Students' Conceptions and the Historical Change of the Concept: Free-fall Motion

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I. INTRODUCTION

Conceptual change has been a focus of researches in science education, especially after the introduction of the constructive approach. Since the end of 1970s many researchers in many countries have investigated students' conceptions in different subject areas of science(e.g., Pfundt and Duit, 1988). Recently several strategies have been proposed as the means to change students' conceptions into scientific ones, for example Generative Learning Model(Cosgrove and Osborne, 1985), DOE(Demonstrate-Observe-Explain)(Champagne *et al.*, 1985) POE(Prediction-Observation-Explanation)(White and Gunstone, 1994), demonstration(Shepardson *et al.*, 1994), TWA(Teaching-with-Analogies) Model(Glynn, 1991), and reflective thinking(Kim, 1991).

However, the efforts for promoting conceptual change in science have been so far mainly concerned with the cognitive aspects of science learning. But it is evident from our teaching experience that students' learning of science is greatly influenced not only by cognitive but also by affective factors. For instance, as students grow up, they tend to diversify their attention from science to other subjects and show greater psychological gaps between scientists and themselves(Song *et al.*, 1992).

Since the introduction of HPP(Holton, 1970), a historical approach has been regarded as one of the most useful ways in science education. Matthews(1994) summarized the reasons for including historical components in science programmes as follows:

① promoting the better comprehension of scientific concepts and methods

② connecting the development of individual thinking with that of scientific ideas

③ being intrinsically worthwhile

④ necessary to understand the nature of science

⑤ counteracting the scientism and dogmatism

⑥ humanizing the subject matter of science

⑦ allowing connections to be made within topics and disciplines of science.

The history of science is largely the products of conceptual changes with which past scientists struggled for more than a thousand years. The details of the struggles(e.g. what kinds of knowledge they inherited from ancestors, how they felt about the mismatches between inherited knowledge and observed phenomena, in what process they succeeded to overcome the mismatches and to develop or accept new ideas) could be used to help students' own conceptual changes.

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. Piaget might be one of the first psychologist, although he would rather prefer to be called epistemologist, who took seriously the problem of the parallelism between the progress of individuals' thinking and the history of science(Piaget and Garcia, 1989). In science education, some researchers recently began to think over this problem and made some suggestions that the history of science could be used to teach science in schools(e.g., Nussbaum, 1990; Gauld, 1991; Sequeira and Leite, 1991; Stinner, 1994). These studies, however, did not seem to investigate this matter detailed enough to give practical guidance for teaching science, for instance, investigating how the history of science can be used to help students' misconceptions to be changed properly.

According to Matthews' list, this study is particularly related to the second. That is, this study is one of the attempts to use the history of science for understanding and changing of students' misconceptions on school science.

In this study, we concentrated our attention on the problem of free-fall motion, the most important on-going problem whose solution leaded to the mechanical revolution in the 17th century and which had been continuously argued by a number of famous ancient scientists(natural philosophers), such as Aristotle, Philoponus, Buridan, Galileo and Newton.

This study tried to compare students' conceptions on free-fall motion of different age groups with the historical change of the concept thus to judge if there is a parallelism between the two and discussed the implications of this study to science teaching in schools.

II. METHOD AND PROCEDURE

Total of 737 students from four different age groups(that is, 158 students of age 11, 189 students of age 13, 206 students of age 15, and 184 students of age 17) were involved in the survey. The students of each age group were selected from two or three schools which are considered as ordinary ones in Seoul, i.e. two elementary schools for the age 11 group, three middle schools for the age 13 and 15 groups and two high schools for the age 17 group. Table 1 shows the distribution of students who participated in the survey.

Table 1. The distribution of students involved in the survey

Age (Grade)	Sex		total
	Boys	Girls	
11 (5th)	86	72	158
13 (7th)	94	95	189
15 (9th)	109	97	206
17 (11th)	82	102	184
total	381	356	737

In developing the questionnaire, special attention was given to ensure that each question represent the very problems which was confronted with and argued by the past scientists. This was considered to be important because differences in terms of the context of problems might affect pupils' performances considerably(for example, see Song and Black, 1991 & 1992; Song and Choi, 1994; Choi and Song, 1995). In other words, for instance, a well-known problem, in which the directions of forces acting on a particle thrown vertically up were asked(e.g., Osborne, 1985), is not the same as the question with which Aristotle and Galileo struggled to find the relationship between the weight of a body and its falling speed, therefore using this problem to compare the conceptions of pupils with those of past scientists could be compounded with the effects of context.

The questionnaire is consisted of three questions, and each of them concerns different aspects of free-fall motion which had been main issues debated over a thousand years, as follows:

Question 1: the cause of free-fall motion
Question 2: the relationship between height and speed
Question 3: the relationship between weight and speed

In each question, a simple drawing was given to help students understand what was asked in the question. Students were required to select one option similar to their own ideas out of the three each of which represents the ideas of Aristotle, Impetus theorists(e.g. Philoponus and Buridan) or Galileo. If there was no similar one to their ideas, they were then asked to write down their own ideas. For the last two questions, pupils were also asked to give reasons for choosing a certain option in the first part of the question.

In addition to a pilot test and following revisions by science teachers, when the developed questionnaires were distributed to pupils, the teachers were asked by the authors to explain in detail if there were any query concerning the questionnaire from pupils. Since the same questionnaire was used to all age groups, some of the youngest group(age 11) could have some difficulty in understanding the questionnaire.

In the analysis of the data of the survey, pupils' responses were interpreted in comparison with historical views(such as of Aristotle, of Impetus theorists and of Galileo) and the distributions of pupils' responses were also compared between the age groups.

III. HISTORICAL CHANGES OF THE CONCEPT OF FREE-FALL MOTION

In this section, the historical changes of the concept of free-fall motion are briefly reviewed. The review is mainly focused on the ideas of eminent past scientists on the three aspects of free-fall motion which correspond to the questions given in the survey questionnaire.

(the cause of free-fall motion)

A great Greek philosopher, Aristotle(384-322 B.C.), in his book called *Treatise on the Heavens*, made a distinction between natural motions and violent motions. The fall of heavy bodies, for example, is a natural motion, while the motion of a projectile is a violent one. Each thing has its own natural place. If something is moved from its natural place it tends to return there.(Dugas, 1988, p.20) Thus, according to Aristotle's view, a stone always has a tendency to return to its natural place, i.e. the ground.

Buridan, one of the eminent natural philosophers during the medieval period supported the impetus theory, put forward the following thesis: "Whenever some agency sets a body in motion, it imparts to it a certain impetus, a certain power which is able to move the body along in the direction imposed upon it at the outset. ... But because of the resistance of the air and also because of the heaviness, which inclines the motion of the stone in a direction different from that in which the impetus is effective, this impetus continually decreases. ... Finally the impetus is overcome and destroyed at the point where gravity dominates it, and henceforth the latter moves the stone towards its natural place..."(Dugas, 1988, pp.49-50). In Buridan's view, the motion of bodies is caused and maintained by impetus as well as the attraction by the earth.

Galileo(1564-1642) solved the problem of projectile motion which had been only imperfectly treated by the Schoolmen in the 14th century with the principle of inertia. When a body is thrown horizontally in air, its horizontal motion will be influenced by the downwards propensity caused by gravity. In Galileo's view, thus, the body's motion is a compound motion, composed of the horizontal motion and the naturally accelerated motion of descent(Dugas, 1988, p.141).

(the relationship between height and speed)

On falling motion, Aristotle argued that a body is attracted towards its natural place by means of its heaviness. Thus, the closer the body comes to the ground, the more that property increases(Dugas, 1988, p.21). In this sense, for Aristotle, the motion of falling body was somehow a function of the distance from its natural place. Aristotle acknowledged that all bodies accelerate as they approach their natural places. But he did not consider this matter seriously, instead treated natural motions as if they were uniform, or, at most, average speeds(Grant, 1977, pp.39-40).

For Galileo, the speed of a falling body was, at the beginning, a function of the distance that the body fell and later a function of the time which took for the body to fall. Finally he arrived at the classical law of distance, that is "the distances gone through in natural motion are in square ratio to the time of fall, i.e.

$s = \text{constant} \times t^2$"(Dugas, 1988, p.132). Thus, for Galileo, how the speed of a falling body changes does not depend on where the body started to fall but on how long the body travelled.

(the relationship between weight and speed)

In Aristotle's view, the speed of a falling body is directly proportional to the weight of the body in natural motion and inversely proportional to the density of the medium through which it moved. That is, in symbols, this relationship can be expressed as follows : $V \propto \frac{F}{R}$ (where V is velocity, F is the motive force by weight and R is the resistance by the medium). The time of its motion, thus, is also directly proportional to the density of the medium and inversely proportional to its weight.(Grant, 1977, p.40).

On the other hand, Galileo, in rejecting Aristotle's explanation of natural falling, argued that homogeneous bodies of unequal size, and therefore unequal weight, would fall with equal speeds plenum and void(Grant, 1977, pp.46). Galileo clearly demonstrated the contradiction of Aristotle's theory of motion through his famous thought-experiment, i.e. the falling speed of a heavier brick which is consisted of two light bricks connected by a very thin string can be different from the falling speed of one light brick.

IV. RESULTS AND DISCUSSION

Here, survey results and discussions on them are given question by question.(See <Appendix> for the contents of the questions used in the survey)

(1) the cause of free-fall motion

In this question, option ①, ② and ③ stand for the views of Aristotle, of Impetus theory and of Galileo respectively. Table 2 shows the results of students' responses to Question 1.

The proportion of students with Aristotle-like view was very small, i.e. four or five percent, in all age groups. With some exception between age 11 and age 13, the proportion of students with Galileo-like view generally increases with age, while that of possessing Impetus-like view shows a reversed tendency. That is to say, students' views on the cause of falling motion change from Buridan-like one to Galileo-like one, as they grow up.

Table 2. Students' responses to Question 1 (the cause of free-fall motion)

Age	Responses in percentage			
	①Aristotle -like	②Impetus -like	③Galileo -like	④Others
11	5.1	34.2	52.5	8.2
13	4.2	38.7	44.0	13.1
15	3.8	20.1	73.7	2.4
17	4.2	9.0	80.4	6.3
average	4.3	25.5	62.7	7.5

On the other hands, typical examples of students' views categorized into 'Others' are as follows : "because there is no more force", "because of horizontal as well as vertical forces", "because gravitational force is getting bigger". These examples reflect the typical students' misconceptions which were shown by numerous studies during the last two decades.

(2) the relationship between height and speed

In this question, option ① and ③ stand for the views of Aristotle and of Galileo respectively. Option ②, however, does not directly correspond to the idea of any particular scientist in the past. Table 3 shows the results of students' responses to the first part of Question 2.

Table 3. Students' responses to the first part of Question 2(falling at different heights)

Age	Responses in percentage			
	①Aristotle -like	②Impetus -like	③Galileo -like	④Others
11	24.1	41.1	32.3	2.5
13	19.8	52.1	22.9	5.2
15	17.1	49.3	32.3	1.3
17	19.0	49.0	28.5	3.5
average	20.0	47.9	29.0	3.1

Table 4. Students' responses to the second part of Question 2 (falling at different heights)

Response to Question 2	Reasons	Response in Each Age (%)				Ave.
		Age11	Age13	Age15	Age17	
① Ball A is more rapidly speeded	(1) Ball A falls from a nearer place	49	34	48	23	39
	(2) Attractive force to Ball A by the earth is stronger	3	20	10	50	18
	(3) Attractive force become stronger as it falls	0	3	0	0	1
	(4) Force or pressure of air to Ball A is stronger	5	6	0	0	3
	(5) Ball A has less or no resistance	8	3	0	5	4
	(6) I did an experiment on it	3	0	0	0	1
	(7) I learned and read about it from books	3	0	0	0	1
	(8) Others	22	34	29	23	27
	(9) No Response	8	0	14	0	5
② Ball B is more rapidly speeded	(10) Ball B falls from a higher place	31	28	30	27	29
	(11) Ball B has a bigger P.E. and/or internal force	3	7	20	22	14
	(12) Attractive force to Ball B by the earth is stronger	2	8	9	6	6
	(13) Attractive force become stronger as it falls	12	32	24	31	25
	(14) Force or pressure of air to Ball B is stronger	8	11	2	0	5
	(15) Ball B has less resistance	0	1	0	0	0
	(16) I did an experiment on it	2	1	1	0	1
	(17) Others	34	13	11	9	16
	(18) No Response	8	0	3	5	4
③ Both Ball A and B are speeded at the same rate	(19) Ball's velocity is independent on height	6	9	11	12	10
	(20) Ball A and B have the same volume, shape & weight	37	9	18	16	20
	(21) Ball A and B have the same resistance	0	2	1	0	1
	(22) Ball A and B take the same time to fall	0	2	0	0	1
	(23) Ball A and B have the same weight	21	14	1	2	10
	(24) Ball A and B have the same gravitational force	2	20	30	33	21
	(25) Ball A and B have the same acceleration	0	4	3	15	6
	(26) I did an experiment on it	6	5	3	0	3
	(27) I learned and read about it from books	2	0	3	0	1
	(28) Others	23	34	27	16	25
	(29) No Response	4	0	3	7	4

About 20% of the students showed Aristotle-like view and about 30% showed Galileo-like view, and this does not seem to related to the age of students. Interestingly, nearly a half of the students in all age groups chose option ②, which would be the most popular misconception in this matter.

Table 4 shows the distribution of students' reasons given for their choices on Question 2.

Among students who chose option ①, i.e. Aristotle-like view, only the students who gave reasons of(1),(2),(3) and(4) explained their choices from the view point of Aristotle. In other words, 61% of the students who chose Aristotle-like view gave Aristotelian explanations. Similarly, only 16%((19)+(25)) of students who chose option ③, i.e. Galileo-like view, gave Galilian explanations. From these students, we could find very similar descriptions about the question as the descriptions given by past scientists. For example, "The attractive force of the earth become stronger as it comes nearer to the earth." and "The stone has a nature of falling fast because it is at the lower place." for Aristotle-like view, "Gravitational acceleration is the same." for Galileo-like view.

In the case of students who chose option ②, 74% of the students who gave reasons like(10),(11),(12) or(13) seem to think that the change of falling body's speed is somehow related to the distance from the ground, via potential energy, internal force or attractive force, whatever it is called. Typical examples for this case are as follows : "The ball from a higher place is likely to have more power than the ball from a lower place." and "It has bigger potential energy and internal force because it falls from a higher place from the earth.".

The rest of the reasons which students gave for their choices varied considerably and they are different from the ideas of past scientists. These might be the counter-instances of the parallelism between the students' conceptions and the historical change of the concepts proposed by some scholars. There were also some responses which can not be possible in the past, such as "I did an experiment on it." and "I learned and read about it from books."

Table 5. Students' responses to the first part of Question 3(falling of objects with different weight)

Age	Responses in percentage			
	①Aristotle -like	②Impetus -like	③Galileo -like	④Others
11	21.9	35.6	35.6	6.8
13	18.4	39.1	39.1	3.4
15	16.9	33.9	46.0	3.2
17	18.7	30.4	48.0	2.9
average	19.0	34.8	42.2	4.1

(3) the relationship between weight and speed

In this question, option ① and option ③ stand for the views of Aristotle and of Galileo respectively. Although option ② does not exactly correspond to the major view of Impetus theorists in the medieval period, this view corresponds to the extension of the impetus theory, like Philoponus. Table 5 shows the results of students' responses to the first part of Question 3.

In question 3, 19% of students chose Aristotle-like view, 35% chose Impetus-like view and 42% chose Galileo-like view. Similar to Question 2 but unlike Question 1, the proportion of students who chose Aristotle-like view in this question were about twenty percent and were nearly the same in all age groups. Like in Question 1, with exception between age 11 and age 13, the proportion of students possessing Galileo-like view generally increase in regard to age, while that of possessing Impetus-like view shows a reversed tendency. That is to say, students' views on the relationship between weight and speed of falling bodies, as they grow up, change from Impetus-like one to Galileo-like one.

On the other hands, typical examples of students' views categorized into 'Others' are as follows : "Ball A(2kg) falls two times faster because a heavier ball get more acceleration" and "Ball B(1kg) falls faster because of the lightness or because the earth attracts a light stone more". The first example seems to reflect the misconception of confusing between force and acceleration, while the second example seems to reflect the misconception that the earth applies the same force to all bodies thus a lighter one gets more acceleration.

Table 6 shows the distribution of students' reasons given for their answers on Question 3.

Table 6 shows the distribution of students' reasons given for their choices on Question 3.

Among students who chose option ①, 88%(from(1) to(6)) of the students explained their choices from the view point of Aristotle. Similarly, 64%((11)+(12)) of students who chose option ② gave Impetus explanations and 28%((21)+(22)+(23)+(24)+(27)) of students who chose option ③ gave Galilian explanations. There were many responses from students which are very similar to the descriptions proposed by the past scientists about the question. For example, "Heaviness is due to the attractive force of the earth. Ball A is two times heavier than Ball B, it means that the earth attracts Ball A two times more.", "Ball A will reach to the ground two times early because its heaviness is two times of Ball B." and "The

Table 6. Students' responses to the second part of Question 3 (falling of objects with different weight)

Response to Question 3	Reasons	Response in Each Age (%)				Ave.
		Age11	Age13	Age15	Age17	
① Ball A will reach to the ground two times earlier than Ball B.	(1) Because of heaviness	51	11	8	17	22
	(2) Ball's speed is proportional to its heaviness	36	53	46	26	40
	(3) Gravitational force is proportional to ball's heaviness	2	4	21	22	12
	(4) Ball's internal force is proportional to its heaviness	2	9	6	0	4
	(5) Ball's energy is proportional to its heaviness	0	0	8	7	4
	(6) Falling is proportional to ball's heaviness	0	6	4	9	5
	(7) I did an experiment on it	2	0	2	0	1
	(8) Others	4	17	0	9	8
	(9) No Response	2	0	4	11	4
② Ball A will reach at the ground a bit earlier than Ball B.	(10) Because of heaviness	68	57	50	49	56
	(11) Heavy ball falls fast but not proportional to weight	6	13	11	2	8
	(12) Gravitational force is proportional to ball's heaviness	0	10	17	8	9
	(13) Ball's internal force is proportional to its heaviness	2	3	3	0	2
	(14) Ball's energy is proportional to its heaviness	0	0	2	0	1
	(15) Ball's acceleration is proportional to its heaviness	2	4	2	10	5
	(16) Because of air resistance	0	2	2	14	5
	(17) I did an experiment on it	6	3	0	2	3
	(18) I learned and read about it from books	0	0	0	2	1
	(19) Others	12	4	11	6	8
	(20) No Response	4	1	3	8	4
③ Ball A and Ball B will reach at the ground at the same time.	(21) Ball's velocity is independent on its weight	6	10	5	10	8
	(22) Ball A and B have the same volume & shape	2	3	2	5	3
	(23) Ball A and B have the same resistance	8	6	1	1	4
	(24) Ball A and B fall from the same height	18	12	7	6	11
	(25) Ball A and B have the same gravitational force	22	28	23	31	26
	(26) Ball A and B have the same force and resistance	0	3	3	3	2
	(27) Ball A and B have the same gravitational acceleration	0	0	0	7	2
	(28) I did an experiment on it	2	6	2	0	3
	(29) I learned and read about it from books	16	13	33	18	20
	(30) Others	18	19	15	16	17
	(31) No Response	10	0	8	1	5

purpose of heavy balls is to be on the ground but light balls love to float in air, so Ball A will reach to the ground two times early because the heaviness is two times more." for Aristotle-like view ; "Ball A will reach to the ground earlier but not two times than Ball B. Because Ball A is heavier that Ball B but velocity is not proportional to weight." for Impetus-like view ; "Gravitational acceleration is the same." and "The stone will reach to the ground at the same time if air resistance is the same because of the same shape and volume." for Galileo-like view.

For Galileo-like view, the most exact explanation would be reasons of "(27) Ball A and B have the same gravitational acceleration.", and these reasons were given only by the students of age 11(11th grade). This might be because only this age group could have the knowledge on gravitational acceleration in schools.

V. CONCLUSION

This study analysed the students' conceptions on free-fall motion based on the historical change of the concept. Total of 737 students from four different age groups(11, 13, 15 and 17 years old) were given three questions which represent the very questions argued by past scientists, like Aristotle, Impetus theorists and Galileo. Each question concerns with three different major aspects of free-fall motion, i.e. its cause, the relationship between height and speed and the relationship between weight and speed.

For the cause of falling motion, 4.3%, 25.5% and 62.7% of the students chose Aristotle-like, Impetus-like and Galileo-like views respectively. For the relationship between height and falling speed, 20.0% and 29.0% of the students chose Aristotle-like and Galileo-like views respectively. Finally, for the relationship between weight and falling speed, 19.0%, 34.8% and 42.2% of the students chose Aristotle-like, Impetus-like and Galileo-like views respectively. Despite some small improvement from Impetus-like view to Galileo-like view, it is generally true that the students' conceptions do not change considerably into the modern concepts as they grow up. From this study, similarities as well as dissimilarities between students' conceptions and the historical change of the concept of free-fall motion are found.

Lythcott(1985) criticized the usage of the term, "Aristotelian view", in calling students' pre-Newtonian views, such as, "a body moves with constant velocity when a constant force is applied", "velocity is proportional to force", "if force is removed the body will come to rest" He also warned against the researchers' assumption that there would be parallelism between students' misconceptions and historical change. We agree with Lythcott's criticism and also believe that our study is not exactly the one he argued against. In our study, as mentioned earlier, the questions given to the students are the very problems argued by past scientists and, thus, different from the questions which presented new contexts so that students' conceptions shown through them could not be directly compared with past scientists' ones.

Our study was initiated by the long-term hope that historical approaches could be effectively applied in order to change such stubborn students' misconceptions as well as to help them appreciate the nature of science, especially together with the method of 'role play'. We believe that changing the misconceptions and understanding the nature of science would be very difficult unless students are fully involved in the process of struggles which past scientists gone through and that the method of role play is one of the most powerful way to do the job. In this sense, this study, identifying students' conceptions in terms of the historical change, is believed to be the first step, thus later the results of the study could be used to suggest each student proper characters of a particular scientist in the past to play with.

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(국문요약)

학생의 개념과 개념의 역사적 변천: 자유낙하 운동

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본 연구는 자유낙하 운동에 대한 학생의 개념을 이 개념의 역사적 변천 과정과 비교하여 분석하였다. 네 연령층(11세, 13세, 15세, 17세)으로부터 총 737명이 설문조사에 참여하였으며, 설문에서 주어진 문항들은 자유낙하 운동과 관련하여 과거의 과학자(예를 들어, 아리스토텔레스, 임페투스 이론가, 갈릴레오)들이 고민하였던 핵심 문제를 반영하는 것이었다. 설문에는 세 문항이 포함되었으며, 각 문항은 자유낙하 운동에 관한 세 가지 측면(즉, 운동의 원인, 낙하높이와 낙하속력의 관계, 낙하체의 무게와 낙하속력의 관계)에 각각 관련된 것이었다.

낙하운동의 원인에 대해서, 전체 학생의 4.3%, 25.5%, 62.7%가 아리스토텔레스, 임페투스, 갈릴레오적 관점을 각각 지닌 것으로 나타났다. 낙하높이와 낙하속력의 관계에 대해서는, 20.0%와 29.0%의 학생들이 각각 아리스토텔레스와 갈릴레오적 관점을 지닌 것으로 나타났다. 그리고 낙하체의 무게와 낙하속력의 관계에 대해서는, 19.0%, 34.8%, 42.2%의 학생들이 아리스토텔레스, 임페투스, 갈릴렐오적 관점을 지닌 것으로 나타났다. 개별 문항에서 부분적으로 임페투스적 관점으로부터 갈릴레오적 관점으로의 변화가 나타났으나, 전체적으로 연령이 증가함에 따라 학생의 개념이 현대적 관점으로 변화한다고 판단하기는 어려웠다. 그리고 본 연구로부터 학생의 개념과 그 개념의 역사적 변천 과정에 사이에 상당한 유사성과 함께 차이점이 존재함을 알 수 있었다.

<APPENDIX> Contents of the Questions Given in the Survey

Question 1(the cause of free-fall motion)

When we throw a stone with a horizontal velocity, the stone will follow a curve shown in the diagram. Why does the stone thrown horizontally follow the curve?

① The stone is consisted of heavy matter. So the stone has a propensity to go back to the ground which is also consisted of heavy matter.

② When the stone is thrown horizontally, a kind of force is transferred to the stone. Thus, the stone will fall downward as the force is lessened gradually.

③ The stone has to move continuously in a horizontal direction, but due to the earth's force, the stone will move along the curve.

④ others : ______________________________

Question 2 (the relationship between height and speed)

One of the two iron balls which have the same shape, volume and mass is falling freely from a tower of 50m height (Ball A) and the other is falling from a tower of 100m height (Ball B).

(1) Compare falling speeds of the two balls.

① Ball A is more rapidly speeded.

② Ball B is more rapidly speeded.

③ Both Ball A and B are speeded at the same rate.

④ others : ______________________________

(2) Why do you think so?

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Question 3 (the relationship between weight and speed)

Somebody is about to release two iron balls (A: 2kg, B: 1kg) at the top of a tower. The two balls have the same shape and volume, but different weight.

(1) Which ball will reach to the ground first?

① Ball A will reach to the ground two times early than Ball B.

② Ball A will reach to the ground a bit earlier than Ball B.

③ Ball A and Ball B will reach at the ground at the same time.

④ others : ______________________________

(2) Why do you think so?

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