Appendix A

Science Reasoning Tasks

TASK 1

SPATIAL RELATIONSHIPS

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Introduction

This Task is one of a series developed by the team 'Concepts in Secondary Maths & Science' at Chelsea College, University of London in the period 1973/78 in order to investigate the relationship between the optimum Piagetian level at which a pupil can function and the understanding of Science which he or she can achieve.

This Task tests coordination of spatial relationships and is based on Piaget and Inhelder's---The Child's Conception of Space", Routledge, London, 1956. Since the pupils draw their answers, it is particularly suitable for younger children and those with writing difficulties. It covers the range from preconceptual to mature concrete (2B) operational thinking. The highest assessment possible is Concrete Generalisation, 2B*, which indicates fluency with concrete operations and the possibility of higher levels of thinking.

As with all the Science Reasoning Tasks the administration of this Task requires the active involvement of the teacher and this makes them aware of what the Task seeks to measure.

Equipment

Unlined paper, pencil and eraser for each child.
Empty jam jar on teacher's table clearly visible to all.
8 or so jam jars with lids or corks. From the centre of each lid hang a plumb-line, weighted with lead shot, plasticine etc., inside the jar. There should be enough jars placed around the class so that each child can see one clearly.

Administration

1 Show the children the empty jam jar and ask them to "Draw this jam jar, but imagine there is some water in it and draw that too".
Ask them to draw a jam jar with water in it again, but this time:

(a) tilted
(b) on its side, and
(c) upside down. If the children start to ask should the water be running out, tell them to draw what they think they will see when the jam jar, half-full of water, has been put in that, position.

2. Ask them to draw a mountain with a house and trees on its sides. Make sure they understand that they are to draw them on the skyline, rather than on the front. If the mountain is drawn too steep pupils wil find it difficult to place the house and trees on it so emphasise that the mountain should be gentle.
Ask them to put a chimney on the house they drew before with smoke rising from it. Tell them it was a still day, with no wind blowing.

3. Ask them to draw the jam jar on their table that has a weight on a line hanging down inside it:

   (a) With the jam jar upright and sitting on the table.
   (b) WITHOUT TOUCHING OR MOVING THE JAR AT ALL, ask them to draw it again as they imagine it would look if they tilted it.
   (c) TELL THEM THEY CAN NOW TOUCH THE JAR AND MOVE IT ABOUT. Draw again if they think their first drawing was not right, but the old drawing is not to be rubbed out.

4. Ask them to imagine they are standing in the middle of a long straight road, lined with trees, going away from them into the distance. Ask them to draw it the way it would look.

Go round the class while the children are doing the drawings. Check that they understand what they are expected to draw and see what -improvements- (if any) can be obtained by discussing any "mistakes", and note their reaction to the discussion. With a group of low ability, question 4 may be omitted if the Task has already gone on long enough. You may need to show them a simple cross-section drawing of a mountain and a jam jar on the board. When you are marking the task remember it is the pupil's intention that is being marked rather than the competence at execution.

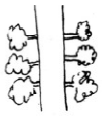
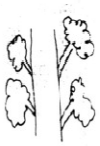
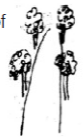
Scoring

Enter the corresponding score for each item on the class assessment sheet. Take their sum, and give an overall assessment using these scoring rules.

Scoring Rules:

Total Score	Piagetian level		
	Numerical		Descriptive
1	1.62	1a	
2	2.15	1b	Pre-operational
3	2.56	1b	
4	2.92	2A	Early Concrete
5	3.24	2A	
6	3.53	2A	
7	3.79	2A	
8	4.05	2A/2B	Mid- Concrete
9	4.29	2A/2B	
10	4.53	2A/2B	
11	4.76	2A/2B	
12	5.00	2B	Mature Concrete
13	5.25	2B	
14	5.53	2B	
15	5.84	2B	
16	6.23	2B*	Concrete Generalisation
17	6.70	2B*	
18	7.36	3A	Early Formal
19	>7.4	3A	

Marking - outline of scoring decisions

Developmental level	Score	Jam jar and water	Mountain, house and trees	Plumb line	Road with trees
Preconceptual	0	Water's presence shown by scribble, no surface 	Tree and house not related to mountain 		No co-ordination between trees and road
Intuitive or Pre-operational **1B**	1	Surface on water but parallel to bas of container, even if tilte 		Line stays nearly parallel to sides 	
Early Concrete **2A**	2	Surface beginning to move towards lip as jar is tilted, but not consistently horizontal 	Tree and house at right angles to the mountain even where the surface is not horizontal 	On questioning they will always say line is vertical, but will still tend to draw it parallel to sides 	No attempt at perspective, trees at right angle to edge 
Mid Concrete **2A/2B**	3		Some objects related to vertical as well as to mountain surface. Try asking about smoke from chimney (windless) 	If it is nearly right 	Trees start to be drawn upright but no perspective 
Mature Concrete **2B**	4	Finding result by trial and error. Maybe be one mistake but will rectify this on quesioning All right. Pupil appears to know before any trial	Maybe an error or two. On questioning will always alter correctly 	As jam jar  All right	Trees drawn upright and they begin to bring far end of road bending together 
Concrete Generalisation **2B***	5		All correct 		Full perspective, even inclination of edges into distance. Trees graded in size 
	6				Perfect co-ordination of trees and road

Marking - extra information for accurate marking

Developmental level	Score	Jam jar and water	Mountain, house and trees	Plumb line	Road with trees
Preconceptual	0		*As diagram*, but be wary: this is only a rare performance if the task has been demonstrated clearly on the board by a nice hill with not-too-steep sides (where the teacher has let them make very steep sides it makes the task more difficult for the children)		Rare: when you see they have evaded the task altogether, and not related the trees to the road at all
Intuitive or Pre-operational **1B**	1	Here we are looking for just one relation used: water is related to base of jar in all orientations			
Early Concrete **2A**	2	If there is some degree of uncertainty in *all* orientations, but some evidence of intention to go beyond a level 1 strategy		*As diagram*, or just a beginning version of plumb and/or line moving away from middle of jar	
Mid Concrete **2A/2B**	3	If jar on side has water horizontal, and also in upright jar, then look for an attempt to *begin* to orientate tilted jar to ground (as diagram)	Either the house or the trees related to the side of the hill, but enough uncertainty about whether to use the vertical or the hillside as the reference frame to fall short of 2B=4	Clear evidence that they know they ought to think about how the plumb-line will change in relation to the sides in the tilted condition, but they have made some kind of incorrect guess as to where the plumb and the string will go	As diagram, *or*, trees drawn vertical but not perspective in the road
Mature Concrete **2B**	4	Give 4 rather than 3 if you can see that the child's *intention* was to draw it horizontal, even if the draughtsmanship was a little imprecise	Look at both trees and house for evidence. The house needs to be related to the vertical, and also some at least of the trees, or you have to see that the *intention* was to use the vertical rather than the hillside for orientation of the trees	If task is demonstrated right, then jar is only slightly tilted, and plumb-line falls freely in space towards the floor. But if jar is more tilted, then you have to look for children using causation, i.e. *As diagram*, they say, 'It can't get vertical, so it slides down the side, and the string has to follow it in a likely way'	Trees drawn upright, and *either* some perspective in the road, *or* some perspective shown in the size of the trees (smaller as farther away)
Concrete Generalisation **2B***	5		This is a rare performance: you are looking for an extra level of co-ordination where there is some indication that the depth of the hill as well as the skyline has been used as frame		Perspective in both road and Trees—as diagram. A rare score of 6 is given if a 3-D view is generated
	6				

Science Reasoning Task I

Name: _____ Date of Birth: _____

Class: _____ School: _____

Secondary school you may go to: _____

Picture 1

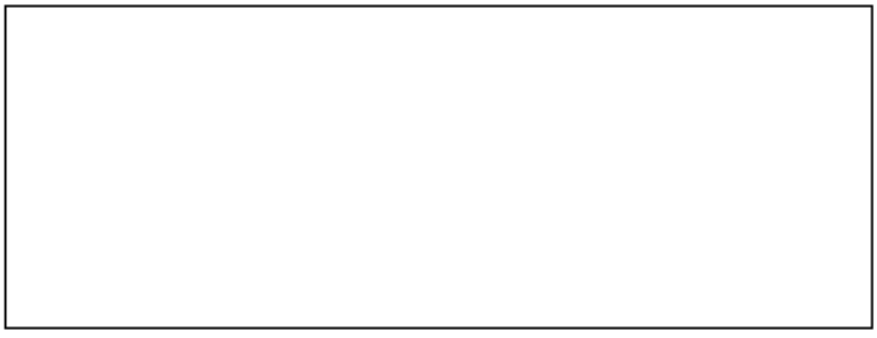
Picture 2

Picture 3

Picture 4

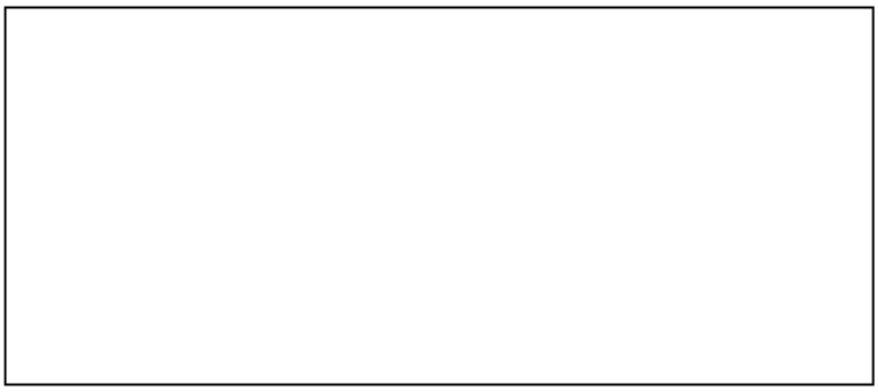
Picture 5

Picture 6



Picture 7

Picture 8



Picture 9

Task 2 Instructions

Equipment

Glass trough

1000 cm3 cylinder

500 cm3 cylinder

250 cm3 cylinder

100 cm3 cylinder

Maize

4 popcorns

17 x 1 cm wooden cubes

5 x 4 x 3 cm brass/ iron block

2 lumps plasticine 5 x 4 x 3 cm

Perspex 10 x 10 x 10 cm box

2 feet stout thread

250 cm3 beaker

Question 1

A is the 100 cm3 cylinder. B is the 250 cm3 beaker.

Fill A in the tap. Emphasise that it is full. Pour it into B. Refill A. Put A and B alongside each other so that they can be seen. Put the questions.

Question 2

Fill A in the tap. Pour it into D. Refill A. Pour it in C. Refill A. Pour it into B. Refill A. Put all 4 together in a line so they can be seen. Put the questions.

Question 3

Emphasise that popcorn is made straight from the grains. Show them both- maize and popcorn. Let them drop on the bench so that they can hear the solidness of the grains.

Question 4

Make sure top of plasticine block is flat. Show them that 5 1 cm cubes measures the height, and then fit 12 cubes so that they just cover the top of the block. Count them in front of the class. Put the question.

Question 5

Fill the 1000cm3 cylinder to overflowing point and stand in the trough. Show them the plasticine behind or in front of the cylinder just below the water surface (NOT in the water.). Put the question. (Emphasise that the volume of water is what is needed.)

Question 6

Use the thread to hang the plasticine block lengthways, by using it like a cheese cutter. Lower it into the water, showing the water overflowing. Remove the plasticine and refill to overflowing point. Put the question (Emphasise that it is the volume of the water that is wanted.)

Question 7

Pour water out of the cylinder until 500 cm3 remains. Say 'If I lower the plasticine into the water until it is just under the surface, what will the water level in the cylinder be?'

Question 8

Actually roll the plasticine to make a sphere so that they can see you do it. Put the question (as compared with question 7)

Question 9

Roll the plasticine to a long thin sausage shape. Put the question (as Q. 7)

Question 10

Pass the metal block together with the plasticine block round the class so that they can 'weigh' both in their hands. Refill the 1000 cm3 cylinder to the top.

Question 11

Squeeze the plasticine so it makes a disc about 10 cm in diameter. Have the trough half full with water. Ask first question.

Then lower it in. (it sinks) Take it out. Remove about 1/3 of it. Squeeze this 1/3 into an even thinner disc. Put the second question, but do not demonstrate.

Then take off a very small piece, so that squeezed as thin as will still hold together it is about 1 cm across. Show it to them and ask the third question.

Question 12

Show the 10 x 10 x 10 cm box. Say it is so light that they can forget about its own weight. Emphasise that the second box in question is just like it, but twice as tall. Repeat the information in question a. Show the box again and put the first question.

Emphasise that it is very important to show the working/ reasoning being used.

When they have finished show the box again and read question b.

Question 13

This is a version of Archimedes and the King. Tell them that the King had a new crown made, which was supposed to be bigger and better than his old one. However, when it arrived the King suspected that his goldsmith has stolen some of the gold and mixed in some lighter metal (copper?) to make the weight up again. The King asked Archimedes to find out if the new crown was pure gold. Archimedes then set about measuring separately the volume of each crown, and the weight of each crown. Put the questions. If pupils ask, say he made a measuring cylinder large enough to a crown in.

Question 14

Explain that A and B are both made of the same metal, but the illustrations are not the same scale, so they cannot get the answer by looking at them. Put the question. Again, as in 12, they must show or explain how they get their answer.

Name: ..... Date of Birth: .....

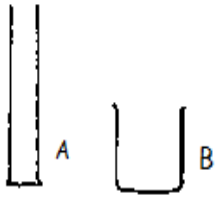
Class: ..... Teacher's Name: .....

School: ..... Secondary School you may go to: .....

Science Reasoning Task 2

Please tick what you think is the best answer.

1.



A has...

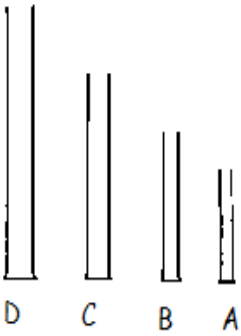
more ☐

less ☐

the same ☐

.. amount of water compared with B.

2.



Do these cylinders all have the same amount of water?

Yes ☐ No ☐

If you answered 'NO' write down which has the most?

..... (A/ B/ C/ D)

3.

(a) The pop- corns have..

less ☐

more ☐

the same ☐

..amount of maize, compared with the grains.

(b) The pop- corns weigh

less ☐

more ☐

the same ☐

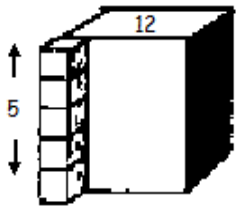
.. compared with the grains.

Explain your answer.

.....

.....

4.



What is the volume of this plasticine block, in cubic centimetres?

Your answer .....

Show your workings here.

Correct answer .....

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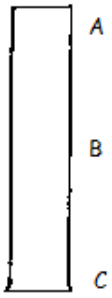
5. How much water will spill over when the plasticine is all under water?

.....

6.



You see that water spills over when the block is lowered to A.

If it is lowered to B instead, will more ☐
less ☐
the same ☐ amount of water spill over.

If it is lowered to C instead, will more ☐
less ☐
the same ☐ amount of water spill over.

7.

What will the new volume reading be?

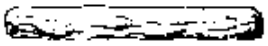
.....

---

8. If the plasticine is made into a ball, will the level of water be the same ☐
higher ☐
lower ☐

---

9. If the plasticine is made into a cylinder, will the level of water be the same ☐
higher ☐
lower ☐



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10. If the metal block is lowered in, will more ☐
less ☐
the same ☐ amount of water spill over?

Why do you think so?

.....

11. **(a)** Will this flat piece float ☐
sink ☐ ?

(b) Will this small flat piece float? Yes ☐ No ☐

(c) Will this tiny piece float? Yes ☐ No ☐
Why do you think so?
.....

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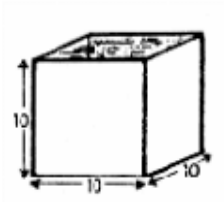
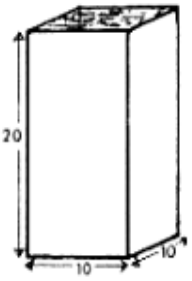
12. **(a)** This box, full of washing-up liquid weighs 1500 grams.



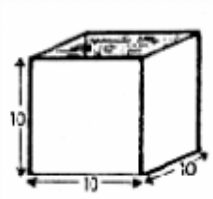
Another box (twice as tall) filled with water weighs 2000 grams



Would the box with the washing- up liquid float ☐
Sink ☐ in water?

How did you work out your answer?
.....
.....

(b) When this box is emptied, and filled with alcohol it weighs 850 grams.



Will it float ☐
sink ☐ in water?

How did you work out your answer?
.....
.....

13. **(a)**

How do you think Archimedes measured the old and new crowns' volumes to compare them, using a measuring cylinder?

.....

.....

.....

.....

.....

(b) Archimedes then weighed the two crowns and found that the new, bigger crown weighed more than the old one. Nevertheless he said that the new crown has some lighter metal in it.

How do you think he worked it out?

.....

14.

A

B

Both blocks are made of the same brass.

A weighs 60 grams, and its volume is 15 cm^3.

B weighs 160 grams.

What is its volume? ..... cm^3

How did you work out your answer?

.....

.....

Science Reasoning Task

Task III

This task investigates the students' ability to sort out the effects of three variables: how the length, weight and push of a pendulum determine the period of oscillation (period of swing). Only the length is important but the student has to overcome strong intuitive feelings in order to realise this. The task should take approximately 45 minutes.

Materials:

Stopclock

2 weights (e. 100g and 400g on hangers)

2 strings looped at either end (Loop to loop distances of 69cm and 35 cm will give about 17 and 22 swings in half a minute)

Firm support to hang pendulum from.

Administration

There are not many questions in this TASK, so your skill as a teacher should be used for creating a comparatively relaxed and slow- moving situation in which the students get the maximum opportunity to reflect on the questions which are asked. At any stage feel free to re- phrase any question in any way, so that the problem for the students is the one on the page, and not that of understanding what the question is about. Here we are trying to maximise the possibility of finding the same range of responses which one might obtain by individual interview.

1.

Introduce the Task as a series of experiments to find out what factors determine how fast a pendulum swings. Talk through the first pages showing them the combinations, with your apparatus, which are given on the cover of their response sheets. "Gentle" and "Hard" may seem loose to you as a trained scientist but they do not worry the students. Occasionally at the end of the Task a few students complain that the push was not standardised, but there is no evidence to indicate that their performances were affected. Make sure they understand that 'how fast' means "How many swings in a given time" and not the velocity of the weights while swinging. Ask them to turn over, and write in the first combination of variables in the columns in the box opposite, and to make a wild guess about the number of swings. Perform the experiment by starting the weight at the bottom, and swinging it very gently out (keep a slight tension on the string so that it doesn't 'bounce'). Time whole swings, "Zero", "One", "Two", etc., and stop the pendulum after ½ a minute. Round off the number of swings to a whole number. Ask students to record the result.

2.Ask them to write in the new combination of variables in the box opposite, tell them that their guess is again a 'free' one, and is just there to help them think, and perform as in 1. Again, ask students to record the result.

3.Ask for their ideas about how the three variables affect the number of swings. We want answers of the form: "If its longer then ……"
* The first three questions (1, 2, 3) are not assessed but are designed to help focus the students attention on the problem.

4.It is hoped that by asking for their ideas in question 3 some students will then distinguish between their ideas and the evidence in 4. They will probably think that the two questions are the same, so point out that " here we are interested in what, if anything, this particular couple of experiments show". If they feel they have already answered this question, then of course they can write "see above". The "if anything" is a hint to the intelligent child who might be worried that he/ she must deduce something from every experiment. Do not labour the point.

5. Make sure they realise that there are THREE parts to their answers. (1) a new combination of Length, Weight and Push, (2) a reason for choosing it, and (3) an explanation of how it ties in with the first two.

6& 7. This page tests their experimental economy, (a typical concrete operational strategy is to 'try everything') and their awareness that variables must be controlled. Explain in your own words that here we are trying to find out how they would have investigated this on their own. "How would they plan the experiments?" Let them write their combinations, and then draw their attention to the note in brackets, about being economical.

8.Say that for this pendulum the "LONG", "HEAVY", etc. weren't quite the same as for the one you demonstrated, ask them to imagine they are looking critically at someone else's experiment so that they cant compare the values with 1 and 2. In this question we get the 3A response from the last part of the question, so for the question "What do they tell us about the effect of the PUSH?" emphasise that it is just these two results they should use, and ask them for a fairly explicit answer i.e. their deduction and also their reason for making it. This gives them the opportunity to give us a 3B response by pointing out that no proper deduction can be made. Read through the last part. Make sure they have all finished, and only then ask them to turn over to the last side.

9.This question, page 4 is the most crucial part of the Task. Two more combinations of variables are demonstrated, and then Question 10 tests their ability to analyse the data reflectively. Here is where most of the evidence is gained as to whether a student is using late Formal Operational thinking.

Note that the 4 combinations set up in Question 9&10 control the variables so as to allow for unambiguous deductions about the effect of LENGTH (Exp. 2

& 4) and WEIGHT (Exp. 1 & 4), but appear not to control the other variables in respect of PUSH. IN fact, once the effect of WEIGHT has been deduced, then Exp 2 and 3 can be used to deduce the (non) effect of PUSH, and the pupil is given a chance to show this, either in 10. (e) or in (g). It is difficult to spot that the evidence is still sufficient for PUSH, so in (g) a 3B assessment can be reached by the alternative strategy of explaining that, for PUSH, the other variables were not controlled.

It is important that the data is as clear as possible. Ask them to write in the values from 1 and 2, to fill in the details for 9 (c) ,and to have a guess about the number of swings. Remind them that their guesses are not assessed, but are designed to help them in their thinking: if their guess is close to the experimental result then their thoughts are probably on the right track, but if not, then they know that they have to think again. Demonstrate 9 (c) and ENSURE that the answer is the same as 9 (b), ask them to record. For the Hard push, swing the pendulum about 30^{o} from the vertical. Repeat the above for 9 (d) and this time make sure the answer is the same as 9 (a).

Explain in your own words that using just these four experiments we want them to deduce the effect, and direction of each factor. E.g. “If you think they show that weight has an effect, then don’t just write ‘it has an effect’ but say ‘If the weight is heavier then you get fewer/more swings in half a minute’”. Explain also that different combinations of the four experiments may be necessary for their various conclusions. Ask them to write in the box labelled “experiments” only those (from 9 (a)- (d)) they really need in order to make their deductions.

9(g) In your own words point out that “maybe you found one of the factors rather more difficult to determine than the other two. If so, say which (and if not, that’s OK), and then you’ve a choice of answers. EITHER show how you used the evidence to make your deduction, OR explain why you think the data is insufficient”.

NB. It is most important that you ensure that the number of swings recorded in 9 (b) is the same as that in 9 (c), and that 9 (a) is the same as 9 (d). Otherwise students cannot make valid deductions in 10 (a- g).

Name: _____ Class: _____

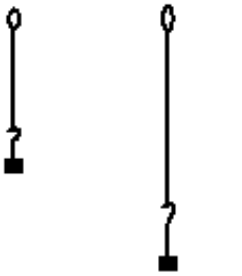
School: _____Teacher's Name: _____

Date of Birth: _____ Primary School attended: _____

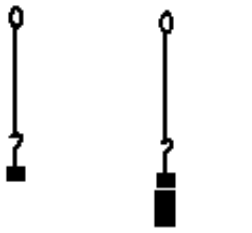
Science Reasoning Task III

We are going to make a pendulum, using a SHORT or LONG string,
and a LIGHT or HEAVY weight,
and we will give it a LOW or HIGH release.

SHORT string LONG string



LIGHT weight HEAVY weight



LOW release HIGH release

1. SHORT string, HEAVY weight, LOW release.
   How many swings in 30 seconds? Your guess: _____

   Experiment 1

Length	Weight	Release	Number of swings in 30 seconds

2. LONG string, LIGHT weight, LOW release.
   How many swings in 30 seconds? Your guess: _____

   Experiment 2

Length	Weight	Release	Number of swings in 30 seconds

3. What effect do you think LENGTH, WEIGHT, and RELEASE have on the number of swings in 30 seconds?
   LENGTH:

   WEIGHT:

   RELEASE:

4. Now what can we tell, if anything, just from these experiments, about the effect of LENGTH, WEIGHT and RELEASE on the number of swings?

   LENGTH:

   WEIGHT:

   RELEASE:

5. Write down one more experiment that you think would be worth trying next, and explain why you have chosen it. Also explain how this new experiment ties in with experiment 1 and 2:

6.
Imagine that we start again with Experiment 1

Length	Weight	Release	Number of swings in 30secs
Short	Heavy	Low	

Which other arrangements would you use to test the effect that LENGTH has on the number of swings?

7.

Again starting with Experiment 1 how would you test for the effect that WEIGHT has?

Length	Weight	Release	Number of swings in 30 secs
Short	Heavy	Low	

8. Imagine the scientist tried these 2 arrangements (with another pendulum)

Length	Weight	Release	Number of swings in 30 secs
Long	Heavy	High	15
Short	Heavy	Low	20

What do they tell us about the effect of the RELEASE?

.....

.....

.....

.....

If there are any other arrangements that you think you would really need to be sure of the effect of the RELEASE, write them down.

9.

(a) Experiment 1

(b) Experiment 2

(c) LONG string, HEAVY weight, HIGH release.
Your guess: _____ swings

Experiment 3

(d) SHORT string, LIGHT weight, LOW release.
Your guess: _____ swings

Experiment 4

Length	Weight	Release	Number of swings in 30sec
Short	Heavy	Low	
Long	Light	Low	
Long	Heavy	High	
Short.	Light	Low	

10. Now write down what these four experiments alone tell us about the effect of LENGTH, WEIGHT and RELEASE on the number of swings,
and for each factor, note down only those experiments that you need to use:

(a) LENGTH:

(b). Experiments:

(c) WEIGHT:

(d). Experiments:

(e) RELEASE:

Experiments:

Is the evidence weaker for deciding about one of the factors than it is for the others?
Yes ☐ No ☐
If so, say which factor: _____
and
EITHER show that the evidence is still sufficient, OR explain why it is insufficient.

Thank you =)

Science Reasoning Task IV

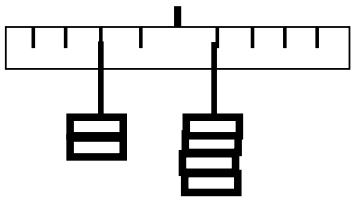
Instruction sheet

Introduce the task by reference to the see- saw. Ask where an elephant and a mouse would have to sit if they wanted to balance. To get them thinking about the problem ask them to sketch the two figures on the seesaw. Discuss their answers and check to see that everybody understands that the heavier of the two should sit nearer the middle.

1. In your own words say that in science we can do better that saying "heavy and light", and "nearer and farther", we can measure things. Show them the beam balance and then hold up a 100g hanger and a 300g hanger. Make sure you have the 300g on their right- so that it is the same as the diagram. Ask them to guess where the weights should be hung to balance and to draw in their guess in the middle box. Make sure they get used to writing the weights next to each hanger. This makes it easier to assess their answers.
Neither the introduction nor the first two questions are assessed but are designed to give the pupils a chance to learn about the system. Show the right answer.

Ask them to copy this into the answer box and explain why the particular arrangement balances.

2. Put 400g on the ruler. Ask them to draw and explain where a 200g weight must be hung to make it balance. When they have finished show them the correct solution and ask them to copy.



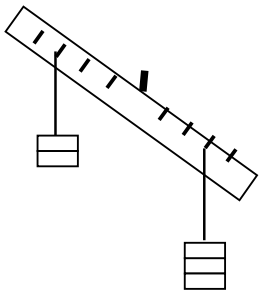
3. Keep the solution to question 2. Now add 100g to the 400 while reading the question. They answer under "1st try". To give more feedback show "the perfectly reasonable strategy" of adding 100g to the 200, this of course is not the correct solution. Tell them that if they wish to change their answer, to write in under "2nd try" and if they think they got it right the first time, to write it in again.

4. This question gives feedback on relative distances from the pivot. Show them that you have again set up the solution to question 2.

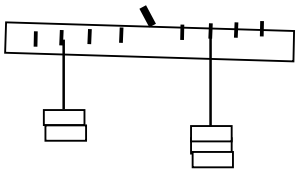
Move the 400g out 1 space to hole no. 2 while reading the question. They answer under "1st try". When they have finished show them that if you try moving the 200g out the same distance (i.e. to position 3) that the ruler does not balance. Once again if they wish to change their answer ask them to do so under "2nd try" and if they think they were correct at the first attempt, to write it in again.

5. Just talk through the question with reference to the diagram. Ask what weight would be needed on the 4th hole out on the left hand side to balance 600g on the 2nd hole on the right. Do not demonstrate the answer.

6. Set up



Ask them to guess where these weights must be positioned if they are to balance. They draw in their guess in the middle box. Check that they all write in the number of weights next to each hanger, and when they have finished show them the correct solution and ask them to record.



7. Now clamp the solution to question 6 by sticking the 2nd nail through a hole at the end of the ruler. Make sure they are aware that the ruler was balanced and then move each weight in one hole. "They were balanced, I've moved them both in the same amount, how will it look now?" Put your guesses in the middle box." Again check for numerals next to each hanger, and when they have all finished gently release the clamp. There should be some dismay and rejoicing, but fairly quickly, ask them to explain in the right hand box why the ruler drops on the light- weight side. "Why does it go down on the 2 weights side?"

8. Just talk through the question with reference to the diagram. Explain that the hangers are not to be moved and that they are only to rearrange the 5 weights shown. They cannot add any new ones. They answer by drawing in on the right hand diagram.

9. Explain that now things are a bit more complex and that the diagram is not necessarily to scale. Here we are giving them the weights (3 and 2) but we are not telling them where thay are hung; beyond the fact that they balance. Say that if you move the (3) out one unit, how many units must the (2) be moved in order to restore the balance? Tell them the units could be centimetres, inches, etc.

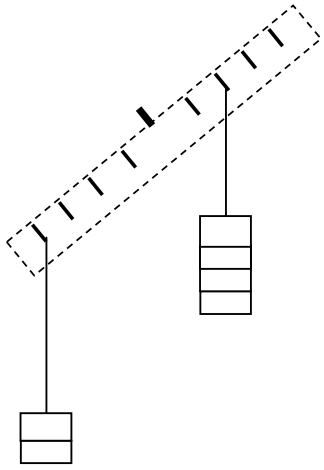
10. Another difficult problem. Explain that the square and round shapes balance at distances of two and three units. Ask (a) "Which is the heavier?" and then (b) "How much heavier is the one you have chosen, than the other one? If, for instance, you think the round shape is heavier then how much heavier than the square is it?" If they ask "can we use grammes?" tell them that they may if they wish but remind them that there is no information as to how heavy either one is.

11. Explain that this asks for a summary of all they have learned so far; a general rule. They may use the notation shown, invent one of their own, or write the whole answers out in words.

(While they are answering, lower the ruler until the bases of the hangers are 20cm above the bench)

12. In your own words explain that this is another way of looking at the problem, this time dynamic. Talk about levers, now focusing on the forces and how far they have to act. You could open and close the classroom door, demonstrating that you do not need to push very hard near the handle, but that you do need to push it a long way. Show them the converse.

With the ruler set up thus:



Show them that by allowing a heavy weight (400g on hole 2) to drop a short way, you can lift a light weight a long way. Point out that we can measure the weights and distances, and then do so. Get them to record your measurements (the 400g weight on hole 2 drops 10cm which raises the 200g weight on hole 4 through 20cm.) Because these are fiddly experiments to demonstrate point out that the results for the next two are written in for them. Just talk through them, then ask the question.

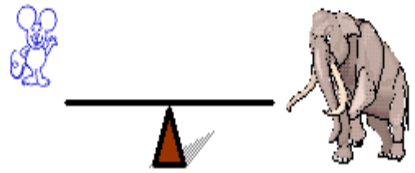
13. Piaget says that an explanation of the balance equilibrium in terms of virtual work is late formal mode of interpretation. If your pupils are at all capable of this, they must be given as much background as possible. So first explain that they may find the concept of WORK useful. Introduce this semi- quantitatively by saying something like "If you carry a 25Kilo sack up a flight of stairs you will be aware of having done some work. If you take it up twice as many stairs you will certainly know you have done much work- twice as much. But if you increase the weight you will also have to do more work. For example if you carried 50 Kilos, you would do twice the work. But if you carried twice as much weight up two flights of stairs you would have done four times as much work. So the work you do depends on both the weight and how far you lift it up. Pose the question. Emphasis that they should direct their answer to the WEIGHTS and the VERTICAL HEIGHTS they rise and fall. They can use the notation given at the beginning of this section, or any other ways they wish to invent.

Name: ..... Class: .....

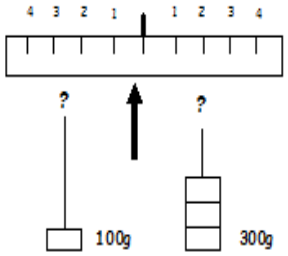
School: ..... Teacher's Name: .....

Date of Birth: ..... Primary School attended: .....

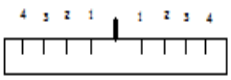
Science Reasoning Task IV



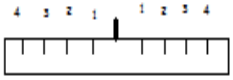
1.



Guess



Answer



Explain:.....

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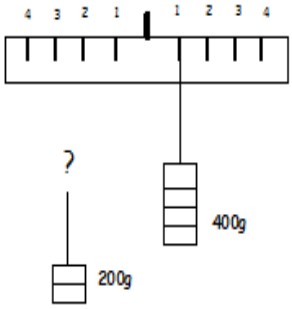
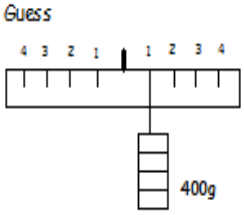
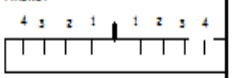
2.



Guess



Answer



Explain:.....

.....

.....

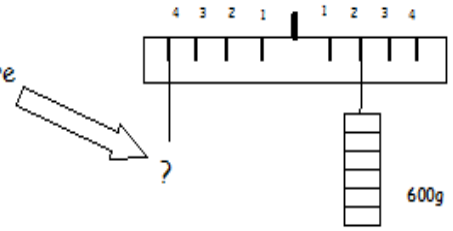
3. If I add 100 grams to the 400g how much must I add to the 200g to keep it balanced?

1st Try ..... 2nd Try .....

4. If I move the 400g to position 2 to which hole must I move the 200g?

1st Try ..... 2nd Try .....

5. What must I hang here to make this balance?



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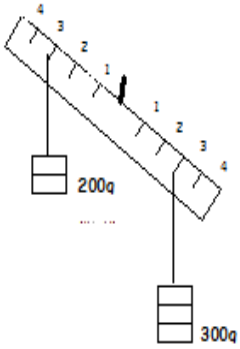
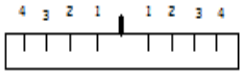
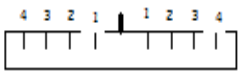
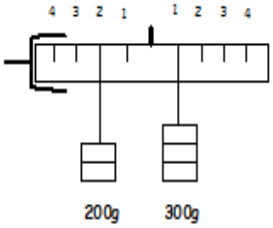
6.



Make this balance by moving the weights.

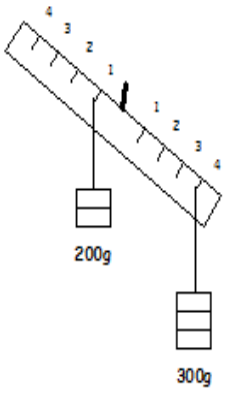
Guess	Answer
	

7.

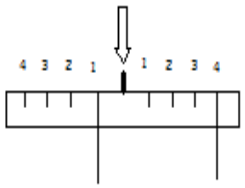


How will it look?	Explain:

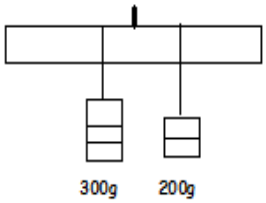
8.



Without changing the position of the hangers, rearrange the weights to make this balance.



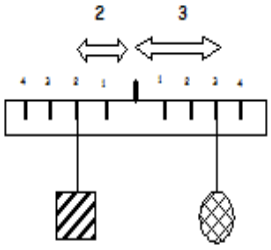
9.



These are in balance.
If I move the 300 gram weight out one unit, how far must I move the 200 gram weight to keep the balance?

…… units

10.



These two balance.

(1) Which is heavier? ▨ or ⊗ ……

(2) How much heavier is it? ……

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11. Can you give a general rule which connects weights and distances and whether the system balances?

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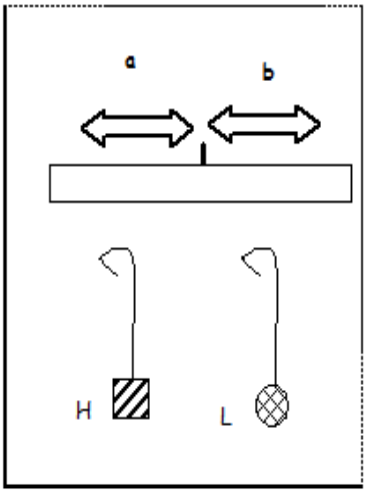
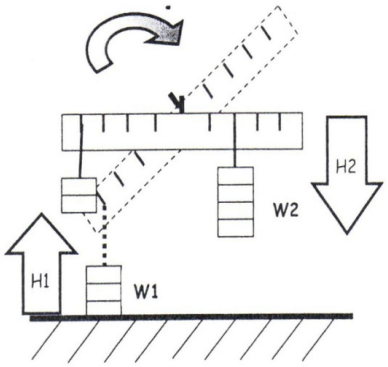


12. **Another way of looking at the problem**

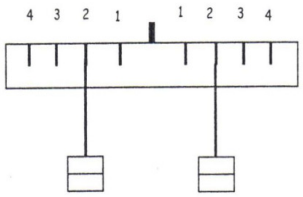
"How are the rises and falls of weights related?"

a.



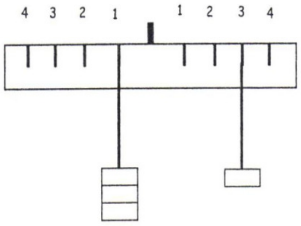
The 400 gram weight on hole 2 drops ..... cm which raises the 200 gram weight on hole 4 through ..... cm.

b.



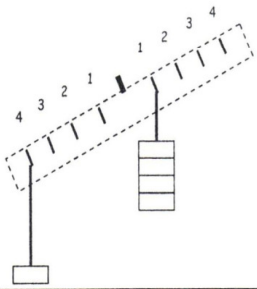
Here one weight rises ..... cm while the other falls ..... cm.

c.



Here the 300 gram weight is raised ..... cm by the 100 grams falling ..... cm.

d.



How far must the 400 gram weight fall in order to lift the 100 gram weight through 20 cm?

Answer: .....

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13. What explanation might you give to an intelligent friend who wanted to understand, WHY it is that a LIGHT weight can lift a **HEAVY** weight and come to balance?
Look at the WEIGHTS (W1 and W2) and the HEIGHTS (H1 and H2).

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TASK VII

FLEXIBLE RODS

Hugh Wylam, Research Fellow
Chelsea College, University of London

Introduction

This Task* is one of a series developed by the team 'Concepts in Secondary Maths & Science' at Chelsea College, University of London in the period 1973/78 in order to investigate the relationship between the optimum Piagetian level at which a pupil can function and the understanding of Science which he or she can achieve.

This Task (based on chapter 3 of Inhelder and Piaget's "The Growth of Logical Thinking", Routledge, London, 1958) investigates the pupil's ability to sort out the effects of five variables which affect the flexibility of metal rods. It tests whether they are aware of the necessity to control variables when conducting experiments and whether they can apply such a strategy effectively. Their deductive reasoning is tested by seeing how they deduce the effect of the less intuitable variables, cross-section and metal. The last page of the Task investigates their ability to handle variables which act in opposite directions to compensate for each other (in Piaget's language this is Reciprocity).

There is an annotated copy of the Task which gives all the cues you need during the administration, provided you have read this manual carefully first.

Allow about 50 minutes to complete the Task.

Equipment

A hardwood block approximately 5" x 1 1/2 " x 11/2. The block has 2 sets of three holes either side of the middle drilled horizontally to take 1/8" round rods, 1/8" square rods and 1/4" square rods‡. Use 9/64",11/64" and 17/64" drill bits respectively. A 1/2" hole drilled vertically through the middle of the block allows it to be supported on a retort stand.

G-Clamp to hold retort stand firmly.

2 Boss-head clamps, one to position wooden block on stand, the other to hold **a clamp** with a metre rule as a reference line.

2 sets of 100 gram slotted-weights with hangers.

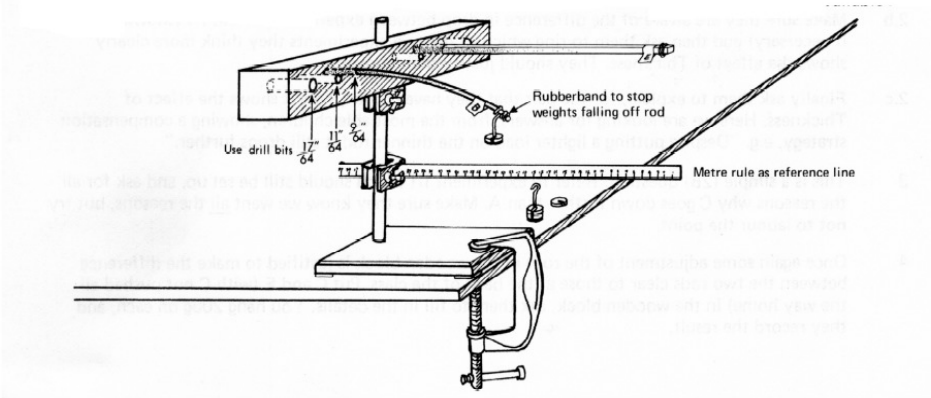
6 rubber bands to wrap round metal rods and stop weights falling off.

6 metal rods labelled with flags:

A: 1/4" round steel rod 0 5")
B: 1/8" round brass rod (15")
C: 1/8" round steel rod (181/2")
E : 1/8" square brass rod 0 6")
G: 1/8" round steel rod (15")
I : 1/4" round steel rod (40")

These lengths are approximate. What is critical is that B & C should both drop the same amount with 100 g.

[‡Metric equivalents are 3 mm and 6 mm, however, 3 mm square brass rod may not be available'in the UK]



Administration

Make sure that every pupil has a copy of the Task and a single sheet showing the rods (these can be used again if treated carefully).

One way of introducing the problem is by referring to the cartoon on the front page of a kingfisher who wishes to get as close as possible to the minnow. What sort of fishing rod should he choose to land on ? Use this if it suits your style and class. Show them the metal rods and wooden block and explain that the problem is to determine the factors which control how far the end of a metal rod drops when a load is applied. As with all these Tasks the crucial point is that the pupils must understand the problem if they are to perform to the best of their ability, so rephrase any question as you see fit.

1.a Put rods G and I into appropriate holes in the wooden block, make sure the pupils have filled in the table correctly (by reference to their diagram of the rods), hang 200g on each and ask them to record the result that "I goes down (or drops) further". Put the first question. This is not assessed, but is designed to get them started thinking about the evidence.

1.b Ask them if they think it a fair test for Length and explain that they can answer this in different ways. If they think it fair, to put a ring round FAIR and then explain why they think so, likewise for UNFAIR, and if they feel its not very fair but just about adequate, to ring ADEQUATE and then explain why. This latter alternative is to encourage the intelligent pupil to start using compensation, for despite not controlling variables you can still make a valid deduction since the uncontrolled variable (Thickness) has been altered in a way that would counteract the effect of the test variable (Length). Thus if you still get a positive result for Length then the effect is shown.

1.c Ask them for their experimental strategy by choosing which pairs of rods they could compare to show the effect of Length. Make sure they understand we want as many pairs as possible, but each pair must show the effect clearly. Point out the example in the box and ask them to write their pairs in underneath, for each rod they should put the load they would use in brackets next to each letter.

2 Ask them to fill in the details of rods A and G and then tell them that you are going to hang 200g on A and 100g on G. Get them to record the result. In experiment I 11, again ask them to fill in the details, and then tell them that this time you are going to hang 100g on A and 200g on C. In 2b we want to see if they realise that although the difference in drop between A and C is greater than that for A and G, in fact, A and G more clearly show the effect of Thickness since the variable Length has been controlled. A child using concrete thinking strategies would choose A and C in an interview situation, where he is close to the apparatus, however, since we are demonstrating these experiments it is justifiable to accentuate the magnitude of the difference between the two experiments by effectively lengthening rod C by pulling it a little bit through the wooden block.

2.a Ask them to record the result of experiment I 11, that C drops quite a bit further, and then ask what these two experiments tell them about the factors affecting bending.

2.b Make sure they are aware of the difference in drop between experiments II and III (showing again if necessary) and then ask them to ring which of the two experiments they think more clearly shows the effect of Thickness. They should justify their choice.

2.c Finally ask them to explain, for the pair that they have chosen, how it shows the effect of Thickness. Here we are looking for answers, from the most able children, showing compensation strategy, e.g. "Despite putting a lighter load on the thinner rod it still drops further."

3 This is a simple (213) question. Refer to experiment I I I which should still be set up, and ask for all the reasons why C goes down further than A. Make sure they know we want all the reasons, but trynot to labour the point.

4 Once again some adjustment of the rods in the wooden block is justified to make the difference between the two rods clear to those at the back of the class. Put C and E (with C not pushed all the way home) in the wooden block, ask them to fill in the details. You hang 200g on each, and they record the result.

4.a b Here they have two chances to show they realise that since you have confounded the variables they can make no positive deduction. In your own words say that if they think that experiment IV shows that Brass is stronger, they should write that down and then, where it says "Explain", to write down why they think so. If they think it shows Steel is stronger, to say so and explain. If they are not sure, to explain why they are not sure, or finally if they cannot tell, to say why they cannot tell.

4.c This question is similar to 1.c. Ask which pairs of rods from their sheets could they use to compare Brass and Steel. Tell them to fill in the table. Emphasise "all" and "clearly".

5 Experiment V is a crucial demonstration. With prolonged use the holes in the wooden block become worn, so it is important that before every testing session you check that rods B and C both drop the same amount with 1 00g on each. If there is a slight difference, then, before the pupils arrive, adjust them by pulling one or the other through the block and mark them with a felt-tip pen or chalk. Thus when you reach question 5 in the test you will be able confidently to set up experiment V.

5.a,b Ask them to fill in the table, show B and C with 100g and get them to record that they both drop the same. Question 5.a asks them to deduce what they can about the relative strengths of Brass and Steel and 5.b, to justify their reasoning.

5.c Ask what, using any of the earlier experiments, they can deduce about the effect of Shape.

5.d Here we want them to justify their answer to 5.c by referring to the earlier experiments showing how they compare them.

5.e Finally, a similar question to 1.c and 4.c. Ask them to give all the pairs of rods from their sheet, which can be used to compare clearly the difference between Round and Square rods. When they have all finished ask them to turn over the last page.

6. This question is not assessed (though do not say so) but is intended as a practice item for 7 and 8 to get them to write answers which explicitly give the effect of each of the variables, and show how they can compensate for each other. Set up the first experiment again, but then push rod I through the wooden block until most ofyour class are prepared to admit that they both drop the same amount. Explain that we want fairly explicit answers, ask them to imagine they are explaining this to someone who does not know the effects of Length, Weight, Shape, Thickness and Metal so that an answer like "Because it's thinner" or "Because it's steel" is not adequate. Ask what is it about the "thinness" or which makes it drop the way it does. When they refer to any of the variables they must give the effect of that variable. Walk round the class and check a few answers.

7 Just talk through the question. As in question 6 we want explicit answers. So, tell them that, "Because it's brass", is not adequate. They must say what effect brass has.

8 Ask them to fill in the details, but this time to use their knowledge to guess what they think will happen BEFORE you put 200g on each. Ask them to guess, justify their guess and as in the preceding two questions to give an explicit answer. ONLY when they have finished show them the result and ask them to record. If they wish to change their answers let them do so where it says "Explain". If they think they got it right first time then ask if they can write it down more simply but still making sure that when they refer to a variable they give it's effect.

9 Simply ask the question, though say they may put down more than one if they cannot decide between them.

10 It is important that you do not let anyone shout out the answer to this question. Explain that someone else with a different set of rods found that a round steel rod and a square steel rod (of the same length and equal load) both dropped the same. Obviously to explain this they must realize that another factor (the Width) is having an effect.

11 Read through the question but point out that their answers should be restricted to Brass or Steel, Long or Short, Thick or Thin and Round or Square. They are not restricted to the rods A-I but we do not want clever answers introducing titanium steels, carbon fibres or H-section girders.

Assessment

Score each result as -1 " for adequate, and "0" for inadequate and record on the class assessment sheet. Treat each answer only for the information it gives at the level specified for the question (see Summary of Answers and top of Assessment Sheet). Thus if it is a –3B" question as in 8 ignore ingenious replies at the 2B level. Similarly a higher level response to a "2B3" question still only gains credit at the 2B level.

Summary of answers

These notes on answers cannot be exhaustive. Indeed this is deliberate, since we do not wish you tc be just a scoring-machine, but rather to maximise your understanding of how your pupils think.

1.a	Ignore replies in assessment.	
1.b	Anything which show awareness of inadequate control of variables. e.g. -UNFAIR because the thickness should be the same" or "FAIR (or ADEQUATE) because the fatter one islonger and still shows the effect of length".	(3A)
1.c	"BH, CG, DF" (with the same Weight on each rod in a pair). All three pairs must be given, with none extra.	(3A)
2.a	As a minimal answer allow "Thickness affects flexibility". Score "0" for anything which does not mention Thickness or Width.	(2 B)
2.b	"A and G" with an explanation that the variables are better controlled for this pair. e.g. "because they are the same length". (see 2.0	(3A)
2.c	An answer like "Even though it has less weight it still goes down further." If they have given this answer as their answer to 2.b then score " 1 " for both 2.b and 2.c. If however, they have just said "There is less weight on the thinner rod" then allow this to count for a 3A answer to 2.b.	(3B)
3	"Because it is Longer, Thinner and has more Weight". They must mention all three.	(2B)
4.a	Score " 1 " for "You can't deduce anything" with a reason why. Allow just "Nothing" only if it is satisfactorily explained in 4.b.	(3A)
4.b	An explanation like "Because the lengths Pre not the same" or "They have different cross- sections".	(3A)
4.c	"BG, CH" (with the same weights on each rod in a pair). Both must be given, with none extra	(3B)
5.a	A deduction that "Brass is the more flexible".	(3A)
5.b	An explanation like "Steel İS longer but it still only goes down the same amount".	(3A)
5.c	A statement that "Round rods drop more easily than square". Allow also an answer pointing out no control of variables.	(2B)
5.d	Only score "1" for an explanation which relates.B to E by using C as a reference, in experiments IV and V, e.g. -E goes down less than C in exp. IV, C goes down the same as B in V so E would go down less than B".	(3B)
5.e	"BE" (with the same weight on each). Only this pair must be given.	(3B)
6	Ignore answers in assessment, unless doubtful about replies to 7 and 8.	
7	Allow any answer showing compensation between the effects of Nflaterial and Width. As a minimal answer allow "X is Brass which helps, but Thicker which hinders". (see 8)	(3A)
8	Score -1 " for a 3B response if their answer to either "Say why" or "Explain" shows reciprocity, i.e. they should give the effect of both Cross-section and Material, but more importantly, an awareness that the effects cancel each other out, e.g. "The brass equals out the squareness" is the least that would be acceptable since the effects are given only by implication but the reciprocity is explicit. You may need to take their answers to 6 and 7 into consideration. If you feel they deserve a 3A rating on this question and if they failed to gain one for question 7, then you may score them " 1 " there now.	(3B)
9	A" (Allow "A and D")	(2B)
10	Only allow an answer as complete as "The round rod must be thicker".	(3B)
11.	"Brass, Long, Thin, Round". They must have all four correct. However, if a mistake here is consistent with incorrect replies earlier in the Task, then allow, e.g. if they concluded that question 8 shows round and square make no difference, then allow "Brass, Long, Square, Round".	(2B)

Scoring Rules

Read from the top, go down the list until you find a combination which fits the pupil

THREE or more 3B items right plus FIVE or more 3A items	3B
S I X 3A or above items right	3A
FO U R or more 3A or above items right	2B*
T H R E E 2B or above items right	2B
Less than the above	2B-

Please fill in your details below

Name: _____ Class: _____

School: _____ Science Teacher's Name: _____

Date of Birth: _____ Primary School attended: _____

Science Reasoning Task VII

1. **(I)** G and I with 200 g each.

Rod	Metal (Brass/ Steel)	Length (L/M/S)	Thickness (6mm/3mm)	Shape ● / ■	Mass (grams)	RESULT Tick the one that drops most
G						
I						

A. What do these steel rods tell you about the effect of LENGTH?

_____

_____

B. Is it a fair test for LENGTH?

FAIR ☐ UNFAIR ☐ ADEQUATE ☐

Explain

_____

_____

C. Give ALL the pairs of rods you could use to show clearly the effect of LENGTH. ⟶

(What mass would you hang on each?)

Rod (Mass)	*and*	Rod (Mass)
A (100g)		I (100g)

2. **(II)** A and G

Rod	Metal (Brass/ Steel)	Length (L/M/S)	Thickness (6mm/3mm)	Shape ● / ■	Mass (grams)	RESULT Tick the one that drops most
A						
G						

(III) A and C

Rod	Metal (Brass/ Steel)	Length (L/M/S)	Thickness (6mm/3mm)	Shape ● / ■	Mass (grams)	RESULT Tick the one that drops most
A						
C						

A. What do these experiments tell you?

_____

_____

B. Which of the two experiments is better for showing the effect of THICKNESS?

A and G ☐ or **A and C** ☐

Explain why the pair you have chosen is better.

_____

_____

C. How does it show the effect?

_____

---

3. Give all the reasons why C goes down further than A.

_____

_____

---

4. **(IV)** C and E with 200 g each.

Rod	Metal (Brass/ Steel)	Length (L/M/S)	Thickness (6mm/3mm)	Shape ● / ■	Mass (grams)	RESULT Tick the one that drops most
C						
E						

A. Using <u>just this</u> experiment, what can you say about BRASS and STEEL?

_____

B. Explain _____

_____

C. Give ALL the pairs of rods you could use to show clearly the effect of METAL. ⟶

(What mass would you hang on each?)

Rod (Mass) *and* **Rod (Mass)**

---

5. **(V)** B and C with 100g each.

Rod	**Metal** (Brass/ Steel)	**Length** (L/M/S)	**Thickness** (6mm/3mm)	**Shape** ● / ■	**Mass** (grams)	**RESULT** Tick the one that drops most
B						
C						

A. What can you say from these results about the effect of METAL?

_____

B. Explain _____

_____

C. Using any of the earlier experiments, what can you now say about the effect of SHAPE?

_____

D. Explain (giving the experiments you need)

_____

_____

E. Give ALL the pairs of rods you could use to show clearly the effect of SHAPE. ⟶

(What mass would you hang on each?)

Rod (Mass) *and* **Rod (Mass)**

---

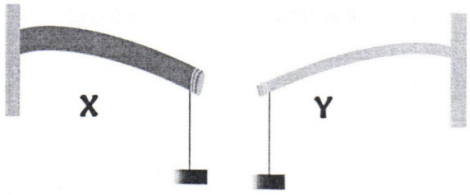
6. We can adjust the length of I (Long/ Steel/ Thick/ Round) so that it drops the same as G (Short/ Steel/ Thin/ Round)
Explain why the both drop the same. If you refer to any of the factors, please say how they help or hinder.

_____

_____

_____

7.



X is a Thick Round Brass rod

Y is a Thin Round Steel rod.

Both X and Y are the SAME length.

Explain why they both drop the same. If you refer to any of the factors, please say how they help or hinder.

_____

_____

---

8. **(VI)** G and E with 200g each.

Rod	**Metal** (Brass/ Steel)	**Length** (L/M/S)	**Thickness** (6mm/3mm)	**Shape** ● / ■	**Mass** (grams)	**RESULT** Tick the one that drops most
G						
E						

What do you think will happen?

_____

Why? _____

_____

Explain _____

---

9. Which of all the rods (A– I) do you think drops the LEAST? _____

---

10. If a ROUND steel rod and a SQUARE steel rod, of equal length with equal weights, drop the same, what can you say about them?

_____

_____

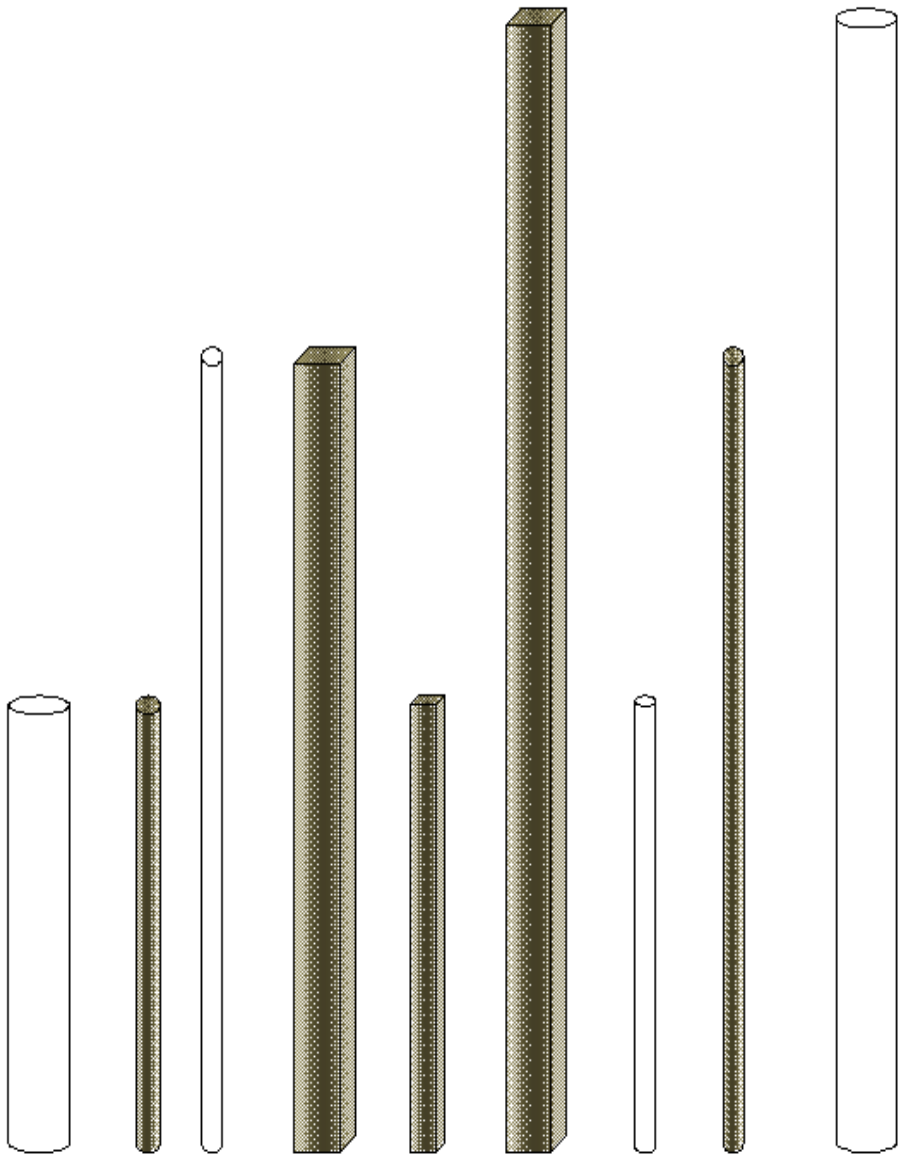
_____

---

11. If you wanted a rod which would drop a long way, describe (in terms of **Metal, Length, Thickness & Shape**) the sort of rod you would choose.

_____

Flexible Rods



Appendix B

Adapted LASSI-HS survey

LASSI-HS

This questionnaire is being used as part of the *Thinking Science* exercises to find out more about how you learn, how you study and how you feel about learning and studying.

Directions

On these pages you will find 32 statements about learning and studying. Read each statement and then mark one of these choices:

1. NOT AT ALL LIKE ME
2. NOT VERY MUCH LIKE ME
3. SOMEWHAT LIKE ME
4. FAIRLY MUCH LIKE ME
5. VERY MUCH LIKE ME

To help you to decide which choice to mark, we will explain what is meant by each one.

By **NOT AT ALL LIKE ME**, we do not necessarily mean that the statement would never describe you, but that it would be true of you only rarely. **Mark 1 for this choice**.

By **NOT VERY MUCH LIKE ME**, we mean that the statement generally would not be true of you. **Mark 2 for this choice**.

By **SOMEWHAT LIKE ME**, we mean that the statement would be true of you about half the time. **Mark the number 3 for this choice**.

By **FAIRLY MUCH LIKE ME**, we mean that the statement would generally be true of you. **Mark 4 for this choice**.

By **VERY MUCH LIKE ME**, we do not necessarily mean that the statement would always describe you, but that it would be true of you almost all the time. **Mark 5 for this choice**.

Thank you for your co- operation.

		Not at all like me	Not very much like me	Somewhat like me	Fairly much like me	Very much like me
1	I worry that I will fail my classes.	1	2	3	4	5
2	I don't care if I finish secondary school as long as I can get a job.	1	2	3	4	5
3	I find that when my teacher is teaching I think of other things & don't really listen to what is being said.	1	2	3	4	5
4	I get discouraged if I get low marks.	1	2	3	4	5
5	I am up- to- date in my class work.	1	2	3	4	5
6	Problems outside of school- friends, conflict with parents, etc.- cause me to not do my school work.	1	2	3	4	5
7	Even when study materials are dull & not interesting, I manage to keep working until I finish.	1	2	3	4	5
8	I feel confused & undecided as to what my educational goals should be.	1	2	3	4	5
9	I come to class unprepared.	1	2	3	4	5
10	I would rather not be in school.	1	2	3	4	5
11	I am very tense when I study.	1	2	3	4	5
12	I work hard to get a good mark, even when I don't like a class.	1	2	3	4	5
13	I often feel like I have little control over what happens to me in school.	1	2	3	4	5
14	Even when I am well prepared for a test, I feel very upset when taking it.	1	2	3	4	5
15	I make excuses often for not doing homework.	1	2	3	4	5
16	When I begin a test, I feel pretty sure that I will do well.	1	2	3	4	5
17	I do not want to learn a lot of different things in school. I just want to learn what I need to get a good job.	1	2	3	4	5
18	I am sometimes unable to keep my mind on my schoolwork because I am restless or moody.	1	2	3	4	5

	Not at all like me	Not very much like me	Somewhat like me	Fairly much like me	Very much like me
19 I set high standards or goals for myself in school.	1	2	3	4	5
20 I find it hard to pay attention during class.	1	2	3	4	5
21 I only study the subjects I like.	1	2	3	4	5
22 I am distracted from my studies very easily.	1	2	3	4	5
23 When work is difficult I either give up or study only the easy parts.	1	2	3	4	5
24 I dislike most of the work in my classes.	1	2	3	4	5
25 While I am taking a test, worrying about doing poorly gets in the way of keeping my mind on the test.	1	2	3	4	5
26 I don't understand some class material because I do not listen carefully.	1	2	3	4	5
27 I read textbooks assigned for my classes.	1	2	3	4	5
28 I feel very panicky when I take an important test.	1	2	3	4	5
29 I pay attention fully when studying.	1	2	3	4	5
30 I get so nervous & confused when taking a test that I don't answer questions to the best of my ability.	1	2	3	4	5
31 My mind wanders a lot when I do schoolwork.	1	2	3	4	5
32 In my opinion, what is taught in my classes is not worth learning.	1	2	3	4	5

Appendix C

Interview questions and Evaluation forms

Interview Questions

(Primary School teachers)

Thinking Science 1

What was your overall impression of the *Thinking Science 1* programme?

Do you think the *Thinking Science 1* programme improved your pupils' thinking and reasoning skills?

Do you think that certain pupils' thinking improved more than others?

How do you think the *Thinking Science 1* programme could be improved?

Would you teach science through the same methodology in the future?

Do you think the *Thinking Science 1* programme helped pupils' ability in other subject areas?

Interview Questions

(Second level teachers)

Thinking Science 2

What was your overall impression of the *Thinking Science 2* programme and the methodology?

Do you think the *Thinking Science 2* programme improved your students' thinking and reasoning skills?

Do you think that certain students' thinking improved more than others?

How do you think the *Thinking Science 2* programme could be improved?

Do you think that this intervention programme is suitable/ practical for use in 1st year? If not do you have any recommendations?

Would you teach science through the same methodology in the future?

Evaluation Sheet

Thinking Science 1

School & Class: _____

Date: _____

Lesson Number: _____

On a scale of 1- 5, how do you feel the *Thinking Science 1* lesson went?

1 2 3 4 5

What did you think was good about the class?

_____
_____

If the same class were to be taught again what would you change?

_____
_____

Was this *Thinking Science 1* class similar/ different to how you would normally teach science? How was it the same/ different?

_____
_____

Would you be prepared to use this *Thinking Science 1* activity as part of how you would teach science to your class in the future?

_____

Any other comments:

Evaluation Sheet

Thinking Science 2

School & Class: _____

Date: _____

Lesson Number: _____

On a scale of 1- 5, how do you feel the *Thinking Science 2* lesson went?

1 2 3 4 5

What did you think was good about the class?

_____
_____

If the same class were to be taught again what would you change?

_____
_____

Was this *Thinking Science 2* class similar/ different to how you would normally teach science? How was it the same/ different?

_____
_____

Would you be prepared to use this *Thinking Science 2* activity as part of how you would teach science to your class in the future?

_____

Any other comments: