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# Final Report

**to the**

**Royal Academy of Engineering**

**on the**

**Development of Physics and Engineering Signs**

**in British Sign Language**

**Dr Audrey Cameron**
**Gary Quinn**
**Rachel O'Neill**

**April 2014**

ROYAL ACADEMY OF ENGINEERING

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THE UNIVERSITY OF EDINBURGH

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SSC BSL Glossary Project: Physics/Engineering at the Scottish Sensory Centre, University of Edinburgh,
funded by the Royal Academy of Engineering, 2013.

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SSC BSL Glossary Project: Physics/Engineering at the Scottish Sensory Centre, University of Edinburgh, funded by the Royal Academy of Engineering, 2013.

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# Final Report Executive Summary

The University of Edinburgh, acting through the Scottish Sensory Centre, based within the Moray House School of Education, has undertaken projects to create, define, catalogue and develop British Sign Language (BSL) signs for Physics and Engineering for deaf people. This latest phase of the work, from April 2013, has been made possible through a second tranche of funding provided by the Royal Academy of Engineering. This report describes the outcomes of this latest phase of work.

In October 2011 RAEng, in conjunction with the STEM Disability Committee, funded an earlier, similar project, which resulted in the Physics vocabulary and definitions being expanded by 117 new BSL signs, which brought the total number of BSL signs created to 201.

1. Project outcomes:
    - A measureable and significant increase in the number of physics and engineering terms captured on the SSC Glossary website, including video definitions. RAEng to act as a conduit for input from relevant professional bodies in determining terminology areas to consider.
    - Publicity and disseminating relating to the new terms. RAEng will support a dissemination event at the end of the project. Published resources resulting from the project to feature the logos of the Academy.
    - Evaluation of the uptake of the new signs.
    - A summary report at the mid-point and a written report on progress to the Academy at the end point

2. The project team met in a two-day workshop during which Physics exams papers (National 4 & 5, Standard Grades, Intermediate 1 & 2, GCSE) and Physics textbooks were scrutinised. The team collected a total of 550 separate terms which pupils and students would require to know and understand. In collaboration with Jenny Young of RAEng the number of terms was reduced to 200 as a realistic target to be achieved within the scope of this project.

3. The topics selected were:
   Electricity; Electronics; Energy; Heat; Light & Sight; Movement; Radiation; Sound.

   The team worked in two groups to produce 185 new signs. The next stage involved producing 168 BSL definitions for the agreed terms. A second two-day workshop was held at Durham University. Six experiments were carried out and filmed for the purpose of demonstrating practical use of some of the newly created signs.

4. The work done to publicise and disseminate the new terms was extensive and widespread involving presentations to the general public and to deaf people – science festivals, invited lectures and a SSC Workshop for teachers working with deaf children - confirmed that the science glossary is being well received.

5. A new type of evaluation exercise was used which involved members of the project team establishing an online video network with young deaf people on Facebook, through which the young people filmed and uploaded science questions and the team members responded in kind. This information gave the project team invaluable feedback on the communication skills of the young people and the extent of their use of the glossary.

6. The report conclusion confirms that all project outcomes were met and recommends that further work is put in hand to complete the Physics and Engineering vocabulary of signs as soon as possible with the existing project team.

# Scottish Sensory Centre BSL Science Glossary Project Report

1. The Scottish Sensory Centre's online BSL Science Glossary consists of BSL signs for different scientific terms (Biology, Chemistry and Physics/Engineering) along with BSL video clips of definitions and lab movies.

## 1.1 Introduction and background

In September 2012, the Scottish Sensory Centre (SSC) completed a project funded by the Royal Academy of Engineering, in conjunction with the STEM Disability Committee, which expanded the Physics vocabulary and definitions in BSL available to students and teachers by 117 new Physics signs, bringing the total to 201. In April of 2013 the Royal Academy of Engineering accepted a proposal by the SSC and agreed to fund another project to further expand the Physics vocabulary in BSL.

This Final Report describes the further work undertaken by the project team and progress made in expanding the Physics BSL vocabulary and definitions into the subjects of electricity, electronics, energy, heat, light and sight, movement, radiation and sound.

## 1.2 Staff involved

The SSC BSL Project team:

Dr Audrey Cameron: Deaf chemist and secondary teacher
Gary Quinn: Deaf linguist and lecturer based at Heriot Watt University
Rachel O'Neill: Lecturer in Deaf Education, University of Edinburgh
Elizabeth Izatt: Website Development Officer, SSC
Sheila Mackenzie: Web and Resources Administrator, SSC
Ruth Simpson: Administrator, SSC.

The BSL vocabulary team**:**

The Project Team worked with the BSL vocabulary team to develop new signs for Physics and Engineering:

John Brownlie (BSc Instrumentation Physics)
Dr Audrey Cameron (PhD Chemistry and teacher of chemistry with science)
Dr Colin Dunlop (PhD Physics and researcher at Durham University)
Mark McQueen (BSL tutor and storyteller with engineering background)
Gary Quinn (MA BSL linguistics, studying for PhD)
Lee Robertson (BEng Hons Aerospace Engineering).

## 2. Project outcomes

2.1 A measureable and significant increase in the number of physics and engineering terms captured on the SSC Glossary website, including video definitions. RAEng to act as a conduit for input from relevant professional bodies in determining terminology areas to consider.

2.2 Publicity and disseminating relating to the new terms. RAEng will support a dissemination event at the end of the project. Published resources resulting from the project to feature the logos of the Academy.

2.3. Evaluation of the uptake of the new signs

2.4. A summary report at the mid-point and a written report on progress to the Academy at the end point.

## 3. Development of new Physics/Engineering signs

3.1 Project proposal:

i. Collection of Physics terms with input from RAEng.
ii. Develop new signs for Physics and Engineering terms – a two-day workshop with a team of 6 Deaf scientists and linguists.
iii. Evaluation of the new signs.
iv. Film the new signs for the BSL science glossary website.
v. Create definition for each term and film for BSL science glossary website.
vi. Show an example of the term being used – experiments to be filmed at Durham University.
vii. Translation of definition and lab movies from BSL to English.
viii. Search for suitable image for each term – if possible with help from RAEng.

Timeline of project, see Appendix 1.

3.2 Project methodology:

*Team during workshop*

Initially, over 550 Physics terms were collected from past Physics examination papers (National 4 & 5, Standard Grade, Intermediate 1 & 2 and GCSE) and from Physics textbooks. With input from Jenny Young of RAEng the list was narrowed to ~200 terms.

A two-day 'Physics' workshop - following the process established by the team in earlier workshops - took place on 3rd & 4th June 2013 and the following topics were addressed:
Electricity; Electronics; Energy; Heat; Light & Sight; Movement; Radiation; Sound.

The team members have expertise in different areas – subject knowledge and linguistic knowledge. A new approach from the previous workshops was tried in that the group split into two, each working on their own topics. Each team made sure that the new signs developed related to signs developed previously, e.g. a family of signs. (The principles of developing new signs were explained in a previous report[1]). The effect of this different approach resulted in many more signs being created in comparison to the earlier project workshop – 185 as against 117 – but in turn this created a higher than anticipated workload in producing definitions and extended the project timescale beyond what was originally planned.

The draft signs were filmed and then evaluated by the team members and Jenny Young of RAEng. The 185 new signs that were created from this workshop are shown in Appendix 2. They were all captured on video and uploaded to the SSC glossary website.

http://www.ssc.education.ed.ac.uk/bsl/physicshome.html

This now brings the number of signs created to a total of 385 Physics/engineering terms for the SSC glossary (achieving project outcome 2.1). The number of signs developed per topic was as follows:

| | |
|---|---|
| Electricity | 44 |
| Electronics | 24 |
| Energy | 41 |
| Heat | 13 |
| Light & Sight | 9 |
| Movement | 13 |
| Radiation | 2 |
| Sound | 39 |

1 Cameron, A., Quinn, G. and O'Neill, R. "Final Report to the STEM Disability Committee, Royal Academy of Engineering on the outcomes of the funded project to produce Physics and Engineering Signs in BSL", September 2012.

There are also 783 BSL video clips for definitions, examples and fingerspelling.

As a result of working in two groups and covering different topics, a much higher number of new signs for Physics and Engineering was achieved with this project than the previous workshop where only 117 signs were created. The whole group got together afterwards to discuss and evaluate the new signs from both groups.

## 3.3 Revision of signs

The process of creating new signs is not always a straightforward or linear process. Sometimes the newly created signs need to be revised as further terminology is introduced that relates to the same concept. The creation of new signs therefore becomes an iterative process. The process of developing new signs first involves the need to understand the meaning of the word and to be able to visualise its concept.

For example, we agreed on the new sign for POWER:

Power

http://www.ssc.education.ed.ac.uk/bsl/physics/power.html#start

An upright fisted right hand is used, with the thumb folded down. The left hand is spread open and placed about a foot away from the fisted hand. It then moves towards the fisted hand; at the same time, the fingers begin to close together; by the time they touch the fisted hand, the closed fingers and thumb are touching each other completely. It was agreed that any words involving ‘POWER’ would use this sign. For example, with POWER CONSUMPTION, the first sign will be as above, repeating the format twice for CONSUMPTION:


Power consumption

http://www.ssc.education.ed.ac.uk/bsl/physics/powerconsumption.html

Another example would be POWER RATING. The first sign, POWER, is the same as above, but the index finger then points out horizontally, slightly touching the side of the fisted hand and moving up and down repeatedly for RATING. This indicates that the 'level' is being measured; when the index finger point horizontally at an upper level, it means the power is high, and when it is at a lower level, it means the power is low.


Power Rating

http://www.ssc.education.ed.ac.uk/bsl/physics/powerrating.html

A particularly good example to share would be creating the definition of POWER SUPPLY. We agreed that the original sign would be the same as POWER, but flicking the index finger out twice for SUPPLY (like the release of electrical energy



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from the power). When we tried to explain the definition of power supply, however, it then became complex, because the signs showed the energy being received and released. It would be better to use signs to show only released energy – like how batteries just release electric energy (apart from rechargeable batteries!).

1st draft of the POWER SUPPLY sign

Therefore, we agreed to alter the sign to use a 'clawed' hand facing down as POWER, flicking the other hand underneath it. This is a much clearer sign for the concept of power supply. BSL does not have to follow English word for word; it simply needs to encapsulate clear concepts.

Revised sign for Power Supply

http://www.ssc.education.ed.ac.uk/bsl/physics/powersupply.html



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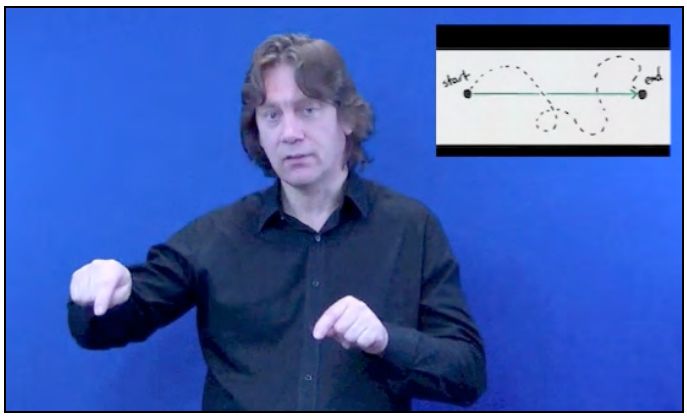
## 3.4 Definitions and Laboratory Movies

Audrey Cameron and Gary Quinn produced 168 BSL definitions for the agreed terms; some definitions included more than one term e.g. input and output voltage. For this new batch of video clips we inserted images within the video clip for some of the definitions. Initial feedback to this development was positive.

e.g. 1 Prism definition video clip

http://www.ssc.education.ed.ac.uk/bsl/physics/prismd.html




e.g. 2 Displacement definition video clip

http://www.ssc.education.ed.ac.uk/bsl/physics/displacementd.html

As with the signs created at the earlier stages of this project, we demonstrated the practical use of the new terminology during experiments carried out with Colin Dunlop at Durham University over 2 days in August 2013. A total of 6 video clips showing Physics experiments covering a group of terms were uploaded to the SSC glossary website.

*Filming a lab demonstration*


http://www.ssc.education.ed.ac.uk/bsl/physics/tidalpowere.html

John Brownlie kindly went to Randal Tidal Power Station in Brittany, when on holiday last summer, to make a film for this project.

Additional images are still required and the team would like to collaborate, if possible, with the Royal Academy of Engineering to source suitable images for the SSC glossary website to represent each sign.

## 4. Publicity and dissemination

The team has sought many opportunities to publicise and disseminate information relating to this project in 2013 and 2014. Support from the Royal Academy of Engineering was acknowledged at each event.

**26th July 2013**: "*Science in British Sign Language*" workshop at the **BIG event 2013** (British Interactive Group – a conference for science communicators) at Glasgow Science Centre, and a Science Show in BSL for families and science communicators

attending the BIG event[2]. Participants were given an opportunity to demonstrate using the new signs from the BSL science glossary!

**28th July 2013**: "*Spectacular Science Signing Show*" at **Sign Circle**[3] in Longridge, near Preston. Sign Circle is a camping festival for BSL users.

**2nd November 2013**: Hosted 2 events during the **Manchester Science Festival**[4,5] - Colourful Chemistry (5 sessions) and BSL Science Soiree – Interactive science activities for adults and exploring the work of deaf scientists. (Sponsored by British Science Association and Manchester Science Festival).

**22nd November 2013**: **BAAL Special Interest Group** "Language and Social Media" Workshop – poster session – *Evaluating the use of technical signs online with Deaf young people*" – discussion of the Facebook project [6]

**12th December 2013**: Scottish Sensory Centre CPD course for teachers working with deaf children, "*Science for Deaf Children*" with Audrey Cameron and Gary Quinn as presenters. We were delighted to learn that the BSL science glossary was well received by 11 participants including teachers for the deaf, mainstream teachers and communication support workers. Sample feedback from participants:

*"I am now able to support the deaf children in science with new signs and I am still able to make it fun and contextualise".*
*"Continue to show pupils SSC glossary regularly. Make use of some of the lab videos with pupils".*
*"More aware of BSL resources which will help me to challenge my kids".*
*"Making sense of the new signs. As a non-signer with a science background the new signs based around family words, e.g. chemical change were simple and made sense!"*
*"It was complete eye opener. I realised how useful signing could be for all visual and kinaesthetic learners in class".*
*The BSL examples were FANTASTIC!"*
*"Experiencing a signing environment – new to me ☺."*

For course programme and full summary evaluation please see following link:

http://www.ssc.education.ed.ac.uk/courses/deaf/ddec13eval.html

[2] http://www.big.uk.com/Resources/Documents/events/BIG%20Event%202013/BIG_Event_Prog_2013.pdf
[3] http://www.signcircle.org.uk/activities/whats-on/
[4] http://events.manchester.ac.uk/event/event:o55-hl6glk28-kkj2ox/colourful-chemistry
[5] http://www.manchestersciencefestival.com/whatson/at/manchester-deaf-centre
[6] http://www2.le.ac.uk/departments/english/news/conferences/baal-special-interest-group/baal-special-interest-group-language-and-social-media-workshop

**12th February 2014**: **TESOL** presentation at **University of Edinburgh** "*Evaluating the use of technical signs online with Deaf young people*" – discussion of the Facebook project.

**22nd February 2014**: **Innovative Learning Week** at **University of Edinburgh**. Hosted a "Late Valentine Show" for students[7].

**11th March 2014**: **EdSign Lecture**: Rachel O'Neill, Gary Quinn and Audrey Cameron were invited to give a lecture at the University of Edinburgh: "*Evaluating the use of technical signs online with Deaf young people*" – discussion of the Facebook project[8]. The EdSign lecture series is run by a group of Deaf and hearing lecturers and researchers from three of Edinburgh's universities: Heriot-Watt University, Queen Margaret University and the University of Edinburgh. They organise evening seminars about issues related to British Sign Language and Deaf Studies. Feedback from the audience:

*"I use the glossary on a daily basis at work as a CSW in a mainstream school".*
*"Thank you for showing the new signs. Very helpful!"*
*"The signs were really good!"*

**22nd-23rd March 2014**: **Dunbar SciFest**[9] - Elephant's Toothpaste Show (3 sessions).

**18th April 2014**: **Edinburgh International Science Festival** – Elephant's Toothpaste Show (2 sessions).

The Project team would like to organise more workshops with teachers and interpreters/CSWs to introduce the glossary.

[7] http://ilwuofe.wordpress.com/2014/02/21/late-valentines-day-science-show-in-bsl-by-ruth-thomson/
[8] http://www.blendedlearning.me/public/EdSign2013/index.php
[9] http://dunbarscifest.org.uk/stageshows

## 5. Evaluation of uptake of the new signs

The SSC's BSL Glossary website continued to receive approximately 5,000 hits per month, peaking at the start of the school year and during prelims and examinations.

From August - November 2013, a small project was run to evaluate the Glossary site (separately funded by the University of Edinburgh Innovation Award and the Birkdale Trust). The project aimed to see how the new technical signs and definitions are actually being used in practice in science based discussion between adults and children fluent in BSL. All the Deaf scientists previously involved in the Glossary sign collection/creation workshops were asked if they wanted to take part. Ten agreed and had police checks to ensure they were able to work with children. Deaf young people aged 13 to 18 with fluent BSL who are interested in science were recruited by using networks such as the heads of services list for the UK (i.e. heads of local authority services for deaf children) and Deaf Jobs UK, which often advertises courses and events. Only 4 young people took part in the pilot project, but this allowed us to test our analysis method.

The project is based on a secret Facebook site, i.e. one which is only open to members who have been approved by the project co-ordinator, Audrey Cameron. All members of the site received information about the research project and gave permission for clips of their signing to be used. The young people filmed and uploaded questions in BSL about science and the scientists responded with video explanations. The other members clicked to show they liked a particular explanation. The BSL is being analysed by looking at the number of technical terms per BSL sentence, and if possible per clause. The project team, Rachel O'Neill, Audrey Cameron and Gary Quinn, are using movement cues, pauses as well as semantic and syntactic decisions to find sentence and clause boundaries. Using Elan software technical signs were identified, then classified according to whether they were in the Glossary or not, or if they are fingerspelt. The lexical density of technical signs per clause was also calculated.

So far there is good evidence that the Glossary is being actively used by both young people and scientists. There are also some interesting examples of signs contributed by young people which are alternatives for ones on the Glossary site. This suggests that this particular group of creative young signers may have access to good models

of science signs through their school, or that they have such a strong foundation in BSL that they are able to use the features of the productive lexicon to create new signs in context. The discussion between adults and children is an example of a new genre: science discussion in BSL. There are limited opportunities to observe this genre because there are not many teachers of deaf children who have the appropriate fluency in BSL at this level, and consequently the children themselves are also not often fluent.

It is hoped that the outcomes of this research will help the SSC BSL Glossary project in a number of ways:

- add to alternative technical signs, when there is widespread agreement on a sign used in context by scientist or young person;
- assist with ways of providing definitions and examples using authentic material from the responses on the site;
- judge which signs are being used more often and discuss why this might be.

## 6. Next Steps

6.1 The project team believes the SSC BSL Glossary Project will give deaf pupils who sign better access to the Physics curriculum.

In the longer term it is intended to complete the Physics and Engineering glossary to match the school curriculum and expand the range of subjects, available on the glossary, including geography, CDT, ICT, computing, history, art and media using the same method for finding signs from Deaf experts.

6.2 The project team also believes it is important to continue with the dissemination of this work with teachers, lecturers, interpreters and communication support workers – for example by hosting workshops.

6.3 The project team is looking into the viability of creating a BSL Science Glossary App to exploit the growing numbers of people who access information through their iPhones, Androids and tablets. Various ways of fundraising will be explored including commercial sponsorship.

6.4 The project team will be meeting the Scottish Qualification Authority to discuss the possibility of running a pilot project for centrally produced exams in BSL.

We would welcome comments on the above steps.

## 7. Conclusion

The funding provided to the SSC by the Royal Academy of Engineering for this project has resulted in a significant expansion of the SSC BSL Science Glossary that is now available to deaf pupils and students, and their teachers and interpreters. Evaluation of the uptake of the signs now available in the glossary is also very encouraging and shows that the SSC project is now offering deaf people considerably improved opportunities to access science than was the case only a few years ago.

The fact that the project team produced the highest number of new signs from any of the workshops they have held to date shows they too are becoming proficient with the experience of the processes involved. Having increased the momentum of the process of creating new signs it would be important to press ahead to complete the glossary of Physics and Engineering signs used in the curriculum whilst the expertise of the project is still available.

It is very satisfying that evidence shows that opportunities to publicly demonstrate the availability and use of BSL signs in science are increasing and reaching an ever increasing audience. This factor, together with the expanding signs glossary can only help to increase demand for a wider use of BSL in education in the UK and in providing services to deaf people.

The SSC and BSL Science Glossary project team are extremely grateful to the Royal Academy of Engineering for their continued funding support for this important project and the future benefits it will bring to deaf people and the deaf community in general. We look forward with confidence to reports of increased educational attainment by deaf students in the Physics/Engineering field in the future and hope it may be possible to develop this project further.

## 8. Acknowledgements

The project team would like to thank the following people who helped and supported the project during this second phase:

- Deaf scientists and BSL linguists: John Brownlie, Dr Colin Dunlop, Mark MacQueen and Lee Robertson.
- University of Edinburgh: Bob Kibble, Nick Hood, Christine Smithers, Dr Douglas Buchanan, Linda Hayne, Valerie Gordon.
- Scottish Sensory Centre: Janis Sugden, Elizabeth Izatt, Sheila Mackenzie, Ruth Simpson.
- Royal Academy of Engineering: Jenny Young, Bola Fatimilehin.

**APPENDIX 1**

## Timeline: SSC BSL Physics & Engineering project 2013 – amended due to project starting in May 2013

| Activities | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|
| 2 day workshop to develop new signs & evaluate | | | | | | | | |
| Filming of new signs | | | | | | | | |
| Search for images | | | | | | | | |
| Definitions | | | | | | | | |
| Check and refilm | | | | | | | | |
| Interim Report | | | | | Due 30.09.13 | | | |
| Lab movies | | | | | | | | |
| Uploading video clips, images and text on to the glossary website | | | | | | | | |
| Translation of video clips | | | | | | | | |
| Final report to RAEng | | | | | | | | Due 31.12.13 |



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# APPENDIX 2

## ELECTRICITY (44)

| | |
|---|---|
| **1** | A.C. supply |
| **2** | Charge (electric) |
| **3** | Crocodile clip |
| **4** | D.C. supply |
| **5** | Diode |
| **6** | Display |
| **7** | Dynamo |
| **8** | Electric field |
| **9** | Electric motor |
| **10** | Electrical power |
| **11** | Electrical units |
| **12** | Electromagnet |
| **13** | Electrostatics |
| **14** | Filament |
| **15** | Gain |
| **16** | Electricity generator |
| **17** | Hydroelectric power (HEP) |
| **18** | Input voltage |
| **19** | Insulation |
| **20** | Lead/connector |
| **21** | Magnetic field |
| **22** | Magnetic field strength |
| **23** | Mains electricity |
| **24** | Mains voltage |
| **25** | Ohm's law |
| **26** | Ohms x 2 |
| **27** | Oscilloscope |
| **28** | Output voltage |
| **29** | Plug |
| **30** | Potential difference = voltage |
| **31** | Power |
| **32** | Power consumption |
| **33** | Power rating |
| **34** | Power supply |
| **35** | Resistance |
| **36** | Resistor |
| **36** | Rotor coil |
| **37** | Short circuit |
| **38** | Solenoid |
| **39** | Transformer |
| **40** | Van de Graff generator |
| **41** | Variable resistor |



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| | |
|---|---|
| **42** | Volt |
| **43** | Watt |
| **44** | Wire |

## ELECTRONICS (24)

| | |
|---|---|
| **1** | Alarm |
| **2** | AND gate |
| **3** | Binary counter |
| **4** | Binary number |
| **5** | Block diagram (electronics) |
| **6** | Buzzer |
| **7** | Components |
| **8** | Display |
| **9** | Electronics |
| **10** | Input |
| **11** | Input device |
| **12** | Light gate |
| **13** | Logic 0 |
| **14** | Logic 1 |
| **15** | Logic gates |
| **16** | Motion sensor |
| **17** | NAND gate |
| **18** | NOR gate |
| **19** | NOT gate (inverter) |
| **20** | OR gate |
| **21** | Output |
| **22** | Output device |
| **23** | Switch |
| **24** | Temperature sensor |

## ENERGY (41)

| | |
|---|---|
| **1** | Biofuels |
| **2** | Biomass energy |
| **3** | Coal-fired power station |
| **4** | Conservation of energy |
| **5** | Dam |
| **6** | Elastic potential energy |
| **7** | Electrical energy |
| **8** | Energy consumption |
| **9** | Energy dissipation |
| **10** | Energy wastage |
| **11** | Energy input (E transfer diagram) |
| **12** | Energy output (E transfer diagram) |
| **13** | Energy stored (E transfer diagram) |



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| | |
|---|---|
| **14** | Energy transfer diagrams |
| **15** | Fossil fuel power stations |
| **16** | Gas-fired power station |
| **17** | Geothermal power station |
| **18** | Gravitational potential energy |
| **19** | Heat energy |
| **20** | Heat radiant energy |
| **21** | Hydro electric scheme |
| **22** | Joule meter |
| **23** | Kilowatt hour |
| **24** | Light energy |
| **25** | Magnetic energy |
| **26** | Magnetism |
| **27** | Non-renewable resource |
| **28** | Solar cells |
| **29** | Solar energy |
| **30** | Solar panel |
| **31** | Solar power |
| **32** | Sound energy |
| **33** | Tidal power |
| **34** | Tidal power station |
| **35** | Tidal turbines |
| **36** | Turbine |
| **37** | Waste |
| **38** | Wave turbine |
| **39** | Wind farm |
| **40** | Wind power |
| **41** | Wind turbine |

## HEAT (13)

| | |
|---|---|
| **1** | Absolute scale of temperature - absolute zero kelvin |
| **2** | Absorb (v) (heat) |
| **3** | Absorber (n) i.e. a material |
| **4** | Convection currents |
| **5** | Emitter (n) |
| **6** | Fluid (liquid and gas) |
| **7** | Heat loss |
| **8** | Heat sink |
| **9** | Heat transfer |
| **10** | Radiate (as a verb) |
| **11** | Reflector (n) |
| **12** | Rods – as used in thermal conduction experiments |
| **13** | Vacuum flask |



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## LIGHT AND SIGHT (9)

| | |
|---|---|
| **1** | Interface – i.e. boundary of air / glass |
| **2** | Law of reflection (angle of incidence = angle of reflection) |
| **3** | Perspex block |
| **4** | Plane mirror |
| **5** | Prism |
| **6** | Ray diagrams |
| **7** | Right angle |
| **8** | Scatter |
| **9** | Virtual image |

## MOVEMENT (13)

| | |
|---|---|
| **1** | Brownian motion |
| **2** | Displacement (velocity) |
| **3** | Free-fall |
| **4** | Instanteous velocity |
| **5** | Kinetic model / kinetic theory of gases |
| **6** | Pressure |
| **7** | Projectile motion |
| **8** | Pythagoras' theorem |
| **9** | Scalar quantity |
| **10** | Terminal velocity |
| **11** | Trigonometry |
| **12** | Vector quantity |
| **13** | Vibration |

## RADIATION (2)

| | |
|---|---|
| **1** | Nuclear fuel |
| **2** | Reactor (nuclear power station) |

## SOUND (39)

| | |
|---|---|
| **1** | Amplifier |
| **2** | Audio signal |
| **3** | Communication devices |
| **4** | Compression (sound) |
| **5** | Decibel |
| **6** | Detector (sound) |
| **7** | Digital signals |
| **8** | Echoes |
| **9** | Electrical signals |
| **10** | GHz |
| **11** | Hertz |
| **12** | High frequency note |



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| | |
|---|---|
| **13** | Pitch |
| **14** | High-pitched sound (>20KHz) |
| **15** | Low pitched sound |
| **16** | KHz |
| **17** | Longitudinal wave |
| **18** | Loudness |
| **19** | Loud (loudness) |
| **20** | Quiet (loudness) |
| **21** | Loudspeaker |
| **22** | Medium (solid, liquid or gas) |
| **23** | MHz |
| **24** | Microphone |
| **25** | Noise pollution |
| **26** | Oscilloscope |
| **27** | Oscilloscope traces |
| **28** | Rarefaction |
| **29** | Sound energy |
| **30** | Sound level |
| **31** | Sound waves |
| **32** | Speed of sound x 2 |
| **33** | Transverse waves |
| **34** | Ultrasound |
| **35** | Vacuum (no air) |
| **36** | Seismic waves |
| **37** | Epic centre |
| **38** | Wave equation - v = f x l |
| **39** | Wave speed |



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