CONSTRUCTION AND DESCRIPTION OF A DIAGNOSTIC TEST OF PHYSICAL SCIENCE IDEAS

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ABSTRACT

Teaching physical science in such a way that the learning outcomes result in effective understanding of conceptions has been recognized as a process which is not occurring as well as it could be in New Zealand.

Recent research shows that most young people's misunderstandings about the natural world around them are retained even after a considerable period of teaching has occurred. One of the main steps for rectifying the misunderstandings young people have is to identify what the misunderstandings actually are. In an attempt to assist teachers with this process a diagnostic test has been prepared so that teachers can use it to identify misunderstandings and see how typical their students or classes are compared with a Local Norm Group which have been tested.

Analysis of the results from the Local Norm Group shows that there are clearly identified misunderstandings that the students tested have about the physical science topics used in this project.

CONTENTS

INTRODUCTION

For some years science teachers have become increasingly aware that many of the more abstract scientific ideas they found are very difficult for most secondary students to understand let alone use. Various studies show that only a minority of students correctly apply a number of basic science concepts. The concepts often used incorrectly are those in the physical sciences and by students of 12 to 14 years old. (Osborne and Freyberg 1985). Such ideas as particle theory of matter, forces, radiant energy, air and air pressure and electricity are among some of the more difficult topics which show this trend.

It appears that one of the main reasons why young people have this difficulty is that teachers tend to focus on the content they are teaching rather than aspects which are to do with how students "see" the science that they are being taught. Aspects such as these include:

(i) Taking time to focus on what students think about various concepts being taught.

(ii) Getting students to verbalize their own ideas and discuss them with others.

(iii) Doing activities which help students to recognize how their own ideas differ from the recognized scientific explanations.

Osborne and Freyberg elaborate this further:

"Children from a young age, and prior to learning science at school have meanings for words and views of the world which are to them sensible and useful. Such views can be strongly held and are often not recognized by teachers, but nevertheless influence the formal learning of science in many unintended ways". (Osborne and Freyberg 1985).

David Ausubel continues the argument. "The most important single factor influencing learning is what the learner already knows; ascertain this and teach accordingly". (D. Ausubel 1968). Jack Shallcrass reasons that for a teacher to start teaching from what the child already knows requires that the teacher listens to the child intelligently. It then is possible for the child to learn, modify and expand what she already knows. (Shallcrass 1986).

BACKGROUND TO TEST DEVELOPMENT

For a young person to learn they have to make their own assumptions about the way the world around them works. These assumptions are based on preconceived ideas and can lead to inaccurate conceptions particularly about abstract scientific phenomena. "Students use their knowledge of the world to comprehend written text and that student's comprehension failures often result from misconceptions or inadequacies in their background knowledge (Eaton, Anderson and Smith 1984). If a scientific conception is not understood fully the student is likely to adhere to a misconception that makes sense to them. This means that any, new related ideas or applications, will be integrated into the faulty misconceptual framework. There will come a time when their faulty misconception does not work.

Once a strongly held view is established in the mind of a young person it is very persistent. The late Roger Osborne found, for example, that the views, 12 year olds held about electricity and forces were essentially the same when they were in their first year University Physics Course (Osborne 1980). These views were persistent through five years of secondary education. This discovery formed the basis of, and help lead to the research project termed "learning In Science Project"(L.I.S.P.) initiated by Roger Osborne and his team at Waikato University.

In 1982 Ross Tasker came to some conclusions about how children see their science learning. These conclusions emerged after careful analysis of many lessons and interviews with children. Three of the analyses are summarized below:

(1) Lessons are seen by children as isolated events even though teachers go to some trouble to make them sequential. teachers assume that children see their past experiences in the same way as they do and this helps to prevent their seeing science as a sequential series of events.

(2) Students quite frequently do not see the purpose of the science activity in the same way as the teacher does.

(3) "Students often fail to recognise the important details of the scientific techniques and design features of the experiment. The conclusions the students come to are often not what the teacher wants". (Tasker 1982)

This is demonstrated further in Richard White's paper where form 6 students were asked to make predictions about the movement of an equally balanced bucket and mass. These were joined together by a cord which was passed over a pully. The weight was pulled down and the students were asked what would happen when it was let go.

"After the students have written their predictions, with reasons, the change is made and they are asked to observe what happens. If their predictions and observations differ, they have to explain the discrepancy." (White 1982). Many had unscientific, pre-Newtonian conceptions of simple force situations such as described above. White goes further by explaining that interviewing individual students about situations using diagrams, photographs etc is a very useful way to explore the students understanding of a concept.

This has also been the main method used by the L.I.S.P. researchers at Waikato University. White explains that he used a definite procedure involving an increasing number of directed cues to "probe" the understanding that students had about science-type situations. He has found a remarkable diversity in knowledge among the science graduates. This depended on their past experiences. In White's opinion, teachers who try out probing techniques, will be in a good position to begin work on how to solve the problem of students misunderstandings concerning their explanations of science-type situations.

While interviewing students individually can provide important information and establish to what extent students understand and misunderstand various science concepts. This can be a very time consuming exercise and almost impossible for many teachers to do because of their teaching loads. Also many teachers lack the skills for satisfactory interviewing. Although an increasing number of teachers are becoming increasingly aware of the L.I.S.P. findings and how it affects their teaching, few find it an easy process to identify clearly understandings and misunderstandings their students have. They tend to teach on, following the prescribed syllabus in the hope that their students will absorb at least some sound scientific ideas and techniques.

It is the writers opinion, based on experience and reading, that their are three main aspects which must be delt with by the teacher, in order to overcome misconceptions and therefore allow appropriate learning to take place:

(1) Try to identify at least, the main misunderstanding the class (or individual students) have over the concept being taught. The teacher must know what the student thinks.

(2) The scientific idea (or model) must be carefully explained and compared with the common misunderstanding in such a way that the student is satisfied that the scientific idea is more adequate then their own idea (if it is a misunderstanding).

(3) There must be appropriate activities or exercises which help the student to move away from their misunderstanding and towards the scientific idea or model.

It is the important initial step of identifying misunderstandings that this study concentrates on. It provides a diagnostic test which identifies student misunderstandings in such a way that the teacher has a base from which she or he can begin teaching a topic.

PURPOSE AND FUNCTION OF THE TEST

The test is diagnostic in so far as it identifies the main misunderstandings that some students have about some form three concepts. It is organized in such a way that statistical analysis can be done to group student responses so that teachers can identify the main misunderstandings that the class and individual students have. This identification should be able to form the basis from which a teacher can begin teaching.

The test has been used on a representative cross section of students to produce a Local Norm Group. The results obtained by any form three class doing the test can be compared with the Local Norm Group so that a teacher can see to what extent their classes and individual student misunderstandings compare with the Local Norm Group.

This diagnostic test concentrates on three physical science topics commonly taught in New Zealand schools. The topics are Forces, Nature of Particles and Radiant Energy. These three topics were chosen because they are usually taught at form three level (i.e. when they receive their initial formal secondary science education). Also these topics are ones which in the opinion of the writer seem to produce the greatest difficulties that young secondary students have understanding the concepts involved.

Statistical information about the test is provided from a computer programme so that performances can be compared between:

(i) individual schools,

(ii) individual classes,

(iii) individual students,

and the Local Norm Group. The list below outlines information provided from each class, each school and the whole Local Norm Group:

(a) Mean number of correct scores.

(b) Standard deviations.

(c) Percentage responses on each alternative answer the students chose, thus indicating the main and other misunderstandings.

(d) Percentage responses on each subtopic grouping of questions.

So that detailed comparisons can be made between a class using the test and the Local Norm Group a calculator or the computer programme would have to be used. However a teacher can easily make visual comparisons between individual student scores and the results of the Local Norm Group as the answer sheet is designed in such a way as to allow this.

SUBJECTS THE TEST IS INTENDED FOR

The test is designed for any students who have not been taught the three physical science topics in question. If a valid comparison is to be made between the Local Norm Group and a class (or school) then the test should be sat by form three students before they have been taught any substantial science material.

TEST CONSTRUCTION

The test was constructed in three phases:

(a) Development of open-ended questions.

(b) Pre-testing the open-ended questions.

(c) Final test preparation.

(a) Development of Open-ended Questions

In order to work out the appropriate wording and reading level of questions a series of open-ended questions was written. An outline set of questions was prepared which covered the general areas that students were to be asked about. Ten students were interviewed and were asked the questions orally. The students comprised 5 girls and 5 boys of average to low ability based on their scores in their school internal reference tests (i.e. scores ranged from 10-22 out of a possible 40 and the mean was 20).

The original list of questions is listed in appendix I. These questions were modified as problems arose while interviewing the students.

In this phase it was important to check the wording of the questions rather than check how well they answered each question. Modifications were made to the question wording depending on how well the students could follow the question. These questions and modifications formed the basis of the open-ended questions used in the pretest phase described below.

e.g. question 1 from the open-ended Interview Question (Appendix I) reads:

"What forces are on a car which is parked on a sloping road?" This needed the following modifications to improve its meaning.

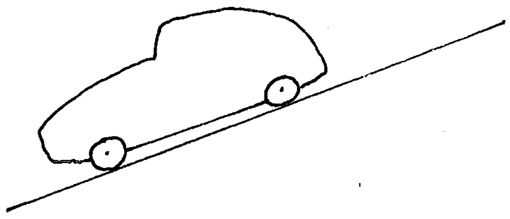
(1) Needed greater clarification of the cars status so inserted "hand break on" and "It is not moving".

(2) Rather than say "what forces are on a car" it appeared better to say "Draw arrows on the car to show which way the forces are acting".

(3) There needed to be a contingency for those who thought there were "no forces acting".

In the Pretest Question Paper the wording was finally modified to:

1. A car is parked on a sloping road with the hand break on. It is not moving.



(a) Draw arrows on the car to show which way Forces are acting. If you think there are no forces acting write NO FORCES under the diagram.

The questions were derived from the writers own sources and from some of the open-ended interview questions used in the L.I.S.P. working papers. (Schollum 1982, Osborne and Cosgrove 1983, Osborne 1986).

(b) Pretesting the Openended Questions

In June 1986 a sample of approximately 100 students were asked to write their answers to the trial questions. These were students who selected from above average, average and below average ability classes. The school that these students came from showed a raw-score mean on TOSCA of 35.13 (Form B, intermediate, age 13) compared with the raw-score mean of 35.41 on the equivalent sample used in standardizing TOSCA. The classes chosen were those that represented the three band levels in the school. The students were encouraged to write what they thought were the correct answers, even if they were unsure. They were also encouraged to write as much as they could. The three topics were made up into booklets and each of the three booklets was given to 33% of the 100 sample chosen at random. The students were given as much time as they wished but had to answer the questions with no help at all and in semi formal test conditions. The students were also asked to use language they were familiar with and draw diagrams as they saw fit. The test papers are included in appendix II. A summary of some responses are listed in Appendix III.

This summary gives an indication of how students typically responded to some questions.

(c) Final Test Preparation

Using the student answers and how well they performed on the pretest, appropriate questions were selected to make up the final test. The following basic criteria were used to do this.

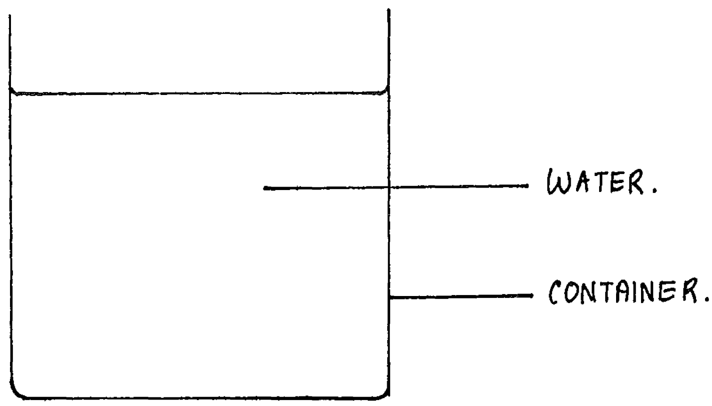
(1) Where 80% or more students gave the correct answers, these questions were not used.

(2) Where students obviously had difficulty understanding the stem of the question then this either was not used or was modified to try and improve the reading level.

(3) Where possible the same or similar wording and diagrams were used in the final test as students used in the pretest.

Some of the pretest questions were of the "yes" or "no" type and so were written as either true or false, or yes or no questions. In cases, where there were several different answers given by students in the pretest, these were written as multichoice questions with four responses (a to d). Apart from the correct answer, the three other responses were chosen from the three most common answers given in the pretest (see Table 1)Pg 13. This represented the main misunderstandings the students had about the question. The example below shows how a pretest question was modified in the trial test.

Question 1b in the pretest booklet on the Nature of Particles was worded "Write down or draw what you think the particles are doing in a liquid such as water in a container (included diagram)."

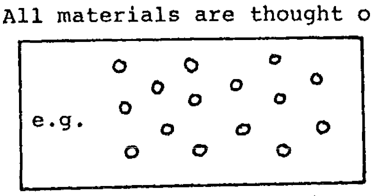


This was modified in question 19 in the final test to:

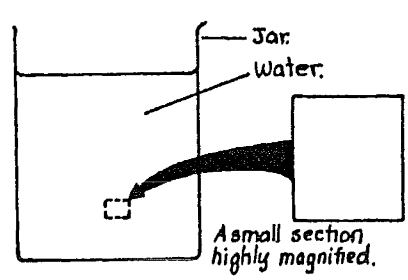
9.

PARTICLES

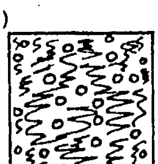
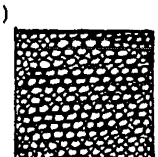
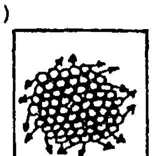
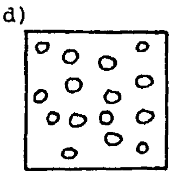
All materials are thought of as being made up of tiny particles.



Imagine the particles above to be making up water in a jar.



19. Which of the following best shows the arrangement of particles in the enlarged section.

(a)	(b)	(c)	(d)
			
particles mixed in with liquid	regular stacking and vibrating.	moving over each other	gaps between the particles.

The table below shows how some questions were made up from the student's own wording.

Table 1: Examples of Final Test Question Construction From Pretest Questions.

Final Test Questions and Comments (compare Appendix III with (the Final Test Paper)
1. Alternatives a,b and c were selected as the Force arrows because most students drew those arrows on Question 1, in the pretest on Forces.
2. Alternatives a,b and c were selected as the main direction of forces drawn on the craft because most students drew those arrows on Question 4, in the pretest on Forces.
21. All Alternatives were selected from the main group of answers given in question 2, pretest on Nature of Particles
29. All Alternatives were selected from the 4 main group of answers the students drew in Question 12, pretest on Radiant Energy.

A draft copy was made up of the test and given to five practising teachers for checking. They were asked to concentrate mainly on:

(a) Clarity and reading level of wording,

(b) clarity of drawings,

and (c) appropriateness of alternatives given in the multichoice questions.

The questions were separated into subtopics and a number of questions allocated to each subtopic. A table of these subtopics appears on page 5 in the Teachers Manual.

The separation of subtopics is more clearly represented in the answer sheet than in the test booklet. (See Appendix II , in the Teachers Manual.) The breakdown in the answer sheet is for the convenience of the teacher, where as the test booklet is simply a set of 36 questions which the students work through from start to finish. However the questions are grouped together in the appropriate subtopics in the test. (See Appendix I, in the Teacher's Manual)

TEST ADMINISTRATION AND MARKING

This information is described in the Teachers Manual under the following headings:

Introducing The Test, pg. 6.

Distributing Materials and Explanation, pg. 7.

Running of The Test, pg. 7.

and Marking of the Test, pg. 8.

FORMATION OF THE LOCAL NORM GROUP

A cross section of ten schools from Christchurch was selected to make up a Local Norm Group. This comprised students from; co-educational schools, state single sex schools and separate (private) schools. The classes chosen were high ability, average and limited ability groups. There were a total of 438 students making up the Local Norm Group and all of these were tested in February 1987. Table 2a shows the breakdown of schools with the class abilities and number of students. The schools were selected as a Judgement Sample based on knowledge of socio-economic characteristics of the 24 High Schools in Urban Christchurch. Selection was made from a ranked list of schools made up from the proportion of form six students attending the school who came from families in the top two Socio-economic levels out of a scale of six. (Elley and Irving 1985).

Table 2a: Listing of Schools used to Make up Local Norm Group

Schools	Type	Class Ability used.	No. of classes used.	Total	Total in Class
A	Single sex, boys state	Gifted Limited ability	1 1	2	26 29
B	Single sex, girls state	Above average Below average	1 1		31 30
C	Single sex, girls	Average	1	1	27
D	Single sex, boys	Average	1	1	35
E	Co-educational state	Average Average	1 1	2	29 25
F	Co-educational state	Average Average	1 1	2	29 31
G	Co-educational state	Gifted Limited ability	1 1	2	26 21
H	Co-educational state	Above average Below average	1 1	2	22 25
I	Co-educational state	Above average Below average	1 1	2	26 26

OTHER GROUPS USED TO PROVIDE INFORMATION ABOUT THE TEST

(a) Intermediate Students

A group of 100 students were selected from a Christchurch Intermediate school to sit the test in late October 1986. These students were selected from the top streamed class, an average band class and a bottom streamed class. The students were placed in the classes based on standard 5 TOSCA results. There was no further information available. These classes had well qualified science teachers teaching them so it was recognised that this sample was probably above average for this age group.

These students were used to determine how well the test discriminated between students and to indicate if it was necessary to make any major adjustments to the test before continuing its use.

(b) Sample of Form Three Students Tested in 1986

A similar group of secondary students as the Local Norm Group was tested in December 1986. The purpose of this was to see if there were differences in performance between this group (having been taught a full year course) and the Local Norm Group (before they had been taught a full year course) and the Local Norm Group (before they had been taught any substantial high school science). This was done to give an indication of how much growth in their understanding has occurred in the course of their form three year. This group comprised 404 students and were selected in the same way as the Local Norm Group.

The analysis for the local Norm Group is listed below:

(1) mean score

(2) standard deviation

(3) % response on each answer and hence their main misunderstandings.

(4) % response on each topic.

In addition the following analysis was performed:

(5) split half reliability for the schools.

(c) Independant Form Three Group

An independent form three group sat the test at the same time as the Local Norm Group. They were selected from a co-educational state High School and were regarded as being reasonably representative of students at age 12-13 years old. This group had a mean raw score on TOSCA of 32.6 and a standard deviation of 13.41. The representative group used to standardize TOSCA for 12 year olds (form B) had a mean raw score of 32.09 and a standard deviation of 13.20. The separate group comprised three classes of below average, average and above average groups; a total of 73 students. This group was used to correlate with:

(1) TOSCA

(2) P.A.T. Reading Comprehension

(3) P.A.T. Mathematics

(4) An internal science Reference Test

(5) Re-test five days later.

INTERPRETATION OF THE RESULTS

(1) Mean Scores and Standard Deviation

(a) The Local Norm Group

The Local Norm Group (L.N.G.) produced an overall mean and standard deviation which was quite small. Obviously the test was rather difficult if one looks at it from an achievement point of view. As pointed out earlier however the main objective of this exercise was to provide information about the student's misunderstandings about these topics. (Table 2b)

It can be seen that the mean scores are low, in all cases well below half marks. The only group which achieved a score which was near half marks was from school I (above average ability class). The number of classes with a mean score above 16 are three. The rest of the scores show an even spread between these two values.

As one would expect, there is a low mean score for the L.N.G. (13.9) and the socres for individual classes and schools is clustered around the mean score. The gifted and above average ability classes do not seem to be particularly high above the mean. The highest class score is two decimal points less than one standard deviation above the mean. However the lowest class score is considerably short of one standard deviation below the mean.

For example: High score 17.5

Mean 13.9

Low score 11.1

Table 2b: Mean Raw Score, Standard Deviation of Classes and Schools Used In the L.N.G.

SCHOOL (etc)	CLASS (etc)	NO. OF STUDENTS	MEAN	S.D.
A state: single sex boys	overall	55	15.3(42%)	3.8
	limited ability	26	13.7	3.0
	gifted ability	29	16.7	3.9
B state: single sex girls	overall	61	13.8 (38%)	3.8
	above average ability	31	15.8	3.2
	below average ability	30	11.8	3.3
C private: single sex girls	average one class	27	12.4 (34%)	2.6
D private: single sex boys	average one class	35	15.4 (43%)	3.9
E state: co-ed	overall	60	13.2 (37%)	3.0
	average ability	29	14.2	3.0
	average ability	25	12.2	3.0
F state: co-ed	overall	47	13.3 (37%)	4.4
	average ability	29	12.7	2.5
	average ability	31	13.6	3.4
G State: co-ed	overall	54	13.3 (37%)	3.1
	gifted ability	26	14.5	3.9
	limited ability	21	11.7	4.6
H State: co-ed	overall	47	13.9 (39%)	3.9
	below average ability	22	11.1	2.0
	above average ability	25	16.4	3.5
I State: co-ed	overall	52	14.8 (41%)	4.2
	below average ability	26	12.0	3.0
	above average ability	26	17.5	3.4
LOCAL NORM GROUP	overall	438	13.9 (39%)	3.8(10.6%)

Table 2b also shows a small standard deviation, which indicates a narrow spread.

The results show that students found this test difficult. The L.N.G. indicated limited understanding of these topics. The low scores (12.5 and below) probably would have been lower on a different kind of question. Out of the 36 questions, 29 were 4 response multichoice items and 7 were true or false type questions. This means that the guess factor could have given them at least 9 correct answers, and this would have inflated all the marks particularly the low scores. This indicates that the mean should have been lower than indicated on this table.

Because the mean and standard deviation of the L.N.G. is so low it would indicate that it is not a good test to use for achievement purposes. This supports the original contention that it is best used for determining student's misunderstandings of these topics.

However teachers can use the data (found in the teacher's manual) to compare their class (or school) results with the results of the L.N.G. They can then determine to what extent their students misunderstandings are as typical of the L.N.G. misunderstandings.

(b) The 1986 Sample

Table 3 shows the mean and standard deviation analysis of a group tested in November 1986. While the schools were the same and the class levels the teachers were asked to select students from were the same, the actual students are not the same. There are bound to be differences between the classes from the L.N.G. and the classes from the 1986 sample. However it was hoped that these differences were minimized with a reasonably large number in the group.

Table 3: Mean Raw Score, Standard Deviation of Schools used in the 1986 Form Three Group.

SCHOOL	TYPE	NO. OF STUDENTS	MEAN	S.D.
A	State: Single sex, boys	51	19.1	4.8
B	State: Single sex, girls	46	16.7	3.0
C	Separate: Single sex, girls	23	13.5	2.0
D	Separate: Single sex, boys	32	14.2	3.3
E	State: Co-educational	55	13.7	3.8
F	State: Co-educational	44	12.6	2.9
G	State: Co-educational	66	14.8	4.5
H	State: Co-educational	33	12.8	3.0
I	State: Co-educational	54	15.8	3.5
OVERALL	-	404	15.0(42%)	4.1

These results show a higher mean and a characteristically higher standard deviation than with the L.N.G. It appears that teaching has had an effect on their performance as this sample was tested in November, after a full form three year. However the "teaching effect" is minimal as the mean score is only 1.1 points higher than for the L.N.G. The questions used in the test are questions which should be used before a topic is taught and there are five possible reasons why the students performance did not appear to be very much higher than the L.N.G.'s performance.

(1) The test is so hard for students at form three level that even after teaching these topics the students still find the questions too difficult and guess most answers.

(2) The students forget what they have been taught.

(3) The teachers don't actually teach all the content areas that the topics were testing.

(4) One or two of the topics are not taught in their form three year but are taught these areas in the fourth form.

(5) The method of teaching is not making much difference to changing the misunderstandings that the students have about these topics (in terms of the questions).

If it was possible to make sure that these topics were taught in Form three, that the content was covered and that the method of teaching employed did attempt to change their misunderstanding then it should also be possible to see if the students perform better on a re-test. If students did perform better that would also explain points 1 and 2. These aspects however are beyond the scope of this study.

The mean scores of the schools are clustered around the overall mean score and the highest mean score (for school A) is almost one standard deviation above the overall mean score. This is a similar situation as for the L.N.G. The lowest mean score is only about .5 of a standard deviation below the overall mean score which indicates guessing had an effect of inflating the low scores as it did in the L.N.G.

In most respects the mean scores and the standard deviations had a similar pattern as for the L.N.G.

(c) The Intermediate Sample

The Table below shows the mean and standard deviation of the Intermediate sample compared with the L.N.G. and the 1986 sample group.

Table 4: Intermediate School Analysis.
Mean, Standard Deviation,
(Number = 100).

Function	Intermediate School	L.N.G. 1987	Form Three Group 1986
Mean	14.0	13.9	15.0
S.D.	4.0	3.8	4.1

It can be seen that the intermediate group shows a mean very close to the L.N.G. This is to be expected as the intermediate group were tested at the end of 1986 and the L.N.G. were tested at the beginning of 1987. The standard deviation shows that the spread is slightly more than the L.N.G. It is possible that this group possibly demonstrates one which has a fairly wide range of ability.

(2) Analysis of Multichoice Answers

(a) Discrimination and Difficulty Factors for the Intermediate Group

Table 5 shows the analysis of the Intermediate School Group which was used to make adjustments to the test based on the Discrimination Factors.

Table 5: Intermediate School Group Analysis of Multi-Choice Answers, Discrimination Factor, Difficulty Factor.

Choice	UQ	LQ	Total	%	Disc Fact	Diff Fact
Question						
1	6	2	12	12	0.16	0.16
2	14	7	41	41	0.28	0.42
3	20	8	55	55	0.48	0.56
4	5	3	16	16	0.08	0.16
5	10	5	28	28	0.20	0.30
6	7	1	18	18	0.24	0.16
7	22	16	72	72	0.24	0.76
8	22	8	55	55	0.56	0.60
9	10	5	23	23	0.20	0.30
10	2	1	3	3	0.04	0.06
11	21	11	52	52	0.40	0.64
12	18	14	65	65	0.16	0.64
13	24	17	88	88	0.28	0.82
14	8	7	42	42	0.04	0.30
15	12	8	45	45	0.16	0.40
16	18	8	49	49	0.40	0.52
17	7	6	22	22	0.04	0.26
18	7	5	24	24	0.08	0.24
19	4	3	15	15	0.04	0.14
20	4	1	9	9	0.12	0.10
21	20	9	49	49	0.44	0.58
22	6	1	13	13	0.20	0.14
23	10	4	30	30	0.24	0.28
24	10	3	20	20	0.28	0.26
25	11	1	23	23	0.40	0.24
26	15	4	48	48	0.44	0.38
27	21	12	67	67	0.36	0.66
28	19	8	56	56	0.44	0.54
29	17	7	46	46	0.40	0.48
30	21	11	61	61	0.40	0.64
31	15	5	37	37	0.40	0.40
32	8	5	24	24	0.12	0.26
33	23	8	56	56	0.60	0.62
34	12	4	27	27	0.32	0.32
35	21	10	69	69	0.44	0.62
36	15	5	43	43	0.40	0.40
Choice	UQ	LQ	Total	%	Disc Fact	Diff Fact

Generally speaking the questions are discriminating reasonably well for the kind of test it is. As the mean scores are low and the standard deviation narrow one would not really expect to have a high discrimination on all questions. Some questions however appear to be working quite well for this group for example:

questions 8, 21, 26, 28, 33, and 35 as they all show a disc. factor of 6.4% or above.

However many questions which show a low difficulty factor have a low discrimination, for example.

questions 7, 12, 13, 27, 30.

This may be due to the fact that generally the students gained low scores. This indicates that rather than those in the upper quarter getting the questions correct (and those in the lower quarter not getting them correct) the students who are getting the questions correct are spread throughout the sample. The more able students then, are having similar difficulties with these questions (as those in the middle quarter). The less able are probably getting more correct answers than one might expect as a result of guessing. Also the distractors could be having a strong effect making the students select them.

Questions which had very low discrimination were looked at carefully to see if they should be improved. Table 6 shows the questions which were examined.

It was felt that although a number of questions were discriminating poorly, it was best not to change them because the test was to be used twice (in 1986 and in 1987) and the results compared.

Table 6: Questions examined for possible modification

Question No	Discrimination Factor	Difficulty Factor
9	0.20	0.30
10	0.04	0.06
14	0.04	0.30
18	0.08	0.24
19	0.04	0.14
20	0.12	0.10
32	0.12	0.26

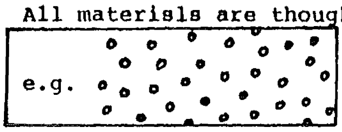
The questions in table 6 were looked at and it was decided to modify only questions 10, 18, 19, 20. These changes were designed to make the question discriminate better and to remove ambiguities. The other questions which were not changed were used in their original form because modifying them would have changed the meaning of the question considerably and therefore invalidate the comparison being made between the L.N.G. and the 1986 Form Three Group.

An example of the type of change made is shown for questions 19 and 20. The form of the questions used in the 1986 sample is shown below.

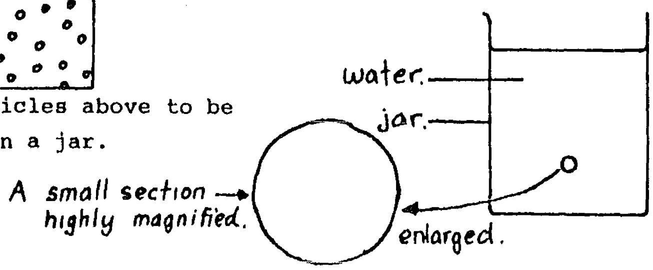
9.

PARTICLES

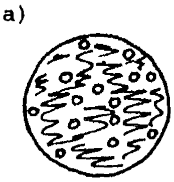
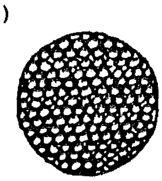
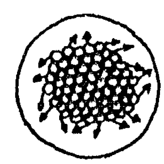
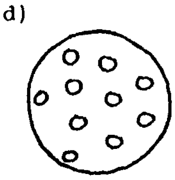
All materials are thought of as being made up of tiny particles



Imagine the particles above to be making up water in a jar.

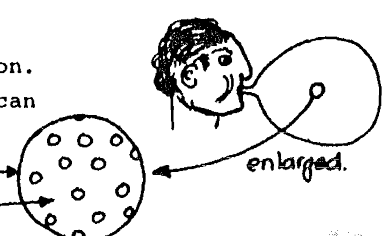


19. Which of the following best shows the arrangement of particles in the enlarged section?

(a)	(b)	(c)	(d)
			
particles mixed in with liquid	regular stacking and vibrating.	moving over each other	gaps between the particles.

20. Suppose a person blows up a balloon. All the particles in the balloon can be thought of as being like this (enlarged).

What is in area x?



(a) air

(b) moisture from the person's breath

(c) nothing

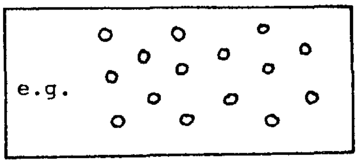
(d) oxygen.

It was felt there was confusion in question 19 where the enlarged sections were circular and mistaken for the actual particles themselves. For question 20 the "area x" was thought to be confusing so that part was modified.

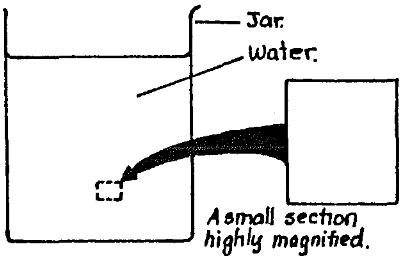
The questions were modified by changing the diagrams as shown below.

PARTICLES

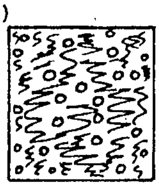
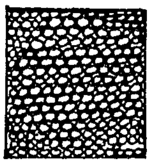
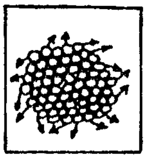
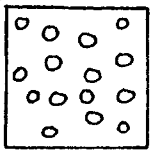
All materials are thought of as being made up of tiny particles.



Imagine the particles above to be making up water in a jar.

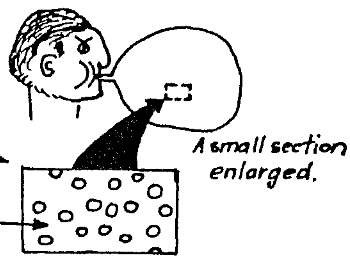


19. Which of the following best shows the arrangement of particles in the enlarged section.

(a)	(b)	(c)	(d)
			
particles mixed in with liquid	regular stacking and vibrating.	moving over each other	gaps between the particles.

20. Suppose a person blows up a balloon. All the particles in the balloon can be thought of as being like this (enlarged).

What is in the area between the particles?



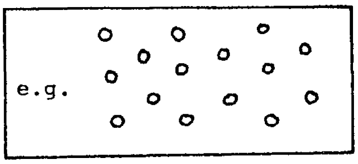
(a) air
(b) Moisture from the person's breath
(c) nothing
(d) oxygen.

The questions were modified by changing the diagrams as shown below.

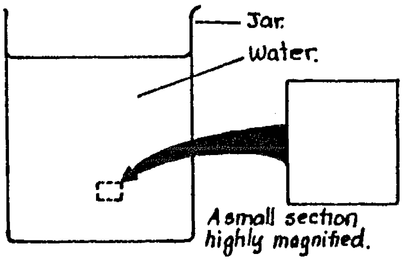
9.

PARTICLES

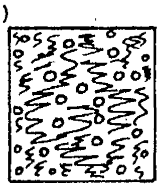
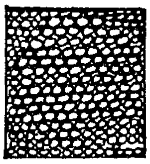
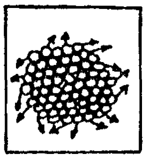
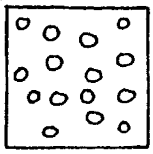
All materials are thought of as being made up of tiny particles.



Imagine the particles above to be making up water in a jar.

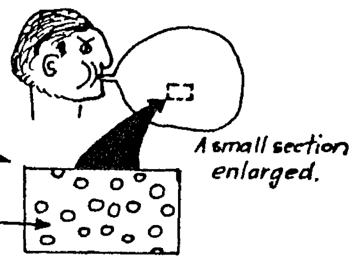


19. Which of the following best shows the arrangement of particles in the enlarged section.

(a)	(b)	(c)	(d)
			
particles mixed in with liquid	regular stacking and vibrating.	moving over each other	gaps between the particles.

20. Suppose a person blows up a balloon. All the particles in the balloon can be thought of as being like this (enlarged).

What is in the area between the particles?



(a) air

(b) Moisture from the person's breath

(c) nothing

(d) oxygen.

Here the response diagrams as well as the "small section highly magnified" was modified to make the question clearer. The same applied to question 20.

Table 7 shows a comparison of the Discrimination Factor of the Intermediate Group, the 1986 Form Three Group, the 1987 Independent Form Three Group and the L.N.G.

Table 7: Discrimination Factors for the Questions which had Low Values Based on the Intermediate School Group.

	Discrimination Factors			
Question Numbers	Intermediate School Group	1986 Form Three Group	1987 Independent Form Three Group	L.N.G. (1987)
9	0.20	0.25	0.39	0.38
10*	0.04	0.03	0.28	0.28
14	0.04	0.25	0.28	0.24
18*	0.08	0.51	0.06	0.29
19*	0.04	0.18	0.06	0.18
20*	0.12	0.13	0.22	0.20
32	0.12	0.18	-0.06	0.23

*Questions which were modified

This table shows that the question modification made little difference to the discrimination factors. Only in question 9 and 10 were there any significant increases. Question 14 seems to discriminate very poorly for the

Intermediate School Group and better for the 1986 Form Three Group. The difference between the 1986 Form Three Group and the two 1987 Groups were not significant at all. In some questions the discrimination went down further e.g. questions 18 and 32.

This seems to support the argument that this test is not really working as an achievement test with such low (and unchanging) discrimination factors. The students responses appear to be at random in many questions showing they are guessing or again strongly influenced by the distractors.

(b) Discrimination and Difficulty Factors for Other Groups

In order to compress the discussion the following symbols are used, these are Local Norm Group (L.N.G.), Independent Form Three Group (I.F.T.G.), 1986 Form Three Group (1986 F.T.G.) and Intermediate Group (I.G.).

A comparison between the L.N.G. and I.F.T.G. on Table 8 shows that there is considerable variation between the Discrimination for some questions e.g. 4, 6, 11, 12, 18, 22 and 32. However other questions are more similar e.g. 2, 9, 17, 26, and 30. These results show that in a similar way to the Intermediate Group there is little discrimination consistency emerging with each question. The test is not generally discriminating well with any groups.

Similarly a comparison between the 1986 F.T.G. and the other two groups (particularly the L.N.G) shows the test questions generally are not discriminating any better with the group which have had a years Third Form Science teaching.

The more able students in the upper quarter don't seem to be finding the test much easier compared with the students in the lower quarter.

Where questions show a discrimination factor of .3 and above with the L.N.G. the discrimination factor for the same questions in the 1986 F.T.G. are generally higher as well. This shows these questions are working in a similar way with both groups.

Comparing the I.F.T.G. and the L.N.G. shows considerable variation with Discrimination Factor. This is presumably due to the fact that the Group size with the I.F.T.G. is only a sixth the size of the L.N.G. Also differences in the number of students in the upper quarter selecting the correct answer tend to cause the discrimination factor to fluctuate more with a smaller sample than with a larger sample.

(c) Analysis of the Multi-choice Question Answers

This aspect is probably the most useful part of this diagnostic Test. It gives an analysis of each student's response expressed as a percentage response. (See table 9). Here it is possible to identify the major misunderstandings by seeing how large the percentage responses are on each response (A to D). Alternative E is indicated where students either selected more than one answer or did not give any response.

(i) Selection of Correct Answer

The low mean scores show that the test was difficult and there are few questions where a large percentage of

Table 8: Comparison of Discrimination and Difficulty Factors fc L.N.G., Independent Form Three Group 1987 and 1986 Form Three Group.

	LOCAL NORM GROUP						Independent Form Three Group 1987						1986 Form Three Group.					
Choice	UQ	LQ	Total	%	Disc Fact	Diff Fact	UQ	LQ	Total	%	Disc Fact	Diff Fact	UQ	LQ	Total	%	Disc Fact	Diff Fact
Question																		
1	22	6	45	10	0.15	0.13	2	1	7	10	0.06	0.08	34	1	63	16	0.33	0.17
2	66	25	171	39	0.37	0.41	9	2	28	38	0.39	0.31	61	25	180	45	0.36	0.43
3	67	37	200	46	0.27	0.47	8	5	33	45	0.17	0.36	67	28	184	46	0.39	0.47
4	26	17	75	17	0.08	0.20	6	2	15	21	0.22	0.22	30	16	81	20	0.14	0.23
5	49	33	162	37	0.15	0.37	5	4	25	34	0.06	0.25	48	20	138	34	0.28	0.34
6	35	28	122	28	0.06	0.29	6	2	22	30	0.22	0.22	43	27	127	31	0.16	0.35
7	91	67	308	70	0.22	0.72	13	11	49	67	0.11	0.67	84	66	307	76	0.18	0.74
8	73	28	178	41	0.41	0.46	11	5	26	36	0.33	0.44	67	29	197	49	0.38	0.48
9	59	17	147	34	0.38	0.35	9	2	32	44	0.39	0.31	39	14	91	23	0.25	0.26
10	48	17	109	25	0.28	0.30	5	0	16	22	0.28	0.14	5	2	14	3	0.03	0.03
11	67	33	156	36	0.31	0.45	7	6	29	40	0.06	0.36	75	19	170	42	0.55	0.47
12	62	43	186	42	0.17	0.48	14	6	32	44	0.44	0.56	71	49	227	56	0.22	0.59
13	106	77	350	80	0.26	0.83	18	14	64	88	0.22	0.89	98	84	374	93	0.14	0.90
14	55	29	147	34	0.24	0.38	11	6	28	38	0.28	0.47	51	26	148	37	0.25	0.38
15	56	24	155	35	0.29	0.36	10	3	23	32	0.39	0.36	65	32	186	46	0.33	0.48
16	76	31	196	45	0.41	0.49	9	8	32	44	0.06	0.47	73	39	214	53	0.34	0.55
17	60	20	140	32	0.36	0.36	10	3	20	27	0.39	0.36	46	10	92	23	0.36	0.28
18	44	12	95	22	0.29	0.25	4	3	15	21	0.06	0.19	59	7	112	28	0.51	0.33
19	28	8	75	17	0.18	0.16	3	2	10	14	0.06	0.14	21	3	49	12	0.18	0.12
20	25	3	40	9	0.20	0.13	5	1	9	12	0.22	0.17	17	4	35	9	0.13	0.10
21	73	55	226	52	0.16	0.58	8	6	31	42	0.11	0.39	68	61	236	58	0.07	0.64
22	19	17	67	15	0.02	0.16	6	1	13	18	0.28	0.19	27	10	61	15	0.17	0.18
23	41	12	104	24	0.26	0.24	9	3	19	26	0.33	0.33	66	19	160	40	0.47	0.42
24	40	26	128	29	0.13	0.30	10	7	34	47	0.17	0.47	34	14	90	22	0.20	0.24
25	44	18	114	26	0.24	0.28	5	3	16	22	0.11	0.22	51	20	128	32	0.31	0.35
26	71	35	215	49	0.33	0.48	12	5	35	48	0.39	0.47	65	35	210	52	0.30	0.50
27	79	43	255	58	0.33	0.55	14	8	38	52	0.33	0.61	73	53	274	68	0.20	0.62
28	76	34	208	47	0.38	0.50	14	5	35	48	0.50	0.53	83	34	248	61	0.49	0.58
29	61	28	166	38	0.30	0.40	10	3	24	33	0.39	0.36	78	29	213	53	0.49	0.53
30	91	48	270	62	0.39	0.63	14	8	41	56	0.33	0.61	92	44	278	69	0.48	0.67
31	61	14	137	31	0.43	0.34	8	2	20	27	0.33	0.28	72	28	170	42	0.44	0.50
32	38	13	71	16	0.23	0.23	3	4	11	15	-.06	0.19	34	16	96	24	0.18	0.25
33	74	27	198	45	0.43	0.46	8	3	23	32	0.28	0.31	75	38	227	56	0.37	0.56
34	50	13	120	27	0.34	0.29	5	2	13	18	0.17	0.19	62	32	168	42	0.30	0.47
35	96	63	298	68	0.30	0.72	16	6	43	59	0.56	0.61	96	62	327	81	0.34	0.78
36	62	40	196	45	0.20	0.46	13	6	38	52	0.39	0.53	58	31	189	47	0.27	0.44
Choice	UQ	LQ	Total	%	Disc Fact	Diff Fact	UQ	LQ	Total	%	Disc Fact	Diff Fact	UQ	LQ	Total	%	Disc Fact	Diff Fact

students selected the correct answer. Only 13 questions showed where a clear majority of students selected the correct answer. These are the questions with a dot to the left of the question number (Table 9). Only 7, 13, 30 and 35 show for the L.N.G. a percentage correct response of over 60%. The rest show a figure of 45% and 60% that correctly responded to these questions. This shows that about 50% of the students for the L.N.G. understand the concept involved in the question.

(ii) Identifying the Misunderstandings

The questions which have been circled show where the students have responded to the distractors in fairly large numbers. All those questions, where more than 30% of the students responded to one or two of the distractors, have been cited. Where there has been a very high percentage response for a distractor it is probable that this displays a major misunderstanding. Where there are fairly high percentage responses for two distractors that this is probably demonstrating two major misunderstandings. Most of these questions however seem to show one major misunderstanding. For example, looking at the figures for the L.N.G.:

Questions 14 and 15

(14) 46% chose A

34% chose B the correct answer

12% chose C

2% chose D.

Table 9: Comparison of Multichoice Question Analysis for the Local Norm Group (L.N.G.), The Independent Form Three Group (I.F.T.G.), The 1986 Form Three Group (1986 F.T.G.) and the Intermediate Group.

(*Denotes the correct Answer).

	L.N.G					I.F.T.G.					1986 F.T.G.					Intermediate Group.				
Choice	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E
Question																				
1	10*	65	11	13	0	10*	59	14	18	0	16*	55	10	20	0	12*	71	7	10	0
2	30	14	39*	16	1	29	22	38*	11	0	30	14	45*	12	0	29	12	41*	18	0
3	28	10	16	46*	0	36	8	11	45*	0	33	7	14	46*	0	22*	9	13	55*	1
4	17*	34	28	20	1	21*	42	18	19	0	20*	30	32	18	0	16	38•	24	20	2
5	63	37*	0	0	0	66	34*	0	0	0	65	34*	0	0	0	72•	28	0	0	0
6	28*	72	0	0	0	30*	70	0	0	0	31*	68	0	0	0	18•	81	0	0	1
7	70*	30	0	0	0	67*	33	0	0	0	76*	24	0	0	0	72	28•	0	0	0
8	56	41*	0	0	0	64	36*	0	0	0	50	49*	0	0	1	45	55	0	0	0
9	13	36	10	34*	1	15	32	10	44*	0	9	60	7	23*	0	16	53	7	23•	1
10	58	7	25*	3	1	64	4	22*	10	0	73	8	16	3*	0	69	11	17	3•	0
11	36*	57	0	0	0	40*	60	0	0	0	42*	57	0	0	0	52•	48	0	0	0
12	42*	50	0	0	1	44*	56	0	0	0	56*	44	0	0	0	65•	35	0	0	0
13	80*	13	0	0	0	88*	12	0	0	0	93*	7	0	0	0	88•	12	0	0	0
14	46	34*	12	2	0	53	38*	5	1	1	52	37*	10	1	0	45	42•	10	3	0
15	45	35*	7	6	0	37	32*	19	11	1	40	46*	8	6	0	44	45•	5	6	0
16	34	45*	9	5	1	38	44*	5	11	1	36	53*	5	5	0	36	49•	10	5	0
17	43	5	32*	13	1	47	7	27*	16	3	62	5	23*	9	0	57	6	22•	15	0
18	22*	53	4	15	0	21*	52	7	19	1	28*	56	4	13	0	24•	53	6	17	0
19	23	15	17*	39	1	27	8	14*	51	0	21	16	12*	51	0	25	22	15•	38	0
20	29	22	9*	33	0	37	16	12*	34	0	35	28	9*	28	0	27	29	9•	34	1
21	3	22	52*	17	0	4	32	42*	22	0	1	26	58*	14	0	3	24	49•	24	0
22	21	15*	12	45	0	16	18*	18	48	0	30	15*	10	45	0	19	13•	12	56	0
23	56	7	24*	6	1	58	12	26*	4	0	48	9	40*	3	0	54	11	30•	5	0
24	28	19	29*	17	0	25	18	47*	11	0	21	35	22*	22	0	26	28	20•	26	0
25	11	26*	47	8	1	12	22*	52	14	0	8	32*	53	7	0	11	23•	56	10	0
26	49*	10	18	16	1	48*	16	16	19	0	52*	11	16	21	0	48•	13	15	24	0
27	16	8	58*	12	0	30	10	52*	8	0	22	5	68*	6	0	15	8	67•	10	0
28	47*	12	14	19	1	48*	8	7	37	0	61*	11	12	15	1	56•	15	14	13	2
29	7	38*	29	19	1	8	33*	40	19	0	5	53*	25	17	0	13	46•	29	12	0
30	62*	11	12	8	1	56*	25	7	12	0	69*	12	11	8	0	61•	13	17	9	0
31	29	3	31*	29	1	26	8	27*	38	0	24	3	42*	30	1	31	5	37•	27	0
32	16*	11	41	24	1	15*	19	41	25	0	24*	7	45	24	0	24•	10	42	24	0
33	45*	13	9	25	2	32*	22	18	29	0	56*	11	7	25	1	56•	5	14	25	0
34	37	27*	21	8	1	40	18*	26	16	0	27	42*	22	8	0	44	27•	17	12	0
35	6	7	68*	11	2	10	16	59*	14	1	8	4	81*	6	1	12	13	69•	6	0
36	4	45*	19	25	2	3	52*	14	32	0	5	47*	15	33	1	13	43•	15	27	2
Choice	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E

(15) 45% chose A

35% chose B the correct answer

7% chose C

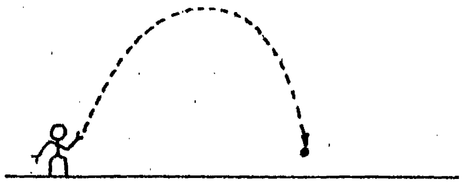
6% chose D

This would indicate that A is a major misunderstanding for 46% of the students in question 14, and 45% of the students in question 15.

The question is shown below:

7.

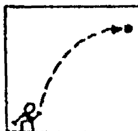
The information below is for the next 3 questions.
A ball is thrown in the air and follows the path in the diagram.



14\. Which best shows the direction of forces on the ball in the position opposite?

(a) Force in direction of flight 46%	(b) Forces due to gravity and friction 34%
(c) Force in direction of throw 12%	(d) No forces on the ball at all. 2%

15\. Which best shows the direction of forces on the ball in the position opposite?



(a) Force in direction of flight 45%	(b) Forcesdue to gravity and friction 35%
(c) Force due to friction only. 7%	(d) No forces on the ball at all. 6%

This means that 46% of the students think that there is a "motion force" on the ball, (in the direction of its flight) for question 14, and 45% think the same for question 15. This shows a similar trend in student thinking as the Learning In Science Project team found in their research.

Taking another example from the L.N.G.

Question <u>32</u>

16% chose A, the correct answer

11% chose B

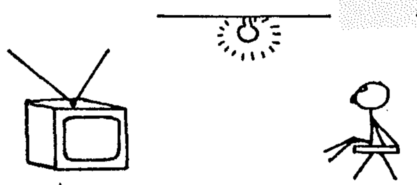
41% chose C

24% chose D

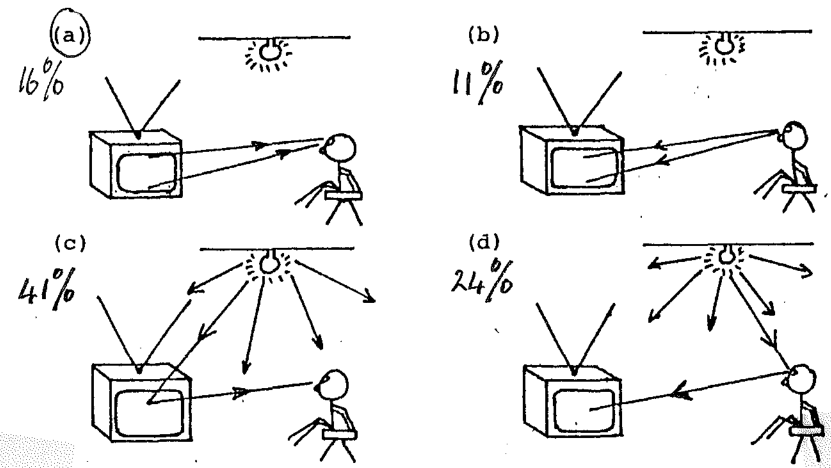
This indicates two possible misunderstandings. See below

15.

32. Suppose a person is sitting and watching T.V. There is a light on in the room.



Which of the following best shows the pathway of the light so that the person can see what's on the screen? (The arrows represent the light rays).



It shows that 41% of the students think the light comes from a persons eyes so they can see the T.V. and 24% think the person can see the T.V. by the light in the room bouncing off the screen into the persons eyes. (However the students could possibly be selecting c for similar reasons as for a, as the diagrams are not too dissimilar).

Where questions show a fairly even percentage response then it may be that the students had little idea of what the question was asking and so guessed. See questions 4, 12, 20, 24, 29 and 31. in Appendix of The Teacher's Manual.

(iii) Comparison of L.N.G. with other Groups

The pattern of percentage responses are very similar for all four groups in table 9. Where the major misunderstanding is indicated for a question on the L.N.G. the same misunderstanding is indicated in similar proportion in the other three groups. For example.

Question 1	A	B	C	D
L.N.G.	10	65	11	13
I.F.T.G.	10	59	14	18
1986 F.T.G.	16	55	10	20
I.G.	12	71	7	10
Question 15	A	B	C	D
L.N.G.	45	35	7	6
I.F.T.G.	37	32	19	11
1986 F.T.G.	40	46	8	6
I.G.	44	45	5	6

This shows that the test is very consistent for identifying understandings and misunderstandings.

(3) Analysis of Sub Topics

This section shows how the students responded on each group of questions as a set of sub topics. This means that the percentage correct indicated how well each school performed on the sub topics compared with the L.N.G. (See table 10).

This means that for sub topic "Forces in Motion" 28% of the L.N.G. got questions 1 to 4 correct. For the next sub topic 45% got questions 5 to 8 correct. For the next sub topic 45% got questions 5 to 8 correct and so on. The individual schools show some variations, but they are minor. Where schools show higher or lower percentages for any one sub topic they appear to be higher or lower on almost all the other sub topics.

It appears the students performed best on the sub topics "Force of Gravity" and "Colour". They had greatest difficulty with "Forces in Motion" and "Particles". This is consistent again with what the L.I.S.P. research teams found with these subtopics. These are subtopics with fairly abstract ideas and students have difficulty understanding them.

Table 11 shows the same percentages for the Form Three Group tested in 1986.

Comparing table 10 with table 11 it can be seen that the results are consistently higher for all subtopics except the subtopic on "Friction". The higher percentages are in keeping with what we would expect as the test was taken at the end of their form three year after a years

Table 10: Analysis of Percentage Correct for Each Sub Topics For each School and Local Norm Group 1987.

Sub Topics	Forces in motion	Forces on a moving car	Friction	Force of Gravity	Force on a moving ball	Particles	Particles in gases	Light Rays	Colour
Question Numbers	1 to 4	5 to 8	9 to 10	11 to 13	14 to 18	19 to 23	24 to 28	29 to 33	34 to 36
School A	33	50	41	56	41	25	47	43	54
School B	31	42	29	52	34	24	48	41	48
School C	25	43	19	43	31	21	42	41	41
School D	32	36	33	64	40	29	57	44	53
School E	26	46	28	53	37	21	41	39	47
School F	31	49	28	54	25	24	41	38	47
School G	22	42	31	61	38	25	41	37	40
School H	28	42	37	64	37	24	38	38	52
School I	22	46	29	61	34	31	45	47	58
L.N.G.	28	45	31	57	35	25	44	41	49

Table 11: Analysis of Percentage Correct for Each Sub Topic For Each School and Overall Form Three Group 1986.

Sub Topics	Forces in motion	Forces on a moving car	Friction	Force of Gravity	Force on A Moving ball	Particles	Particles in Gases	Light Rays	Colour
Question Numbers	1 to 4	5 to 8	9 to 10	11 to 13	14 to 18	19 to 23	24 to 28	29 to 33	34 to 36
School A	53	67	38	82	69	20	44	60	49
School B	43	51	11	73	33	38	51	57	51
School C	34	37	4	61	30	28	48	37	55
School D	19	40	17	63	25	31	53	48	57
School E	29	45	12	63	33	38	41	39	51
School F	23	39	7	55	26	19	50	43	49
School G	28	52	14	53	41	25	45	48	63
School H	21	42	2	58	36	25	38	44	46
School I	28	45	5	64	31	29	54	56	77
OVERALL	31	48	13	64	37	27	47	49	56

teaching. The low result for the Friction section is due to the ambiguity in the original question as this was a question requiring not only modification but an answer change.

Table 12 shows the Intermediate School Group as having fairly consistently high values for the subtopics (except "Friction"). Their results are higher than LNG in some areas and even higher than the 1986 F.T.G. This indicates that the Intermediate Group were probably an overall higher ability group even though the students were selected as being typical of form three students. It probably reflects the fairly high scocio-economic backgrounds these students came from.

Table 13 shows that the results for the Independent High School Group were very close to the L.N.G. This tends to support the fact that they were chosen as a reasonably representative group to use for correlations for reliability and validity.

(4) Reliability

Two measures of relability were used. Split half was used for the L.N.G. and the I.F.T.G. and Test-retest used with the I.F.T.G. The I.F.T.G. was selected especially for reliability and validity checks because the conditions under which they sat this diagnostic test could be controlled. Also the PAT tests were taken at about the same time.

Table 12: Intermediate School Analysis.

Subtopics	Forces in Motion	Forces on a Moving Car	Friction	Force of Gravity	Force on a Moving Ball	Particles	Particles in Gases	Light Rays	Colour
Questions	1 to 4	5 to 8	9 to 10	11 to 13	14 to 18	19 to 23	24 to 28	29 to 33	34 to 36
Intermed. School	31	43	13	68	36	23	43	45	45
L.N.G. (1987)	28	45	31	57	35	25	44	41	49
1986 F.T.G.	31	47	13	65	37	26	46	48	54

Table 13: Independent Form Three Group (I.F.T.G.) Analysis of Percentage Correct for Each Sub Topic

Sub Topics	Force in Motion	Forces on a Moving Car	Friction	Force of Gravity	Force on a Moving Ball	Particles	Particles In Gases	Light Rays	Colour
Question Numbers	1 to 4	5 to 8	9 to 10	11 to 13	14 to 18	19 to 23	24 to 28	29 to 33	34 to 36
Separate High School	28	42	33	57	32	22	43	33	43
L.N.G.	28	45	31	57	35	25	44	41	49

(i) Split Half Reliability

Table 14 shows the split half reliability for the L.N.G.

This shows considerable variation in the split half reliability coefficients. For the KR correction, school G has a quite a high coefficient for the kind of test it is. However some coefficients are very low (and negative for school C) showing that for these schools there was poor internal consistency. This is due to a narrow standard deviation and mean which shows the students scores were clumped together rather than spread out. The overall coefficient for both K.R. and Spearman Brown corrections are a little higher than some individual school results. Presumably this was due to a higher standard deviation compared with those schools, with a lower standard deviation. For example, School C had a standard deviation of 2.6 and a mean of 12.4 compared with the L.N.G. standard deviation 3.8 and mean of 13.9.

The results for the 1986 F.T.G. shows higher KR coefficients. Presumably these students were not guessing as much and had a clearer idea of the correct answers, having been taught a years science.

The picture is similar with the I.F.T.G. where:

split half, Kuder Richerdson correction is 0.46
and Spearman Brown correction is 0.61.

This shows that for the I.F.T.G. the test is a little more reliable but still lacking strong internal consistency.

Table 14: Split Half Reliability for L.N.G., Schools February 1987. Whole Group and Schools November 1986.

School	L.N.G. 1987 No. of Students	1987 Spearman Brown Correction	1987 Kuder-Richardson Correction	F.T.G. 1986 No of Students	1986 Spearman Brown Correction	1986 Kuder-Richardson Correction
A	55	0.60	0.50	51	0.73	0.72
B	61	0.80	0.53	46	-0.36	0.31
C	27	-0.38	-0.06	23	-0.42	-0.52
D	35	0.29	0.52	32	0.38	0.39
E	54	0.67	0.30	55	0.59	0.56
F	60	0.58	0.23	44	-0.49	0.25
G	47	-0.03	0.64	66	0.72	0.67
H	47	0.62	0.53	33	0.50	0.26
I	52	0.89	0.60	54	-0.04	0.47
OVERALL	438	0.51	0.49	404	-*	-*

*Overall correlation coeff. were not available for this.

(ii) Test-Retest Reliability

If re-test was performed 5 days later on this group and the results are shown below (see table 15)

Table 15: Test-Retest Reliability Coefficient for I.F.T.G.

(Number = 73

	Diag Test	Re-Test
Mean	13.0	13.0
S.D.	3.0	13.0
r	-	0.62

This still shows a low value which could indicate that some students did not take these tests seriously enough. A list of some suspect scores is included below.

Student	Test	Re-Test
9	12	6
46	16	8
50	8	13
56	13	8
62	13	6
63	13	6

These results either indicated they didn't care how they performed on the test (and guessed most, if not all answers) or there was faulty marking. Their papers were checked for marking and were found to be correctly marked. They sat the test (and re-test) under fairly formal conditions and the test conditions were as controlled as could be expected in a school setting where different teachers are doing the administration. However these students were subjected to a battery of tests with two PAT test, an internal science test and this test twice. It is possible they had had enough of doing tests by the time they had to sit the re-test. This could have affected their performance as the re-test was run at the end of the battery of tests described above.

Correlating the test re-test excluding the scores listed on the previous page gave a value of 0.69 which improves the reliability somewhat but it is still a fairly low score. There were 54 students out of the 73 in the group who had scores that were within 3 points of each other (75%). This means that only about three quarters were responding to the re-test in the same way as they did the original test.

(5) Validity

(a) Face Validity

The test on the face of it did appear to do what it was supposed to do, and that was identify the misunderstandings. The final questions were made up from using very similar wording and diagrams that the students used in the pre-test. The idea was to provide alternatives that the students identified with and appeared to be a plausable answer to them. Analysis of the multichoice questions shows it does this fairly well.

(b) Content Validity

The content was selected fairly carefully from the material that is currently being taught in New Zealand Secondary Schools. The test was carefully checked by Teachers to make sure the content was appropriate. Adjustments were also made, based on this checking.

Concurrent Validity

The test doesn't seem to show very high values when correlated with other measures (See table 16).

Table 16: Independent Form Three Group Test Correlations with Other Test Measures and Reliability Coefficients (Number = 73).

	DIAGNOSTIC TEST	TOSCA	PAT MATHS	PAT READ. COMP.	SCIENCE REF	RE-TEST
MEAN	13	32.6	20.8	28.7	18.4	13.0
S.D.	3.6	13.4	10.3	15.0	6.6	4.0
r	-	0.60	0.60	0.63	0.58	0.62

These values are consistently low. The internal Science Reference Test is considerably low and this is surprising. However on examination of the content of both tests they overlap in content about 12%. This means they are testing slightly different things. The same could be said of the other measures used to correlate with the test. The low correlation figures show that the test is doing what it was designed to do.

Conclusion

As had been emphasized this test is best used as a diagnostic test, rather than an achievement test. Its strength is in the identification of student misunderstandings rather than the number of correct answers they get. The analysis show best the misunderstandings in the multichoice analysis section where as the analysis for the other aspects is not as significant or consistent. Hopefully teachers by using this test can use it to indicate student weaknesses and show what areas teachers need to work at to change their misunderstandings.

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Towards Generative Learning.

APPENDIX I

SCIENCE IDEAS

Open-ended Interview Questions Used to Form the Basis of the Pretest Questions

Set A Forces

1. What forces are on a car which is parked on a sloping road?
2. A person pushes a car but the car doesn't move. What forces act on the car?
3. A person is peddling a bike, what forces are on the bike?
4. A rocket travels through space with its engines switched off. What forces are on it?
5. A parachutist is floating down. What forces are on the parachut?
6. A field gun fires a shell. What forces are on the shell?
7. What frictional forces are on a person sliding down a slide?
8. Is gravity on a person who is (a) swimming, (b) on the moon (c) falling from a plane.
9. If a car is travelling at steady speed are there any forces on the car?
10. Four people standing on different parts of the earth drop a ball at the same time, where will the balls fall?
11. What forces act on a ball after a person throws it?

12. What forces are on a ball as a person drops it from a building?

13. What causes a rolling ball to come to a stop on a bench top?

14. Which would be hard to stop, a truck full of coal or an empty truck?

15. Why is a car travelling at 80 km/hr harder to stop than one travelling at 50 km/hr?

16. One large ball is allowed to fall at the same time as a smaller ball. Which hits the ground first?

17. A charged comb will pick up bits of paper. How does this happen?

18. What will happen when a magnet is brought close to a pin?

19. What happens when two like poles of a magnet are brought close together?

20. What happens when a magnet is brought up close to (i) wood, (ii) copper (iii) rubber (iv) iron (v) plastic.

Set B Nature of Particles

1a. What do you think a lump of salt is made up of?

b. What are the particles doing in a glass of water?

c. What are particles like in the air we breathe?

d. Why is it easier to see through air than through water?

2. What happens to a drop in ink when it is put in water?

3. Why does a sugar cube disappear when you put it in water?

4. What happens to the particles of sugar when you put sugar into water?

5. When sugar is put into water and stired, why does the sugar disappear fairly quickly?

6. Why does sugar disappear more quickly in hot water?

7. If you could magnify the particles in a jar of water so you could see them what would they be doing?

8. If condies crystals were dropped in water, what would happen?

9. When a vitamin C tablet is put in water, bubbles form and rise to the surface, how does this happen?

10. What causes bubbles from boiling water to rise to the surface?

11. How come you can smell a person wearing perfume when they walk into a room?

12. When you put a pumped up ball out in the cold air it goes down a bit. How does this happen?

13. If a bowl of water is left outside on a warm day, what happens to it?

14. If a jar half full of water has glad wrap covering it what happens to the area above the water when the jar is put in a warm room?

Set C Radiant Energy

1a. If you are looking at a candle burning in a dark room how far does the light travel?

1b. If someone turns on the light what happens to what you can see of the candle?

c. Suppose you put the candle room 100 m away how well would you be able to see the candle?

2. How are you able to see the T.V. in a room?

3. How are you able to see the glow of a heater bar?

4. Where does the light come from when you see yourself in the mirror?

5. Why are you not able to see a projector beam before it hits the screen. What about in a smoking room?

6. How are we able to "see" a shadow?

7. When we hold a ball up to a light so that it casts a shadow, how is it that the shadow is round?

8. When a stick is placed in water it appears bent, how come?

9. When white light shines through a red filter what happens to the light?

10. How are we able to see a jersey as green when light shines on to it?

11. If red light shines onto a green jersey what colour would you expect it to be?

12. How are we able to see that tree over there?

Appendix II

PRETEST PAPERS

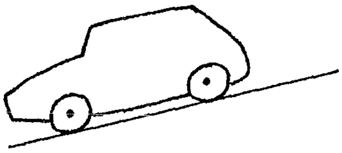
Test A - Forces.
Test B - Nature of Particles.
Test C - Radiant Energy.

TEST A SCIENCE IDEAS FORCES

These questions below ask what you think about some ideas in science. It is important that you try to answer each question in your own words as best as you can.

PUSH PULL AND GRAVITY FORCES

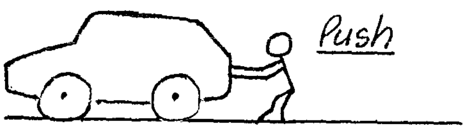
1. A car is parked on a sloping road with the hand brake on. It is not moving.



a) Draw arrows on the car to show which way forces are acting. If you think there are no forces acting write No Forces under the diagram.

b) Are there any forces acting on the brakes? Which way do they act?

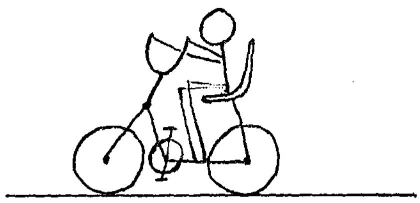
2. A person is trying to push the car, but the car is not moving. The engine is not going and the handbrake is on.



a). Are there any forces acting on the car? Which way are they acting?

b) Are there any forces acting on the person? Which way are they acting?

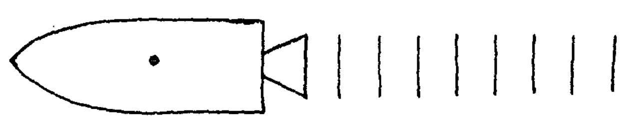
3. A person is sitting on a bike but not pedalling. The bike is slowing down



a) are there any forces on the bike? if yes,
(i) which way are they acting?

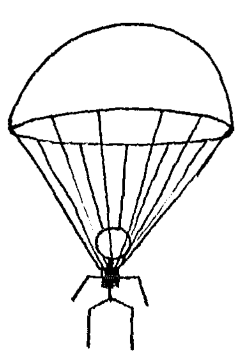
(ii) What are they due to?

4. A space craft is travelling through deep space with its engines switched off. The craft is travelling to the left and is not speeding up or slowling down



a) From the spot in the middle, draw arrows to show what forces you think are present on the craft. If you think there are no forces acting write NO FORCES under the diagram.
b) If you think there are forces acting explain what causes them.

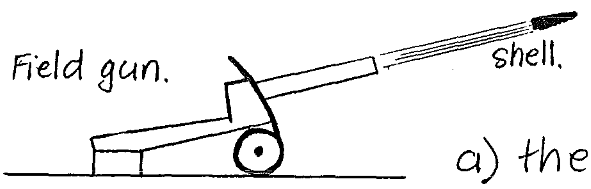
5.



A parachutist is falling towards the earth.
a) What forces are acting on the parachutist?

b) What causes these forces to act?

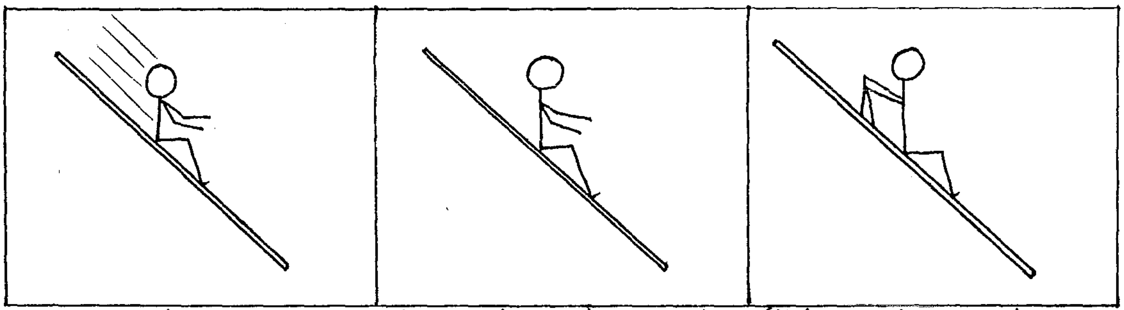
6. A field gun fires a shell. Describe what forces you think are acting on:-



a) the shell as it flies through the air?

b) the gun as the shell is fired.

7. A person is playing on a slide. The pictures show what is happening at three different times. The questions are about friction between the person and the slide.



(i) coming down the slide fast and getting faster.

(ii) coming down the slide slowly and steadily.

(iii) not moving on the slide.

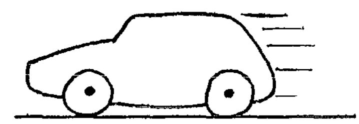
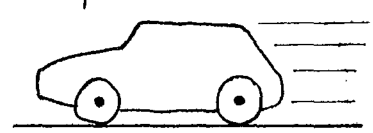
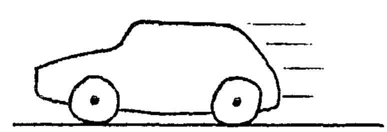
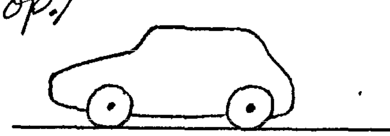
a) In which of the pictures above would there be friction ______

b) In which picture would you
(i) expect there to be greatest friction? ______
(If you think they have the same friction put "same".)
Say why.

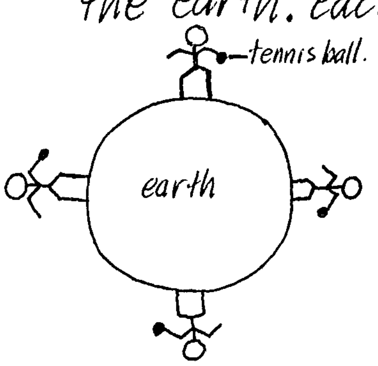
(ii) In which would you expect there to be least friction? ______
Say why.

8. Does gravity act on a person who is:- (yes or no)
a) standing on the moon ☐
b) swimming under water ☐
c) a sky diver falling from a plane ☐

9. In the following situations, decide in which direction the forces are greatest. Here we are interested in only those forces to the left or right NOT up or down (If you think these forces are equal put equal)

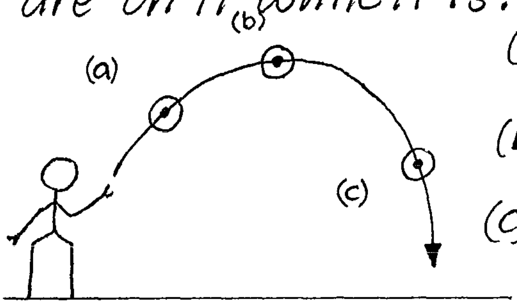
Greatest force to the→ ________ Explain Why ________	Travelling at a steady speed of 50 kilometers per hour. 
Greatest force to the→ ________ Explain why ________	Travelling at a steady speed of 80 kilometers per hour. 
Greatest force to the→ ________ Explain Why ________	Car is speeding up (getting faster). 
Greatest force to the→ ________ Explain Why ________	Car is slowing down (coming to a stop.) 

10. Imagine 4 people standing on opposite places around the earth. Each person is holding a tennis ball.



At exactly the same time each person lets the tennis balls go.
Draw arrows from each person's ball to show which way they will fall.

11. All ball is thrown into the air and follows the path in the diagram. Draw arrows from the point at the center of the ball showing which forces you think are on it while it is:

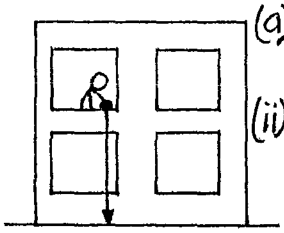


(a) in position a, as it is thrown upwards.

(b) in position b, as it is at the top of its flight.

(c) in position c, as it is going down.

12. A tennis ball is dropped from a window of a second story of a building.



(a)(i) Does the ball travel as fast at the top of its flight as it does at the bottom?

(ii) What causes it to fall?

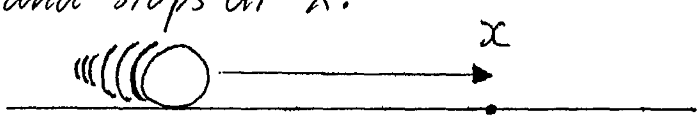
(b) Is there a force due to gravity on the ball:-

(i) as it is held?

(ii) as it is allowed to fall?

(c) If a metal ball is dropped would you expect any differences in its travel compared with the tennis ball? What differences?

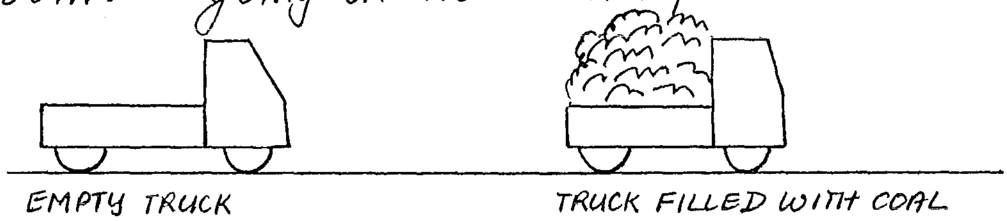
13 A ball is rolling along a flat table. It slows down and stops at X.



a) What do you think causes it to stop?

b) Is there any force on it as it comes to a stop?

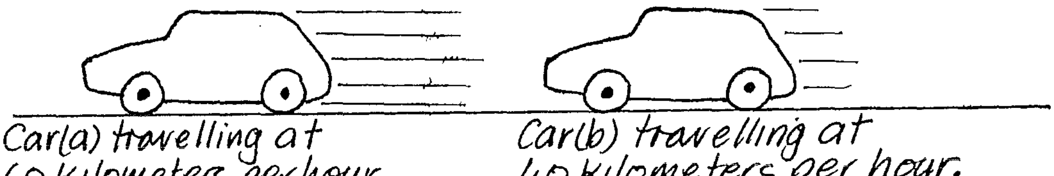
14 Look at the trucks below.
Both are going at 40 kilometers per hour.



a) Which truck would be harder to stop? (If you think there would be no difference say <u>no difference</u>)

b) Explain your answer above.

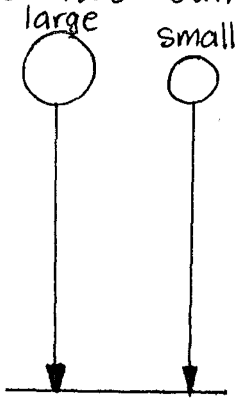
15 Look at the cars below.



(i) Which car would be harder to stop?

(ii) Say why you chose your answer above.

16 Two balls are allowed to fall at the same time:

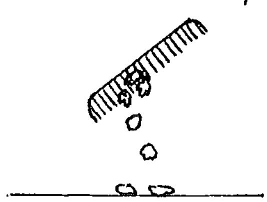


a) Which one will hit the ground first? Say why?

b) What happens to the downwards forces on the balls as they fall. Explain.

OTHER FORCES

17. A comb which is rubbed on a jersey will pick up some small pieces of paper.



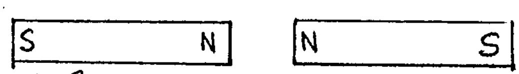
a) Why do you think this happens?

18 A magnet has a force field around it. When it is brought up close to a pin:-

a) What will happen to the pin?

b) Why do you think the pin behaved the way it did?

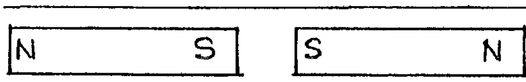
19 Say what you think will happen when the magnets are brought close together in each situation below.

a) 

why?

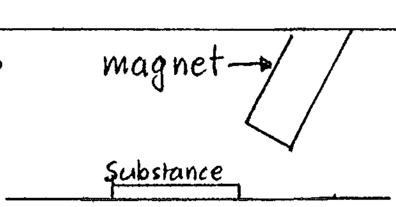
b) 

why?

c) 

why?

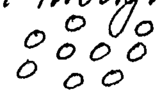
20. A strong magnet is brought up close to the following substances, as in the diagram. For each substance below say what will happen.

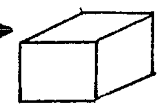


(a) aluminium.	(b) wood.	(c) copper.	(d) plastic.	(e) iron.

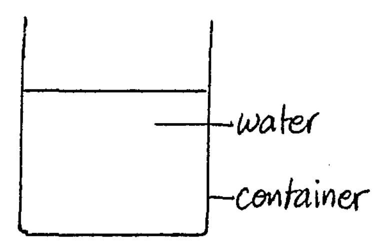
TEST B SCIENCE IDEAS. NATURE OF PARTICLES

The questions below ask what you think about some ideas in science. It is important that you try to answer each question in your <u>own</u> words as best as you can

1. All substances are often thought of as being made up of tiny particles eg. 

a) Write down or draw what you think the particles are like in a solid such as a salt crystal which has a shape like this → 

b) Write down or draw what you think the particles are doing in a liquid such as water in a container.

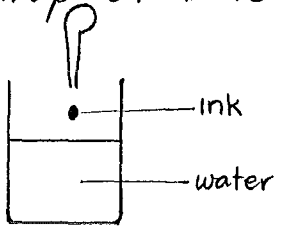


c) Write down or draw what you think the particles are doing in a gas such as the air we breathe

d) Why is it easier to see through air than through water?

2 . Suppose a jar of water has a drop of blue ink placed in it:

a) What would happen to the drop of ink after a long time?



b) Explain why.

c) What would be the difference if the ink was dropped into hot water?

d) Why?

3 . When you place sugar in water it seems to disappear after a long time.

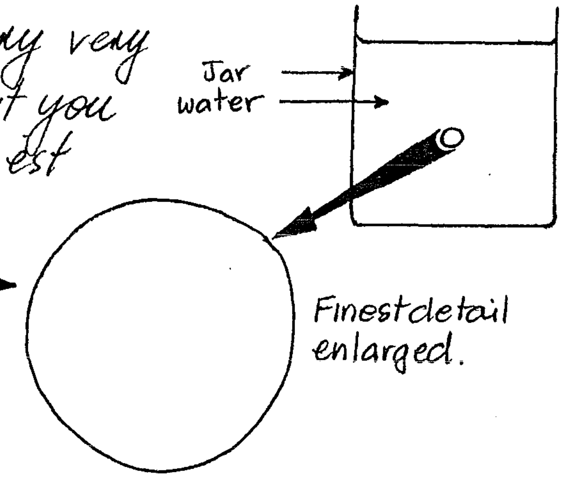
4 . When sugar is dissolved in water the particles making up the sugar seems to disappear. What happens to the sugar particles?

5 . When the water is stirred the sugar dissolves more easily. Why does this happen?

6 . When sugar is put into hot water it dissolves more quickly. Why does this happen?

7. Imagine you were able to see into a jar of water with a very very powerful magnif'ier so that you coued see the water in finest detail.

Inside the circle → opposite draw what you think the water would be like when magnified greatly.



8. Condies crystals when dropped in water make it go purple. What causes the water to become completely purple?

9. When a vitamin C tablet is put in water mony bubbles can be seen coming off the tablets.

a) What do you think the bubbles are mode of?

b) Why do they rise to the surface?

10. When water boils, bubbles form and rise to the surface.

a) What are the bubbles made of?

b) How do you think they form?

11. When a person walks into a room and is wearing perfume, you sometimes can smell the perfume after the person has left.

(a) Why are you able to smell the perfum on the person when she comes into the room?

(b) Why does the perfume remain after the person has left.

12. If you blew up a foot ball so that it was tight and put it outside when it was very cold.

(a) What would you expect to happen to the tightness of the ball while it is outside?

(b) Explain your answer above.

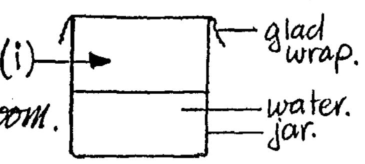
13. If a bowl of water is left outside on a warm day:-

(a) What will happen

(b) Under what conditions will any changes (described above) occur fastest?

(c) Explain why.

14. Suppose a jar which is half filled with water is completely sealed over with a piece of glad wrap. The jar is in a warm room.



a) What is in area (i)?

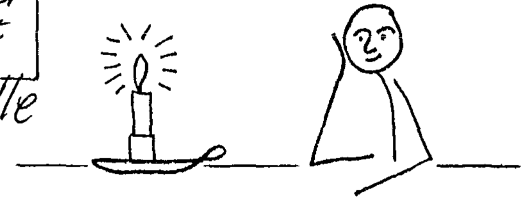
b) If the jar is gently heated what will happen to:-

c) area (i)?

d) the water level?

TEST C SCIENCE IDEAS. RADIANT ENERGY

The questions below ask you what you think about some science ideas. It is important that you try to answer each question in your own words as best as you can.



1. Suppose you are watching a candle burning in a dark room.

a)(i) Draw arrows on the picture above to show what you think happens to the light

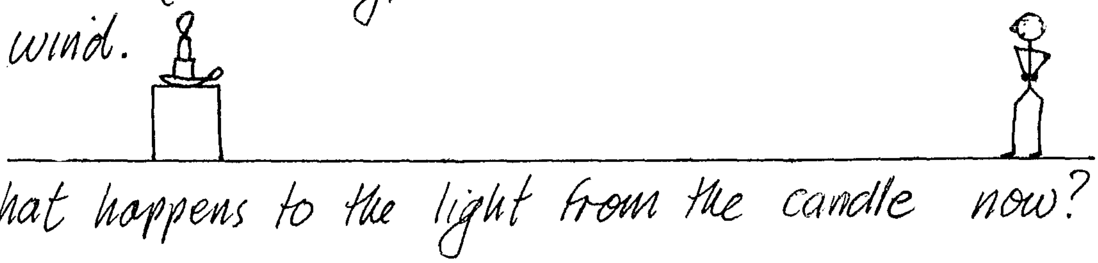
What is it that allows you to see the light?

b) How far does the light travel?

c) Suppose you move to the otherside of the room, what happens to the light from the candle in this situation?

d) Suppose somebody comes into the room and switches the electric light on. What happens to the light from the candle now?

e) Suppose you took the candle outside at night and put it down on a box. You then walked to the other side of a field (100 m away) and looked at the candle. There is no wind.



(i) What happens to the light from the candle now?

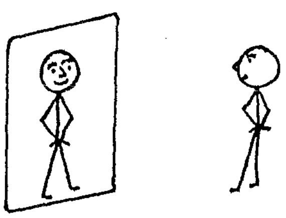
(ii) How bright will it be to you?

(iii) Explain your answer above.

(2) Suppose you are watching T.V.
What is it that allows you to see the light?

(3) Suppose you are in a room with a heater <u>glowing</u>
What is it that allows you to see the light from the heater?

(4) You are looking at yourself in the mirror.



a) Where does the light come from so you can see yourself?

b) What happens to the light <u>from the mirror</u> so you can see yourself?

(5) When a beam of light from a projector shines on to a screen so that you can see a picture:-

a) Why is the beam <u>not</u> able to be seen, <u>in a clear room</u> until it hits the screen?

b) Why can the beam be seen, <u>in a room full of smoke</u>?

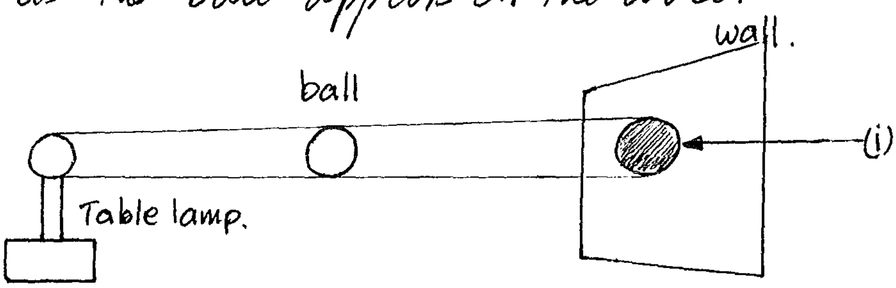
c) How are you able to see the picture on the screen even though the projector is behind you?

⑥ If a foot ball is held in front of a bright light, such as a table lamp, a fuzzy shadow appears on the wall behind.

a) Why is the shadow fu y?

b) When would the shadow be clear?

⑦ When a ball is held up in the path of a light, such as a table lamp a shadow which has the same out-line as the ball appears on the wall.

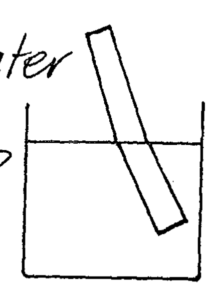


a) Why is the shadow much the same shape as the ball?

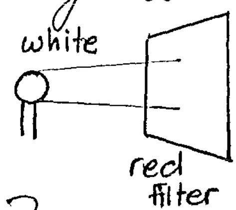
b) Why is the area (i) darker than the rest of the wall?

c) Why is the area(i) not jet black but a grey colour?

⑧ When part of a stick is placed in water the stick seems to bend, when you look down onto it. Why does it seem to bend?



⑨ If ordinary white light is shone through a red filter (such as red coloured glass):-



a) what happens as it passes through?

b) Explain why it behaves the way it does?

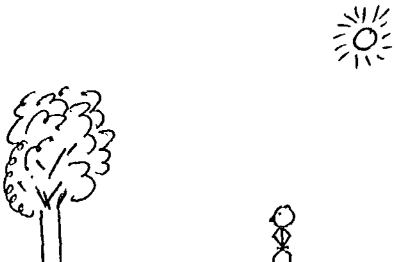
⑩. If ordinary white light shines onto a green jersey, what colour woued the jersey appear to you looking at it?

b) Explain why you gave your answer above.

⑪ (a) If red light (from a red coloured glass plate) is shone onto a green jersey, what colour would the jersey appear?

(b) Explain your answer above.

12



(a) Draw arrows or lines to show how you think the person is able to see the tree

(b) Where does the light come from?

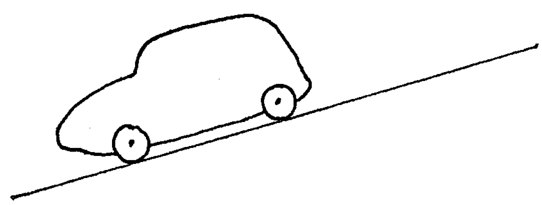
(c) Explain how the light gets into the person's eyes.

Appendix III

This shows four examples of the main kinds of answers given by students and the approximate % response. This method was used to form the basis for the Final Test Paper.

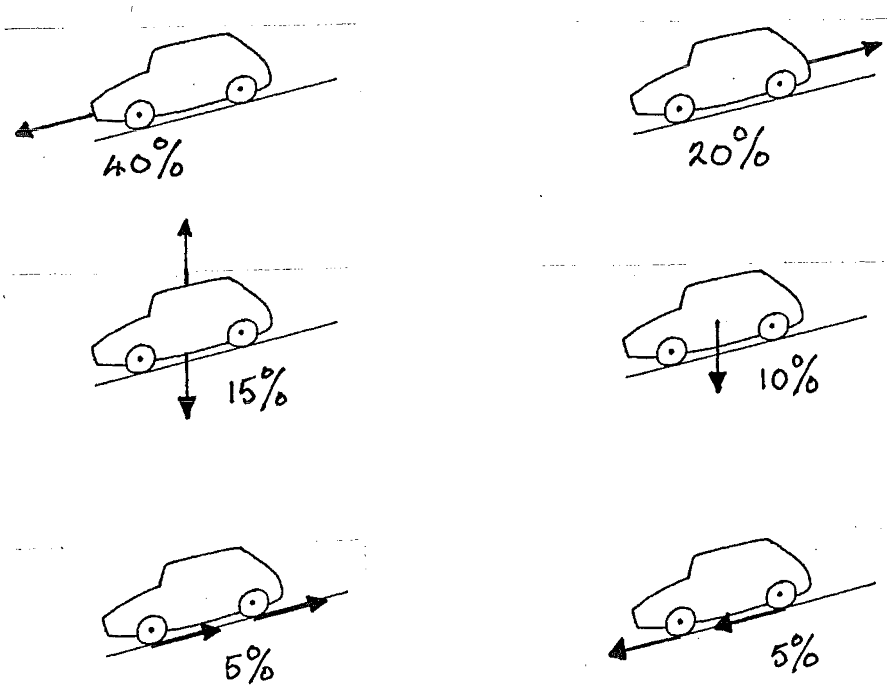
PRETEST ON FORCES

1. A car is parked on a sloping road with the hand brake on. It is not moving.



(a) Draw arrows on the car to show which way forces are acting. If you think there are no forces acting write NO FORCES under the diagram.

summary of main answers and % responses

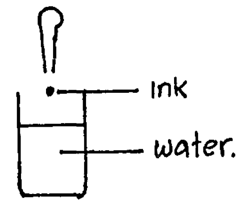


All others 5%

PRETEST ON NATURE OF PARTICLES

2. Suppose a jar of water has a drop of blue ink placed in it.

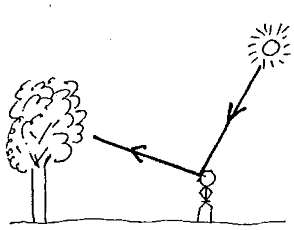
(a) What would happen to the drop of ink after a long time?



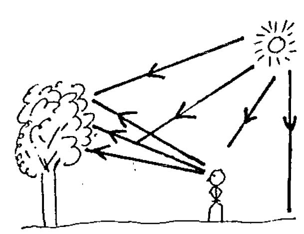
- make its way to the bottom (22%)
- it would spread out and turn the water blue (24%)
- would spread out (slowly) over the top (15%)
- would spread out over the bottom (10%)
- would spread out evenly through the water (23%)
- other answers (6%)

PRETEST ON RADIANT ENERGY

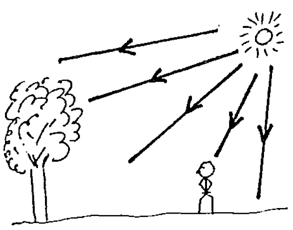
12. (a) Draw arrows or lines to show how you think the person is able to see the tree.



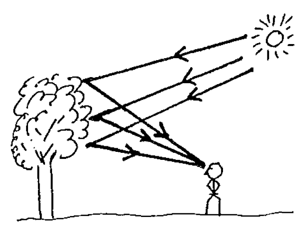
57%



15%



12%



9%

OTHER DIAGRAMS 7%

DIAGNOSTIC TEST OF PHYSICAL SCIENCE IDEAS

TEACHERS MANUAL

Brian W. Taylor

University of Canterbury

1. TEST DESCRIPTION

A. Purpose and Functions of the Test

This diagnostic test has been constructed to provide information about how well 3rd form science students understand basic aspects of three physical science topics commonly taught in New Zealand schools. The topics for which this test has been prepared are Forces, Nature of Particles and Radiant Energy.

The test should be used to assist teachers to determine basic misunderstandings (and misconceptions) the students have before these topics are taught. It must be emphasized that this is not a conventional achievement test. The teacher should focus on what the student thinks is the correct answer rather than what the correct answer actually is, even though scores and mean scores of the number correct are reported. If teachers use the best in this way then it is possible to get a clearer idea of how much (or how little) the students understand these topics and thus know what teaching approach they should take.

A Local Norm Group has been tested and a statistical analysis made of their results. This information about the test is provided so that a comparison can be made between the results from the Local Norm Group and

(i) individual schools

(ii) individual classes

(iii) individual students.

The analysis for the Local Norm Group is listed below:

(a) mean number of questions correct

(b) standard deviation

(c) a summary of total percentage responses on each student answer

(d) a summary of each subtopic grouping of questions.

The answer sheet is also designed in such a way that a teacher after marking, can make a quick visual appraisal of each student's performance on the overall test and each subtopic grouping. However if a teacher wishes to provide a mean score or standard deviation, a calculator would be necessary. To produce all information from a to d it may be necessary to use the computer programme provided (see appendix).

Please note: The programme written for this test can be used in a school for any test, particularly if it is used across a complete form level. The programme will perform the same analysis and correlations used to complete the analysis for this test.

B. Subjects The Test Is Intended For

The test can be sat by any students who have not been taught any of the Physical Science topics listed above. However for valid comparisons to be made between a teachers class and the Local Norm Group then it is best to have form three students sitting the test at the beginning of the year before they have been taught any substantial material. It is the ideas that students bring with them to their form three classes which should be identified rather than a test of how much they can remember of what they have been taught.

2. TEST CONSTRUCTION

The test was constructed in three phases:

(A) Development of open-ended questions.

(B) Pre-testing open-ended questions.

(C) Final test preparation.

A. Development of Open-Ended Questions

In order to work out the appropriate wording and level of questions a series of open-ended questions was written. An outline set of questions was prepared and a number of students were interviewed where they were asked the questions orally. This way unclear wording could be improved, and the correct level of difficulty of questions could be determined. From this a set of open-ended questions were written into three booklets, one for each topic. Many of these questions were adapted from the Learning In Science Project Working Papers and the Learning in Science Book (Osborne and Freyberg 1985).

B. Pretesting the Open-Ended Questions

A sample of approximately 100 representative form three students were asked to write in their answers to the questions. This group was taken from; above average, average and below average classes. The students were encouraged to write what they thought might be the correct answers, even if they were unsure. They were also asked to use language they were familiar with or draw what they thought where appropriate.

C. Final Test Preparation

Using the information from the pretest described above, questions were selected to make up the final test. Where 80% or more students gave the correct answers, these questions were not used, as it appeared the students had no real difficulty understanding the idea behind the question. Also questions which students had difficulty reading were either not used or reworded to make it easier to follow.

Most of the questions are of the multichoice type where the students select one answer from the four alternatives offered. There are a total of 36 questions, 29 are multichoice type, four are true or false type and three are Yes or No type questions. Where appropriate, particularly on multichoice items, the possible answers (alternatives) were written using the same wording or the same diagramic ideas that the students used in their pretest answers.

The questions were separated into 9 subtopics and a number of questions allocated to each subtopic. These are summarised in Table 1.

The separation of subtopics is more clearly represented in the answer sheet than in the test booklet

Table 1. Summary of Subtopic Test Questions

Topic	Subtopic	Question Nos.	Description
Forces	(i) Forces in motion	1-4	Circumstances when forces exist.
	(ii) Forces on a moving car	5-8	Existence of forces when speeds are steady and changing.
	(iii) Friction	9-10	Static and moving Friction.
	(iv) Force of gravity	11-13	Circumstances when gravity forces are present.
	(v) Force on a moving ball	14-18	Direction and extent of gravity forces on a falling ball.
Nature of Particles	(i) Particles	19-23	Characteristics of particles in different states.
	(ii) Particles in gases	24-28	Characteristics of particles in gases.
Radiant Energy	(i) Light Rays	29-33	Presence of light rays in different circumstances.
	(ii) Colour	34-36	Circumstances of colour formation

(see Appendix I). This breakdown in the answer sheet is for the convenience of the teacher, whereas the test booklet is simply a set of 36 questions which the students work through. However each of the questions are grouped together in the appropriate subtopics (see Table 1).

3. TEST ADMINISTRATION AND MARKING

Introduction

In order to get the best possible responses from the students it is important that they:

(i) Be familiar with multichoice type questions.

(ii) Have a room which is as quiet as possible to write the test.

Some of the questions require considerable concentration and a room with as little disturbance as possible is important.

(iii) Be allowed as much time as they wish to finish the test.

(It should take no more than one hour even with limited ability students).

(iv) Should sit the test in the morning if possible when the students are likely to be more fresh.

(a) Introducing the test

It is important to explain to students what the teacher is trying to find out from this test. As it is a diagnostic test the students need to understand that they must try to answer each question as well as they can and not leave any blanks. They should do this even though they feel they may not know the correct answer. It must be emphasized again that the test is designed to see what they think about each question.

(b) Distributing materials and explanation

The students should receive a test booklet together with an answer sheet. They should put their name in the left hand box, leaving the other blank. In order to help familiarize students with the questions (particularly the multichoice ones) and the layout of the answer sheet, it is most important to go through the two sample questions at the start of the main test.

They should put a cross under the letter which they think is the correct answer. Remind them not to write in the extreme right hand series of boxes as they are for the teacher to score each topic. If they wish to change a choice they have made then they should shade in that box and make another choice.

(c) Running of the test

The student should all begin the test at the same time and they have as much time as they wish to finish. The lowest ability student should take no more than three quarters of an hour to complete the test.

(d) Marking the test

A marking schedule is supplied for the teacher. The teacher should cut out the squares (below the letters which correspond to the correct answers) and use the master as a stensil overlay. It is advisable to cut out the name square and the "total" square so that the student's score can be recorded easily. Many teachers find making an overhead transparency an advantage as the student's answer sheet can be seen easily underneath. This way it is possible to check quickly if more than one response has been marked.

The answer sheet has been made up so that each group of questions are arranged in a row. The rows correspond to the groups of questions made into topics listed in table 1 (Pg 4). This way the teacher marking the test can get a subtotal for each topic (as well as the overall total) so that a comparison can be made between each student. This can be done fairly quickly by casting one's eye down a pile of answer sheets which are sitting on top of each other and the right hand side topic boxes exposed. To get more detailed information it would be necessary to use a calculator or the computer programme to determine such things as mean, standard deviation, percentage responses, and compare the class results with the Local Norm Group tested.

4. USING THE RESULTS

A. Formation of Local Norm Group

A cross section of ten schools from Christchurch made up a Local Norm Group. This comprised students from;

co-educational schools, state single sex schools and separate (private) schools. The classes chosen were high ability, average and limited ability groups. There were 438 students used to make up the Local Norm Group. Each of these students were tested in February 1987.

A similar group was tested in December 1986. The purpose of this was to see if there were differences in performance between this group (having been taught a full year course) and the Local Norm Group (before they had been taught any substantial high school science). This was done to give an indication of how much growth in their understanding had occurred in the course of their form three year.

The analysis performed for the Local Norm Group is listed below:

(1) Mean score.

(2) Standard deviation.

(3) % response on each answer and hence their main misunderstandings.

(4) % response on each topic.

In addition the following analysis was performed:

(5) Split-half reliability for the whole group.

(6) Various test scores from the Local Norm Group were correlated with those of TOSCA.

Also a separate representative 3rd form group from one high school (outside the Local Norm Group) sat the test in February 1987. Their scores were correlated with the following:

(i) TOSCA.

(ii) PAT Mathematics.

(iii) PAT Reading Comprehension.

(iv) Internal Science Reference Test.

(v) Re Test.

This group comprised 73 students and made up three classes. These classes were from below average, average and above average levels within the school.

USING THE RESULTS AND TECHNICAL INFORMATION

As stated before the primary aim of this test is to indicate to teachers the students' misunderstandings about the three physical science topics in question. It can also show how much the students do understand (by how many questions they get correct) and provides an opportunity for teachers to compare their class and individual student performances with the Local Norm Group (L.N.G.).

Steps to Take After Marking the Test

The information below summarizes the steps which can be taken in order to make full use of the results of the test to interpret the students' performance, particularly what misunderstandings they have .

Type of Result	Steps to take	Technical Instructions
1. Raw Scores (a) Individual	Individual raw scores can be compared with the mean score of the L.N.G.	mean of LNG 13.9 (39% correct)
(b) Class mean	The class mean score can be calculated and compared with the L.N.G.	
(c) School mean	This can be calculated and compared with the L.N.G.	
(d) Standard deviation	Calculating the standard deviation of the class and/or whole school would need a calculator. The results can be compared with the L.N.G.	S.D. of LNG = 3.8
2. Multi-choice answers (a) Individual responses	Individual responses on each question can be compared with the % response by L.N.G.	See the print-out of the responses below.

Table 2: Analysis of Multichoice Answers for the Local Norm Group.

Choice	A	B	C	D	E	Correct answer	UQ	LQ	Total	%	Disc Fact	Diff Fact
Question												
1	10*	65	11	13	0	A	22	6	45	10	0.15	0.13
2	30	14	39*	16	1	C	66	25	171	39	0.37	0.41
3	28	10	16	46*	0	D	67	37	200	46	0.27	0.47
4	17*	34	28	20	1	A	26	17	75	17	0.08	0.20
5	63	37*	0	0	0	B	49	33	162	37	0.15	0.37
6	28*	72	0	0	0	A	35	28	122	28	0.06	0.29
7	70*	30	0	0	0	A	91	67	308	70	0.22	0.72
8	56	41*	0	0	0	B	73	28	178	41	0.41	0.46
9	13	36	10	34*	1	D	59	17	147	34	0.38	0.35
10	58	7	25*	3	1	C	48	17	109	25	0.28	0.30
11	36*	57	0	0	0	A	67	33	156	36	0.31	0.45
12	42*	50	0	0	1	A	62	43	186	42	0.17	0.48
13	80*	13	0	0	0	A	106	77	350	80	0.26	0.83
14	46	34*	12	2	0	B	55	29	147	34	0.24	0.38
15	45	35*	7	6	0	B	56	24	155	35	0.29	0.36
16	34	45*	9	5	1	B	76	31	196	45	0.41	0.49
17	43	5	32*	13	1	C	60	20	140	32	0.36	0.36
18	22*	53	4	15	0	A	44	12	95	22	0.29	0.25
19	23	15	17*	39	1	C	28	8	75	17	0.18	0.16
20	29	22	9*	33	0	C	25	3	40	9	0.20	0.13
21	3	22	52*	17	0	C	73	55	226	52	0.16	0.58
22	21	15*	12	45	0	B	19	17	67	15	0.02	0.16
23	56	7	24*	6	1	C	41	12	104	24	0.26	0.24
24	28	19	29*	17	0	C	40	26	128	29	0.13	0.30
25	11	26*	47	8	1	B	44	18	114	26	0.24	0.28
26	49*	10	18	16	1	A	71	35	215	49	0.33	0.48
27	16	8	58*	12	0	C	79	43	255	58	0.33	0.55
28	47*	12	14	19	1	A	76	34	208	47	0.38	0.50
29	7	38*	29	19	1	B	61	28	166	38	0.30	0.40
30	62*	11	12	8	1	A	91	48	270	62	0.39	0.63
31	29	3	31*	29	1	C	61	14	137	31	0.43	0.34
32	16*	11	41	24	1	A	38	13	71	16	0.23	0.23
33	45*	13	9	25	2	A	74	27	198	45	0.43	0.46
34	37	27*	21	8	1	B	50	13	120	27	0.34	0.29
35	6	7	68*	11	2	C	96	63	298	68	0.30	0.72
36	4	45*	19	25	2	B	62	40	196	45	0.20	0.46
Choice	A	B	C	D	E	Correct answer	UQ	LQ	Total	%	Disc Fact	Diff Fact

Explanation

From the analysis above major misunderstandings can be indentified. The asterix indicates the correct answer and the figures under each option (A to D) are the percentage response that the L.N.G. gave for each alternative. Column E represents those who did not answer anything, or who selected more than one answer.

For example:

(a) Question 1; 10% of the LNG sample chose A
65% of the sample chose B
11% chose C etc.

This pattern indicates that B is a major misunderstanding.

(b) Question 19; because 23% chose A and 39% chose D then this would indicate that there are two areas of major misunderstanding.

The "Disc Fact" column shows the extent to which the question discriminated between the upper quarter and the lower quarter. The closer the figure is to one, the more the question discriminates between the two quarters.

The "Diff Fact" column shows the degree of difficulty indicated for the L.N.G. The closer the figure is to 1 the easier the question was.

Type of Result	Steps to Take	Technical Instructions
2. Multi-choice answers. (b) Class responses	It is possible to work out the class percentage on each response manually. By asking all students to show their hands (for each option chosen) and listing this number the percentage response can be calculated.	See the print-out of the responses above.
(c) Whole School responses	This again can be done manually. However it may be more desirable to use the computor programme where all the individual responses have to be loaded and the programme will print the percentage responses (plus all the other information) automatically. Details of the programme are included in the enclosure at the back of the teachers' manual.	See the print-out of the responses above.

Type of Result	Steps to Take	Technical Instructions
3. Subtopic analysis (a) Individual	By using the answer sheet and counting the scores on each section the teacher can record the student's performance on each of the sub-topics. The total correct can be recorded in the right hand column on the answer sheet and it is a simple task to turn those sub-totals into a percentage. This can be compared with the overall percentage correct for the L.N.G.	See the following table.

Table 3: Summary by subtopics: Percentage correct for L.N.G. for each group of questions.

Subtopics	Question Numbers	L.N.G. Percentage correct on all items
Forces in motion	1 to 4	28
Forces on a moving car	5 to 8	45
Friction	9 to 10	31
Force of Gravity	11 to 13	57
Force on a moving ball	14 to 18	35
Particles	19 to 23	25
Particles in gases	24 to 28	44
Light rays	29 to 33	41
Colour	34 to 36	49

Explanation

From the table above it can be seen that for the subtopic "Forces in motion" 28% of the Local Norm Group had all those questions correct. This means that just over one quarter had a clear understanding of all the ideas about "Forces in Motion" which were in the test.

For the subtopic "Force of Gravity" 57% managed to get all those questions correct. This means that just over a half had a clear understanding about "Gravity Forces" (as it relates to those questions in the test).

By comparing the individual classes (or schools) performance with the LNG performance it is possible to see if the class in question is as typical in the understanding as the LNG is.

Type of Result	Steps to Take	Technical Instructions
3. Subtopic analysis		
(b) Class Results	This can be obtained manually, by asking individuals in class how many they got correct in each sub-topic and calculating the percentage for the class. Using the computer programme and loading each student's response will result in this information being listed automatically.	See the table above
(c) School Results	Unless it is more convenient to get each teacher to collect their class results and combine each teacher together, than it is best to use the computer programme for this.	

OTHER INFORMATION

Comparison with 1986

Table 4: Mean scores and standard deviation of 1986 sample and L.N.C.

	L.N.G. (Feb. 1987)	L.N.G. (Nov. 1986)
Mean score	13.9 (39% correct)	15 (42% correct)
S.D.	3.8	4.1

Table 4 shows there is some increase in mean score between the two year groups tested. As the 1986 sample were tested at the end of their form three school year it would seem that teaching has had some effect on improving their performance. However in terms of the questions answered the improvement has been slight and the mean score is still below half marks. This would indicate that there is little change in their understanding of the topics questioned in the test during the form three course.

1. Reliability

Reliability is the consistency with which this test is measuring the understandings assessed in these topics. It is an indication of how "dependable" the test is. Statistically it is expressed as a correlation coefficient and it gives an estimate of the stability of what the test is trying to measure.

Reliability (correlation) coefficients are expressed as a range from 0.00 (zero relationship) to 1.00 (perfect relationship). The closer the reliability coefficient is to 1.00 the more dependable the test results may be said to be.

The method that was used to estimate internal consistency was test-retest relaibility, using a High School group which was separate from the L.N.G. This group was fairly representative of form three students as they had a mean TOSCA score of 32.6 compared with the score of 35.4 on the equivalent sample used in standardizing TOSCA. Exactly the same test was rerun approximately five days later with the same group. The correlation of the results of the second run with those of the first run was 0.62.

This means the students are responding to the questions in much the same way on the second test. However it compares poorly with say TOSCA test-retest reliability correlation which is from .90 - .92 with the different forms. The reasons for the difference is more than likely due to the fact that there is a greater guessing factor, reflected particularly where there is an even distribution of percentage responses on each alternative answer. This is because students have found these questions difficult and were instructed to respond whenever possible. Where there have been high percentage responses on some alternative answers this means there is a major misunderstanding which students have opted for. These factors together probably contribute to a rather low correlation.

VALIDITY

Validity can be assessed by providing information which shows the extent to which the test measures adequately the aspects it was designed to measure. Some aspects are judgmental and others are statistical.

(1) Face validity (judgmental)

The test seems to have reasonable face validity. Five practising teachers went over the test carefully to determine if it was measuring the misunderstanding it was supposed to measure. Suggestions were made by those teachers and they were written in to the final test format.

(2) Content validity (judgmental)

The test was divided up into subtopics (see table 1) according to the areas which have traditionally caused problems with students understanding. These were allocated a limited number of questions which asked about these areas from slightly different viewpoints.

This strategy was designed to get a range of responses, which have been grouped as the total percentage correct for each subtopic.

(3) Predictive Validity (Statistical)

This is not possible to determine at present.

(4) Concurrent Validity (Statistical)

Concurrent validity involves the relationship of the test with other criterion-related measures. Validity in this situation is expressed as a correlation coefficient with the other test. This gives an estimate of whether or not the test is measuring aspects which the other test is also measuring.

Correlation with Other Tests

The separate High School groups' results were correlated with TOSCA, PAT mathematics, PAT comprehension and internal science reference test.

Table 5: Correlations with Four Tests Taken by Separate Form Three Group.

	Diagnostic Test	TOSCA	PAT Maths	PAT Read Comp.	Science Reference	Re-Test
Mean	13.0	32.6	20.8	28.7	18.4	13.0
SD	3.6	13.4	10.3	15.4	6.2	4.1
r	-	0.60	0.60	0.63	0.58	0.62

Generally these correlations should be higher, particularly with the science reference test used in the school. It seems that the upper limited for correlations with other tests is set by the relaibility correlation. This reflects the kind of test that it is, in that students are not selecting their choices in a totally consistent way. This probably indicates that they are either selecting the alternatives in a haphazard way by guessing or they are drawn to the answers which seem logical to them. Probably students are doing both throughout the test.

Conclusion

Because the scores on the Local Norm Group are rather low it would indicate that:

(a) the test is very difficult for most students

(b) the test did show that students had a number of misunderstandings in various subtopics for the three physical science topics being tested. It is the misunderstandings which are of greatest value to the teacher.

Appendix I

PHYSICAL SCIENCE IDEAS

INSTRUCTIONS

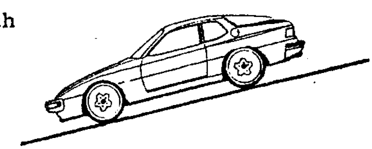
The questions below ask what you think about some ideas in science. It is important that you try to answer each question as well as you can.

SAMPLE QUESTIONS

> Read these sample questions first and check on your answer sheet to see how to answer them.
>
> S1 The planet which is closest to the sun is:
>
> (a) Mercury (b) The Moon (c) Mars (d) Neptune
>
> S2 What is the biggest animal on earth?
>
> (a) an elephant (b) a Lion (c) a sperm whale (d) a cow.

DO NOT BEGIN UNTIL YOUR TEACHER TELLS YOU TO.

1. A car is parked on a sloping road with the hand brake on. It is not moving. Which of the following best shows the direction of forces on the car?



(a)

Reaction force from the road up is equal and opposite to the force due to gravity down.

(b)

Force pointing down the slope.

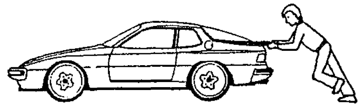
(c)

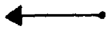
Force pointing up the slope.

(d)

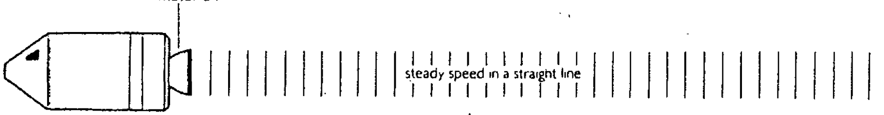
There are no forces of any kind as the car is not moving.

2. A person is trying to push the car, but the car is not moving. The engine is not going and the hand brake is on. Which of the following best shows the direction of forces between the car and the person?

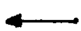
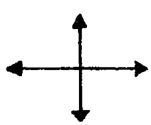


(a)  Force pointing forwards	(b)  Force pointing backwards.
(c)  Force from the car is equal to the force from the person.	(d) No forces, as the car is not moving.

3. A space craft is travelling through deep space where there is no gravity and no friction. Its engine is switched off. The craft is not speeding up or slowing down and is travelling to the left



Which of the following best shows the forces on the craft?

(a)  Force point to the left.	(b)  Forces point to the left and down.
(c)  Forces point in all directions.	(d) No forces are on the craft.

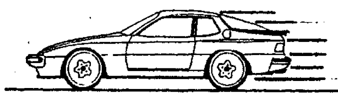
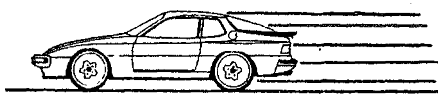
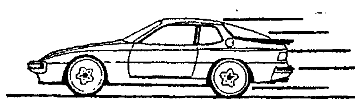
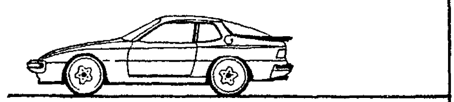
4. A person is sitting on a bike but not pedalling. <u>The bike is slowing down</u>.

Which of the following best shows the direction of the forces on the bike which affect its <u>motion only</u>?

(a) ← Force points to the left.	(b) → Force points to the right.
(c) ←——→ The force to the left is bigger.	(d) No forces on the bike.

The information below is for the next 4 questions.
The diagrams below show a car travelling in 4 different situations.

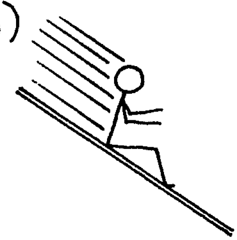
You have to mark (T) for true or (F) for false, if you think each statement is correct or not.

	STATEMENT	SITUATION
5.	The force to the left (←) is greater than the force to the right (→).	Travelling at a steady speed of 50 kilometres per hour. 
6.	All the forces left and right are equal.	Travelling at a steady speed of 80 kilometres per hour. 
7.	The force to the left (←) is greater than the force to the right (→).	Car is speeding up (getting faster). 
8.	All the forces left and right are equal.	Car is slowing down (coming to a stop). 

The information below is for the next 2 questions.

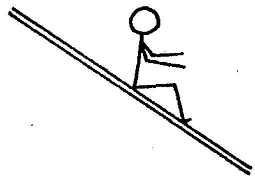
A person is playing on a slide. The pictures show what is happening at three different times. The questions are about friction between the person and the slide.

(i)



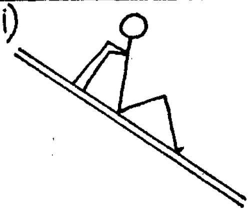
coming down the slide fast and getting faster.

(ii)



coming down the slide slowly and steadily.

(iii)



The person is holding the sides of the slide.

9. In which of the pictures above would there be friction?

(a) (i) only. (b) (i) and (ii) (c) (iii) only
(d) all 3 pictures.

10. In which picture would you expect greatest friction?

(a) (i) (b) (ii) (c) (iii) (d) all 3 pictures have the same friction.

(Turn over)

The information below is for the next 3 questions.

Put a (Y) for yes or (N) for no, for each of the following situations.

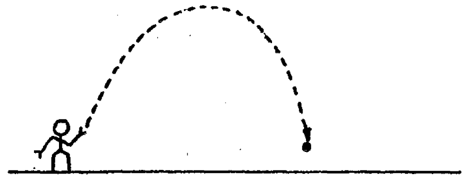
11. Is there gravity acting on a person standing on the moon?

12. Is there gravity acting on a person swimming under water?

13. Is there gravity acting on a sky diver falling from a plane?

(Turn Over)

The information below is for the next 3 questions.
A ball is thrown in the air and follows the path in the diagram.



14. Which best shows the direction of forces on the ball in the position opposite?

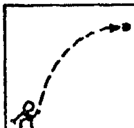
(a) 
Force in direction of flight

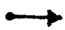
(b) 
Forces due to gravity and friction.

(c) 
Force in direction of throw

(d)
No forces on the ball at all.

15. Which best shows the direction of forces on the ball in the position opposite?



(a) 
Force in direction of flight

(b) 
Forces due to gravity and friction

(c) 
Force due to friction only.

(d)
No forces on the ball at all.

16. Which best shows the direction of forces on the ball in the position opposite?

(a) 
Force in direction of flight.

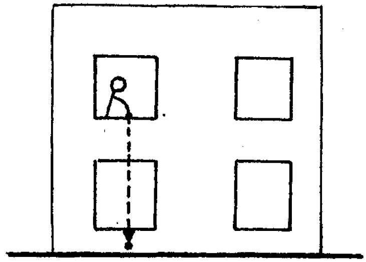
(b) 
Forces due to gravity and friction.

(c) 
Force due to friction only.

(d)
No forces on the ball at all.

The information below is for the next 2 questions.

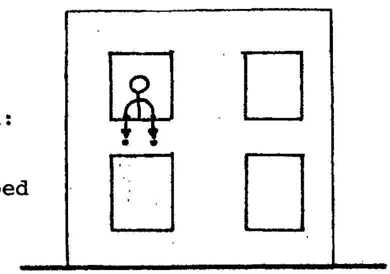
A tennis ball is dropped from a window on the second storey of a building.



17. What effect does gravity have on the force on the ball as it falls?

(a) It becomes greater because the ball gets faster.
(b) It becomes less and is zero when the ball hits the ground.
(c) It remains much the same as the ball falls.
(d) It is greater at first then decreases steadily.

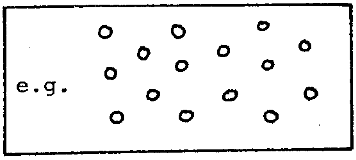
18. The person does the experiment a second time. This time she drops 2 balls which are the same size. One is made of lead: the other made of wood, which is very smooth. They are dropped <u>at exactly the same time</u>.
The metal ball:



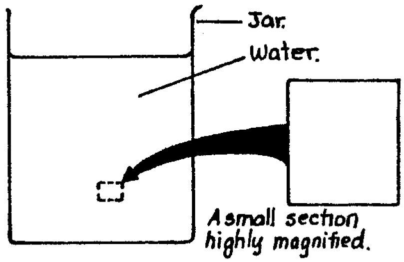
(a) Falls at the same speed as the wooden ball.
(b) Falls faster then the wooden ball because there is more force on it.
(c) Falls more slowly than the wooden ball because its heavier.
(d) Falls more slowly at first, then speeds up and travels faster than the wooden ball.

PARTICLES

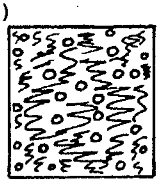
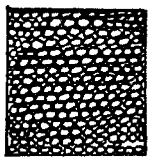
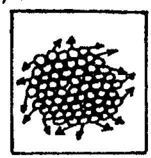
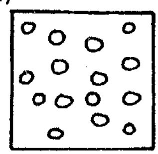
All materials are thought of as being made up of tiny particles.



Imagine the particles above to be making up water in a jar.

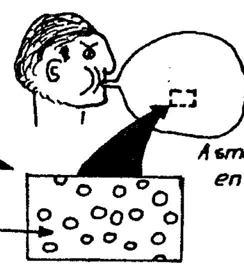


19. Which of the following best shows the arrangement of particles in the enlarged section.

(a)	(b)	(c)	(d)
			
particles mixed in with liquid	regular stacking and vibrating.	moving over each other	gaps between the particles.

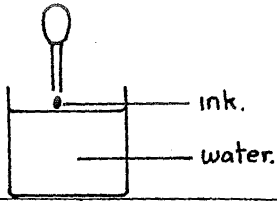
20. Suppose a person blows up a balloon. All the particles in the balloon can be thought of as being like this (enlarged).

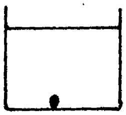
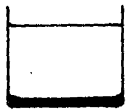
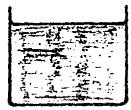
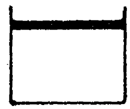
What is in the area between the particles?



(a) air
(b) Moisture from the person's breath
(c) nothing
(d) oxygen.

21. Suppose a jar of water has a drop of blue ink placed in it. Which diagram shows what would happen to the ink after a long time.



(a)	(b)	(c)	(d)
			
sink to bottom stay as a drop	spread out on bottom	spread out everywhere evenly	spread out over surface

22. When a sugar cube is dissolved in a cup of very hot water the particles making up the sugar seem to disappear. What happens to the particles?

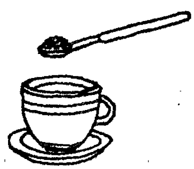
(a) The individual sugar particles break down into smaller pieces and can't be seen.

(b) The sugar particles break off the sugar cube and as single particles can't be seen.

(c) The sugar particles spread out over the bottom of the cup so thinly they can't be seen.

(d) The sugar particles move into the water particles and eventually become water particles themselves.

23. When sugar is put into hot water it dissolves more quickly than in cold water. Why does this happen?



(a) The heat melts the sugar particles.

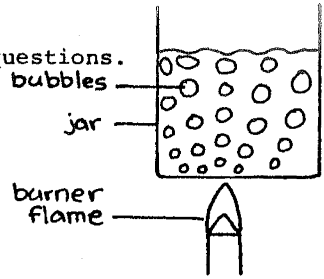
(b) The sugar particles are attracted to the water particles more because they are hot.

(c) The water particles are moving faster and so collide with the sugar particles more quickly.

(d) The heat rises from the bottom and causes the sugar particles to rise also.

The information below is for the next 2 questions.

When water has been boiling for a long time, bubbles are produced at the bottom and rise to the surface.



24. What are the bubbles mainly made of?

(a) hot air (b) oxygen (c) water vapour (d) carbon dioxide.

25. How do you think the bubbles above form?

(a) Many particles of the same kind join together to make a big particle which rises to the surface.
(b) The water turns into a gas where the heat is applied.
(c) The air in the water is heated, forms into bubbles and rises to the surface.
(d) The particles grow too big and rise to the surface.

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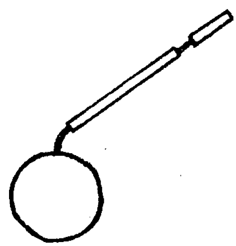
26. Suppose you pump a football so that it is hard, and put it outside when the weather was very cold.

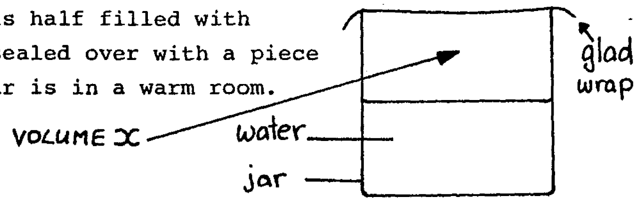
What would you expect to happen to the ball while it is outside?



(a) It would become soft because the air particles inside would move closer together.
(b) It would become soft because the air particles move apart slightly.
(c) It would become harder because the air particles would move closer together.
(d) It would become harder because the air particles would move apart slightly.

The information below is for the next 2 questions

Suppose a jar which is half filled with water is completely sealed over with a piece of glad wrap. The jar is in a warm room.



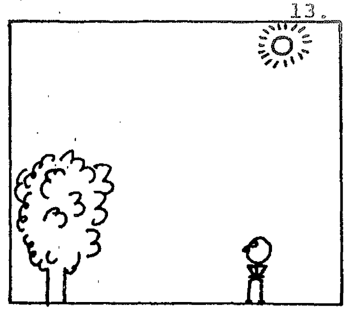
27. What is in volume x?

(a) air only
(b) water vapour only
(c) water vapour and air
(d) a vacuum (nothing in area x).

28. What will happen to volume x as the jar is placed on a hot element and heated?

(a) The total number of particles in this area will increase.
(b) The total number of particles in this area will decrease.
(c) The volume will become smaller.
(d) The particles in x will be absorbed into the water.

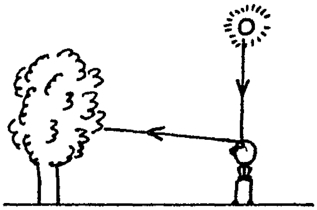
(turn over)



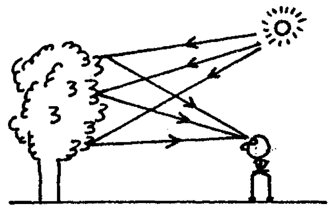
Radiant Energy

29. Suppose a person is standing a short distance from a tree, looking at it. Which of the diagrams best shows how the person is able to see the tree?
The arrows represent light rays.

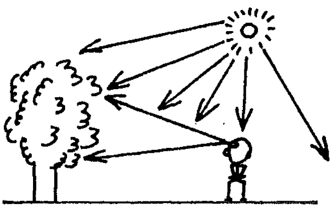
(a)



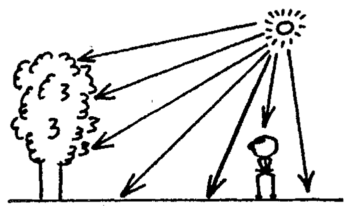
(b)



(c)

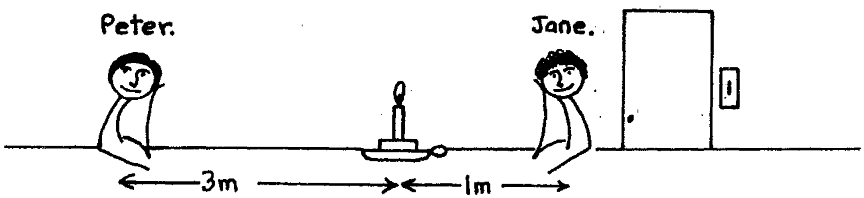


(d)



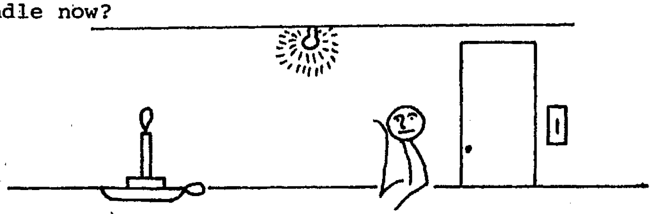
Use the information below to answer the next 2 questions.

Two people are looking at a candle in a dark room. Jane is sitting 1 metre from the candle, and Peter is sitting 3 metres from the candle.



30. How much light would you expect Peter to get compared with Jane?
(a) Less light than Jane as the light spreads out.
(b) The same amount of light as Jane as the light is much the same everywhere.
(c) More light than Jane as some light bounces off the walls.
(d) None, as the light only travels as far as Jane.

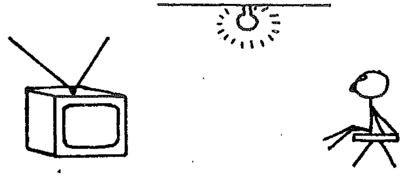
31. A person comes into the room and switches the electric light on. What happens to the light from the candle now?



(a) The light given off by the candle is weakened.
(b) The light given off by the candle is made stronger.
(c) The light given off by the candle is not changed.
(d) The person would hardly be able to see the candle because the strong electric light would make it hard to see.

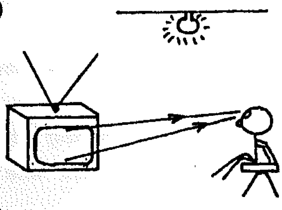
(turn over)

32. Suppose a person is sitting and watching T.V. There is a light on in the room.

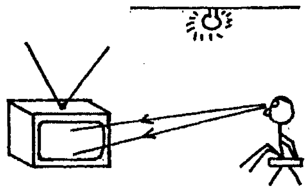


Which of the following best shows the pathway of the light so that the person can see what's on the screen? (The arrows represent the light rays).

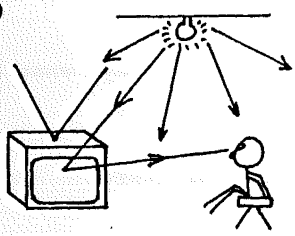
(a)



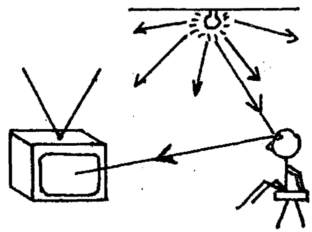
(b)



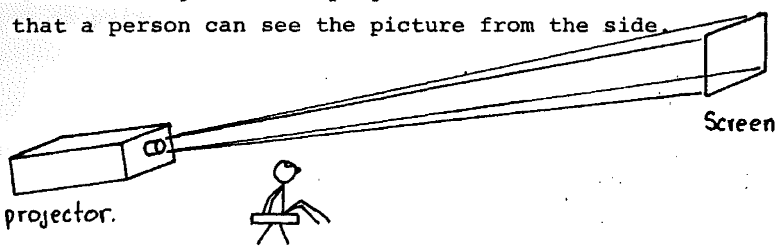
(c)



(d)



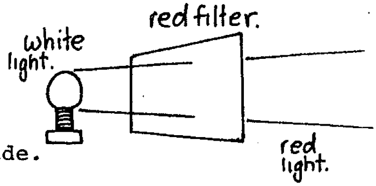
33. A beam of light from a projector shines on to a screen so that a person can see the picture from the side.



Why is the beam not able to be seen in a clear room until it hits the screen?

(a) There is nothing in the air for the beam to reflect off.
(b) The beam is so strong it passes through the air easily.
(c) The beam is very small until it hits the screen so can't be seen.
(d) Because there is as much light in the room as the projector produces, so it doesn't show up at all.

34. If ordinary white light is shone through a red filter (such as red coloured cellophane or glass) red light passes out the other side. Why does red light pass out?



(a) As the white light goes through the filter it adds red colour to the white light.
(b) All the colours in white light are removed by the filter except red.
(c) Because the red light is reflected back along the rays.
(d) The white light is removed by the filter and the red light bounces off the walls behind.

35. If white light shines onto a pure green jersey, what colour would the jersey appear to you looking at it?

(a) white (b) black (c) green (d) grey.

36. If pure red light only shines on to a pure green jersey what colour would the jersey appear to you looking at it?

(a) white (b) black (c) green (d) red.

FINISH

Appendix II

PHYSICAL SCIENCE IDEAS

ANSWER SHEET

Put your name here →

Sample Questions (You have as much time as you wish to finish the test.)

S.1.

a	b	c	d
X			

"a" is the correct answer so you place an x under the a.

S.2.

a	b	c	d
		X	

"c" is the correct answer so you place an x under the c.

DO NOT BEGIN UNTIL YOUR TEACHER TELLS YOU TO. Don't write here.

1 a b c d 2 a b c d 3 a b c d 4 a b c d

5 True False 6 True False 7 True False 8 True False

9 a b c d 10 a b c d

11 Yes No 12 Yes No 13 Yes No

14 a b c d 15 a b c d 16 a b c d 17 a b c d 18 a b c d

19 a b c d 20 a b c d 21 a b c d 22 a b c d 23 a b c d

24 a b c d 25 a b c d 26 a b c d 27 a b c d 28 a b c d

29 a b c d 30 a b c d 31 a b c d 32 a b c d 33 a b c d

34 a b c d 35 a b c d 36 a b c d

Please put raw scores if possible.

Toscas		P.A.T. Mathematics →		P.A.T Comprehension →		Total →	