5. **Group Activity:** Draw your [illegible] diagrams for certain simple a how it is best to lay [illegible] components (i.e. series or parallel).

Lesson Plan 14: Investigate Electricity: Therm

Learning Aims

All students should:	Describe the use of a thermistor or LDR for an a Investigate an application of thermistors or LDR
Most students should:	Mathematically or graphically process the resul thermistors or LDRs to draw conclusions.
Some students should:	Evaluate the investigation into thermistors or L to a real-life application.

Keywords: thermistor, LDR, resistance, temp ra ur , ight intensity, NTC,

Starter
Review of pr io . Discuss with class the basic functions of a therm

Main

1. Introduction to thermistors. Explain how NTC thermistors resp and that this can be used in applications.
2. Discuss applications in which a thermistor could be useful.
3. Introduction to LDRs. Explain how LDRs respond to changes in can be used in applications.
4. Discuss applications in which an LDR could be useful.
5. Analyse and discuss the current–voltage profiles for thermistors
6. Investigation into thermistors and LDRs: Students construct a si NTC thermistor and a bulb and vary its temperature to see the e of the bulb. Repeat with an LDR, by varying its exposure to ligh on what this shows about the function of a thermistor and an LI
7. Discuss results of thermistors/LDRs investigation with students. Disc which a thermistor or LDR could be useful, based on the students' fin
8. Answer Questions 1–6 from the pa k.
9. Elicit answers during d s ussion.

Plenary
Text it: Pup to explain how thermistors or LDRs work in 160 characters.

Thermistors and LDRs

Thermistors

A **thermistor** is a form of resistor. However, unlike an ordinary resistor, a thermis
resistance varies with **temperature**.

A **negative temperature coefficient** (NTC) thermistor **decreases** in resistance as i
allowing more current to flow at higher temperatures.

*NB: There are also positive temperature coefficient thermistors, which do the opp
know about these for your BTEC course.*

NTC thermistors can be useful in appliances which control or monitor **temperatu**
the thermistor can be used to affect the appliance directly, or it can be detected a
which controls other circuits within the appliance.

Uses of NTC thermistors

- *Air-conditioning systems / thermostats*
  When the ambient temperature in a room changes, it will affect the resistan
  in resistance is picked up as an input signal by a control device, which alters
  accordingly.
- *Temperature monitors in cars, e.g. for oil and coolant*
  Again, any change in temperature in the oil/coolant will change the resistan
  is detected by a control device, which can give a reading for temperature or
  temperature is too high.
- *Ambient temperature monitors, e.g. in a greenhouse or an incubator*
  These work in a similar way to ordinary thermostats – a change in ambient t
  resistance of the thermistor and a control device can interpret this change t
  a monitor.

LDRs

Another form of resistor is an **LDR** (light-dependent resistor). An LDR is designed so that its resistance varies with **light intensity**.

The resistance of an LDR **decreases** as light intensity **increases** – allowing more current to flow when it is more exposed to light.

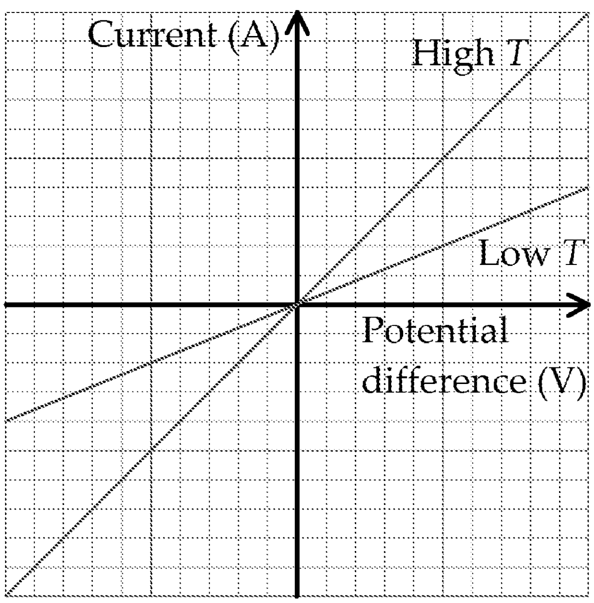
LDRs are found in many everyday applications which control or monitor brightness of **light**. Like a thermistor, the change in resistance of the LDR can be used either to directly affect the function of the appliance, or as an **input signal** to a control device.

Uses of LDRs

- *Street lighting*
  As light intensity drops, the LDR's resistance increases; at a certain point, th
  will trigger a circuit to switch the street lamp on. When the light intensity ris
  will drop again and the control device will switch the lamp back off.
- *Burglar alarms*
  Some alarms can be placed in lit areas, where if a shadow is cast by a burgla
  intensity. This changes the resistance of the LDR, which sends a signal to the
  alarm.
- *Camera light meters*
  The light meter can use the resistance of the LDR as a measure of the light i
  being taken. A control device interprets this as a measurement for the came
- *Solar lighting, e.g. in gardens and in road studs*
  These work in the same way as street lighting.

Current–Voltage Graphs for Thermistors and LDRs

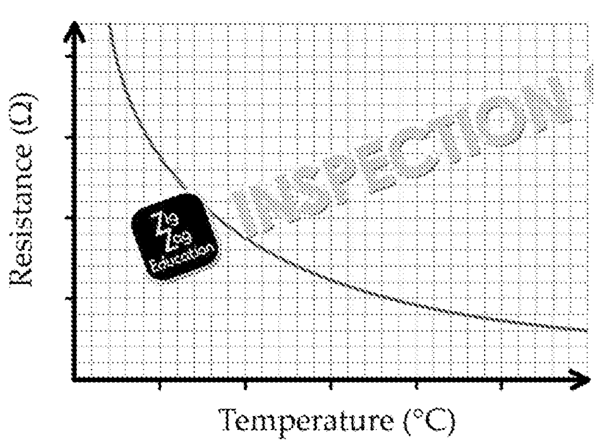
Thermistors and LDRs are both forms of **resistor** and so they are both **ohmic** con
constant temperature, the current flowing through them is **directly proportiona**
Their current–voltage graphs both show a straight line through the origin.



Thermistors drop in resista
increases – so the higher t
current flows through ther

The graph shows how the c
affected by a high tempera
More current flows at high
increases as temperature i

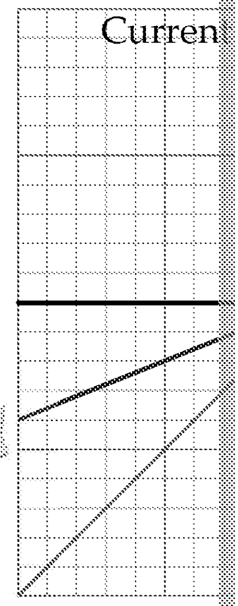
The lower the temperature
allows through and so the r



This graph is an easier way
increasing temperature on

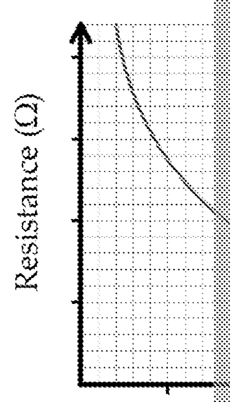
LDRs drop in resistance as the intensity of light they are exposed to increases – so the brighter the light that falls on them, the more current flows.

The graph shows how the current through an LDR is affected by brighter light compared with dimmer light. More current flows when the LDR is more exposed to light, so the **gradient increases** as light intensity increases.



The dimmer the light intensity, the less current the LDR lets through and so the **more effective** it is.

This graph is an easier way of showing the effect of increasing light intensity on the resistance of an LDR.



D

How to Evaluate an Investigation into Thermistors or LDRs

For your assignment you will need to draw conclusions from an inve or LDRs work. From these conclusions, you should be able to descril which a thermistor or LDR could be used. In each case, you will need could be useful based on what you have found from your own work

For example, the resistance of a thermistor depends on heat – your e the relationship is, and from this you should be able to think of some heat that you could use the thermistor for, and suggest improvements

Thermistors and LDRs Questions

1. Copy and complete the phrases using some of the following words:

current	higher	less	light intensity	l
negative	positive	resistance	resistor	tem
voltage				

The ________ of a ________ varies with temperature. If it has a ______

resistance will fall as its ________ rises, allowing more ________ to flo

An LDR is also a form of ________. Its resist... ...aries with ________

exposed to, the ________ its resis... ...and so the ________ current ca

2. What d... t... ...) LDR, b) NTC stand for?

3. List three applications which use thermistors. For each one, explain w important part of the application.

4. List four applications which use LDRs. For each one, explain why an the application.

5. a) Sketch and label a current–voltage graph for a thermistor at a hig Explain what the graph shows.
   b) On a new set of axes, sketch a current–voltage graph for an LDR intensity. Again, explain what the graph shows.

6. **Group Activity**: Discuss the types of applications which may benefit LDRs. Can you think of any new ideas that they might be useful in?

Thermistors and LDRs Questions

1. Complete the phrases using some of the following words:

current	*higher*	*less*	*light intensity*	*l*
negative	*positive*	*resistance*	*resistor*	*tem*
voltage				

The ___________ of a ___________ varies with temperature. If it has a

coefficient, its resistance will fall as its ___________ rises, allowing mo

An LDR is also a form of ___________. Its resi... varies with ______

it is exposed to, the _________ ... stance, and so the ___________

2. What d... LDR, b) NTC stand for?

   a) ....

   b) ....

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   1 ....

   ....

   2 ....

   ....

   3 ....

   ....

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   2 ....

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   3 ....

   ....

   4 ....

   ....

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intensity. Again, explain what the graph shows.

....

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6. **Group Activity**: Discuss the types of applications which may benefit f
LDRs. Can you think of any new ideas that they might be useful in?

Assignment D: Electric Circuits, Thermistors a

Learner's name:		
Start date:	Deadline:	Da

Electric Circuits, Thermistors and LI

Scenario

You are working for a company that produces electronic components for use in thermistors and LDRs. Your first task today is to check the circuits that run inside A particular product requires three light bulbs – you have been given the job o both series and parallel circuits and compiling a report.

Your manager then asks you to compile a report on either a thermistor or an LD The report must include a description of exactly how the thermistor responds responds to light exposure, along with a number of suggestions for application component ... existing applications which could be improved.

Task 1

1. Draw two circuit diagrams – one showing how you would set these bulbs showing how you would set them up in parallel. Build these circuits to te *You could include photos of your circuits in your report as well.*

2. Put together 'test cards' for each of the circuits, showing the current and through each component of the circuit. Test whether these values are co yourself.

3. Use your current and voltage values to work out the resistance of each co *Show the formulae you use and remember to give units.*

4. Explain what a non-ohmic conductor is and explain why the filament bul *To do this you will have to measure the current through one of the bulbs a Plot a voltage–current graph for your bulb and use your graph to find out law. Describe the effect this will have on the function of the toys.*

Task 2

1. Introduce your report with a description of the basic function of your com for in an application.

2. With your teacher's guidance, set up an electric circuit which allows you t and voltage across, your component. Take readings at a wide range of ten light intensities (for an LDR) to gather data on the effectiveness of the co

3. Use your results to make a graph showing how temperature/light intensi Explain what your graph shows. *If time allows, you could compare several different components and use you best for a particular application.*

4. Conclude your report by summarising what your experiment has shown. them to explain how a real life application using thermistors or LDRs cou

Learner's name:	Start Date:

Learner's declaration:
I certify that the work submitted for this assignment is my own. I have clearly refe[r]
work. I understand that false declaration is a form of malpractice.

Learner's Signature: Date:

Learner's comments for the assessor:

Teacher's/assessor's name:

Task:	Crit[eria]	[L]earner must:
Marking Criteria		
1	**2D.P9**	Measure currents and voltages in series and parallel circuits.
	2D.M7	Calculate resistances from measured currents and voltages.
	2D.D6	Analyse an everyday life situation in which the resistance of a conducting wire is not constant.
2	**2D.P10**	Investigate an application of thermistors or LDRs using primary data.
	2D.M8	Mathematically or graphically process the results of the investigation into thermistors or LDRs to draw conclusions.
	2D.D7	Evaluate the investigation into thermistors or LDRs, suggesting improvements to a real-life application.

Deadline:

Summative feedback:

Date assessed:

Internal verifier's name:

Internal verifier's feedback:

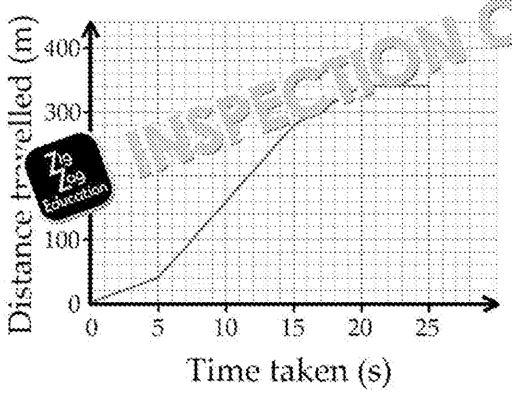
Date:

If a learner has not met th[e] [Level] 2 [c]riteria, they can be assessed on the Level	
1D.9	Desc[ribe] us[ing] [dia]grams, how to build series and parallel circuits.
1D.10	Des[cribe] [th]e use of a thermistor or LDR for an application.

Answers to Questions

Lesson Plan 1: Speed and Velocity

1. Distance only has a size; displacement has both size and direction (distance i
2. **Velocity** is speed in a given **direction.** It is the rate of change of **displacemen** change of **distance**. The **gradient** of a distance–time graph represents speed. be **stationary**.
3. Distance = speed × time = 5 m/s × 30 s = 150 m
4. Speed = distance / time = 250 m / 100 s = 2.5 m/s
5. Distance = speed × time; time = distance / speed = 80 m / 5 m/s = 16 s
6. Speed = distance / time (or gradient of line) = 8 m / 6 s = 1.33 m/s (to 2 d.p.)
7. a)



   b) Speed = distance / time (or gradient of line) = (280 – 40) / (15 – 5) = 240 / 1

   c) The car is stationary.

Lesson Plan 2: Acceleration

1. Acceleration is the rate of change of **velocity**. An object is **accelerating** if it sp **direction**. If the acceleration of an object is **negative**, it can be described as de The **gradient** of a velocity–time graph represents **acceleration** and the area u **distance**.
2. a) It is accelerating from rest, with constant acceleration.

   b) It is moving at constant velocity

   c) It is decelerating to a stop, with constant deceleration.
3. a) $a = \frac{v-u}{t}$ (or gradient of line) = (6 – 0) / 12 = 0.5 m/s²

   b) $a = \frac{v-u}{t}$ (or gradient of line) = (0 – 4) / 4 = - 1 m/s², or deceleration of 1

   c) Distance travelled = area under line.
   Solid-line car: area = (0.5 × 12 × 6) + (5 × 6) + (0.5 × 8 × 6) = 36 + 30 + 24 = 9
   Dotted-line car: area = (0.5 × 5 × 4) + (× 4) + (0.5 × 4 × 4) = 10 + 72 + 8 = 9
   Both cars travelled the same distance.
4. a) $a = \frac{v-u}{t}$ (or gradient of line) = (4 – 0) / 2 = 2 m/s²

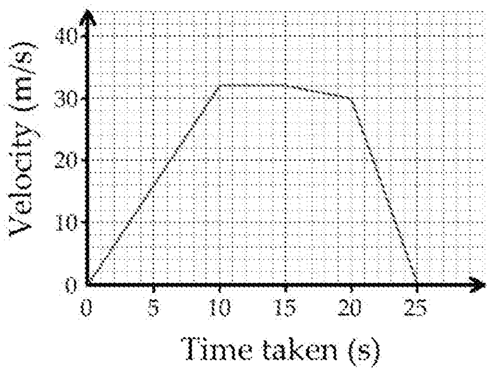
   b) At seconds – until this point it is travelling at a steady speed while this point its speed dramatically increases.

   c) Sharp acceleration – the rollercoaster is probably rolling down a steep s

   d) Distance travelled = area under graph
   Area = (0.5 × 2 × 4) + (8 × 4) + [(5 × 4) + (0.5 × 5 × 30)] + [(5 × 26) + (0.5 × 5 ×
   Area = 4 + 32 + [20 + 75] + [130 + 20] = 281 m

   e) Average speed = distance / time = 281 / 20 = 14.05 m/s

5. a)



b) The car is travelling at constant velocity.

c) The car is decelerating to a stop, with constant deceleration

d) $a = \frac{v-u}{t}$ (or gradient from graph) = (32 – 0) / 10 = 3.2 m/s²

e) Distance = area under line
= (0.5 × 10 × 32) + (5 × 32) + ((5 × 30) + (0.5 × 5 × 2)) + (0.5 × 5 × 30)
= 160 + 160 + 155 + 75 = 550 m

Lesson Plan 3: Conservation of Energy

1. a) Input: electrical energy — Output: heat and sound energy
   b) Input: kinetic energy — Output: sound energy
   c) Input: electrical energy — Output: light and heat energy
   d) Input: gravitational potential energy — Output: kinetic energy
2. Energy cannot be **created** or destroyed; it can only be **transferred** or converte process is always **equal** to the total energy output.
   Energy processes transfer **useful** energy, which is in the form we want, but s usually as **heat** or sound lost to the surroundings.
3. $K.E. = \frac{1}{2} \times m \times v^2$; $v^2 = \frac{2K.E.}{m}$ = (2 × 900,000) / 2,000 = 900 v = 30 m/
4. a) 80 J × 80% = 64 J
   b) It is lost to the surroundings as heat and a small amount of sound energ
   c) $K.E. = \frac{1}{2} \times m \times v^2$; $m = \frac{2K.E.}{v^2}$ = (2 × 64) / (16^2) = 128 / 256 = 0.5 k
5. a) $P.E. = m \times g \times h$ = 75 × 10 × 500 = 375,000 J (375 kJ)
   b) $K.E. = \frac{1}{2} \times m \times v^2$; $v^2 = \frac{2K.E.}{m}$ = (2 × 375,000) / 75 = 10,000 v = 1

Lesson Plan 4: Energy and Braking

1. When a vehicle brakes, its **kinetic** energy is converted into **heat** and **sound** e
travelling, the more **work** needs to be done to stop it over a certain **distance**
The **stopping** distance of a vehicle is the sum of the thinking distance and **br**
drugs affect the **thinking** distance, while the condition of the road, **tyres** and
distance. The greater the **speed** of a vehicle, the greater both distances will b
2. a) Distance = speed × time = 30 m/s × 2 s = 60 m
   b) Thinking distance
   c) Stopping distance = thinking distance + braking distance = 60 m + 35 m =
   d) Travelled at a slower speed
3. a) Alcohol/drugs – slow down a driver's reaction time, increasing thinking
   Distractions, e.g. phone or radio – distract dr[illegible] [illegible]easing thinking di
   Visibility – poor weather conditions can ma[illegible] harder for the driver to
   thinking distance.
   b) Road conditions – w[illegible] ro[illegible]s, or poorly maintained roads, carry a da
   brake more [illegible] [illegible]n[illegible]easing braking distance.
   B[illegible]nc[illegible] – worn out brakes are less effective at slowing the vehic
   di
   Tyre condition – worn tyres do not grip the road as well, so the vehicle
   increasing braking distance.

Lesson Plan 5: Resultant Forces

1. Every action has an equal and **opposite** reaction. A body resting on a table e
experiences a **reaction** force from the table in response.
A **resultant** force is a single force with the same effect as all the forces acting
object is in **equilibrium**; if it is **stationary** it remains so, and if it is moving it
A non-zero resultant **force** causes an **acceleration** in the direction of the force
2. The book is at rest, so the reaction force must be equal and opposite to the w
Reaction force = 5 N.
3. $F = m \times a$ = 1,000 kg × 5 m/s^2 = 5,000 N
4. a) $a = \frac{v-u}{t}$ = (13 – 3) / 5 = 2 m/s^2
   b) $F = m \times a$; $m = F / a$ = 50 N / 2 m/s^2 = 25 kg
5. a) $F = m \times a$ = 4 kg × 8 m/s^2 = 32 N.
   b) $W = m \times g$ = 4 kg × 10 N/kg = 40 N.
   c) 40 N – 32 N = 8 N.

Lesson Plan 6: Forces and Work

1. When a **force** moves an object, it does **work** on the o[illegible]. The greater the for
more work is done.
A **compressive** force does work t[illegible] [illegible]he shape of an object; a **tensile** fo
of an object. If the object i[illegible] [illegible]sti[illegible] stores this as **elastic potential** energy, w
shape once the for[illegible] [illegible]ved.
2. a) F[illegible] = 20 kg × 10 N/kg × 1.5 m = 300 J
   b) W[illegible]ne = energy transferred. So, the weight lifter has done 300 J of w
   c) $K.E. = \frac{1}{2} \times m \times v^2$; $v^2 = \frac{2K.E.}{m}$ = (2 × 300) / 20 = 30 v = 5.48 m
3. a) Tensile force
   b) Elastic potential energy
   c) $K.E. = \frac{1}{2} \times m \times v^2$; $v^2 = \frac{2K.E.}{m}$ = (2 × 30) / 0.2 = 300 v = 17.32 m/s (
   d) Not all the elastic potential energy would be transferred to the rock; so
   sound to the surroundings.

Lesson Plan 7: Resistive Forces

1. Friction is a **resistive** force which **opposes** motion. In fluids it is more comm air it is usually called **air resistance.**
   Up to a point, friction matches the **force** applied to an object – this is known limit, **kinetic** friction occurs.
   A falling object reaches **terminal velocity** when its **weight** is balanced by res
2. Friction and the normal reaction force are both resistive forces which only ac both act against the force applied to oppose motion.
3. a) $W = m \times g$ = (75 kg + 25 kg) × 10 N/kg = 1,000 N
   b) At terminal velocity, forces are balanced so air resistance = 1,000 N
4. When a force is applied to push an object across a surface, at first the friction and the object will not move – this is static friction.
   If the applied force is increased above a certain limit, the applied force will b force and the object will start to move – the friction experienced during its m
5. An object falling through a fluid accelerates due to the weight of the object. T opposed by an increasing upward resistive force known as the drag force. Th point where the drag force equals the object's weight. At this point the object steady speed known as the terminal velocity.

Lesson Plan 8: Reflection of Light and Sound

1. **Light** travels in straight lines. When it is **reflected**, the angle of **incidence** is reflection. A **plane** mirror is a flat surface designed for **reflection** of light.
   Sound waves can also be reflected – this is known as an **echo**. Bats use **ultras** surroundings, while ships and submarines use it in a technique called **sonar.**
2.

Angle of incidence	Angle of reflection
30°	30°
45°	45°
90°	90°

3. a) Virtual – the source of the light rays appears to be behind the mirror, alt
   Upright – the image is formed the right way up, not upside down.
   Laterally inverted – the left and right sides of the image are reversed.
   b) The image in a concave mirror would be upside down.
4. **Rear-view mirrors** in cars give the driver a view of what is happening behin useful for this purpose because they provide a wider field of view – but they plane mirrors which provide an accurate image.
   Mirrors are also used at **road junctions** where a driver might not have full vi mirror can provide a wide view of the junction from a different angle, showi approaching.
   Reflecting telescopes use mirrors to focus an image of a distant object. Refle used in astronomy, since they tend to be more accurate than refracting telesc
5. Distance = speed × time = 1,500 m/s × 5 s = 7,500 m
   The obstacle is half this distance away – 3,750 m

Lesson Plan 9: Refraction of Light

1. **Refraction** occurs when a wave passes from one medium into another. The c
   to change **direction**.
   If the wave is passing from a **denser** medium to a **less dense** one, it will be p
   up to a **critical** angle where the whole wave is deflected along the **boundary**
   reflection occurs at the boundary.
2. When the wave travels along the normal, perpendicular to the boundary.
3. a) Total internal reflection is used to send light along optical fibres. This al
   through a narrow incision into a patient's body and receive images fron
   exactly what they are doing on a monitor.
   b) Road safety reflectors contain a series of prisms, which are designed to r
   of the source using total internal reflection.

Lesson Plan 10: Lenses and the Eye

1. **Convex** lenses refract light rays so that they converge. They are used to co
   refract light so that they **diverge**, and are used to correct **short** sight.
   power by using a more **refractive** material, or by making the shape more c
2. The eyeball being too long, or the focusing power of the lens being too great.
3. Using a more refractive material, or increasing the curvature.
4. **Short sight** (or myopia) occurs when the eyeball is too long, or when the foc
   great. This causes images of distant objects to focus slightly in front of the re
   at the retina is out of focus. Short sight is treated by placing a concave lens in
   correct the extra focusing power of the eye's own lens and focuses distant im
   Long sight occurs when the eyeball is too short, or when the focusing power
   causes images of close objects to focus slightly behind the retina, meaning th
   out of focus. Long sight is treated by placing a convex lens in front of the eye
   divergence of the rays from the near object. This causes the image to focus on

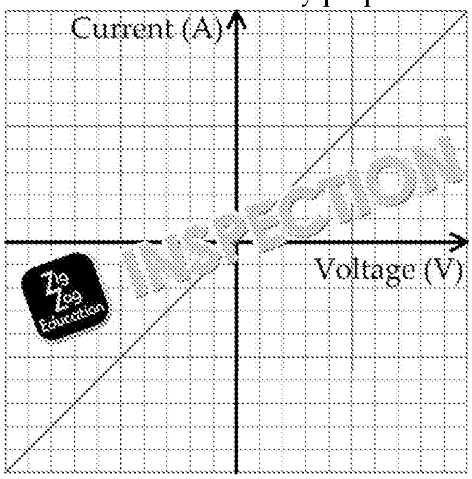
Lesson Plan 11: Sound Waves

1. Sound waves are **longitudinal**; they travel by creating areas of compression a
   medium. Sound waves cannot travel in a **vacuum**.
   The higher the **amplitude** of a sound wave, the higher its volume. The highe
   pitch of the sound.
2. $v = f \times \lambda$ = 50 Hz × 7 m = 350 m/s
3. $v = f \times \lambda$; $f = v / \lambda$ = 340 / 0.17 = 2000 Hz
4. The sound will be very quiet and high-pitched.
5. The molecules in water are much closer together than in air, so they can pass
6. **Sonar** is used by ships and submarines to send pulses of sound which reflect
   them the positions of these objects around them.
   Prenatal scans of unborn babies are done using ultrasound. The echoes of ul
   boundaries are detected and put together to form an image inside the body o
   Kidney stones can be broken up using ultrasound. High-energy waves of ul
   kidney stone, causing it to vibrate strongly enough to break up into smaller f
   then small enough to exit the kidney by themselves.
   Voice recognition is used by police and forensics analysts to identify a perso
   Each person's voice has a unique frequency spectrum (range of sound freque
   The police can use computer software to match a voice (e.g. in a telephone ca
   signature.

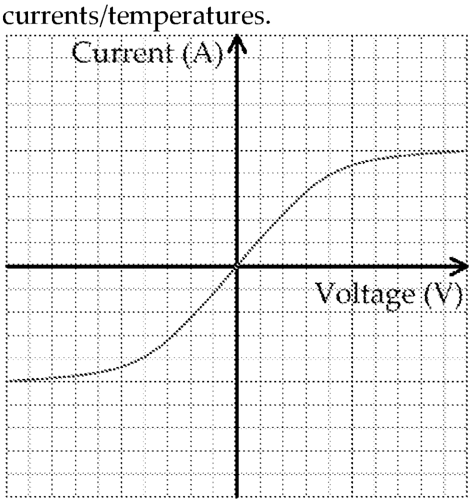
Lesson Plan 12: Electric Circuits

1. **Ohm's** law states that at constant **temperature**, voltage and **current** are direc
   which obey this rule are called **ohmic** conductors. These include wires and **r**
   Components which do not obey the rule are called **non-ohmic** conductors. A
   non-ohmic as **current** through it increases, because its temperature rises and
2. a) $V = I \times R$ = 2.7 A × 3 Ω = 8.1 V

   b) $R = \dfrac{V}{I}$ = 22 V / 5 A = 4.4 Ω
3. a) Ohmic – current is directly proportional to voltage.

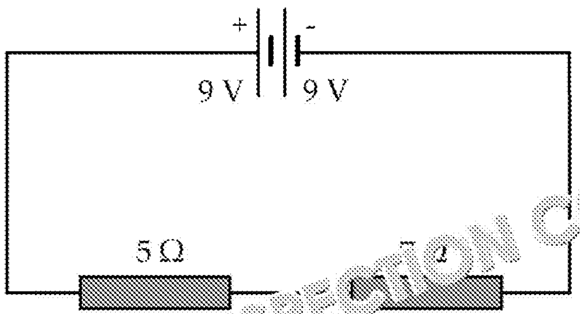


   b) Non-ohmic – line curves as current rises, due to the increase in resistanc
   currents/temperatures.

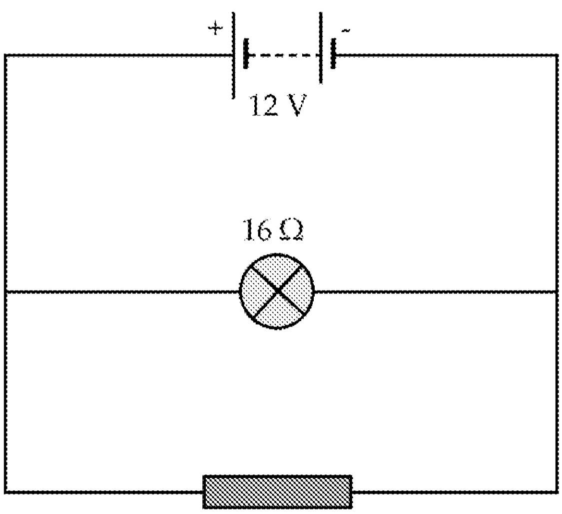


Lesson Plan 13: Series and Parallel Circuits

1. In a **series** circuit, the current is the same at any point. The **voltage** provided [illegible] between the individual **components**.
   A **parallel** circuit has the same **voltage** across each branch of the circuit – equ[illegible] **power supply**. The **current** in the circuit is divided between branches – the a[illegible] direction depends on the **resistance** of the components.
2.



   a) 9 [illegible] = [illegible] V
   b) 5 [illegible] = 12 Ω
   c) $V = I \times R$
      5 Ω resistor: $V = 1.5\text{ A} \times 5\ \Omega = 7.5\text{ V}$
      7 Ω resistor: $V = 1.5\text{ A} \times 7\ \Omega = 10.5\text{ V}$
3.

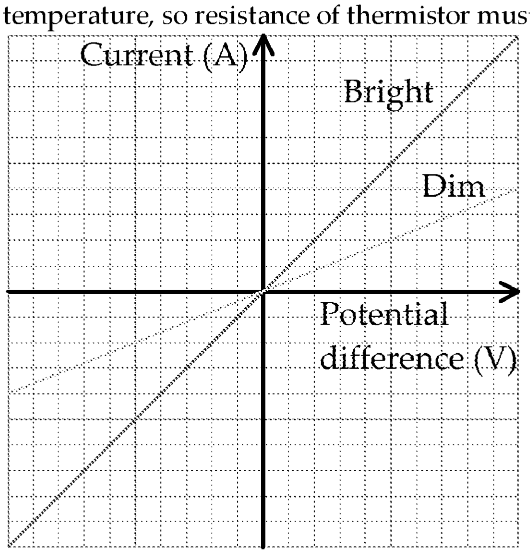


   a) $I = \dfrac{V}{R}$ = 12 V / 16 Ω = 0.75 A
   b) Current through resistor = 3.75 A – 0.75 A = 3 A
      $R = \dfrac{V}{I}$ = 12 V / 3 A = 4 Ω

4. a) i) $V = 9\text{ V}$
      ii) [illegible]
   b) i) [illegible] + 15 Ω = 27 Ω
      ii) $I = \dfrac{V}{R}$ = 9 V / 27 Ω = 0.33 A (to 2 d.p.)
      iii) I = 0.33 A + 0.5 A = 0.83 A
   c) $R = \dfrac{V}{I}$ = 9 V / 0.5 A = 18 Ω

Lesson Plan 14: Thermistors and LDRs

1. The **resistance** of a **thermistor** varies with temperature. If it has a **negative** te resistance will fall as its **temperature** rises, allowing more **current** to flow.
   An LDR is also a form of **resistor.** Its resistance varies with **light intensity**. T to, the **lower** its resistance and so the **more** current can flow through it.
2. a) LDR – light-dependent resistor
   b) NTC – negative temperature coefficient
3. **Air conditioning systems / thermostats** – the resistance of a thermistor will v temperature and this can be sent as an input signal to a control device which conditioning.
   Temperature monitors in cars, e.g. for oil and coolant – again, the resistance control device what the temperature of each fluid is.
   Ambient temperature monitors, e.g. in a greenhouse or an incubator – simil
4. **Street lighting** – once the resistance of the LDR reaches a certain amount, a c lights need switching on.
   Burglar alarms – if a burglar casts a shadow in a well-lit area, the LDR resist will tell the control device to set off the alarm.
   Camera light meters – the resistance of the LDR can send an input signal to a user how bright the light is.
   Solar lighting, e.g. in gardens and in road studs – similar to street lighting.
5. a) Current and voltage are proportional, so the thermistor is ohmic. More c temperature, so resistance of thermistor must decrease as temperature ri



   b) Current and voltage are proportional, so the LDR is ohmic. More curren so resistance of LDR must decrease as intensity rises.