3.10 CONCLUSION

In this section individual views have been put together in order to have a collective analysis of the ideas given by the interviewees.

3.10.1 Pictorial Representation

The following diagrams were given by the respective interviewees in question 3.1.

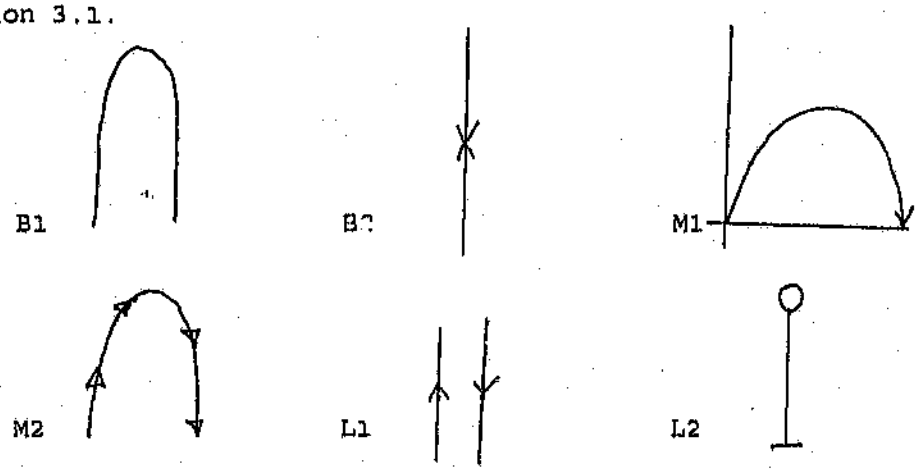


Figure 3.30 Pictures of the ball thrown by the interviewees

From the above it seems that students do not understand what is meant by a simple picture describing motion. B1 and M2 draw acceptable paths of the motion but the ball is not in the picture. The argument behind the picture as a graph by M1 is based on:-

(a) straight and visible,
(b) graphical representation means picture.

The other unexpected answers (by B2,L1 and L2) could be explained by their reasoning that:

L2's speed-time graph shows some initial speed which slowly increases. But his velocity-time graph starts from the origin. Although he talked about some initial momentum as well as initial energy needed for the motion of the swing, he did not relate the ideas to speed or to velocity.

761 S: Initially I believe the child has gained momentum as he began to swing.

63 S: Yes I believe there must be energy applied to the child in order that he must swing. Energy must be involved.

The ideas of momentum and energy do not seem to be reflected in the graph because of the symbols used for the axes. I infer, therefore, that L2 had difficulty in interpreting the motion of the swing into velocity-time and speed-time graphs.

3.9.4 Conclusion

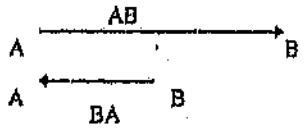
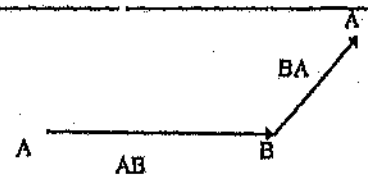
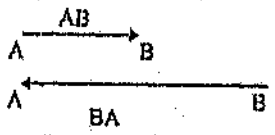
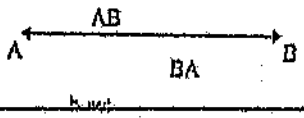
L2's performance in the test was in the lower group, but he showed some potential understanding during his interviews. Unlike others, he brought the concept of kinetic energy being contradicted by the force of gravity during the motion of the ball. He means that when kinetic energy at the top is zero the ball has potential energy. But he draws the picture of the motion of the ball as a graph. In vector drawings he confuses the magnitude of the vector of the velocity with the mass of the ball. It appears that L2's background understanding of interrelationship of the variables which decide the shape of the graphs are weak, so he could not produce relevant and sensible graphs. His pictures look like graphs and graphs do not give the meaning in the context.

effect of magnitude of the velocity on the path is understood. The second part tests the understanding of length and direction of line-vectors. The third part is related to the graph of the motion. The two main ideas to be understood are that the return velocity is negative and 2V. The students' answers to these three areas are seen in the following tables.

Question 1.2: Vector understanding of the motion of the tennis ball.

Table 2 Vector understanding of the motion of the tennis ball

A tennis player A hits a ball with velocity v. After being hit by the opposite player B, the ball returns to the player A with velocity 2V.
1.2 Which one of the following represents the vector diagrams of the above motion?

choices	answers		%
A. 	10	X	13
B. 	19	X	24
C. 	31	C	39
D. 	19	X	24
TOTAL	79		100

Conventions

In the Tables below, the following conventions are used:

X indicates an unacceptable answer

C* indicates an acceptable answer

C indicates a correct answer

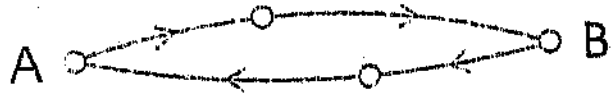
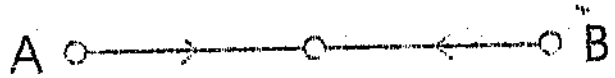
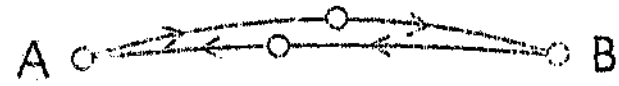
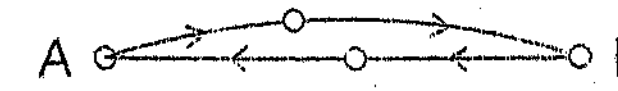
Analysis.

Analysis: Question 1.

Table 1 Pictures of the motion of the tennis ball

A tennis player A hits a ball with velocity v. After being hit by the opposite player B, the ball returns to the player A with velocity 2V.

1.1 Which one of the following represents the motion best?

choices	answers		%
A. 	15	X	19
B. 	18	X	23
C. 	20	C	25
D. 	26	C*	33
TOTAL	79		100

The motion of a tennis ball is seen from three angles in the form of three questions. The first section has possible pictures of the path of the ball. It can be answered if the

APPENDIX B

QUESTIONNAIRE DISCUSSION AND ANAIYSIS

Introduction

The questionnaire was used as a tool to diagnose students' ways of thinking about speed and velocity in terms of graphs, vectors and pictures of real life motion. In this section the questions are reviewed, and the data obtained from answers are presented in tables for each question. The pictorial representation of motion, the scalar and vector nature of speed and velocity and the students' interpretation of velocity-time and speed-time graphs formed the focus of the investigation. The analysis is done qualitatively to describe the concepts and ideas of students' and quantitatively to find the commonality of a particular idea or concept.

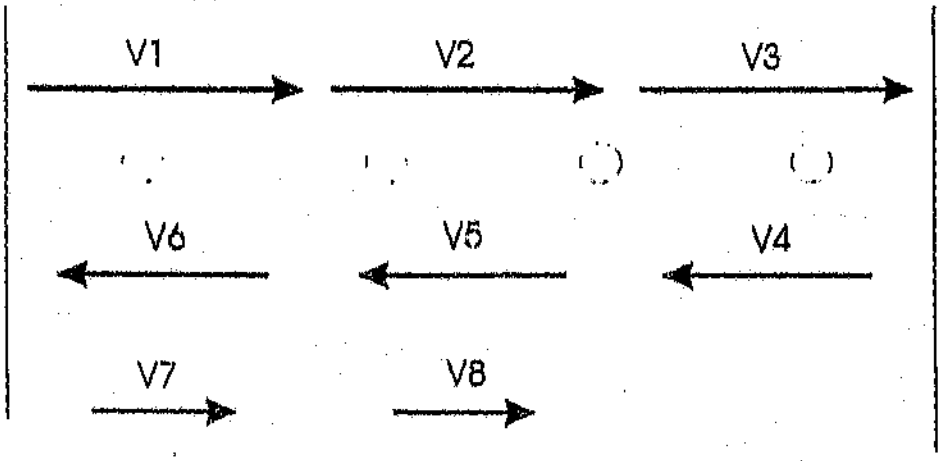
Diagnostic Questions and Answers

The questionnaire consisted of examples of real life motion to diagnose the students' understanding of motion in the following three areas:

1. Pictorial representation.
2. Drawing velocity and speed as vectors and scalars respectively.
3. Drawing and interpreting velocity-time and speed-time graphs.

The type of questions used were multiple-choice, open-ended, construction and interpretation. The question types were chosen in an attempt to supplement the weakness of one question by the other and to make the data more valid.

7. A ball rolls between two walls on a smooth floor. After rebounding, the ball loses loses a little velocity, but while moving moves with constant speed/velocity. A vector diagram of the motion is given below:



a.. Draw a velocity - time graph of the motion up until v8.

b Draw a speed - time graph of the motion up until v8.

****

(a) Which part of the graph represents the following?

(i) A constant velocity .....
(ii) A motion in a forward direction .....
(iii) A motion in a backward direction .....

(b) Change the graph by a dotted line so that it may represent a speed - time graph.

(c) Use the graph to describe a situation in real life represented by the graph :

.....
.....
....
.....
.....

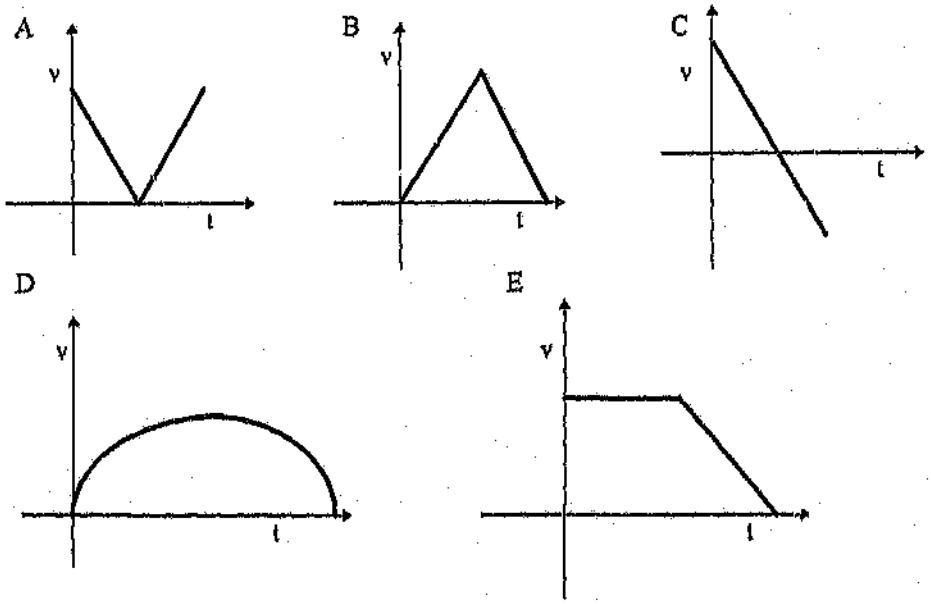
(d) Represent the motion in the graph in real life, in vector diagram

5. A child on a swing has a speed zero m/s at the top e.g.

(a) Draw a speed - time graph for the child on the swing.
(b) Draw a velocity - time graph.

(a). (b)

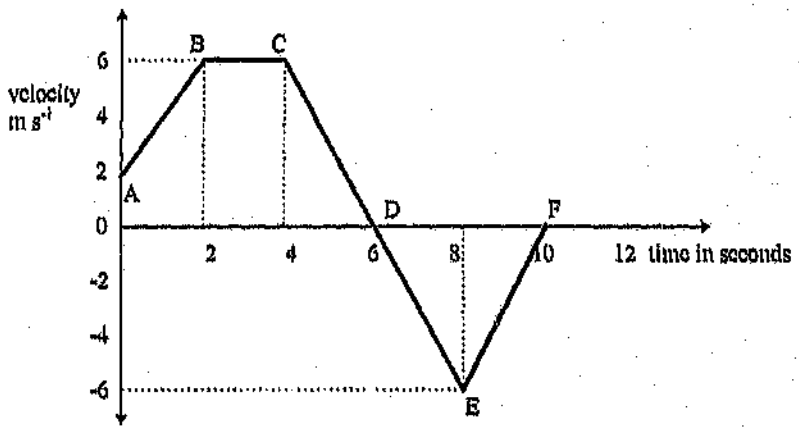
3.4. Study the following graphs and answer the questions asked.

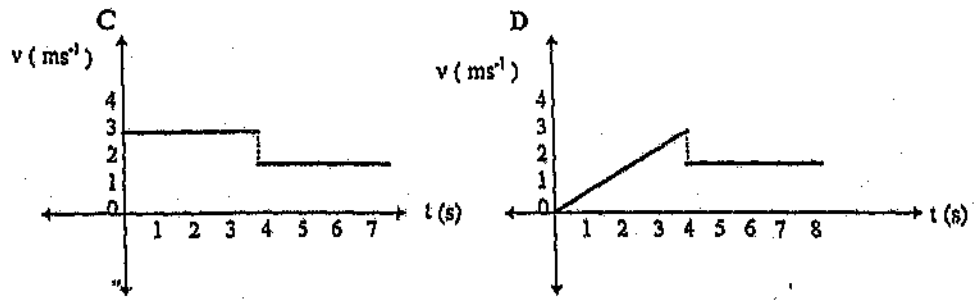


Which one of the above best represent the ball thrown upwards?

(a) Speed - time graph .....
(b) Velocity - time graph. .....

4. The motion of an object is represented by the following velocity - time graph.





Objects changing direction. Constant acceleration.

3. Consider a ball thrown straight up into the air and caught as it falls back.

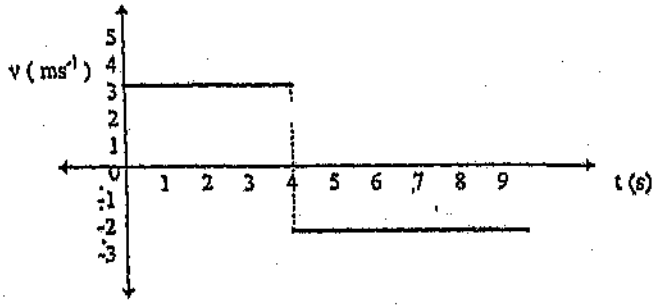
3.1. Draw a picture of the motion of the ball:

3.2. In which positions does the ball have the highest speed?

3.3.1. Draw the vector of the velocity at half way going up.

3.3.2. Draw the vector of the velocity while the ball is caught.

2.



2.1 Which one of the following is the best real motion of the graph of the object A?

(i) A ball is dropped from the top of a building.
(ii) A ball is thrown vertically upwards. V = 3 m./s.
(iii) Motion of a car when it has attained a constant speed of 3 m/s.
(iv) A marble ball is rolled with 3 m/s along a horizontal hard smooth surface of marble. The ball strikes a wall and rebounds back towards the origin.

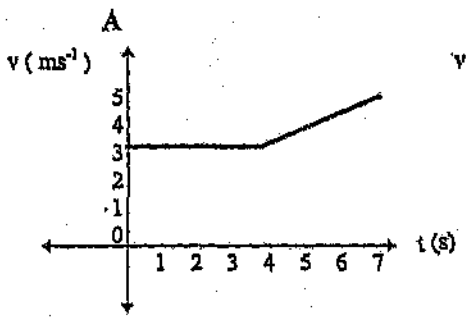
2.2.1. What is the velocity of the object A, at 4s and 6s?

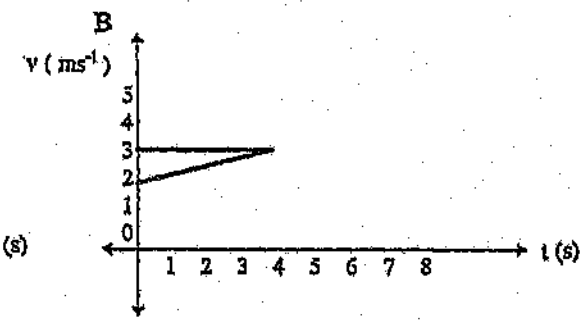
....

2,2.2. Can you say what is the velocity after 5 hours, if only time changes .....

2.3. What is the speed of the object A at 4s. .....

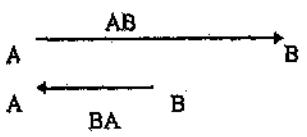
2.4. The following are the sketches of the speed versus time graph of the object A. Choose the correct one .....



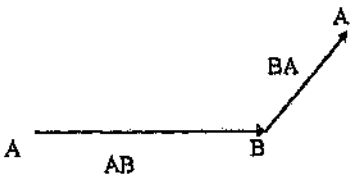


1.2. which one of the following represents the vector diagram of the above motion

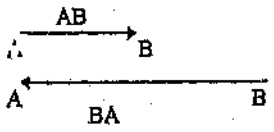
A.



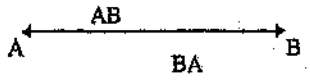
B.



C.



D.

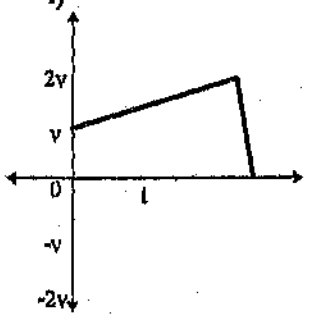


1.3. Which one of the following is the correct graphical representation of the motion? Write the correct Roman number.

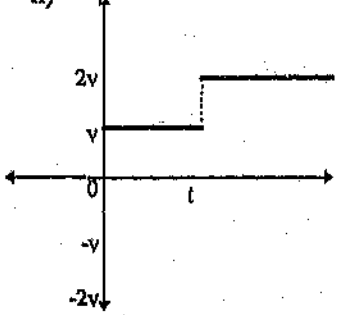
(1) Velocity versus time. .....

(2) Speed versus time. .....

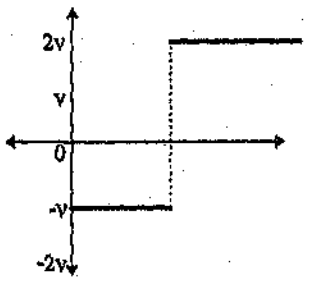
i)



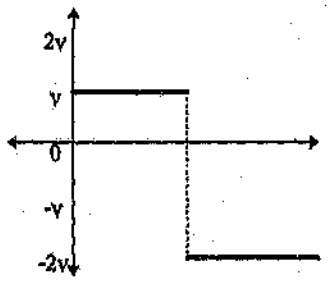
ii)



iii)



iv)



Appendix: A

QUESTIONNAIRE

Dear students,

The questions below are designed to investigate the preconceptions, conceptions and misconceptions in the field of motion. The focus is on real motion, related vector understanding and graphical representations and interpretations in respect of velocity-time and speed time graphs.

Try to answer all the questions to the best of your understanding and capabilities. Feel free your scripts shall remain anonymous.

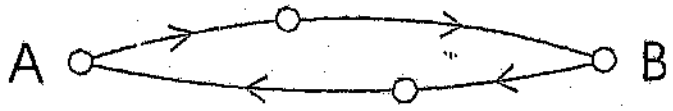
COURSE. SPTD / STD 1/2/3.

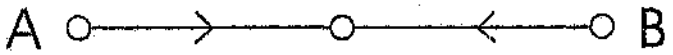
Name. .....

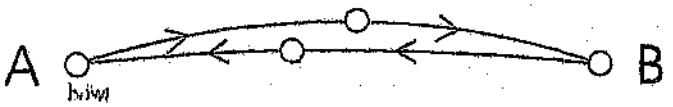
Objects changing direction. Constant velocity.

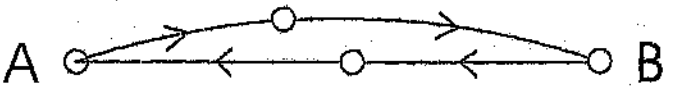
1. A tennis player A hits a ball with velocity V. After being hit by the opposite player B, the ball returns to the player A with velocity 2V.

1.1. Which one of the following represents the motion best?

A 

B 

C 

D 

Investigation of student understanding of the concept of acceleration in one dimension." American Journal of Physics, 49, 242-253.

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University of Zimbabwe.

Mackay, J. R. (1993), " An investigation into some High School pupils' ideas of speed and acceleration." Unpublished M. Sc. research report, University of the Witwatersrand , Johannesburg.

Mathison, S. 1988, " Why Triangulate." Educational Researcher, March 1988, 13-16.

McDermott, L. C., Rosenquist, M. L. and Van Zee E. H. (1987), " Students difficulties in connecting graphs and physics : Examples from kinematics." American Journal of Physics, 55(6), 503-513.

Osborne, R. and Gilbert,J.K. (1980), " A technique for exploring students ' views of the world." Physics Education, 15, 376-379.

Piaget, J. (1970), " The Child's Conception of Movement and Speed." Ballantine: New York.

Ravan, R. J. (1972), " The development of the concept of acceleration in elementary school children." Journal of Research in Science Teaching, (3), 201-206.

Schultz, K. and Clement, J. and Mokros,J., (1986), "Adolescents' Graphing Skills: A descriptive analysis." A Research Report. University of Massachusetts.

Trowbridge, D. E. and McDermott, L. C. (1980), " Investigation of student understanding of the concept of velocity in one dimension." American Journal of Physics, 48, 1020-1028.

Trowbridge, D. E. and McDermott, L. C. (1981), " Investigation of student understanding of the concept of

Question 3.4. (b) Velocity-time graph

Table 15 Students' answers for question 3.4. (b)

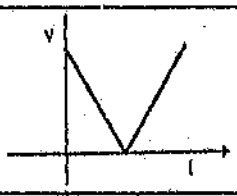
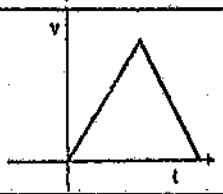
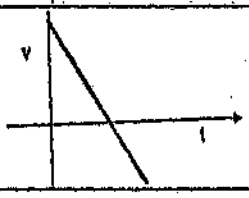
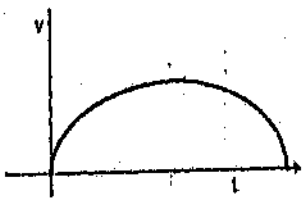
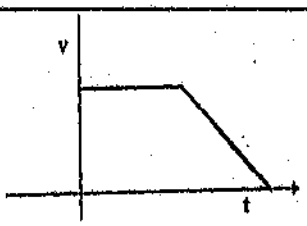
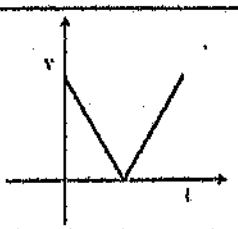
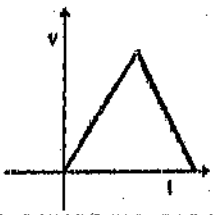
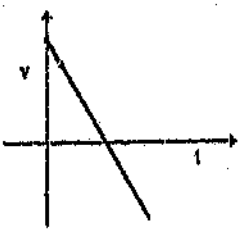
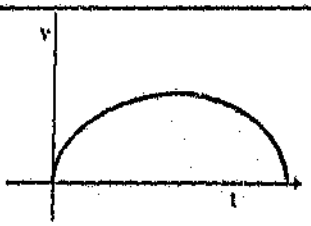
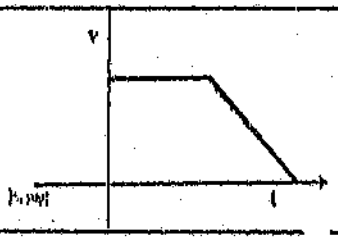
Which one of the graphs below best represent the ball thrown upwards? 3.4. (b) Velocity-time graph ...			
choices	answers		%
A. 	8	X	10
B. 	18	C	23
C. 	23	X	29
D. 	13	X	16
E. 	15	X	19
No Idea	2	X	3
TOTAL	79		100

Table 14 Answers chosen by students in question 3.4 (a)

Which one of the following best represents the ball thrown upwards? 3.4.(a) Speed-time graph			
choices	answers		%
A. 	18	C	23
B. 	26	X	33
C. 	12	X	15
D. 	20	X	25
E. 	2	X	3
TOTAL	79		100

Question 3.4

Study the following graphs and answer the questions asked. In two sub-sections the aim is to test the understanding of velocity-time and speed-time graphs of the motion of the ball thrown upwards. Students are asked to choose the correct graph from the given four choices.

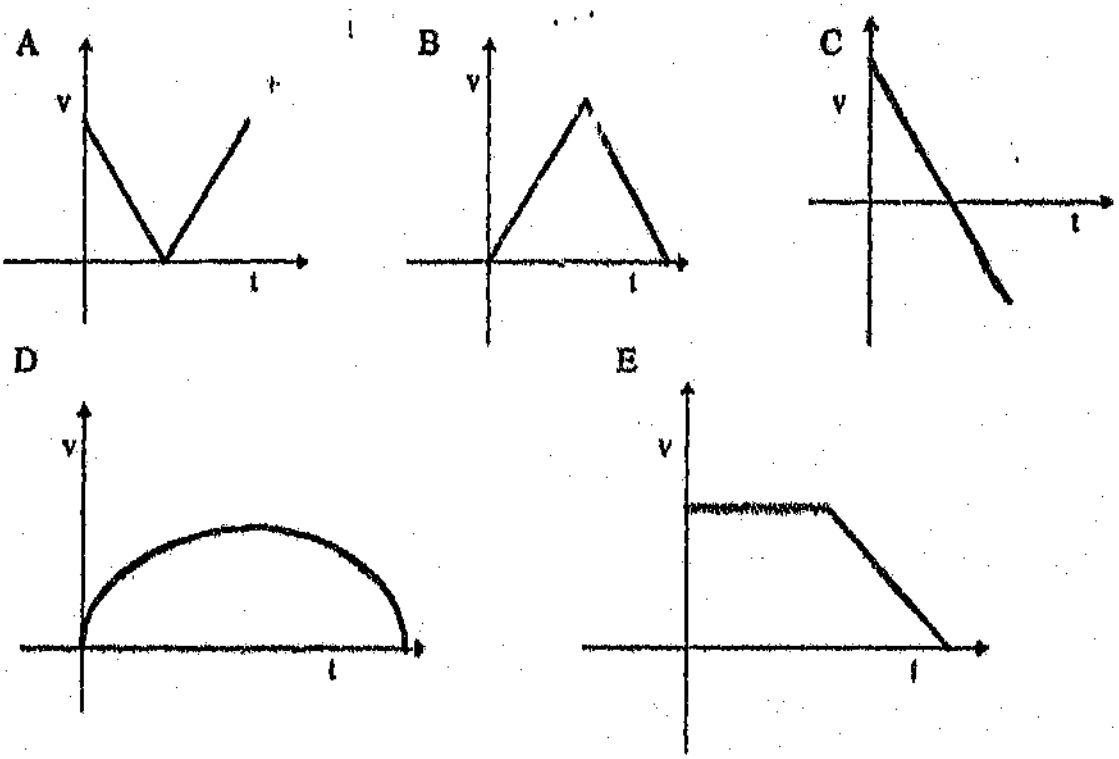


Figure 2 Graphs of the ball thrown upwards

Table 12 Students' answers for question 3.3.1

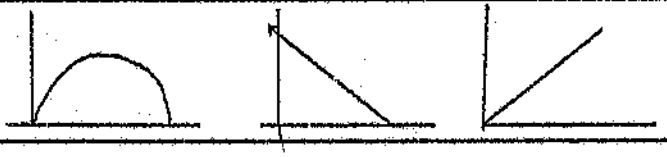
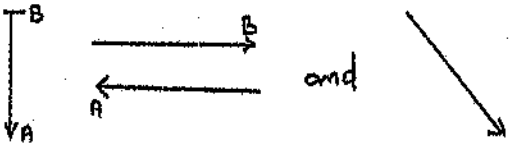
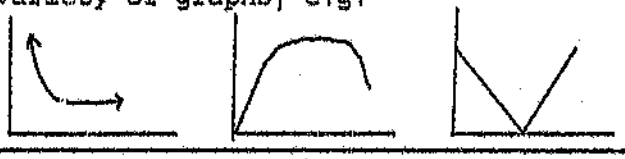
3.3.1. Draw the vector of the velocity at half-way going up.			
Answers given by students. (Summary)	answers		%
A. 	25	C	32
B. 	39	X	49
No answer	15	X	19
TOTAL	79		100

Table 13 Students answers for question 3.3.2

3.3.2. Draw the vector of the velocity while the ball is caught.			
choices	answers		%
A. 	28	C	35
B.(variety of graphs) e.g. 	38	X	48
No answer	13	X	16
TOTAL	79		100

Question 3.2.

It aims at students' understanding of motion of the ball at different positions while going up and coming down.

Table 11 Students answers for question 3.2

Which places does the ball have the highest speed ?			
choices.	answers		%
A. i) When thrown ii) When caught	23 6	C	29 8
B. At the top upward	8	X	1
C. Downward motion	21	X	27
D. Velocity remains constant	3	X	4
Half-way up and half-way down	4	X	5
No answer	14	X	18
TOTAL	79		100

Question 3.3.1

The two ideas to be tested in this part are velocity at half way up and the line vector diagram of the velocity. The table 12 shows the answers given by the students.

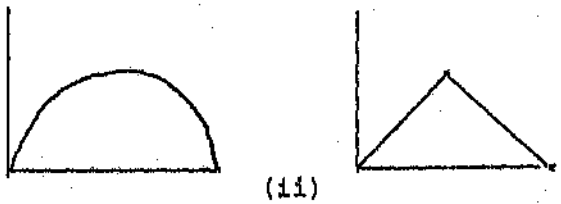
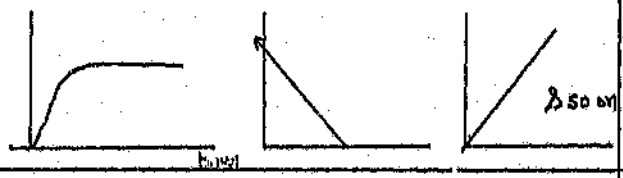
Question 3.3.2.

This section aims to test whether the students can make out the difference between magnitude and direction of the velocities between two positions of the motion namely: halfway going up and when the ball is caught. Secondly the ability to draw the line vector of the velocity. Students' answers are given in table 13.

caught as it falls back. The ball reaches the maximum height and it accelerates as it falls under gravity. It is assumed that the initial and final velocities are the same.

Question 3.1. In this part pictorial representation is the main thrust to be tested. Students need to correlate the changing velocities of the ball at various positions of time during the motion and based on this to draw a picture.

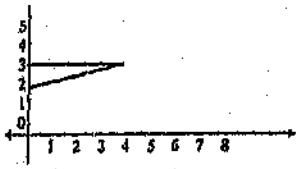
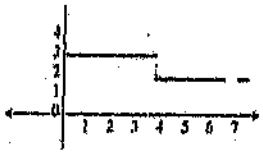
Table 10 Students' answers for question 3.1

3.1 Draw a picture of the motion of the ball.			
choices	answers		%
A. 	23	C	29
B. 	9	C*	11
C.  (i) (ii)	22	X	19
D. 	15	X	28
No idea and random lines as graphs	10	X	13
TOTAL	79		100

Question 2.4.

The speed-time graph of the object A is given in four options. It is aimed to test the understanding of the scalar nature of the speed and its meaning in graphical representation.

Table 9 Speed versus time graph of the object A

The following are the sketches of speed vs time graph of the object A. Choose the correct one.			
choices	answers		%
A. 	25	X	32
B. 	13	X	16
C. 	25	C	32
D. 	14	X	18
No answer	2	X	3
TOTAL	79		100

Analysis: Question 3

Consider a ball thrown straight upwards into the air and

Question 2.2.2.

This question aims to test the understanding or concept related to uniform velocity and the meaning of a graph parallel to the time-axis or in general the X-axis.

Table 7 Answers of question 2.2.2 as given by students

2.2.2 Can you say what is velocity after 4s if only time changes.			
several answers appeared.	answers		%
-2cm/s	14	C	18
2cm/s	5	X	6
0.5cm/s	5	X	6
0cm/s	4	X	5
no idea or irrelevant	51	X	65
TOTAL	79		100

Question 2.3.

Table 8 Answers of question 2.3 as given by students

2.3 What is the speed of the object A in figure (3.1) at 4s.			
choices (cm/s)	answers		%
0	3	C	4
3	18	C*	23
0.75	17	X	22
1	5	X	6
no idea or irrelevant	46	X	58
TOTAL	79		100

Analysis: Question 2.1

The four options based on the interpretation of the graph above, aim to test the ability of the students to choose the right physical reality of the graph. The graph has a constant positive velocity up to the first four seconds and at the fourth it is zero. Immediately after the fourth second the graph gives a negative constant velocity of 2V which is less than the previous velocity before the fourth second.

Question 2.2.1. The question tests the conceptual knowledge of the shapes of graphs namely (a) the discontinuity in graphs when the direction of motion is reversed; (b) secondly the negative values of the range with positive domains.
[This is an open ended question testing the capability of a student reading the graph].

Table 6 Answers of question 2.2.1 by students

velocity at 4s.				velocity at 6s.			
answers(m/s)	no. of stud.		%	answers (cm/s)	no of stud.		%
3	17	C*	22	-2	8	C	10
-2	9	C*	11	2	7		9
3cm/s	5	C*	6	0.5	3	X	4
0m/s	7	C	9	0	6	X	7
0.75 =3/4m/s	12	X	15	no idea	55	X	70
2cm/s	8	X	10		-	-	-
40cm/s	3	X	4		-	-	-
no idea	18	X	23		-	-	-
TOTAL	79			TOTAL	79		

Question 2 Analysis :

In this question a graphical representation of the motion of an object A is given below as:

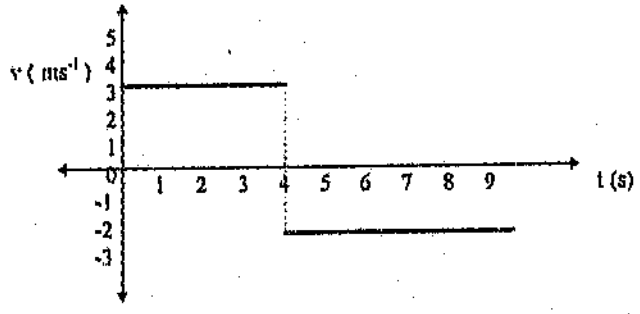


Figure 1 Velocity-time graph of an object A

Table 5 Motion of the object 'A' in real life as interpreted from graph

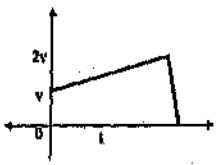
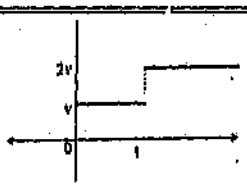
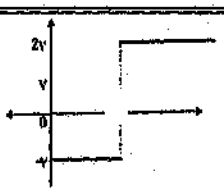
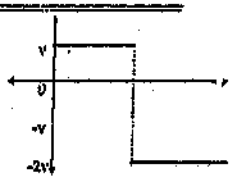
Which of the following is the best real motion of the graph of the object A in figure 1. ?			
choices	answers		%
i. A ball is dropped from the top of a building	5	X	6
ii. A ball is thrown vertically upwards. V=3 m/s	10	X	13
iii. Motion of a car when it has attained a constant speed of 3 cm/s	22	X	28
iv.A marble ball is rolled with 3 m/s along a horizontal hard smooth surface of marble. The ball strikes the wall and rebounds back to the origin	39	C	49
No answer	3		4
TOTAL	79		100

Analysis: Question 1.3 (1)

Velocity vs time graph.

It aims to see the ability to translat. the picture of a given motion into velocity/time graphs and to use the negative axis for reverse velocities. The second idea was to observe the vector difference of speed and velocity and its effect on graphical representations.

Table 4 Question 1.3. (2) speed/time graph

choices: speed/time graphs of the tennis ball	answers		%
(i) 	19	X	24
(ii) 	14	C	18
(iii) 	3	X	4
(iv) 	7	X	9
no answer	36		46
TOTAL	79		100

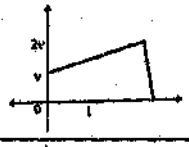
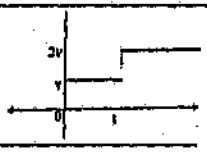
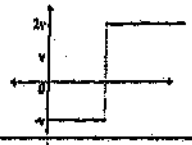
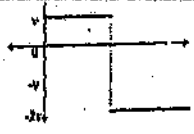
Analysis: Question 1.2

In this part the motion of the tennis ball is presented in four options of vector diagrams. The aim is to test students' conceptual understanding of velocity as a vector in real life motion. Another area, to investigate was the students' abillty to represent velocity by using directed straight lines as vectors (length of the line representing magnitude and the arrow as direction).

Question 1.3: Graphical analysis of real motion.

Table 3 Students performances in Question 1.3 (1)

A tennis player A hits a ball with velocity v. After being hit by the opposite player B, the ball returns to the player A with velocity 2V.
1.3 Which one of the following is the correct graphical representation of the above motion?

choices for : (1) velocity vs time		answers		%
i.		17	X	22
ii.		17	X	22
iii.		5	X	6
iv.		34	C	43
no answer		6		8
TOTAL		79		100

APPENDIX C

RESPONDENTS OF CORRECT ANSWERS

In this section the list of respondents of correct answers in questions 1, 2 and 3 are prepared. The list helps to find out the common respondents of the correct answers and to assess the ratio of correct answers in different questions and the sub-questions.

Respondents of the correct answers in questions 1, 2 and 3 below are represented by their code numbers.
(The codes were allocated to the respondents when they answered the questionnaire.)

Question 1.

Pictures (N=20)

1.1. 8, 12, 21, 24, 26, 31, 32, 34, 36, 37, 39, 57, 63, 64, 67, 69,70, 72, 76, 79.

Vectors (N=31)

1.2. 3, 5, 6, 7, 10, 15, 16, 17, 21, 29, 32, 34, 35, 37, 38,40, 41, 42, 48, 49, 52, 54, 56, 60, 63, 64, 65, 70, 71, 72, 73.

Graphs.

1.3 (i) Velocity/time (N=34)
1, 3, 5, 6 ,7, 10, 11, 12, 13, 15, 18,19, 20, 24, 25,27, 33, 38, 41, 42, 43, 51, 53, 54, 56, 57, 59, 65,66,69, 70, 72, 74,79.

(ii) Speed/time (N=14)
11, 12, 13, 18, 22, 23, 27, 33, 35, 43, 47, 63 73,79.

Question 2.

Table 25 Examples of graphs as vectors

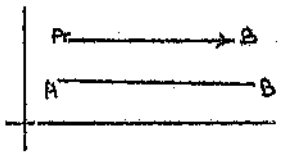
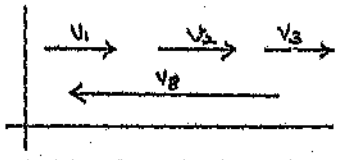
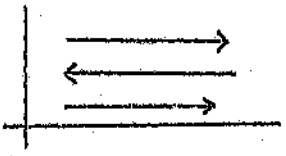
students' code	graphs
24	
7	
2	

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Table 24 Students' answers for question 7b

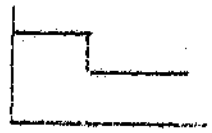
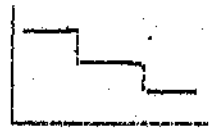
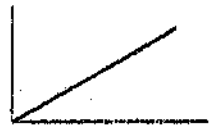
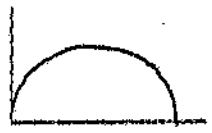
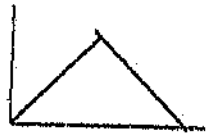
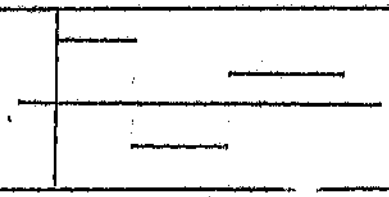
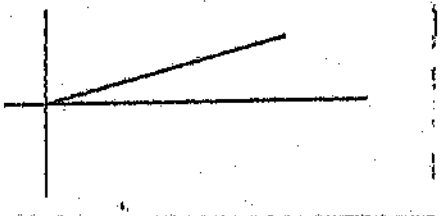
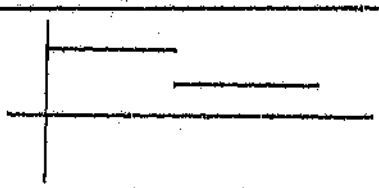
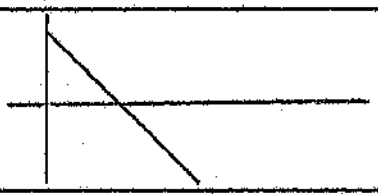
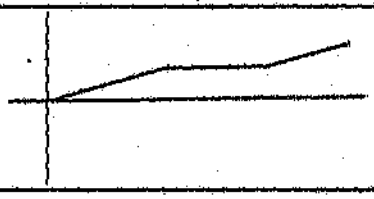
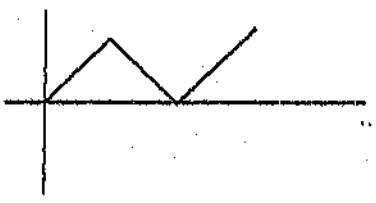
7. (b). Draw a speed - time graph of the motion.		No.	%
	C*	3	4
	C	1	1
	X	13	16
	X	6	8
	X	5	6
	X	4	5
irrelevant	X	47	59
TOTAL		79	100

Table 23 Answers given by students for question 7a

a) Draw a velocity /time graph of the motion above until V8.		No.	%
	C	4	5
	X	10	13
	X	6	8
	X	3	4
	X	4	5
(graphs starting from zero)	X	12	15
	X	3	4
other graphs make no meaning	X	24	30
TOTAL		79	100

Analysis: Question 7

A motion between two walls is described through vector diagrams. Students are expected to understand the motion in reality. The question aims at testing the understanding of the motion through line vectors and putting the understood motion in graphs. For this purpose velocity-time and speed-time graphs have been asked in its two sub-sections. The focal area of testing is where the swing motion changes its direction in reverse and when it slows down.

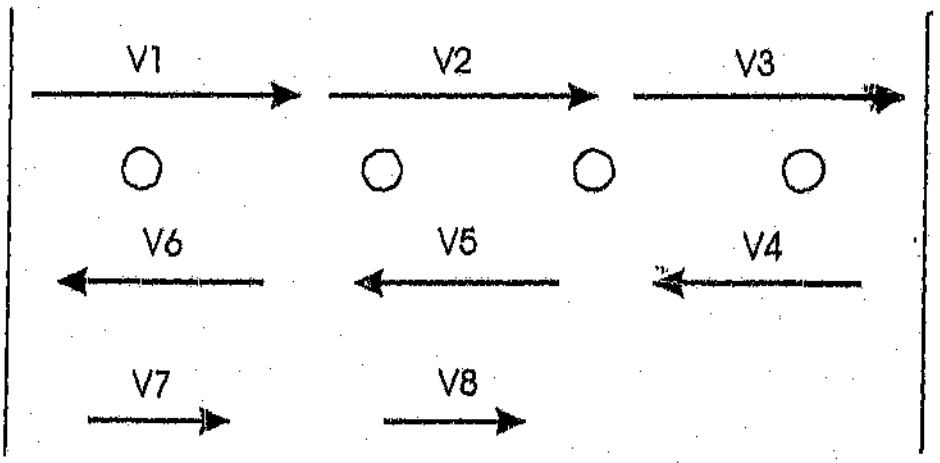


Figure 4. Vector diagram of the motion of a ball between two walls

Table 22. Students answers for question 5(b)

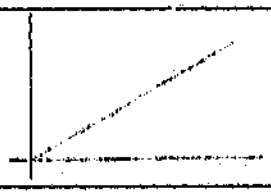
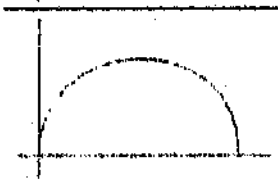
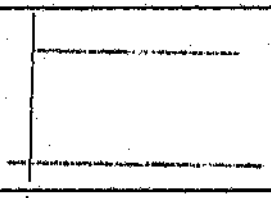
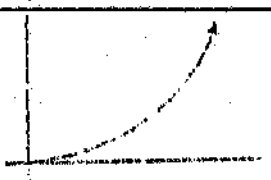
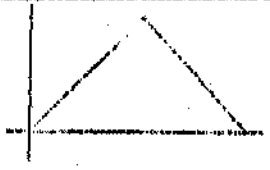
5 (b) Swing : Velocity - time graph.		No	%
	X	14	18
	X	3	4
	X	4	5
	X	7	9
	X	7	9
	X	6	8
	X	7	9
irrelevant random line	X	31	39
TOTAL		79	100

Table 21 Students answers for question 5 (a)

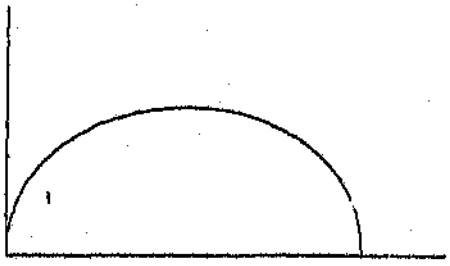
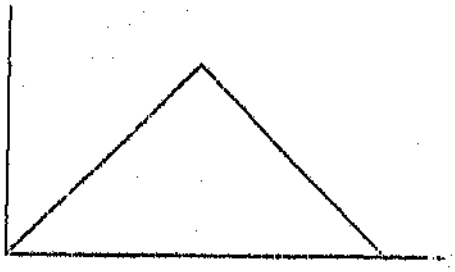
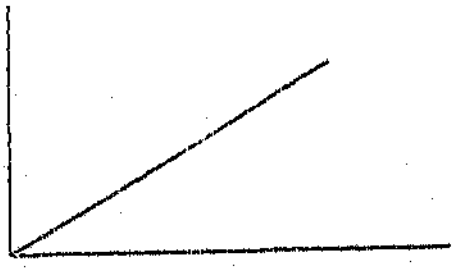
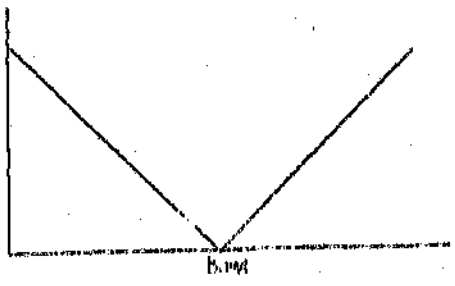
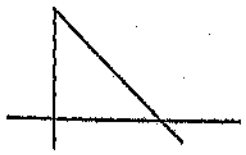
(a). Draw a speed-time graph for the child on the swing.		No.	%
	C	13	16
	X	9	11
	X	8	10
	X	13	16
No significant meaning.	X	36	46
TOTAL		79	100

Table 20 Question 4 (d)

4.(d). Represent the motion in the graph in real life vector diagram.		No	%
no idea	X	65	82
As graph starting from zero	X	2	3
	X	1	1
Others making lines and arrows with no sense	X	11	14
TOTAL		79	100

Analysis: Question 5.

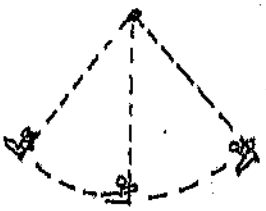


Figure 4 Motion of a child on a swing

The question is from a daily life reality. It aims to test:

i) the understanding of changing direction as well as magnitude of the motion of the swing with time and various physical positions occupied by the swing during the motion.

ii) the ability to draw the corresponding graph of such motion in form of (a) speed-time and (b) velocity-time.

Table 19 Question 4 c Use the graph to describe a situation in real life represented by the graph

answers		No.	%
Speed increase as time increases	X	5	6
Objects accelerates uniformly from rest	X	21	26.5
A girl is throwing a stone along a wall-drop {upward and top-down}	X	2	2.5
AB - car accelerates BC - moves with constant velocity CD - decelerates DE - accelerating in opposite direction EF - decelerates in forward direction	X	22	28
no answer	X	29	37
TOTAL		79	100

Question 4 (d)

The aims of this activity are:

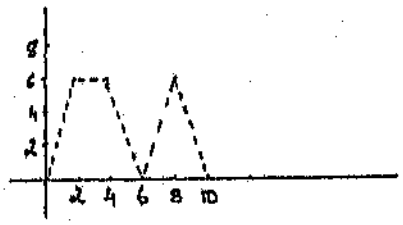
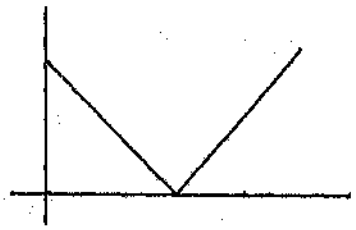
i) to test the ability to make out vectorial meaning from a graphical representation of a motion.
ii) to test the understanding of vector diagrams in the perspective of changing magnitudes and changing directions.

The students' answers shown in table (20) reveals a very poor understanding on the part of the students. No student could draw the vector diagrams. 65 students came with no idea. Two answered in the form of graphs starting from zero as in the previous questions. We can infer that students have poor understanding of vectors, especially when ideas have to be drawn from a graphical representation.

Question 4 (b)

This question aimed to investigate: the understanding of the graph of velocity and the changes needed when the same converts to speed or the effect on the graph when only magnitude changes with time.

Table 18 Question 4. (b) Amend the graph by dotted line so that it may represent a speed-time graph

answers		No.	%
	C	0	0
	X	9	11
no idea or irrelevant	X	70	89
TOTAL		79	100

Question 4 (c)

This part aims to test the understanding and interpretive ability of a student on graphical representation in a real physical situation.

None of the answers given by students showed a sensible meaning of the graphs in real life. It simply indicates that the students have difficulty in interpreting the segments of the given graph in reality.

Question 4 (a).(ii) Motion in the forward direction.

Table 16 Answers for question 4 (a) (ii) given by students

answers		No.	%
A to D	C	8	10
AB	C*	43	54
BC	C*	6	8
AB and EF	X	4	5
CD	X	3	4
AC	X	3	4
EF and DF	X	3 + 3	8
no idea and irrelevant	X	6	8
		79	100

Question 4 (a) iii) Motion in backward direction.

Table 17 Students' answers for question 4 (a) (iii)

answers		No	%
DF	C	6	8
DE (only)	C*	23	29
CE	X	15	19
EF	C*	10	24
No ideas	X	25	32
TOTAL		79	100

Analysis: Question 4.

The motion of an object is represented by the following velocity-time graph. The four sub-sections of the question are designed to show the understanding of the various parts of the graph. Section (a) again has three sub-sections and tests three ideas represented by the graph i.e. constant velocity, forward motion and [illegible]ward motion. In section (b) the speed-time graph from a [illegible]y-time is the main thrust. Section (c) is designed to test the understanding of the graph in physical real motion. And the fourth section tests the understanding of the graph in terms of vector diagrams. Understanding the graph includes the ability to draw narrative information from the segments of the graph at one place and from the whole graph at another.

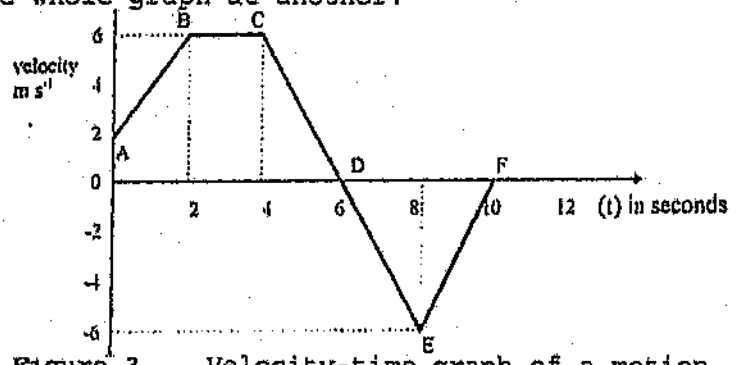


Figure 3 Velocity-time graph of a motion

4.(a) Which part of the graph represent the following:

Table 15 Question 4 (a).(i) A constant velocity

answers		No.	%
BC	C	65	82
AB	X	12	15
Upper part	X	2	3
TOTAL		79	100

58. S. It is thrown straight upwards into the air and is caught as it falls back. Yes I think the motion will be like this (he draws) straight upwards and it comes back again.

Figure: B1's understanding of the motion of the ball

59. I. Yeah.

60. S. Yes.

61. I. All right, what can you say more about this motion?

62. S. Which motion?

63. I. This thrown ball, meaning how does it go and how does it come? Can you say something more?

64. S. How does it go and how does it come (he repeats)?

65. I. What can you say more about this?

66. S. Just high light me about this velocity or ..

67. I. About the whole motion.

68. S. Oh! About the whole motion. Will they throw it with a higher velocity?

69. I. Oom hmm.

70. S. Yes then when it goes upwards, because of the gravitational force which act against the ball the ball starts to decrease in the velocity until the velocity is zero and then it returns back again. And when it returns it increases and increases .... I don't know how can I explain this.

71. I. Well, that you have explained.

72. S Until it reaches down.

73. I. Yes good, let us see some mathematical operation on this, like what is here? Read it.

74. S. In which position does the ball have the highest speed? In which position ....(he reads again).

75. I. Yes.

76. S. Yes. Ah, when it goes upward:. in fact, how can I explain this? From the thrower's hand, few metres from the thrower's hand upwards . When it returns backwards again on the same level, is where the ball is going to have the highest speed.

77. I. Yes.

36. S. Of acceleration? In fact I have got the idea because in terms of acceleration, does not have a direction. It does not have the direction.

37. I. Humm.

38. S. Yes.

39. I. Then.

40. S. We are going to consider only the motion, only the velocity. We are going to consider only the velocity, I think so.

41. I. Suppose this (a piece of chalk) is the ball, throw it.

42. S. Upwards? (He throws the piece of chalk).

43. I. Yes, and catch it. ... what?

44. S. It goes upwards stops and returns again.

45. I. So do you understand how it goes upwards and comes back?

46. S. Yes I understand.

47. I. Then draw the picture, the pictorial representation. Suppose you have to say it in picture, how will you say it?

48 S. If they say to draw , I think I will represent it as like this. (Draws a picture). To turn again ...

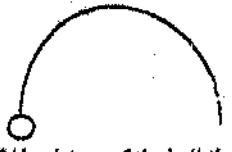


Figure: B1's picture of the ball thrown upwards

49. I. Yes.

50. S. With constant acceleration.

51. I. No this (constant acceleration) is not related this.

52. S. It is not related to this? Is it a topic?

53. I. Hum, it is just a type of topic. The question starts from here.

54. S. The question starts from here?

55. I. Hum.

56. S. I just consider when the ball is thrown up?

57. I. Yes.

14. S. When the ball is thrown into the air and caught as it falls back. Constant acceleration, that means that the ball was just moving with the same velocity from the throwers hand to upward until it comes back again.

15. I. Well that constant acceleration is just a type of direction that is not necessary. But you have to think about the ball only.

16. S. The ball only?

17. I. Yes the ball is thrown up and it is caught when it comes back, then how do you consider the motion?

18. S. The motion?

19. I. Hun.

20. S. To draw the motion of the ball.

21. I. Yes.

22. S. It is thrown upwards then when it comes back it is caught again.

23. I. The thrower catches it.

24. S. With the constant velocity? No with the constant acceleration (Repeats twice himself). I must draw what? Constant acceleration or what?

25. I. No no, you draw the picture of the motion of the ball.

26. S. The vector?

27. I. No the picture.

28. S. The picture?

29. I. Yes.

30. S. OK the ball is thrown upwards, aamm with the constant acceleration, with the constant acceleration, meaning that when the time, aamm it move with this, when it move with constant acceleration, it increase.

31. I. How does...?

32. S. This is the, hurre..., it increase with the same....

33. I. Where do you get the constant acceleration?

34. S. Constant acceleration, we get constant acceleration when the object moves with constant velocity.

35. I. Well, but in this case when the ball is thrown upwards do you have the idea of acceleration?

APPENDIX G

Example of Interview Transcript of B1 (excerpt)

TRANSCRIPT OF INTERVIEW B1

PHOLOTO DINGAAN AS B1

INTERVIEWER : D PANDEY

DATE : 22 Aug 1995, 3pm.

PLACE : Mamokgalake Cluene College of Education Groblersdal

Dingaan appeared as a sincere student not only in class but out of the class environment as well. When he performed well in the test, I decided to interview him for the proposed case study. I informed him of my intention and he agreed. He did not hesitate over his interview being audio-taped. The date was fixed three days later on the 22nd Aug 95 after lunch at 3pm at my office in the physical science laboratory well known to him.

During the August month in late winter it was still a bit chilly. After lunch I hurried to the laboratory and prepared for the interview with my tape recorder and opening questions. Dingaan knocked at the door just 3min to 3pm. I asked him to enter and he walked in, dressed simply with a jersey on. After greeting I offered him a seat nearby the Sony tape recorder and we were set for the interview.

1. I. So you are B1 & not Thobela.

2. S. Consider a ball thrown straight up into the air and caught as it falls back.

3. I. Oon Hun, can you make out the idea.

4. S. Ball thrown up. Consider a ball thrown straight up into the air and caught as it falls back. The question says objects changing direction (constant acceleration).

5. I. What is the question here?

6. S. Draw the picture of the motio n of the ball.

7. I. Yes. can you draw the picture?

8. S. The picture of the motion?

9. I. Yes.

10. S. Constant acceleration, constant acceleration..., (muttering and thinking).

11. I. Where is constant acceleration, when the ball is thrown, do you have any idea?

12. S. When the ball is thrown upwards?

13. I. Hun.

I give permission for PHOLOTO M SIMSHAN to participate in the Science learning study.

Parent or guardian

Student

07-08-95 1990
Date

I give permission for the interview tap to be used at the seminar or a conference on Science learning.

Yes I give permission for data to be used in this way.

K I do not give permission for data to be used in this way.

Parent or guardian

Student

APPENDIX - F

PARENTAL PERMISSION SLIP FOR STUDENT PARTICIPATION IN A SCIENCE LEARNING STUDY

A Science education project at the University of Massachusetts is conducting a study of factors that influence the learning of science . The study help us to design better science courses. We should like to request your permission to have our daughter or son participate in the study.

The study will involve two 30-40 minute interviews after school, and the students will be paid R10 per interview . Each student will be asked to solve some science problems concerning the use of levers in simple machines aloud in an interview.. The interviews will be audio or video taped. This allows us to keep an accurate record and to study the learning processes that occur.Students ' names will not be used in the reports of the study of the study and the results will not affect the students' grades. I shall use the interview data in my dissertation and for the contributions to the journals and conferences.All identities will be protected at all times.

Participation is voluntary and consent can be withdrawn at any time

Please sign and return this form if you wish to give your permission for participation in the study. Students usually find the problems interesting to solve.Please call me if you have any questions.

Dhruva Pandey ,(Lecturer(Physical Science)
Mamokgalake Ehlers college of education,
Motetema, P/Bag * 8678
GROBLERSDAL 0470
Tel 013-2690034
013-2690378

how

(24) No : 44 = 1
(25) 1,25 : 47 = 1
(26) The time will change : 48 = 1
(27) 0.6m/s : 58 = 1
(28) 1cm/s : 59, 79 = 2
(29) 166x10^-5m/s : 60 = 1
(30) 100km/h : 61 = 1
(31) Velocity changes : 72 = 1
(32) Velocity is accelerating : 75 = 1
(33) No answer : 8, 10, 21, 24, 27, 41, 42, 45, 46, 49, 50, 51, 54, 63, 68, 77, 78 = = 1
Total = 79

2.3. (1) 3m/s : 1, 3, 4, 5, 15, 24, 26, 36, 42, 52, 53, 54, 64, 65 = 14
(2) 3cm/s : 2, 8, 59, 30 = 4
(3) 3/4m/s : 6, 14, 29 = 3
(4) 0.75m/s : 7, 12, 18, 19, 22, 27, 32, 35, 37, 38, 46, 47, 50, 58 = 14
(5) 0.2m/s : 9 = 1
(6) 4m/s : 78 = 1
(7) 2m/s : 11 = 1
(8) 12m/s : 13, 17, 57 = 3
(9) 1m/s : 16, 51, 56 77, 79 = 5
(10) 30m/s : 20 = 1
(11) 1200m/s : 23 = 1
(12) 1,05m/s : 25 = 1
(13) 0,86m/s : 28 = 1
(14) 12cm/s : 31 = 1
(15) 5m/s : 33.80 = 1
(16) 10m/s : 39 = 1
(17) -2m/s : 40 = 1
(18) 8m/s : 44 = 1
(19) 80m/s : 48 = 1
(20) Uniform speed : 55 = 1
(21) 0,007m/s : 60 = 1
(22) 20m/s : 61, 76 = 2
(23) 39,2m/s : 63 = 1
(24) 1.25m/s : 66, 72 = 2
(25) 0m/s : 67, 70, 74 = 3
(26) 0,5m/s : 68 = 1
(27) 0,45m/s : 69, 75 = 2
(28) 40m/s : 71 = 1
(29) No answer : 10, 21, 34, 41, 43, 45, 49, 73 = 8 Total = 79

2.4. A : 4, 5, 14, 18, 23, 24, 25, 31, 36, 39, 41, 42, 43, 45, 47, 49, 50, 51, 61, 63, 64, 67, 68, 71, 72 = 25
B : 8, 10, 16, 46, 55, 56, 60, 73, 76, 77, 78, 79, 80 = 13
C : 2, 9, 11, 15, 19, 20, 22, 26, 27, 28, 29, 33, 35, 37, 38, 48, 53, 54, 57, 58, 65, 66, 69, 70, 74 = 25
D : 1, 6, 7, 12, 13, 17, 21, 30, 32, 34, 40, 44, 52, 75 = 14 Total = 79

****

(24) No : 44 = 1
(25) 1,25 : 47 = 1
(26) The time will change : 48 = 1
(27) 0.6m/s : 58 = 1
(28) 1cm/s : 59, 79 = 2
(29) 166x10^-5m/s : 60 = 1
(30) 100km/h : 61 = 1
(31) Velocity changes : 72 = 1
(32) Velocity is accelerating : 75 = 1
(33) No answer : 8, 10, 21, 24, 27, 41, 42, 45, 46, 49, 50, 51, 54, 63, 68, 77, 78 = = 1
Total = 79

2.3. (1) 3m/s : 1, 3, 4, 5, 15, 24, 26, 36, 42, 52, 53, 54, 64, 65 = 14
(2) 3cm/s : 2, 8, 59, 30 = 4
(3) 3/4m/s : 6, 14, 29 = 3
(4) 0.75m/s : 7, 12, 18, 19, 22, 27, 32, 35, 37, 38, 46, 47, 50, 58 = 14
(5) 0.2m/s : 9 = 1
(6) 4m/s : 78 = 1
(7) 2m/s : 11 = 1
(8) 12m/s : 13, 17, 57 = 3
(9) 1m/s : 16, 51, 56 77, 79 = 5
(10) 30m/s : 20 = 1
(11) 1200m/s : 23 = 1
(12) 1,05m/s : 25 = 1
(13) 0.86m/s : 28 = 1
(14) 12cm/s : 31 = 1
(15) 5m/s : 33.80 = 1
(16) 10m/s : 39 - 1
(17) -2m/s : 40 = 1
(18) 8m/s : 44 = 1
(19) 80m/s : 48 = 1
(20) Uniform speed : 55 = 1
(21) 0.007m/s : 60 = 1
(22) 20m/s : 61, 76 = 2
(23) 39,2m/s : 63 = 1
(24) 1.25m/s : 66, 72 = 2
(25) 0m/s : 67, 70, 74 = 3
(26) 0.5m/s : 68 = 1
(27) 0,45m/s : 69, 75 = 2
(28) 40m/s : 71 = 1
(29) No answer : 10, 21, 34, 41, 43, 45, 49, 73 = 8 Total = 79

2.4. A : 4, 5, 14, 18, 23, 24, 25, 31, 36, 39, 41, 42, 43, 45, 47, 49, 50, 51, 61, 63, 64, 67, 68, 71, 72 = 25
B : 8, 10, 16, 46, 55, 56, 60, 73, 76, 77, 78, 79, 80 = 13
C : 2, 9, 11, 15, 19, 20, 22, 26, 27, 28, 29, 33, 35, 37, 38, 48, 53, 54, 57, 58, 65, 66, 69, 70, 74 = 25
D : 1, 6, 7, 12, 13, 17, 21, 30, 32, 34, 40, 44, 52, 75 = 14 Total = 79

****

0.15m/s : 22 = 1
20m/s : 27, 61 = 2
0.3m/s : 32 = 1
6m/s : 38 = 1
40m/s : 43, 69, 71 = 3
0.0075m/s : 60 = 1
uniform : 75 = 1
No answer : 16, 41, 45, 49, 77, 78 = 6 Total = 79

At 6sec :

2m/s : 5, 17, 26, 31, 36, 53, 56, 65, 67, 72, 74, 76, 79, 80 = 14 uniform : 75 = 1
0m/s : 12, 14, 24, 73 = 4
60m/s : 69, 71 = 2
2m/s : 4, 11, 23, 52, 70 = 5
1.5m/s : 2, 3, 8, 9, 10 =5
0.005m/s : 60 = 1
0.5m/s : 18, 19, 37, 46, 58 = 5
5m/s : 48 = 1
1m/s : 47 = 1
60m/s : 43 = 1
0.3m/s : 35 = 1
0.33m/s : 28 = 1
-0.33m/s : 25 = 1
24m/s : 21 = 1
160m/s : 20 = 1
18m/s : 13 = 1
No answer : 6, 7, 15, 16, 22, 27, 29, 30, 32, 33, 34, 38, 39, 40, 41, 42, 44, 45, 49, 50, 51, 54, 55, 57, 59, 61, 62, 63, 64, 66, 68, 78 = 32 Total = 79

2.2.2 Velocity after 5h :
(1) 75cm/s : 1 = 1
(2) 3cm/s : 2 = 1
(3) Object is decelerating : 3 = 1
(4) Velocity is constant : 4, 12, 14, 35, 52, 55, 56 = 7
(5) 4km/h : 5 = 1
(6) 3m/s : 6, 29, 36 = 3
(7) 1.6x10^4 : 7 = 1
(8) 30km/h : 76
(9) v = 0 : 9, 17, 30, 38, 39, 73 = 6
(10) 2cm/s : 11, 57, 65, 70 = 4
(11) 600m/s^2 : 13 = 1
(12) -2m/s : 15, 26, 33, 53, 64, 66, 67, 74 = 8
(13) 1/60m/s : 16 = 1
(14) Velocity increases : 18 = 1
(15) 0.01m/s : 19, 28 = 2
(16) 1500m/s : 20 = 1
(17) Will remain same : 22, 34 = 2
(18) 1m/s : 23 = 1
(19) 0.016m/s : 25 = 1
(20) I don't know : 31, 32 = 2
(21) 0,03 : 37 = 1
(22) -3m/s : 40 = 1
(23) 3000m/s : 43, 69, 71 = 3

APPENDIX E
QUESTIONNAIRE ANALYSIS QUANTITATIVE
(Example of the analysis : the numbers shown are the codes allocated to individual students)
NB : Code 62 is not allocated.

Q1. 1.1 A : 1, 3, 4, 5, 6, 11, 25, 27, 35, 41, 58, 59, 68, 78, 80 = 15
B : 13, 18, 20, 22, 30, 42, 44, 45, 46, 47, 49, 53, 54, 55, 65, 66, 71, 75 = 18
C : 8, 12, 21, 24, 26, 31, 32, 34, 36, 37, 39, 57, 63, 64, 67, 69, 70, 72, 76, 79 = 20
D : 1, 7, 9, 10, 14, 15, 16, 17, 19, 23, 28, 29, 33, 38, 40, 43, 48, 50, 51, 56, 60, 61, 73, 74, 77 = 26 Total = 79

1.2 A : 2, 24, 28, 33, 46, 47, 50, 58, 75, 76 = 10
B : 9, 11, 13, 14, 18, 19, 25, 27, 36, 39, 43, 44, 61, 68, 69, 77, 78, 79, 80 = 19
C : 3, 5, 6, 7, 10, 15, 16, 17, 21, 29, 32, 34, 35, 37, 38, 40, 41, 42, 48, 49, 52, 54, 56, 60, 63, 64, 65, 70, 71, 72, 73 = 31
D : 1, 4, 8, 12, 20, 22, 23, 26, 30, 31, 45, 51, 53, 55, 57, 59, 66, 67, 74 = 19 Total = 79

1.3 (1) Velocity vs Time.
(i) : 2, 17, 22, 26, 29, 40, 44, 45, 47, 50, 55, 58, 63, 71, 73, 76 = 17
(ii) : 9, 14, 23, 28, 30, 34, 36, 39, 46, 48, 52, 60, 61, 64, 67, 78, 80 = 17
(iii) : 16, 31, 32, 35, 37 = 5
(iv) : 1, 3, 5, 6, 7, 10, 11, 12, 13, 15, 18, 19, 20, 24, 25, 27, 33, 38, 41, 42, 43, 51, 53, 54, 56, 57, 59, 65, 66, 69, 70, 72, 74, 79 = 34
No answer : 4, 8, 21, 49, 75, 78 = 6 Total = 79

(2) Speed vs Time.
(i) : 1, 5, 14, 19, 20, 25, 28, 30, 36, 39, 51, 56, 67, 69, 70, 72, 74, 75, 77 = 19
(ii) : 11, 12, 13, 18, 22, 23, 27, 33, 35, 43, 47, 63, 73, 79 = 14
(iii) : 10, 15, 40 = 3
(iv) : 4, 7, 9, 24, 29, 32, 68 = 7 .
No answer : 2, 3, 6, 8, 16, 17, 21, 26, 31, 34, 37, 38, 41, 42, 44, 45, 46, 48, 49, 50, 52, 53, 54, 55, 57, 58, 59, 60, 61, 64, 65, 66, 71, 76, 78, 80 = 36 Total = 79

Q 2. 2.1 (i) : 23, 28, 42, 44, 51 = 5
(ii) : 35, 43, 46, 58, 60, 61, 67, 78, 79, 80 = 10
(iii) : 3, 5, 8, 12, 17, 20, 21, 29, 30, 31, 36, 37, 41, 48, 50, 52, 53, 55, 63, 72, 74, 75 = 22
(iv) : 1, 2, 4, 6, 7, 9, 10, 11, 13, 15, 16, 18, 19, 22, 24, 25, 26, 27, 32, 33, 34, 38, 39, 45, 47, 49, 54, 56, 57, 64, 65, 66, 68, 69, 70, 71, 73, 76, 77 = 39
No answer : 14, 50, 59 = 3 Total = 79

2.2.1 At 4sec :

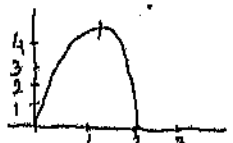
3m/s : 1, 4, 5, 7, 15, 24, 26, 31, 36, 47, 52, 53, 54, 56, 65, 76, 80 = 17
3cm/s : 2, 6, 8, 59, 63 = 5
0.75cm/s : 8, 9, 19, 23, 25, 28, 35, 37, 46, 48, 50, 58 = 12
1.25m/s : 10 = 1
2m/s : 11, 29, 34, 44, 51, 55, 57, 66 = 8
0m/s : 12, 14, 67, 70, 72, 73, 74 = 7
12m/s-2 : 13 = 1
2m/s : 3, 30, 33, 39, 40, 42, 64, 68 = 9
30m/s : 20 = 1
18m/s : 21 = 1

TRANSCRIPTION OF ANSWERS

Stud. No: 1 COURSE: SPTD - 1

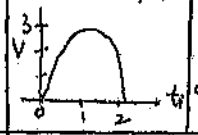
1.1	A	1.2	D	1.3(i)	iv	1.3(ii)	(i)	2.1.	iv		
2.2.1.	At 4s: 3m/s.	At 6s, 5 m/s.		2.2.2 Velocity after 5hr	75m/s	2.3.	3 m/s	2.4	D		

3.1. Draw a v-t graph.

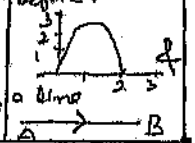


3.2. At the maximum point when it is upward. (Maximum point has maximum velocity)

3.3.1 Again draw v-t graph

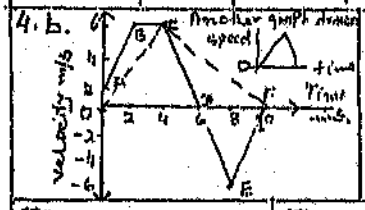


3.3.2. He draws a graph as before.



3.4. a	B	3.4.b.	D	4.1 a.	i) 16 m/s. He means BC. ii) A to B, He understood increasing V	4.1 a(iii) C to E

4.b.

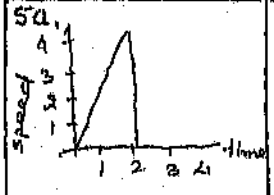


4.c The increase in speed causes less time to be elapsed by an object, speed is indirectly proportional to time.

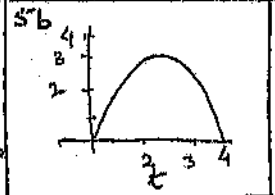
speed $\propto \frac{1}{\text{time}}$.

4.d. The arrow in form of vector shows forward and reverse motion, No other ideas could be drawn.

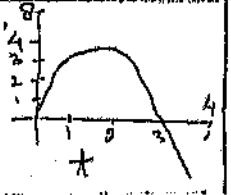
5a.



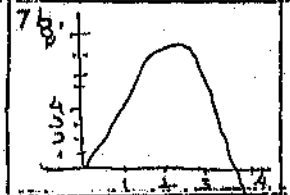
5b



7a.



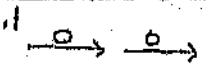
7b.



Stud. No: 2 COURSE: SP-2 Kinetics option ①

1.1	D	1.2	A	1.3(i)	①	1.3(ii)	-	2.1	iv		
2.2.1	At 4s, 3 cm/s in opposite direction	At 6s, 2 cm/s		2.2.2	Yes 3cm/s	2.3	3 cm/s	2.4	C		

3.1



3.2

(i) When comes down near the floor

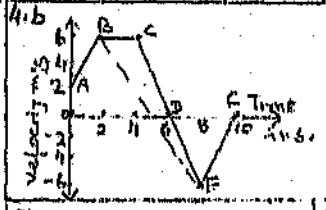
(ii) When it moves from the hand.

3.3.1 Not answered

3.3.2 Not answered.

3.4 a	B	3.4 b.	D	4.1 a.	i) BC	(ii) ABCD	(iii) DF

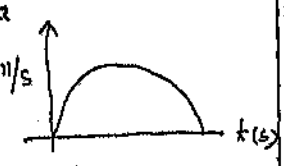
4.b



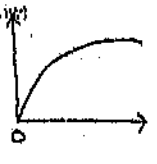
4c. The car moves with increase velocity for two minutes and further moves with constant velocity 4m/s for 2 min. The car slows down for 2 min and moves in opposite direction for 2 min. and stops later and increases speed for 2 minutes.

4d. Not answered.

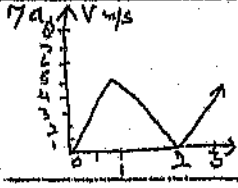
5a



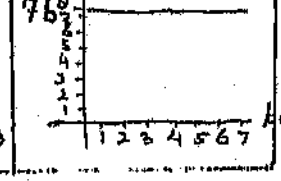
5b(i)



7a



7b



2.1. Picture understanding (N=39)
1, 2, 4, 6, 7, 9, 10, 11, 13, 15, 16, 18, 19, 22, 24, 25, 26, 27, 32, 33, 34, 38, 39, 45, 47, 49, 54, 56, 57, 64, 65, 66, 68 69, 70, 71, 73, 76, 77.

2.4. Speed/time graph (N=13)
8, 10, 16, 46, 55, 56, 60, 73, 76, 77, 78, 79, 80.

Question 3.

3.1. Picture of the ball. (N=23)
5, 9, 10, 15, 17, 20, 22, 24, 32,39, 41, 43, 48, 52, 54, 55, 61, 63, 65, 70, 72, 73, 75

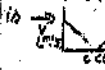
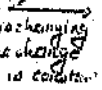
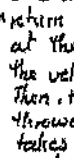
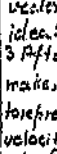
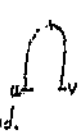
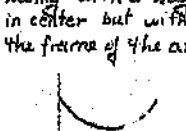
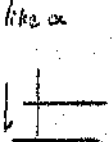
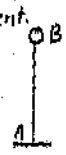
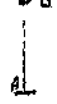
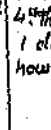
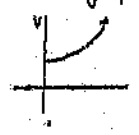
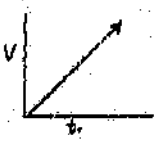
3.2 Places of highest speed (N=11).
2, 4, 8, 13, 15, 18, 19, 33, 65, 69, 73 = 11

3.3.1 Vector half-way (N=25)
4, 5, 6, 8, 9, 11, 12, 15, 24, 29, 30, 38, 39, 41, 43, 45, 47, 48, 58, 59, 60, 67, 71, 73, 76.

3.3.2. Vector when ball is caught (N=27)
4, 6, 11, 12, 15, 16, 18, 21, 26, 23, 29, 30, 38, 39, 43, 45, 55, 56, 58, 59, 65, 66, 72, 73, 74, 75, 76.

3.4. (a) Graph (speed/t) (N=18)
4, 10, 13, 17, 22, 27, 37, 54, 55, 65, 67, 68, 70, 76, 77, 78, 79, 80.
(b) Graph (velocity./t) (N=18)
4, 10, 17, 18, 19, 22, 23, 24, 29, 30, 42, 47, 56, 58, 63, 64, 66, 70.

****

	(3.1) PICTURE	(3.2) PICTURE INTERPRETATION	(3.3.1) VECTOR	3.3.2. VECTOR	(3.4) GRAPH	5(a) GRAPH	5(b) GRAPH
④ M_2	It appears that he understands the motion. The ball moves under gravity. After being thrown it loses the velocity and returns. 	① Highest speed is just at the thrower's hand. The ball goes up and at its maximum it has zero speed and the ball turns down and gets a maximum speed. This maximum speed becomes constant if there be no air friction. Its velocity changes as it falls downward and it becomes constant.	He understands vector as a quantity having magnitude and direction. Magnitude by the line and direction by the arrow. But about the vector of velocity half way he says as "B half way to mean half of the length of the magnitude. The half length of the line.	velocity where the ball was thrown and caught back are equal and so will be the distance going up and coming down. "The distance from the starting point to the point of return is the same as from the top as it goes back to the starting point.	His answer 'A' is correct, but while explaining he gets contradictory statements and changes 'A' to C "...at turning point its speed is zero, then it goes up i.e. it increases again	Some how the top point of the graph is not fully understood. Though he tries to say it can not be zero. Some how he agrees that after time 't' it would increase. His graph is 	The given speed zero at the top is not fully understood. Though he tries to say it can not be zero. Some how he agrees that after time 't' it would increase. His graph is Yet... somewhere at the top there must be certain number of speed >0	... as time increases its velocity also increases, meaning it is changing. He says the change in velocity is constant because its acceleration is constant. 
⑤ L1	He used a chalk as ball and threw it upwards. He explains "If you throw a chalk upward it will return and when it is at the maximum point the velocity will be zero. Then it returns at the thrower's hand." He takes the motion as up ward and downward. 	The force of gravity pulls the ball and when the ball comes back to the ground it has maximum speed. "...when it returns to the thrower's hand. the velocity will start to be higher to the thrower hand, and from then it will have the highest speed.	1. A vector has magnitude and direction e.g momentum. 2. How to represent a vector "I don't have idea." 3. After the push he makes a figure to represent the velocity half way up.  4. Discussion reflects that "I know it but I don't know it fully." It is accepted that poor information about concepts are responsible.	He understand vector as the diagram after explanation of the motion. "...from here it reaches the maximum point where velocity is zero, it is at rest. So it returns to the thrower's hand. 	Answer is B it is supported with the help of sketching of picture.  Just like before when you throw the object upwards we it vertically... when object returned, it is also vertically but facing the ground.	1. Velocity is the rate of change of acceleration. 2. He answers 'B' and pleads "The length is circle like. Again he accepts it is difficult, and blames poor background knowledge at S.S.S.S.	His speed-time graph of the swing is just like the path of the swing with a loop in center but within the frame of the axes. 	He takes the swing motion as a half circle and as a graph he feels it will look like as 
6. L2.	1. Energy takes the ball up and gravity contradicts it to stop at the top. 2. At the top K.E. finishes and P.E remains. 3. In questionaire he made picture as graph or both mixed. But now he understands that the two are different. His picture. 	1. Highest speed is when it leaves the thrower's hand. 2. No other position. 3. But, he says it will return to the thrower hand at the same speed. 4. Energy involvement is three and it is supplied in the beginning. He gives a picture as in previous one. 	1. Vector has magnitude and direction (635) 2. Magnitude is related to mass. "...direction which was upward and magnitude will be determined by its mass." (635,3) 3. He draws a picture to show the vector  4. The magnitude I don't know how it is.	1) The direction of this velocity is down words A when it is in the hand back and the vector is shown by figure. B 2) Magnitude is still confused with the mass of the ball and he has no idea. how to represent the magnitude of the vector in this case of the velocity.	i) Rightly he takes the graph (A) as absolute value graph and (B) as a half circle. (ii) Speed time graph is C. Velocity time graph is B. (iii) He explains part AB of the graph as time is decreasing. (iv) He accepts his problem to be because of graphing skills and understanding. v) He blames the aim of study was to pass test and exams and not the concept understanding.	i) He involves the idea of momentum. "initially, I believed the child had gained momentum as he began to swing... as he swings back and forth that is the reason. ii) He considers energy involvement too. His graph 	Velocity time graph should start from the origin. 

APPENDIX-H

Draft-profile INTERVIEWS | CASE STUDY

	(3,2) PICTURE INTERPRETATION	(3,3,1) VECTOR	(3,3,2) VECTOR	(3,4) GRAPH	(5a) GRAPH	(5b) GRAPH
...uestion → Consider a ball thrown straight up into the air, and caught as it falls back. ② Draw the picture of the motion of the ball.	In which position does the ball have the highest speed?	Draw the vector of the velocity at halfway going up.	Draw the vector of the velocity while the ball is caught.	(a) speed-time (b) velocity time-graph	Speed-time graph of the swing.	velocity-time graph of the swing.
(a) Constant acceleration, uniform velocity. "Constant acceleration that means that the ball was just moving with the ball was just moving with the same velocity from the throwers hand." (b) Acceleration is scalar. "Acceleration does not have direction" (c) Gravitational force reduces the velocity and increases.	The highest speed of the ball will be when it is thrown and when it is caught back. highest speed	He defines vector quantity as having magnitude and direction. He could make the angle and draw the relevant line. Through the length of the line represents the magnitude did not come explicitly.	The velocity as a vector has downward direction and the arrow represent the magnitude when required to say which part of the vector represent magnitude he answered "I am not sure, I am not told about this."	Answered it correctly and can explain too.	He is not able to comprehend this motion and he accepts "I am not sure about this.	As in 5(a) he thinks the graph should be like 5(a), Both have initial velocity zero. Here he says "This one is challenging."
B2 "Ball gives to highest point and returns on the same path. "It reaches a highest distance, it is now falling back to initial point, it is moving on the same path." 2- Initial concept of graphas picture of something. If they say, draw the picture of the motion, means you are going to represent it graphically.	1. Highest speed when it is thrown and when it is caught by the thrower. "When it leaves the throwers hand and when it reaches the throwers hand again" 2. At the top the ball stops and has zero speed." It should stop first before it changes, its course."	1. Vector consists of magnitude and direction. "It is that quantity which possesses both magnitude and direction". 2. Vector presentation: It appears he has the idea but not good probes. "we draw a line which represents the magnitude, and an arrow head which represent the direction".	1. The idea of position and velocity not very clear. while drawing vector he takes the tale of the arrow as highest at. eg." This is the highest maximum point, I should think this is our representation	Answered it correctly. Apparently he understands it. (2415)	Answered it correctly and understands it "... this shows that it has changed the direction after it has reached the highest point.	1. The point where the curve is changed from a vertical line is the central position, where the speed will be maximum other extreme ends speed is zero, this graph. He did not label the axes.	1. Vector nature of velocity is expressed. The motion is considered horizontal and not vertical. changing vertical acceleration has not been considered. He feels the direction change only at extreme ends of v, t
B1 M, ① Picture as a graph "when I draw it will not be visible and not be straight" ② She is not clear about the position of the ball. When asked. She answers. "from the bottom to the top and comes back again downwards"	1. Highest speed in the air, but "exact positions are not clear, "I mean that the ball is thrown straight up in the air and it is caught back, as what way in the air I mean before it is caught back down to the air, when asked about position. She points at the highest point in the graph. 2. Highest point highest speed "It reaches the highest peak the highest speed, the gravity will pull it back down."	1. She knows the definition of a vector, but in drawing it, side or magnitude is not clear. "Vector is a physical quantity which has magnitude and direction. 2. About wise another idea that etc. presented. Through the idea is connected to bearing. "The vector is pointing upward to the north with the protector it will be the naught degree celsius.	1. Vector is understood the same way as in 3.3.1. But still the magnitude has confused meaning comparing the two she says. "The other one is pointing upward and the other one is pointing downwards. That means when we combine the two vectors it will be zero." The idea to represent a vector with Arrow is there.	Answer-Para. says it starts from zero and it increases the speed when it goes up, what it feels clear that means speed decreases. She defines the speed as the rate of change of distance.	Answered B. She defines velocity as "the rate of change of displacement and displacement has direction and magnitude. displacement means a straight line from the starting point to the end." the ball is thrown from zero and back again to zero.	No relevant idea, rather seems confusing statements. "(a) the speed does not change, the speed remains the same, "constant." speed time (b) "It will not be a Straight line. it must be in the shape of a hyperbola.	① 0 — Velocity remains zero. 2) "Velocity, time graph is a St line graph, that means it has direction and magnitude." and speed-time graph is not a St. line graph but it is a curve.

172.S. Since it is zero, our graph is going to be like this. No more here.

173.I. Where is it?

174.S. When it is at rest.

175.I. So is zero at the top?

176.S. Yes. It means no motion at the top, when the child is at the top there is no motion.

177.I. There is no motion ... means, does it mean it is at rest every where? (Jokingly).

178.S. But how can I go with the graph of this? I think the graph will be as a straight line because we didn't talk about when it goes backwards again.

179.I. Yes, OK. Thank you very much.

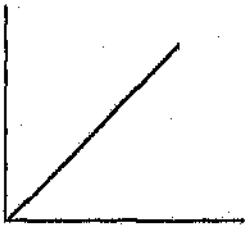


Figure: B1's velocity-time graph of the motion of the swing.

153.I. At this point and at this point. These are the points at the top.

154.S. Are at the top?

155.I. Yeah, what is the velocity there?

156.S. Zero.

157.I. Yes, when it moves draw the speed-time graph.

158.S. Draw a speed-time graph for the child on the swing (He reads). For the child on the swing. But I'm not sure about this

159.I. Try, nobody is sure of anything. (There is a laughter). Yeah.

160.S. The child on the swing has a speed of zero at the top, I think...(He draws).

161.I. All right let us try this Q.5. b.

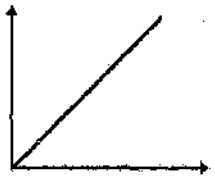


Figure [illegible]d-time graph of the motion of the swing

162.S. Draw the vel[illegible]e graph of the motion of the child on the swing. Here I don't understand where they say zero, at the top or where.

163.I. Well zero, actually this is the same question, there it was speed and here you have to talk about velocity.

164.S. Oh, about the velocity. Yes, so speed goes hand in hand with velocity, the difference in direction, I think we are going to have the same sketch.

165.I. As speed? Why do you think the same?

166.S. Velocity is the, our velocity is zero ..., I think the velocity here is zero, when the speed is zero, is when the object is at rest.

167.I. Humm, so when the swing is at the top.

168.S. At the top? Is there at rest and is going to come back again.

169.I. Oom humm.

170.S. This one is challenging!

171.I. (A laughter) Is challenging. I think try.

153.I. At this point and at this point. These are the points at the top.

154.S. Are at the top?

155.I. Yeah, what is the velocity there?

156.S. Zero.

157.I. Yes, when it moves draw the speed-time graph.

158.S. Draw a speed-time graph for the child on the swing (He reads). For the child on the swing. But I'm not sure about this.

159.I. Try, nobody is sure of anything. (There is a laughter). Yeah.

160.S. The child on the swing has a speed of zero at the top, I think...*(He draws).*

161.I. All right let us try this Q.5. b.

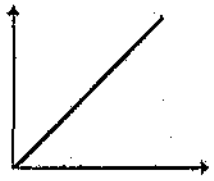


Figure: Speed-time graph of the motion of the swing

162.S. Draw the velocity-time graph of the motion of the child on the swing. Here I don't understand where they say zero, at the top or where.

163.I. Well zero, actually this is the same question, there it was speed and here you have to talk about velocity.

164.S. Oh, about the velocity. Yes, so speed goes hand in hand with velocity, the difference in direction, I think we are going to have the same sketch.

165.I. As speed? Why do you think the same?

166.S. Velocity is the, our velocity is zero ..., I think the velocity here is zero, when the speed is zero, is when the object is at rest.

167.I. Humm, so when the swing is at the top.

168.S. At the top? Is there at rest and is going to come back again.

169.I. Oom humm.

170.S. This one is challenging!

171.I. (A laughter) Is challenging. I think try.

135.I. Then velocity-time graph.

136.S. Velocity-time graph. This one from zero, no I think this one can represent displacement, yes I think.... no.... 'C' is correct.

137.I. OK, what can you tell about this part of the graph? This means suppose I say CBA, and ask about BA.

138.S. In fact here is where the ball stops and turns back again.

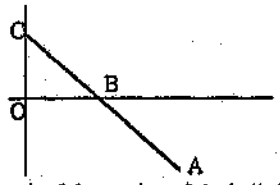


Figure: B1's graph of the motion of the ball thrown upwards

139.I. Yes.

140.S. Velocity-time graph, velocity is a vector quantity, it has both magnitude and direction that is why here is our graph to see, I can say if the negative Y-axis, the ball came backwards the upward movement is positive and the downward movement is negative.

141.I. So what part is BA representing?

142.S. What part, actually BA this part. Actually BA represents the downwards motion.

143.I. Thank you, now read this one.

144.S. A child on a swing has a speed 0 m/s at the top. (Interviewer illustrates with a sketch). (A)Draw a speed-time graph for the child on the swing. So the child on the swing has a ....

145.I. Have you seen a swing?

146.S. No, I think....

147.I. Come on, you people hang ropes from a branch of a tree and children go like this.

148.S. Yes, yes I understand the swing, but it is at zero velocity, the swing actually ....

149.I. What is the velocity at the top?

150.S. No, is zero. The velocity where?

151.I. Here.

152.S. Here?

Figure: Path of the swing

114.S. Draw the vector of the velocity while the ball is caught. Meaning when the ball returns.

115.I. Yes, can you explain t.. direction and the magnitude here?

116.S. The direction is when it came down and this one is our magnitude.

117.I. How do I know that this is the magnitude?

118.S. We are not given the units.

119.I. Ohmm humm.

Figure: B1's vector of the velocity when the ball is caught back

120.S. No the measurements.

121.I. You don't have the measurements but you can be able to say that which part of the line represents the magnitude, that is important.

122.S. What part of the line represents the magnitude? This part here.

123.I. What do you call that part?

124.S. The part which represents the magnitude? This one I'm not sure, I'm not told about this.

125.I. All right lets see this one.

126.S. Study the following graphs and answer the questions asked.

127.I. Yes.

128.S. All of them are the velocity-time graphs. The gradient of the velocity-time graph represents...(He repeats as if trying to recollect something)

129.I. Here is speed-time graph and velocity-time graph.

130.S. OK. Which one of the above best represents the ball thrown upwards.... Speed-time graph, firstly the speed does not have direction, you are going to consider the magnitude.

131.I. Let us see in the graph.

132.S. A, B, C, ...(mutters). I think 'B' is correct. Since....

133.I. OK write down here.

134.S. Is it 'B'? Initial velocity high. No it is 'A', because it starts with a higher velocity and as it goes up the gravitational force acts against it, and it starts to decrease as it goes upwards, then stops and then comes down again. 'A' is correct.

92. S. What?

93. I. What do you think about a vector?

94. S. By the word vector, Vector in fact includes two things i.e. direction of the motion and the magnitude.

95. I. OK.

96. S. Yes.

97. I. Are you sure that this represents the motion?

98. S. The velocity of the stone when it goes upwards halfway. Yes, I think so.

99. I which part represents the magnitude here?

100.S. Which part represent s the ...

101.I. Magnitude in this, what you have drawn.

102.S. This part represents the magnitude, even if you are not given, I mean you don't know the magnitude and this will represent the direction.

103.I. [illegible] Suppose I say, a force of 5N is acting 30 degrees from the north. Can you draw it.

104.S. A force of ... 5N is ...

105.I. Acting 30 degrees from the North.

106.S. 30 degrees? Aamm 30 degrees to the horizontal? You are not given....

107.I. I'm saying 30 degrees from North.

108.S. Oh from North, 30 degrees, acting 30 degrees.

109.I. From North, can you draw it?

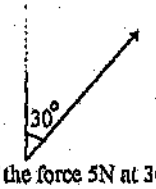


Figure: B1's vector of the force 5N at 30 degrees from North

110.S. 30 degrees from north, the force is 5N. (He draws)

111.I. Yes, which is the angle, and which one represents the 5N?

112.S. (Indicates to drawing). This is the angle and this part is the 5N.

113.I. OK. Let us see this one.

76. S. Yes. Aa, when it goes upwards, in fact, how can I explain this? From the thrower's hand, few metres from the thrower's hand upwards . When it returns backwards again on the same level, is where the ball is going to have the highest speed.

77. I. Yes.

78. S. Yes.

79. I. All right let us continue.

80. S. Yes to explain where the ball is going to have a highest speed?

81. I. Yes.

82. S. Can I draw here?

83. I. Yes, that is for that .....

84. S. I can represent my motion as .... (he draws). The ball is going to have the highest speed, from the one who is throwing it upwards and then because of the force of the gravity it will decrease, the force of gravity will decrease the speed or velocity of the stone because it acts against it.

Figure: B1's understanding of the speed of the ball thrown upwards under gravity

85. I. Hum.

86. S. Yes and then the velocity is going to decrease until it reaches at zero, and at zero it is going to return back again, and from zero it is going to increase, and increase again when it comes to the thrower's hand.

87. I. Yes. OK thank you. Yes here (showing the next question).

88. S. (Reads). Draw the vector of the velocity halfway going up. (Repeats) At halfway going up.

89. I. Hum.

Figure: B1's vector of the velocity of the ball halfway up

90. S. At halfway going up. The vector of the velocity, straight upwards at halfway.

91. I. (Interruption) What is a vector?