Physics Education Report

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Abstract

The aim of my special project was to plan and deliver a piece of assessed coursework for the year 11 Additional Applied Science pupils, allowing them to gain access to the higher mark bands. A brief account of previous tests which the pupils had carried out for this part of their coursework is given, before a detailed outline of the planning and delivery of my special project. The marks obtained by the pupils are compared with those for their previous attempts, and an evaluation of the coursework and its delivery is presented.

1 Background and Introduction

The Netherhall School and Sixth Form College is a comprehensive, maintained school situated 3 km south-east of the centre of Cambridge. Netherhall is a 'High Performing'[1] Specialist Sports College[2] and Training School. The school is split between two sites: the Lower School, catering for years 7–9, and the upper school, accommodating years 10–11 and the fairly small sixth form of up to 250. The main entry points to the school are at 11+ (240 pupils) and 16+ (125 pupils).

I worked with a group from year 11, following the GCSE Additional Applied Science specification at foundation tier (their provisional marks from year 10 in their Science GCSEs are shown in Table 1). This specification[3] comprises six modules (two broadly in each of physics, chemistry and biology), of which the candidates study three for assessment. In the higher tier, the Applied Science course is split 50:50 between coursework and examination, but for foundation tier candidates, the marks available at examination are restricted, so that the balance is more like 60:40, making coursework effectively more important.

[1] Awarded Training School designation as a 'high performing' school in 2006.

[2] Designated as a Specialist School and Sports College in 2001

[3] For further information on how this fits in with the new GCSE Science structure, see Appendix A.

D	3
E	6
F	3
G	1
	13

Table 1: Year 11, set 5 pupils' results obtained in year 10 in GCSE Science. Note that these are provisional results, since some coursework undertaken in year 11 can be double counted towards their science mark, and re-sits are possible. Despite this, an idea of the standard and range of attainment of the 13 pupils, made up of 4 boys and 9 girls, is obtained.

During the term for which I worked with the class, they were training for and completing coursework assessments, and my special project was therefore to prepare and deliver a "suitablility test" as a piece of coursework for the pupils to prepare for assessment near the end of the term.

2 Previous treatment of topic

Although this is the first year in which Netherhall has tried Additional Applied Science with the lowest sets (in physics, the module **A6: Materials and Performance**, was chosen), I was quite fortunate that during my observation lessons in the first part of the term, I helped to deliver two suitability tests, since the pupils were given three attempts during the term.

2.1 Fishing line

The mass of fishing lines was compared in this test, with strength and cost also given on a datasheet. A reel with a known length of line had been prepared in advance, from whose mass that of an empty reel could be subtracted.

This first test was carried out with lots of guidance, and so much direction that the marks were only based on four of the five possible bands from the assessment criteria. For example, pupils were given a template printed report, on which to write their 'answers', and were led in detail through the collecting and recording of their data.

In the lesson after the test, the pupils marked each other's work, and also a piece of sample coursework, against the assessment criteria in groups. I led one group, and we explored how the marks might be improved on subsequent suitability tests. Some of the pupils had quite a shock when they realized that their scores in the coursework were very low indeed.

2.2 Yarn

Samples of various yarns had been prepared beforehand, along with a laminated copy of the labels as background information, for comparison for their suitability for use in clothing. A template report was used as for the fishing line test.

This test engaged the pupils much better than the test on fishing lines, especially during the first lesson. They were also able to define their own suitability criteria, with some guidance, and some groups focused on measuring qualitative characteristics such as 'softness', rather than conducting a measurement of tensile strength.

3 Planning

Previous tasks had intentionally restricted pupils' marks by closely defining the approach, and providing a 'fill in the gaps' style report, with a given results table. My suitability test had to be more open-ended to allow the pupils to access the higher mark bands by allowing them to choose their own approach, and carry it out independently; to devise their own format for observations, and decide which data to include or make reference to; and to write their own report from scratch on A4 lined paper, rather than using a pre-defined format. To do this, it would have to engage as many of the class as possible (cf. the positive start of the yarns test), and be familiar enough that they might be able to devise their own approach for an experiment.

Looking through the exam board's suggestions in the specification[4] and the teachers' guide, I found that two of the board's suggested tests had already been implemented, and some of the other tasks would either be too unfamiliar, and impossible for the pupils to carry out without closely defined guidance from a teacher, or would not engage the pupils in the class. For example it would not have been feasible to attempt the test on lenses, since the pupils had very little familiarity with optical phenomena, and I felt that the test to compare the thermal expansion of metals would not be of interest to the pupils in my class.

I seriously considered the test on soundproofing, especially since the Cavendish undergraduate laboratory has a sound-proof box which might have been borrowed. A recorder with an air pump could be placed in one half of the box, and a microphone in the other half, with a screen in between: pupils could prepare their own 'sound-proof' walls for testing. In the end I decided that this would have to be demonstrated, and therefore rejected it, since one of the aims of my project was to enable the pupils to carry out the test independently.

The pupils had previously carried out a "standard procedure" (in which candidates follow instructions to measure some physical property) to find the stiffness of a tennis racket, and this gave the idea for a suitability test on rods of various materials to find out which would be of use in making beams for use in buildings. This test was not specifically outlined by the

[4] See Appendix F. Those in this module are "comparing the tensile strength of fishing line", "comparing the transmission of light or infrared radiation through glass and Perspex acrylic" and "comparing the thermal expansion of two metals".

exam board, but had several advantages for my class:

- A similar technique had been conducted as a standard procedure, meaning that the pupils could be expected to come up with the method themselves.
- The pupils were familiar with the workplace context and the main uses of beams (in fact, the school was undertaking an expansion programme, so I-beams were in use in construction on site).
- The previous piece of coursework, on yarn, did not engage the four boys in the group, and it was hoped that they might find a test on beams more stimulating.
- Equipment and materials for the test were easily obtainable.

To find out whether results which allow materials to be compared can be obtained, I sourced some materials from the technology department at Netherhall, and carried out a crude test (see Appendix C). From this I decided that an investigation to find materials suitable for use in beams would make a feasible piece of coursework.

When I was writing the lesson plans, I decided to use a quite different approach to what had gone before. Rather than starting out straight away on the test, I first decided on a fairly lengthy classroom discussion about beams, and how to conduct the test. This was to enable the pupils to help each other with ideas, and then write their own introduction describing how beams are used. I prepared a factsheet about beams and datasheet of material properties (Appendix G), and a short slide presentation.

I went on to prepare samples of the same dimensions, so far as possible, for each material, as outlined in Appendix D. I also made up a template report as had been used previously, in case the pupils were unable to produce adequately structured reports unaided.

4 Delivery

My time in the school culminated in the delivery of my special project: I led three hour-long lessons for the pupils to complete the test for assessment. The pupils tested materials' stiffness in order to determine their suitability for use as beams. To do this, they defined their own approach, but all of them hung masses onto a long section of the material somehow, and measured deflections.

The lessons at Netherhall are one hour in length, with a five minute break in between, to allow the pupils to move between lessons. In the lessons which I observed and helped in earlier in the term, I found that typically the pupils would arrive two or three minutes late, and it would then take a further five minutes or so to get them to take their large outdoor coats off, get their books out and sit down. I had to take this into account when devising lesson plans (Appendix E).

In the final lesson on the coursework (which was also my last with this class), I prepared a demonstration for the pupils, to reward them for completing their results graphs, and as a useful break in the middle of the lesson. This was on the related topic of the use of laminates in the construction industry to improve material properties. Several layers of normally brittle ice cream wafers were cross-laminated together using wood glue, and the final beam produced was able to support a full bottle of water. Unfortunately, not all went to plan (see evaluation section).

5 Evaluation

Overall, the piece of coursework which I delivered went well. Not only were the main goals achieved (the pupils generally achieved higher marks on the beams test, as shown on the graphs), but I also genuinely think that the pupils gained something from working with me and learned more about materials and how they are used.

In my lessons, generally I found it difficult to keep pupils focused on the assessment task, even with less than thirteen pupils. They were easily distracted by their mobile phones, and most of all by each other. A minority of the class became disengaged with the task, and consequently produced very little work. Also, I found it impossible to help one pupil who had been absent from the first two lessons due to exclusion, as I had to focus my attention on the others. I discussed these points with the link teacher, who on the whole thought I handled the difficulties very well during the special project.

I was pleased that the pupils did not need to use the template reports, though much guidance was given on report structure. As I had hoped, the pupils were also able to devise their own practical techniques (this led to a split in the group between end-loaders and centre-loaders).

The first lesson, in which ideas were exchanged in the group by means of a class discussion, went particularly well, and the pupils' feedback made it clear that my slide presentation engaged their interest effectively. Indeed, one girl came and sat closer to the front to hear what I was saying! I was also pleased that we kept to my lesson plan, and by the end almost everyone managed to finish their introduction and had a plan for taking measurements.

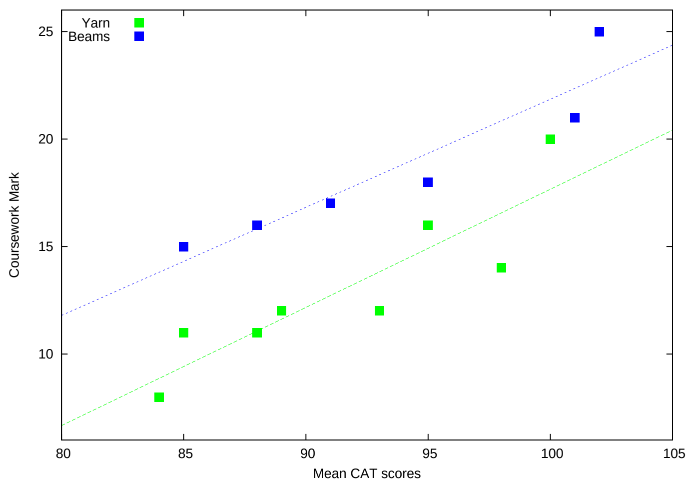


Figure 1: The marks obtained by pupils on the yarns and beams suitability tests for the class which I taught, plotted as a function of their mean performance in Cognitive Ability Tests (CAT), with best-fit lines. Note that only one pupil out of thirteen submitted coursework for both tests, achieving 16 in yarns and 18 in beams, and that the sample size is very small. No pupils submitted the fishing lines test (which was peer-marked).

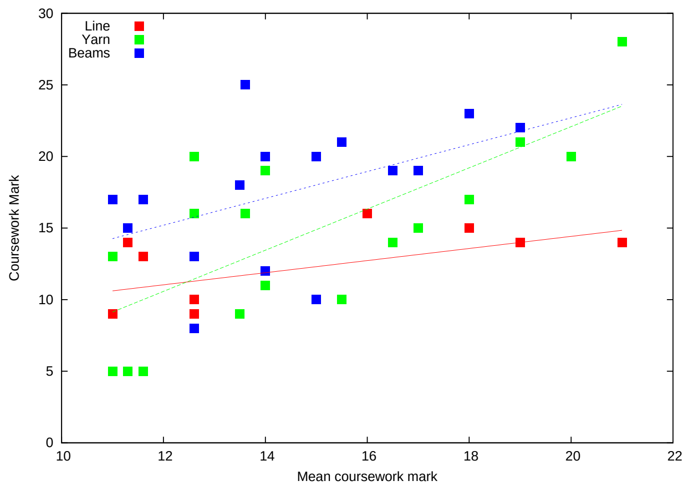


Figure 2: Marks obtained by pupils in one of the other classes studying Additional Science. In this class all three tests were marked (though not all of the test were submitted by each of the 21 pupils), and they are plotted here as a function of their mean coursework mark. Lines of best fit are superposed onto the data. Note that the beams test was completed last, and one might expect the marks to improve naturally with time; also that the yarns task was more accessible or appealing for some of the pupils.

The highlight of the final lesson was the demonstration on laminates, which entertained and engaged the pupils. They particularly enjoyed it when the ice cream wafer beam snapped in half, and the demonstration helped the pupils to think a little more deeply about what they had learned in the coursework, and how materials are used in buildings.

6 Conclusions

The following conclusions may be draw from my experiences during the physics education

- Thorough preparation in advance is the key to keeping pupils under control. It is important to know what the plan is without having to think about it.
- Pupils will engage with something if it is made interesting to them.
- Much contact time is devoted to getting the pupils to jump through the hoops of the coursework assessment criteria. I feel that more physics could be learnt if this time were better used.

7 Acknowledgements and References

I am particularly grateful to Mr. Ally Davies of Netherhall school for all his advice and guidance during my placement. Also, the laboratory staff at the Department of Materials Science and Metallurgy were most helpful.

References

Netherhall Prospectus **2009**
GCSE Additional Applied Science Teacher Support, OCR, **2006**

A New GCSE Science structure

The structure of science GCSE examinations has changed even since I did them (2004). The new assessment structure for GCSE science in the National Curriculum arises from the perceived purposes of secondary science education: both to be the first stage in the training of future scientists, but also to comprise a preparation for life in a modern society for all candidates[5] This has led to the development of courses with different content and different approaches to meet these two purposes (the former "Double Award" science has been discontinued, as it tried to combine the different purposes into a single course). The new scheme of assessment is called "Dual Science" – two separate specifications, taught with different aims in view, and leading to two independent qualifications.

At Netherhall, the Twenty First Century Science suite of specifications, developed by the examination board OCR, is followed throughout the school. The National Curriculum core requirement for science is a minimum of single award science, which must provide a basis of "scientific literacy", allowing young people to understand the science behind major issues in modern society. This is provided through the **Science** specification, which all pupils take at the end of year 10 at Netherhall (see Table 2). The majority of candidates are expected to learn more about science, and at Netherhall, all pupils take one of the two alternative varieties of Additional Science – **Additional Science**, which extends the work in the Science course, or **Additional Applied Science**, which offers a more work-oriented approach, focussing on the applications of science – in year 11.

Year 10			Tier	Year 11		
Triple award	29	30	H	32	26	Triple award
Science	27	28	H	27	26	Additional
Science	22	23	F/H	29	21	Additional
Science	21	20	F	21	19	Applied
Science			F	–	**13**	Applied
	99	101		109	105	

Table 2: Numbers of pupils in 2008–2009 at Netherhall School. Each year is divided into two bands, with four or five sets in each. In the new 21st Century Science scheme, pupils complete one GCSE at the end of year 10, and then go on to study for another in year 11. The group with which I worked is marked in bold.

[5]These needs are identified in the report "Beyond 2000 – science education for the future", Robin Millar and Jonathan Osborne, eds, King's College, London, 1998.

B Worksheet

An extract from the short book which I wrote for the course. This was used along with a sample exam question, for those who got ahead in lessons to do whilst the others caught up.

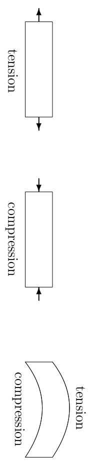
Chapter 2

Mechanical Behaviour of Materials

The mechanical properties of a material tell us about what will happen as it is pushed, pulled or twisted (its mechanical behaviour). Objects usually change their shape (or *deform*) to some extent when a force acts on them, but how much they will change depends on the size and direction of the force and the properties of the material.

2.1 Stretching, squashing and bending

The forces on materials affect them differently depending on which direction they push in. Sometimes forces act to stretch a material. These are called *tensile forces*, and place the material in *tension*. Forces which squeeze a material are *compressive forces*, which place the material under *compression*. Bending involves a combination of tension and compression.



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4 CHAPTER 2. MECHANICAL BEHAVIOUR OF MATERIALS

2.2 Describing materials

We use lots of words in everyday life to describe materials. Scientists also use words to describe how materials behave, and some of these are given here:

- *Stiffness* and *flexibility* — Materials like rubber which are easily deformed are *flexible*, whearas materials which hold their shape when a force is applied, like glass, are termed *stiff*.
- *Strength* — This is determined by how much force is required to break the material. *strong* materials require much more force to break them than do weak ones. The strength of the same material can be very different depending on its shape and how it is measured, so normally we measure both *compressive* and *tensile* strength.
- *Hardness* — The hardness of a material tells us how difficult to dent or scratch. *Soft* materials have surfaces which are easily deformed.
- *Toughness* — *Brittle* materials such as china have tiny cracks which can spread and open up, making them snap cleanly and sharply. This means that they can often fail catastrophically, with the release of lots of energy. Materials which resist the formation and spreading of cracks, such as steel, are *tough*.
- *Ductility* — *Ductile* materials are those which can be stretched, and the term is normally used of metals which can be drawn out into a thin wire.
- *Elasticity* and *plasticity* — Materials which return to their original shape after a deformation, like rubber, are known as *elastic* materials, but materials which are permanently deformed, like plasticine, are known as *plastic* materials.
- *Density* — The *density* of a material tells us how heavy it is for a given volume. Of course, if a material is stronger, we may be able to make it thinner, and so it might turn out to be lighter for a given purpose, even though it has a higher density.

2.3 In tension

Most materials show some degree of elasticity as they are stretched. Elastic materials will return to their original size if the force stretching them is removed, and they will extend in proportion to the stretching force. This proportionality was discovered by the English scientist Robert Hooke[1] (1635–1703).

In the region where the extension is proportional to the force applied, the material obeys Hooke's Law, expressed in the equation $F = kx$, where F is the force, x, the extension, and k is a constant of proportionality which depends on the material. If a spring's properties are being plotted, it is known as a spring constant. In this region, the energy stored in the spring is given by $E = \frac{1}{2}kx^2$.

[1]Hooke wrote *Ut tensio, sic vis*, meaning "As the extension, so the force".

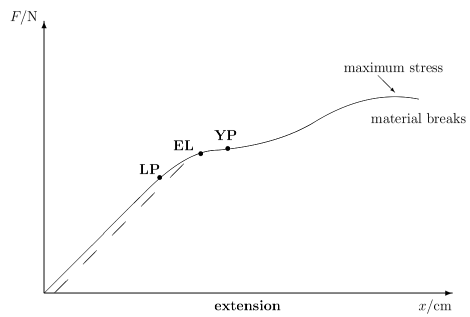


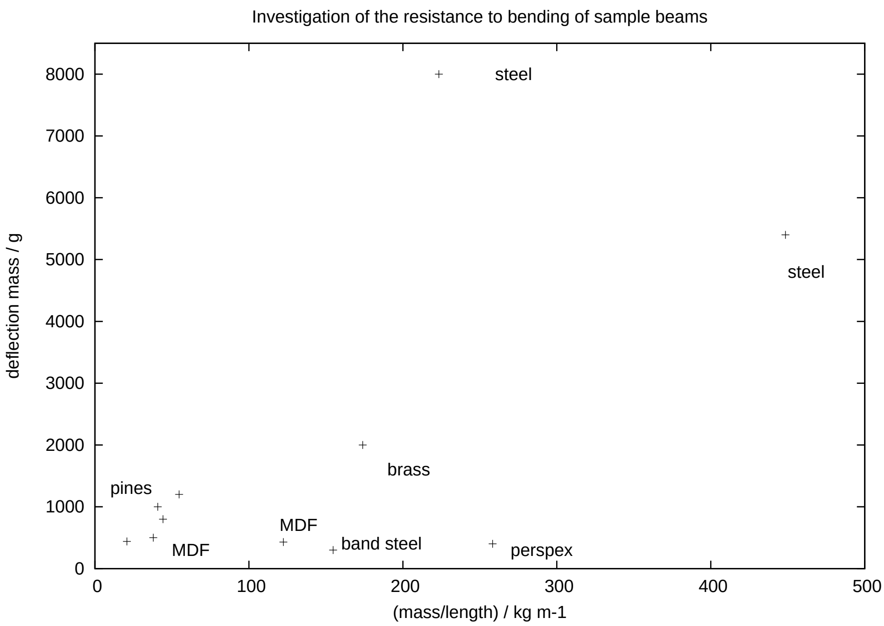
Figure 2.1: The extension of a typical ductile material in tension is shown on the graph above. As the material is extended, the force needed on the object is plotted out.
There is an elastic (Hookean) region, where the extension is directly proportional to the applied force, before the *limit of proportionality* (**LP**).
After the *elastic limit* (**EL**), just after the limit of proportionality, has been passed, the material will return to a similar shape and size when the force is removed, but there will be some permanent extension (it will continue to return to this new form if forces are applied) – this is shown as the dashed line.
Just after the elastic limit, there is a point called the *yield point* (**YP**), at which a distorting force causes a major change in a material. The material undergoes plastic deformation, meaning that in a ductile material, the bonds between molecular layers break, and the layers flow over each other. Eventually, it will keep on extending with no additional force, and even if the force is reduced. The material finally breaks at its tensile strength.
The work done in extending the material is equal to the energy stored in the material, and is given by the area under the curve.

C Initial investigations

The results below are those of a feasibility test which I conducted, to ensure that a suitable range of data was obtainable safely by the pupils, and that this would enable them to make suitable comparisons between the materials, and draw conclusions about the materials' suitability for use as beams.

These materials were obtained from the technology workshop at Netherhall school, and so were not of uniform cross section or length. I therefore calculated the mass per unit length as a rather crude comparable variable for this initial test. The materials were suspended between two tables set 50 cm apart, and the mass required to obtain a 2 cm deflection was recorded for each sample.

height/mm	width/mm	mass/g	length/mm	defl mass/g	material	$\frac{\text{mass}}{\text{length}}$ / kg m-1
4.0	9.0	19.9	957	440	pine	20.8
5.0	14.0	34.4	629	1200	pine	54.7
4.0	20.5	32.5	736	800	pine	44.2
4.0	14.0	34.8	852	1000	hardwood	40.8
6.0	8.5	29.8	787	500	MDF	37.9
3.5	49.0	74.8	611	430	MDF	122.4
0.5	18.0	130.4	843	300	steel	154.7
3.0	9.0	184.3	1060	2000	brass	173.9
6.0	6.0	178.7	800	8000	steel	223.4
2.5	19.0	571.0	1273	5400	steel	448.5
3.0	88.0	155.0	600	400	perspex	258.3



D Preparation of materials

I spent a considerable amount of time in preparing the materials for the coursework. Some of this was done at the school, using the tools and materials available in the technology department – samples of pine, hardwood (oak), MDF and perspex were prepared in this way. For the metals, however, I was fortunate to get help from the University of Cambridge Deparment of Materials and Metallurgy, who loaned samples of steel and aluminium, and cut them to a suitable cross section and length.

Figure 3: The store cupboard at the Department of Materials Science and Metallurgy, from which the metal samples were obtained.

Figure 4: This machine was used to cut the samples down to size. These images were included in the presentation which I gave to the pupils at the start of the coursework, and aroused considerable interest.

E Lesson plans

Below are the original lesson plans which I wrote for the delivery of the coursework in three hour-long lessons. I have added references to the assessment criteria in *italics* from my handwritten marginal notes, to make it clear where I hoped to stretch the pupils into achieving the higher grade criteria.

Lesson 1

- Discuss first two suitability tests as a group, revising the idea of testing materials for suitability by measuring relevant properties and discuss the tests used.
- Slide show presentation: Introduce into group discussion **beams** – uses of beams (with particular reference to the construction industry and bridge building) [*Strand A (a): "detailed description of use and ... workplace context"*], useful properties, problem properties [*Strand A (b): "full desription of desirable properties ..., explaining why these are necessary"*], how to measure [*Strand B (a): "more general brief"*].
- Fill in sheets up to actual tests, make a plan [*Strand B (a): "approach defined by candidate"; Strand E (a): Structure and organization of report; (b): full and correct use of scientific vocabulary*].

Lesson 2

- Start by discussing properties to measure [*Strand C (a): "appropriate degree of precision"; (b): "relevant range, with values well-chosen"*] & plans from last time [*Strand B (b): "explaining how [test] relates to criteria for suitability"*]. Note safety arrangements – e.g. limit to maximum mass to prevent breakage of samples.
- Practical time, in which test to measure flexibility (NOT ultimate tensile strength: this is in a table on the datasheet) is carried out [*Strand B, (a): "carried out independently"; (b): "skilfully carries out a complex task"; Strand C (c): Quality of data*].
- Results tables should be filled in by the end of this lesson [*Strand C (a): "devises own format and correctly records data"*].

Lesson 3

- Quick recap on the suitability test and what was done last time. Graphs are drawn [*Strand C (a): "correctly records data"*] to represent the data gathered in the last lesson (the graph can be teacher-defined with no loss of marks).

- Suitable conclusions are drawn by the pupils individually [*Strand D (a): "draws correct conclusion from pattern"*].
- Demonstration on laminates as reward, and since it is final lesson.
- Group discussion on the various methods employed, limitations [*Strand D (b): "describes in detail and explains improvements"*].
- Write evaluation sections before the end of the lesson [*Strand E (a): Structure and organization of report; (b): full and correct use of scientific vocabulary*].

F Assessment criteria

Below are the exam board's assessment criteria and suggested "suitability tests" for the coursework, and in more detail from the teachers' guide.

Marking Criteria – Suitability Test

Aspect of Performance	Mark 2	4	6	8
Strand A Purpose of the test				
(a) The use or purpose of the material, procedure or device to be tested, related to its workplace context.	Makes some reference to its use or purpose.	Gives a limited description of both its use and some aspect of the workplace context.	Gives a reasonable description of both its use and some aspect of the workplace context.	Gives a detailed description of both its use and relevant aspects of the workplace context.
(b) The criteria for 'suitability' of the material, procedure or device	Gives some description of its desirable properties or characteristics.	Gives a full description of its desirable properties or characteristics.	Gives a full description of its desirable properties or characteristics, explaining why at least one of these is necessary	Gives a full description of its desirable properties or characteristics, explaining why these are necessary.
Strand B Carrying out an appropriate test				
(a) Student autonomy & independence	The approach is based on specific, task-related structured worksheets with further guidance from the teacher at most stages.	The approach is closely defined by the teacher, and is carried out with further guidance at several points during the testing.	The approach is closely defined by the teacher, but is carried out with little further guidance.	The approach is defined by the candidate from a more general brief, and then carried out independently.
(b) Complexity and appropriateness of the test	Carries out a simple measurement or comparison task.	Carries out a task of limited complexity.	Skilfully carries out a complex task.	Skilfully carries out a complex task, explaining how it relates to the criteria for 'suitability'.

Aspect of Performance	Mark 2	4	6	8
Strand C Collecting data or observations				
(a) Recording the data	Partially records data or observations in a given format.	Fully records data or observations in a given format.	Devises own format and correctly records data or observations including all units of measurement.	Devises own format and correctly records data or observations to an appropriate degree of precision.
(b) Range and quantity of data or observations	Data or observations are limited in amount, covering only part of the relevant range.	An adequate amount or range of data or observations.	An adequate amount and range of data or observations, with repeats or checks for reliability.	Data or observations collected cover the relevant range, with values well-chosen across the range.
(c) Quality of data	Data generally of low quality.	Data of variable quality, with some operator error apparent.	Data generally good quality – adequately precise and reliable.	Data has a high level of precision and reliability.
Strand D Evaluation of suitability				
(a) Conclusion about suitability, drawn by appropriately linking data or observations to the purpose of the test, and awareness of any limits to the conclusions.	Draws some conclusion, but data or observations not linked back to the purpose of the test.	Draws a correct conclusion from individual results or simple pattern in results, by linking these to the purpose of the test.	Draws a correct conclusion from overall pattern of results, by linking clearly to the purpose of the test.	Draws a correct conclusion from overall pattern of results by linking clearly to the purpose of the test. Discusses any limitations, such as range over which it is suitable.
(b) Evaluation of testing procedure used	Makes a relevant comment about how the data was collected.	Comments on any problems associated with the apparatus and techniques used.	Suggests improvements to apparatus or techniques, with little practical detail.	Describes in detail and explains improvements to apparatus or techniques.

Aspect of performance	Mark			
	2	4	6	8
Strand E Quality of scientific communication				
(a) The structure and organisation of the report	The report has little or no structure or coherence, or follows a structure provided by worksheets.	The report has an appropriate sequence or structure.	Information is effectively organised, with contents listing of key elements and page numbering.	Considerable care has been taken to present the information clearly to a chosen audience.
(b) General quality of communication	Uses little or no relevant technical or scientific vocabulary.	Use of appropriate vocabulary is limited.	Uses an adequate scientific vocabulary.	Makes full and correct use of scientific vocabulary achieve effective communication.

Appropriate suitability tests include:

- comparing the suitability of different devices for measuring body temperature;
- comparing different methods of measuring blood glucose;
- comparing different ways of measuring a person's physical capabilities, such as strength, power, or flexibility;
- testing a growth media such as soil, peat-based compost, peat-free compost for seed germination rate;
- comparing different types of flour by measuring their gluten content and/or the quality of bread made from them;
- testing a device which measures the hardness of a tomato;
- identifying features of a sample using the naked eye and a light microscope;
- comparing different solvent systems with paper chromatography to separate the dyes in ink;
- comparing the effectiveness of either an active ingredient or a formulation for its specified purpose e.g. antacids to neutralize acids, or acids used to remove limescale;
- comparing the quality of signal transfer with and without earth shielding;
- comparing the frequency response for different types of microphones or loudspeakers;
- testing an electrical or electronic product against its specification;
- testing the tensile strength of fishing line;
- comparing the transmission of light or infra-red radiation through glass and Perspex acrylic;
- comparing the thermal expansion of two metals.

A6 Materials	
In some of these tests, individuals could collect enough data to make a comparison (Strand C) but could also share data to help in evaluating their results (Strand D). Very weak classes could collect a limited amount of data but could use shared data together with a writing frame to support work for the Evaluation.	
Find the most suitable type of fishing line by comparing tensile strength and stiffness Safety considerations may restrict measuring tensile strength to a demonstration, but data from this could be shared and used together with data on stiffness to form a conclusion.	Activity AA6.3
Choose elastic for clothing by comparing its stiffness and elastic behaviour Data on extension can be supplemented by measurements of length without the load, to check the load at which the behaviour becomes plastic.	Activity AA6.4.3
Find which mortar mixture has the highest compressive strength • When planning, remember that the mortar requires time to set. Spare samples may be needed for absentees and disasters. • A clear labelling system is needed. • This could be used with low ability candidates if safety can be guaranteed.	Activity AA6.8
Find the best material for a crumple zone This could be used for low ability classes, generating very simple data such as the number of layers needed before the magnet falls off.	Activity AA6.7 (could count layers or measure thickness of crumple zone materials)
Find the most suitable lens power for correcting an eye defect Lenses of different powers can be used to form an image on a screen. The image distance should be recorded for each lens. The most suitable lens is the one which gives an image closest to 5 cm from the 'eye lens'. This would be suitable for higher-ability candidates.	Activity AA6.26 (using an 'eye lens', a screen to locate the image and lenses of different powers)
Find the best material for soundproofing a room This could be used for lower ability classes. It could be done as a demonstration, but the marks for data collection would be low. For Strand C, candidates could describe the loudness of the sound by the height of the oscilloscope trace, which might need to be qualitative. Quantitative data could also be given to help with the evaluation. This Suitability Test could be helpful where class management issues cause problems.	Activity AA6.24

G Datasheet and Factsheet

This is the datasheet which I distributed amongst the pupils during the coursework, for additional data to base their comparisons on, and on the next page is a factsheet which I handed out in the group discussion at the start of the coursework. This allowed them to write introductions to the coursework with fuller knowledge of how beams might be used in the real world.

Density

Material	ρ / kg m^{-3}
Pine	560
Oak	730
Perspex	1190
Steel	7850
Aluminium	2700

Melting Point

Material	T_m / °C
Pine	–
Oak	–
Perspex	130
Steel	1370
Aluminium	660

Strength

Material	σ_f / MPa
Pine	40
Oak	60
Perspex	75
Steel	2000
Aluminium	600

Cost

Material	Cost / £ kg^{-1}
Pine	1.423
Oak	2.730
Perspex	4.520
Steel	0.614
Aluminium	0.931

Beam Factsheet

Introduction

Beams are used widely in the construction industry to build structures such as buildings and bridges. A beam can be made of any material if it is made into a long and thin extended structure. Beams are a good way of spanning gaps in buildings, since they go a long way without becoming too heavy.

Figure 5: A simple log bridge in the mountains in France

Properties

Engineers and builders who use beams everyday need to understand their properties. This helps them to make sure that structures will be safe by using a beam which will be strong enough to support the required load. Beams of various materials and dimensions are tested before being used in a real building. In modern construction, beams are typically made of steel, reinforced concrete, or wood.

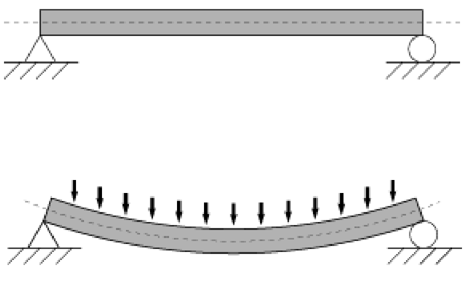


Figure 6: A beam supported at both ends bending under a uniform load.

Shape

Beams can also be made in special shapes, which make them stiffer, and less likely to bend – in steel-frame buildings and bridges, steel I-beams are often used, which have an I-shaped cross section. These beams are light and very resistant to bending for their weight, since this is the most efficient shape for loading in one direction only. Efficiency is a measure of how little deflection a beam will have for the same cross sectional area of beam and the same load.

A universal I-beam is only the most efficient shape in one direction of bending: up and down looking at the profile as an I. If the beam is bent side to side, it functions as an H where it is less efficient. The most efficient shape for both directions in 2D is a box (a square shell) however the most efficient shape for bending in any direction is a cylindrical shell or tube. But, for unidirectional bending, the universal (I or wide flange) beam is king. Other common beam profiles are the C-channel, the hollow structural section beam, the pipe, and the angle.

Bridges

Figure 7: This bridge in Japan has the longest span of any in the world.

Figure 8: Two beams are used cleverly in the construction of this bridge in the Swiss Alps.