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Student's Alternative Conceptions of Free-Fall, Speed, Velocity and Acceleration, In High School in Tripoli Libya

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ABSTRACT

The study was conducted to find out the conceptual understanding and misconceptions of students in objects undergoing freely falling motion, speed, velocity and acceleration. Open-ended questions are utilized and are given to three science classes to assess students' understanding of the most basic concepts in free-fall speed, Velocity, and Acceleration. Results showed that majority of the students in both classes were able to correctly describe the motion of an object in free-fall in terms of velocity. Similar to previous studies, misconceptions were mostly on the acceleration of the object when it is at the highest point of its flight. Further analysis showed that there is no significant difference between the answers of science. Regardless of their concentration, students have the same general misconceptions on free fall speed, Velocity, and Acceleration. The results were analyzed by (SPSS) (subject package for social science) to identify Students' misconception on free-fall speed, velocity, and acceleration. The findings revealed that most of the students held alternative conceptions of free-fall speed, velocity, and acceleration. Finally, Implications and Suggestions for the Teacher for Teaching and Learning

KEYWORDS: Misconceptions, Free-fall, speed, Velocity, and Acceleration.

I. INTRODUCTION

Many researchers have investigated students' understanding of concepts of physics (Hestenes, Wells, & Swackhamer, 1992; McDermott, 1984; Bayraktar, 2009). Students' commonsense beliefs have been described as misconceptions or alternative conceptions. The most common observed alternative conception related to mechanics is that students think that a force is needed to keep an object moving. As a consequence they think that it should be a force in the direction of motion (McDermott, 1984; Bayraktar, 2009). Clement (1982) used written tests and video-taped interviews to show that many physics students have an alternative view of the relationship between force and acceleration. Many students applied the idea that continuing motion implies the presence of a continuing force in the same direction as the motion; the "motion implies force" misconception. Clement also noted that it is not likely that this misconception disappears simply because students are exposed to a physics course. The Newtonian ideas can be misperceived or distorted to fit students existing preconceptions or they may be memorized separately as formulas with little connection to the fundamental concepts. When misconceptions arise it is, according to Clement, necessary for the student to express them and to actively work out their implications. It has also been found that students often cannot distinguish between velocity and acceleration (McDermott, 1984; Hestenes, et al., 1992). Trowbridge & McDermott (1981) found that fewer than half of the students demonstrated sufficient qualitative understanding of acceleration to be able to apply this concept in a real situation. Aim and research questions The main aim of this study is to investigate what problems and possibilities arise when physics teaching in Lao universities is changed to include more group discussions. We want to answer the following research questions: How do students discuss and argue about physics during the group discussions? Do the students coconstruct their answers to the questions? What difficulties with physics concepts do the students show? What problems and possibilities regarding the changed teaching can be identified from the recorded group discussions and from interviews with teachers and students? METHODS Description of the context In the beginning of the first semester 2010 the tutorials for the freshman students were organized in a somewhat different way than before. At the start of the tutorial each tutorial teacher explained some important points

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from the last lesson and then the teacher solved some example problems. After that the teacher told the students that they should answer some questions in small groups. The first author explained the purpose of the research and the procedure for the rest of the tutorial. She advised the students to set up groups with three to four students in each. The teacher and the first author distributed the questions to the groups (two questions per group). The students had about ten minutes to discuss these two questions. When the group discussion session was ended the teacher told the students to give their answers to the teacher, who wrote the students' answers on the blackboard. The written answers were then given back to each group. One student from each group presented the reasons why they had chosen their answer while the other students listened. After that the teacher explained which answer was correct and why.

The concepts of free-falling motion free-fall, speed, velocity and acceleration are often introduced to students as parts of natural science courses in university level Physics classes. Physics classes traditionally begin with classical mechanics, with freely falling bodies Free-fall, Speed, Velocity and Acceleration discussed in both high school and universities. The range, breadth and depth of the topics discussed in the entire course vary according to instructors' area of expertise.

The Investigations in physics teaching at the high school and undergraduate level have shown that a majority of science students have difficulties to understand physics concepts (Hake, 1998; Halloun & Hestenes, 1985). Students often attend classes with solid initial misconceptions. Conventional physics instruction produces only little changes in their conceptual knowledge. The students may know how to use formulas and calculate certain numerical problems but they still fail to comprehend the physics concepts. The mentioned studies indicate that instruction can only be effective if it takes into account the student preconceptions. The proper concepts have to be learned but also the misconceptions have to beunlearned (Wagner & Vaterlaus, 2011). This requires the diagnosis of student concepts and misconceptions. We have designed a diagnostic test with the purpose of identifying the student concepts and misconceptions in kinematics at the high school level. The test is based on the following list of kinematics concepts:

1- Free-fall: A free falling object is an object that is falling under the sole influence of gravity.
2- Speed: is the change in distance over the change in time.
3- Velocity: is the change in distance over the change in time. If the distance changes from time to time, then the parameter which is responsible for change in distance is called velocity. In other words, it is defined as the rate of change of distance with respect to time.
4- Acceleration: is the change in velocity over the change in time. If the velocity changes from time to time, then the parameter which is responsible for change in velocity is called acceleration. In other words, it is defined as the rate of change of velocity with respect to time. Like velocity, acceleration imparted on an object is also a vector quantity.

<u>Acceleration Formula:</u>

Consider any body moving, it will be having some acceleration, the equations of motion related to acceleration is given by

$V = U+at$

$S = ut + 12at^2$

$V^2 - U^2 = 2as.$

Where:

U = initial velocity

V = final velocity

a = acceleration

t = time taken

S = distance covered by the body

The concept of free-falling motion, speed, velocity and acceleration are often introduced to students as parts of natural science courses in university level Physics classes. Physics classes traditionally begin with classical mechanics, with freely falling bodies discussed in both high school and universities. The range, breadth and depth of the topics discussed in the entire course vary according to instructors' area of expertise.

Undergraduate students, who took part in this study, are classified into science (SC) and non-science (NSC) students. Almost all students are familiar with the concept of free-fall, as required by the Basic Education Curriculum. The non-science students, mainly first year college students, have taken Physics classes in the previous year, as it is part of the Basic Education Curriculum. Science students, who are graduating non-Physics students, had their last Physics classes at least four years prior. They are required to take Physics classes in preparation for medical school. The non-science classes are made up of students from various

disciplines with class size of at least 30 students while the science class is a large class with a class size of 60 students. Eleanor

METHODS:

Test Instrument The kinematics diagnostic test is designed for last year level of high school students. The test items are based on the list of concepts presented in the previous section. To every concept there is also a set of corresponding misconceptions. The misconceptions have been verified by asking the students open questions and by analyzing their answers. Furthermore they have been confirmed by experts. The test consists of 10 multiple-choice items on kinematics (Free-fall, Speed,Velocity and Acceleration), each item containing one right answer and three to four distractors. Every distractor has been chosen in a way that it can be assigned to a single misconception. This is different from the other kinematics tests mentioned before. Thus the test not only uncovers student concepts but also student misconceptions. The items can be furthermore divided into three levels of abstraction:

Question-by-question analysis:

Q.1- A ball is thrown upwards from the roof of house, in same time other similar ball fall down to the ground. Choose the correct answer regarding velocity?

a- The velocity of first ball greater than the second ball.
b- The velocity of second ball greater than the first ball.*
c- Both balls have same velocity.

Table (1)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (1)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1-traditional teaching, which did not explain the difference between the concepts of kinematics and dynamics concepts. Curriculum no link between the different concepts. -Traditional teaching method, which means to teach the student memorize the concept for the purposes of the exam. -School book Translator that contains zero scientific meaning of texts (the acceleration is the rate of change in speed for the time. 2-experiences of everyday life.	1-match speed with the offset (distance) only. (P $v_1 = v_0 + 2\ a\ s$ 2-speed is not affected by the acceleration. 3-speed can be greater if the direction of movement of the body has not changed for influencing the direction of the acceleration. 4-speed in the presence of v_0, fixed acceleration and does not depend on the offset, but on the block. 5-forces make without the presence of antibodies (the concept of force is not the subject of the question, but the student used state force to clarify his answer.	%74.3	Speed of the ball will be thrown to the top faster than lob when you reach the Earth's surface, In the case of libel and at maximum height, the final speed = zero, $v^2_0 = -2as$ Including $s = v^2_0 / -2\ a$, and compensation for s in the equation that $v_1^2 = v_0^2 + 2a(v^2_0/-2a)$ in the case of falling speed down ≠ zero but = speed that tossed out and fell to the bottom and therefore it is the law $v_1 = v_0 + 2\ a\ s$, in the case of a fall are the final speed = $v_1 = v_0 + 2\ a\ s$, $v_1 = (0) + at$ valuable libel case $v_0 \neq 0$, $v2 = v_0 + at$ permission v2 > v1

Q-2- In the diagram showing the swing of the pendulum, which of the correctly explains a complete period? o K's to.

a- The time required to move from A to G to A.
b- The distance bob need from A to G to A.
c- The velocity bob move from A to G to A .
d- The angle which bob complete in moving from A to G to A

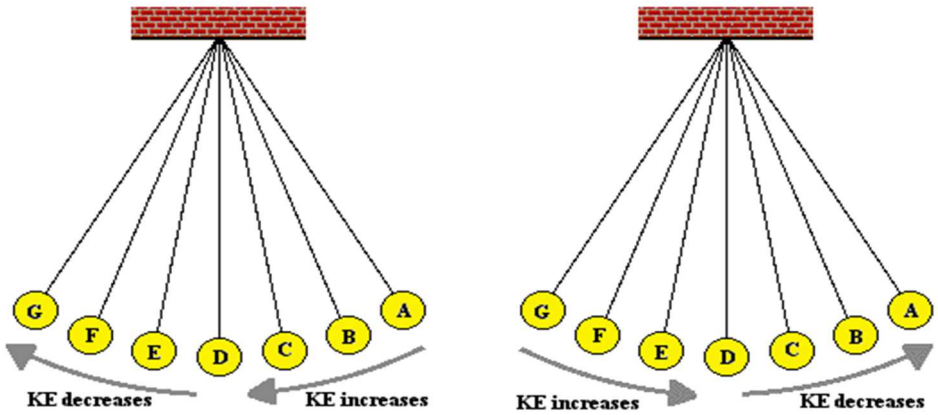


Table (2)
Summarizes the alternative concepts students about the concept
of the acceleration Through their answers
to the question number (2)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1-The textbooks not Content for the concept of the time period in a scientific manner and not to clarify that eating a single cycle is an expression of a period of time and not about anything else. -2 uses the daily life of a single cycle (period of time) are different from the scientific used (such as distance)	1- cycle (time period) is the distance. 2-cycle (time period) is the speed. 3-cycle (time period) is the angle	% 90.0	The time required to move from A to G to A.

Q-3- Tow objects (A , B) deferent in mass are in same high falling down to the ground, which one of them take long time to riche the ground?

A- object (A).
B- object (B) .
C- objects (A , B) in same time.

Table (3)
Summarizes the alternative concepts students about the concept
of the acceleration Through their answers
to the question number (3)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1-traditional teaching: - - the Do not approach emphasizes the difference between the concepts of kinematics and dynamics concepts. -the traditional method of teaching, which means to teach the pupil and memorize information for the purposes of the exam. -the School book Translator that contains zero scientific meaning of texts (the acceleration is the rate of change in speed for the time). 2-experiences of everyday life.	The acceleration is proportional to the mass.	%57.2	If the two bodies fell in the cluster are different from one high and at the same time, they arrive at one time because the gravity acceleration = 9.8 m / s² in the direction of the center of the earth, and using kinematic relationship. $v = v_0 t + ½ a t^2$ In both cases, the time to get to the ground evenly.

Q-4- Ball shot from the edge of the roof to the top, fell while at the same moment another ball from the same edge similar free fall to the bottom.
Explain any of the following statements are true and why?

A- The acceleration the first ball of the largest acceleration of the second ball.
B- Acceleration the second ball of the largest acceleration first ball.
C-Two balls have the same acceleration.

Table (4)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (4)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1-Traditional teaching, which did not explain the link between the concept of force and objects causing them (the first law of Newton, as well as the link between the direction and amount of force and the acceleration and the second law of Newton, due to: - -Curriculum And way of teaching focus only on the cognitive side of science and ignore the scientific skills. -School book translator that contains zero scientific meaning of texts (the acceleration is the rate of change in speed for the time). 2-experiences of everyday life.	The acceleration is always in the direction of motion. (acceleration in the case of free fall is different from the case of libel plumb up and will be in two opposites).	% 54.2	Two balls have the same acceleration, because they are under the influence of gravity acceleration, a = 9.8 m/s².in the direction of the center of the earth.

Q-5- Particle velocity increased from 0.4 cm / sec to 1.2 cm / sec in the amount of 0.02 sec, how the acceleration of this particle in units of centimeters / second box?

A- 0.96 cm /s².
B- 24 cm /s² .
C- 34 cm /s².
D- 40 cm /s².

Table (5)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (5)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1- Traditional teaching: - -curriculum where no link between the scientific concepts such as the word "average" and physical concepts. -Traditional teaching method, which means to teach the student memorize the concept for the purposes of the exam. -School book translator that contains zero scientific meaning of texts (the acceleration is the rate of change in speed for the time). 2-experiences of everyday life. 3-linguistic use of the word in the sense accelerate speed up or increase the speed.	1. The question is not can identify alternative concepts students. (But determines whether the concept of medium acceleration as a change in the speed divided by the change in time or not a firm for students).	% 17.1	Medium acceleration = change in velocity / change in time, a= (1.2-0.4) /0.02 =0.8/ 0.02= = 40 cm/ s²

Q-6- Moved from the trailer to the bottom of the slope after it was balanced, with the first cut in the second distance of 0.8 meters, what are the regular acceleration?

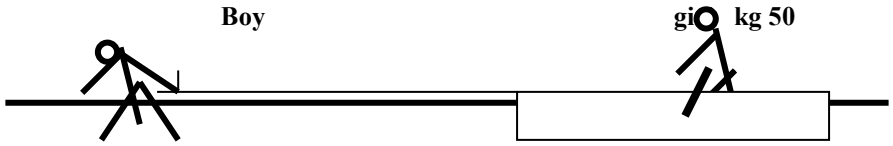
A zero m/s².
(B) 3.2 m/s²,.
C - 0.8 m/s².
(D) 1.6 m/s²,

Table (6)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (6)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1. Traditional Teaching: - -curriculum where he did not focus on the link between the general scientific concepts such as the word "instant" and physical concepts. -Traditional teaching method, which means to teach the student memorize the concept for the purposes of the exam. -School book translator that contains zero scientific meaning of texts (the acceleration is the rate of change in speed for the time), and the lack of linkage between the different concepts. 2-experiences of everyday life. 3-linguistic uses of the word in the sense accelerate speed up or increase the speed.	1-position of the body is changing, even if the speed is constant equal to zero (the basic lack of understanding of the relationships between displacement and time). 2. The acceleration is not subject to specific relationship between displacement and time. 3-acceleration offset is equal to the square of time (and not a change in the change in the displacement of time	% 37.2	The use of the concept of the acceleration as the instantaneous rate of change speed can prove kinematic relationship, including the acceleration = change in the speed of change in time, through the equation $s = v_0t + ½ a t^2$ $0.8 = 0 + ½ a (1)^2$ $a= 0.8 * 2 =1.6 m / s^2$

Q-7- A boy pulls a sledge with mass 10 kg, there is a girl seating on the sledge with mass 50 kg on smooth surfer by constant force, with acceleration 0.5 m/s², as in below, what is the acceleration after the girl fall side, and the boy continues pulls the sledge by same force?

A- 3.0 m/s²,
B- 2.0 m/s²,
C- 1.0 m/s²,
D- O.5 m/s²,



sledge 10 kg

Table (7)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (7)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1. Traditional Teaching: - -curriculum where he did not focus on the link between the scientific concepts and physical concepts. -Traditional teaching method, which means to teach the student memorize the concept for the purposes of the exam. -School book translator that contains zero scientific meaning of texts (the acceleration is the rate of change in speed for the time). 2-experiences of everyday life.	1. The amount of the acceleration does not vary when the block be fixed power. (Lack of understanding of the Second Law). 2-amount of force is not equal to the product of the mass and the acceleration, (not to absorb the meaning of the second law of Newton). 3-wearing concepts for each of force, mass and acceleration and the relationship between them	% 35.7	Acceleration before change mass = 0.5 m/s², and using dynamic relationship change F = m * a can be found in the amount of force in the first case = (50 + 10) * 0.5 = 30 Newton, cart acceleration after the mass change, $a = f /m = 30/10 = 3.0 m / s^2$

Q-8- A boy Threw from 10 feet high and at the same moment, the two pieces of equal lengths of plastic and other copper, is expected to: -
A- The copper reach first.
B- The plastic reach first.
C- The two pieces reach together to ground.
Explain why?

Table (8)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (8)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1-traditional teaching, which did not explain the difference between the concepts of kinematics and dynamics concepts. Approach, where it focuses on the link between different scientific concepts. -Traditional teaching method, which means to teach the student memorize the concept for the purposes of the exam. 2-experiences of everyday life.	-Gravity acceleration vary for different objects in the blocks. 2. objects heavier ground up first, (in kinematics relationships do not affect Ingredients such as dynamic force and mass).	% 81.4	The two pieces reach together because they are under the influence of gravity acceleration, one and equal to 9.8 m/s², in the direction of the center of the earth and using kinematics relationship $s = v_0t + ½ a t^2$ the arrival in the ground one time.

Q-9- The weight of a space 70 men Newton at the surface of the ground, what is the weight at a point 1,600 kilometers away from its surface? (The radius of the earth = 6400 km).
A 11 Newton.
(B) 35 Newton.
(C) 44.8 Newton.
(D) 70 Newton.

Table (9)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (9)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1-traditional teaching, which did not explain the difference between weight and mass. -curriculum no link between the different scientific concepts. -Traditional teaching method, which means to teach the student memorize the concept for the purposes of the exam. 2-entrenched Obviously concepts based on the life experiences of a non-scientific.	1-constant weight in all positions and is equal to the amount at the surface of the earth. 2. f = ma only. (Lack of understanding of Newton's law of gravity, and then change the gravity acceleration with position)	%78.6	1. Newton's law of gravity and Newton's second law, we find that the relationship (f = ma) and f = w * / (s + v) ² 2-man mass on the surface of the earth = 70 / 9.8 kg. 3. That we find that the weight Space man at a point located 1600 km from the surface of the earth = 44.8 Newton

Q-10- How much gravity acceleration at a point 1,600 kilometers away from the Earth's surface? (The radius of the earth = 6400 km). How much gravity acceleration at the point mentioned?
A -3.6 m / s².
B -5.7 m / s² .
C -6.27 m / s² .
(D) 9.8 m / s² .

Table (10)
Summarizes the alternative concepts students about the concept of the acceleration Through their answers to the question number (10)

Special factors researcher sees it led to entrenched alternative concept	Alternative concepts based on the students' answers and General Notes	Percentage of wrong answers	Answer model
1-traditional teaching, which did not explain the inverse square law. Approach, where it focuses on the link between different scientific concepts. -Traditional teaching method, which means to teach the student memorize the concept for the purposes of the exam. -School book translator that contains zero scientific meaning of texts (the acceleration is the rate of change in speed for the time). 2-entrenched Obviously concepts based on everyday life experiences.	1-relationship between the amount of gravity acceleration at a specific position and the distance between that position and the center of the earth is not subject to the law of inverse square. 2-acceleration fixed gravity in all positions and equal to its value at the surface of the earth.	% 81.4	1. Newton's law of gravity and Newton's second law, we find that the relationship between the Earth's gravity acceleration in a specific position inversely proportional to the square of the distance between that position and the center of the earth. $\frac{v_1^2}{v_2^2} = \frac{d2}{d1}$ 2-man block on the surface of the earth = 70 / 9.8. 3-weight to 1600 km and so we find that the gravity acceleration 1600 km=6.27 m/s²

Analyses:

Q1	**74.3%**	**Q6**	**37.2%**
Q2	**90.0%**	**Q7**	**35.7%**
Q3	**57.2%**	**Q8**	**81.4%**
Q4	**54.2%**	**Q9**	**78.6%**
Q5	**17.1%**	**Q10**	**81.4%**

Most of students they have misconception in acceleration, the percentage of the students misunderstand the acceleration is between the (35.0% and 90%)

Implications and Suggestions to teachers for Teaching and Learning:

From the fundamental ideas, it is recommended that teachers could teach Free-fall, Speed, velocity and acceleration concepts along withstudents' experiences and then identify contrast and make comparisons between conceptionuntil students clearly understand how the concept describes that situations. Thus, an understanding of students' priorknowledge is useful in providing appropriate situations and effective pedagogies as well. Multi-contexts should beused to introduce and explain acceleration concepts, so students can better understand the concept and seehow the concepts are transferred and applied. The new approach should address students' prior knowledge of free-fall, speed, velocity and acceleration. The students already have the ideas of kinematics situation before they get into the classroom. Thenew learning approach should pay more emphasis on helping students to build scientific thought and analysis.

Additionally, to develop students' understanding of the differences of speed and velocity, distance and displacement, and velocity and acceleration teachers should help students to recognize that mass is also an important factor of heat energy. The terms intensive and extensive quantities should be explained to students. Understanding these terms will help students clearly to identify the differences of velocity and acceleration.
Hence, teaching should give more emphases on:
1) Encourage students to use the experimental of physics Lab.
2) Physics teacher should use modern approach of teaching physics course.
3) Develop student's conceptual understanding before solving theoretical or mathematical problems.
4) Encourage students to express their ideas by using the technical terms and concepts with an event consistently in order to improve student's transfer of velocity, acceleration and kinematics concepts.
5) Make the education and psychology period for the scientific courses professors as (physics, chemistry, biology and mathematics) because they are not studied any educational and psychological courses.

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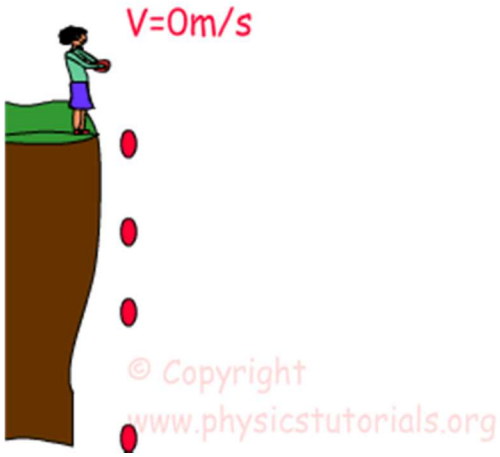
Free Fall with Examples



FREE FALL

Free fall is a kind of motion that everybody can observe in daily life. We drop something accidentally or purposely and see its motion. At the beginning it has low speed and until the end it gains speed and before the crash it reaches its maximum speed. Which factors affect the speed of the object while it is in free fall? How can we calculate the distance it takes, time it takes during the free fall? We deal with these subjects in this section. First, let me begin with the source of increasing in the amount of speed during the fall. As you can guess, things fall because of the gravity. Thus, our objects gain speed approximately10m/s in a second while falling because of the gravitation. We call this acceleration in physics *gravitational acceleration* and show with "g". The value of g is 9,8m/s² however, in our examples we assume it 10 m/ s² for simple calculations. Now it's time to formulize what we said above. We talked about the increase in speed which is equal to the amount of g in a second. Thus our velocity can be found by the formula;

V=g.t where g is gravitational acceleration and t is the time.

Look at the given example below and try to understand what I tried to explain above.

Example The boy drops the ball from a roof of the house which takes 3 seconds to hit the ground. Calculate the velocity before the ball crashes to the ground. ($g=10m/s^2$)

Velocity is;

V=g.t

$V=10m/s^2.3s=30m/s$

We have learned how to find the velocity of the object at a given time. Now we will learn how to find the distance taken during the motion. I give some equations to calculate distance and other quantities. Galileo found an equation for distance from his experiments.

This equation is;

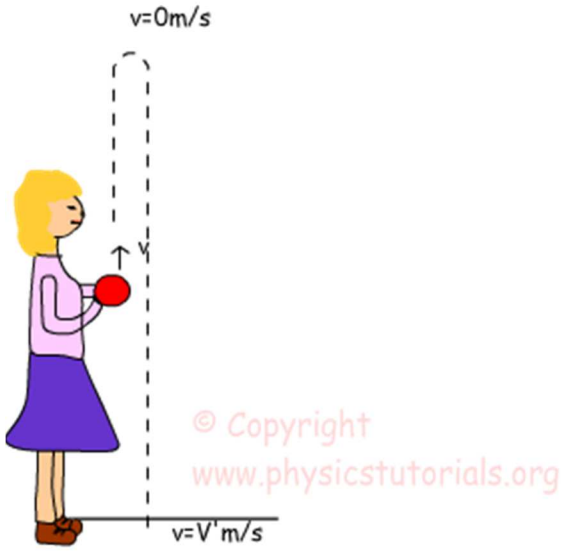
$$\text{Distance Traveled}=\frac{1}{2}g.t.t=\frac{1}{2}g.t^2$$

Using this equation we can find the height of the house in given example above. Let's found how height the ball has been dropped? We use 10 m/s^2 for g.

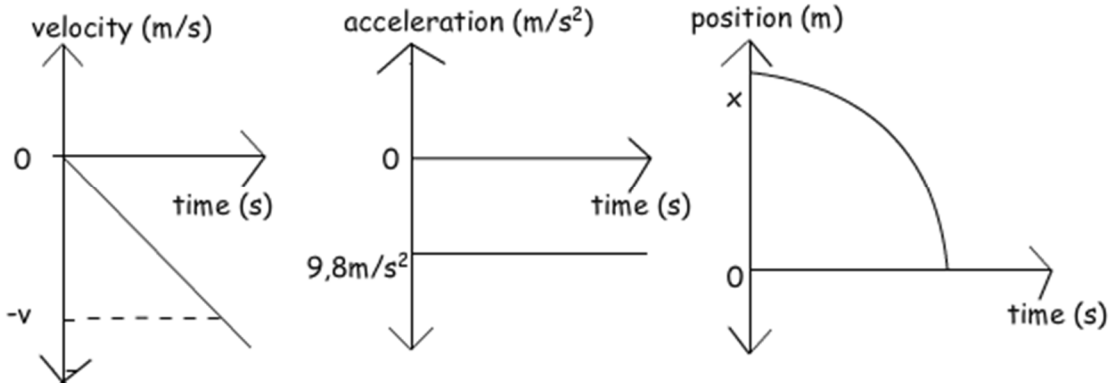
$$\text{Distance Traveled}=\frac{1}{2}g.t.t=\frac{1}{2}10.3^2$$

$$\text{Distance Traveled}=45m$$

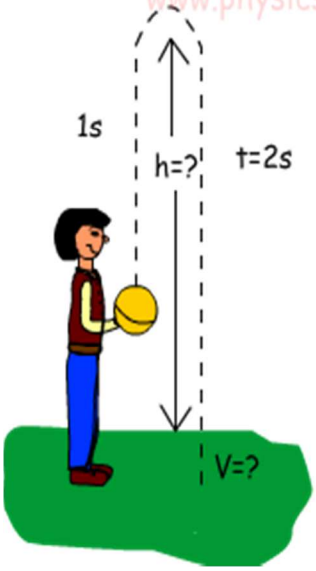
I think the formula now a little bit clearer in your mind. We will solve more problems related to this topic. Now, think that if I throw the ball straight upward with an initial velocity. When it stops and falls back to the ground? We answer these questions now.



Picture shows the magnitudes of velocity at the bottom and at the top. As you can see the ball is thrown upward with an initial v velocity, at the top it's velocity becomes zero and it changes it's direction and starts to fall down which is free fall. Finally at the bottom before the crash it reaches its maximum speed which shown as V'. We have talked about the amount of increase in the velocity in free fall. It increases 9,8m/s in each second due to the gravitational acceleration. In this case, there is also g but the ball's direction is upward; so the sign of g is negative. Thus, our velocity decreases in 9,8m/s in each second until the velocity becomes zero. At the top, because of the zero velocity, the ball changes its direction and starts to free fall. Before solving problems I want to give the graphs of free fall motion.



As you see in the graphs our velocity is linearly increases with an acceleration "g", second graphs tells us that acceleration is constant at 9,8m/s², and finally third graphic is the representation of change in our position. At the beginning we have a positive displacement and as the time passes it decreases and finally becomes zero. Now we can solve problems using these graphs and explanations.



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$V = g.t$

$V = g.t = 10m/s^2.1s = 10m/s$ ball is thrown with 10 m/s velocity

at the top our velocity is zero,
ball does free fall

$V = -g.t$ we put "-" sign in front of the g because

$V = -g.t = -10m/s^2.2s = \underline{-20m/s}$ we take upward direction "+"

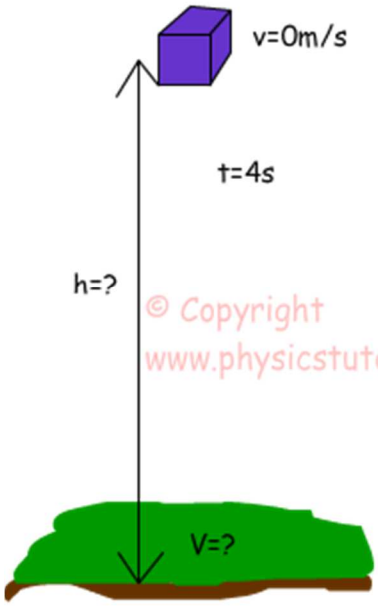
$$Distance = \frac{1}{2} g.t^2$$

$$h_{max} = \frac{1}{2} 10m/s^2.(2s)^2$$

$$h_{max} = 20m$$

Example John throws the ball straight upward and after 1 second it reaches its maximum height then it does free fall motion which takes 2 seconds. Calculate the maximum height and velocity of the ball before it crashes the ground. ($g=10m/s^2$)

Example An object does free fall motion. It hits the ground after 4 seconds. Calculate the velocity of the object after 3 seconds and before it hits the ground. What can be the height it is thrown?



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Velocity after 3 seconds is;

$V = -g.t$

$V = -10m/s^2.3s$

$V = -30m/s$

Velocity after 4 seconds is;

$V = -g.t$

$V = -10m/s^2.6s$

$V = -40m/s$

Height is;

$$h = \frac{1}{2} g.t^2$$

$$h = \frac{1}{2} 10m/s^2.4^2 = 80m$$

Two examples given above try to show how to use free fall equations. We can find the velocity, distance and time from the given data. Now, I will give three more equations and finishes 1D Kinematics subject. The equations are;

$$V=V_0+at$$
$$X=V_0t+\frac{1}{2}.a.t^2$$
$$V^2_f=V^2_i+2.a.X$$

First equation is used for finding the velocity of the object having initial velocity and acceleration. Second one is used for calculating the distance of the object having initial velocity and acceleration. Third and last equation is timeless velocity equation. If distance, initial velocity and acceleration of the object is known then you can find the final velocity of the object. Now let's solve some problems using these equations to comprehend the subject in detail.

Example Calculate the velocity of the car which has initial velocity 24m/s and acceleration 3m/s² after 15 second.

We use the first equation to solve this question.

$$V=V_0+a.t$$
$$V=24m/s+3m/s^2.15s$$
$$V=69m/s$$

Example The car which is initially at rest has an acceleration 7m/s² and travels 20 seconds. Find the distance it covers during this period.

$$X=V_0t+\frac{1}{2}.a.t^2$$
$$X=\frac{1}{2}.7m/s^2.(20s)^2$$
$$X=1400m$$

Kinematics Exam2 and Problem Solutions

1. An object is dropped from 320 m high. Find the time of motion and velocity when it hits the ground.(**g=10m/s²**)

h=1/2.g.t² , v=g.t

h=320m

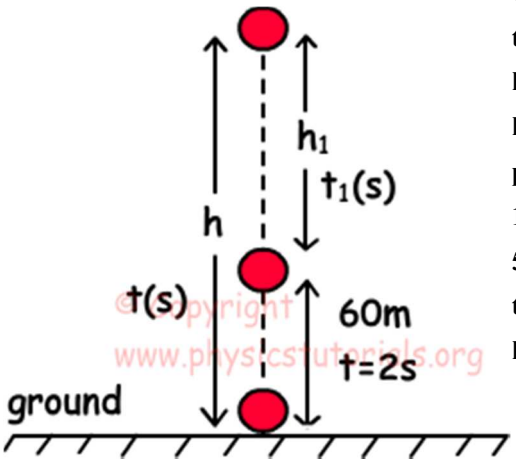
g=10m/s²

320=1/2.10.t²

t=8s.

v=g.t=10.8=80m/s

2. An object does free fall and it takes 60m distance during last 2 seconds of its motion. Find the height it is dropped.(**$g=10m/s^2$**)



t is the time of motion

$h=1/2.g.t_2$

$h_1=1/2.g.t_1^2$

put $t_1=t-2$ and $h-h_1=60$ in the equation,

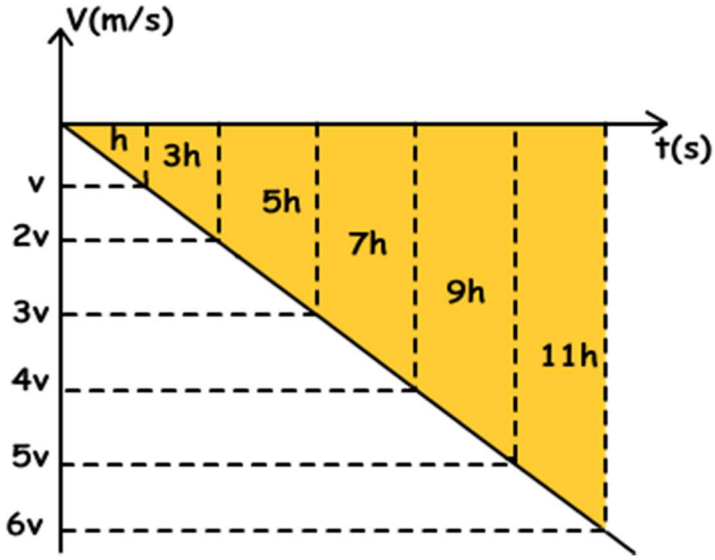
$1/2.g.t^2-1/2.g.t_1^2=60$

$5t^2-5(t^2-4t+4)=60$

t=4s

$h=1/2.g.t^2=1/2.10.4^2=80m$

3. An object is dropped from 144m height and it does free fall motion. Distance it travels and time of motion are given in the picture below. Find the distance between points B-C.



We can draw velocity time graph of object and area under this graph gives us position of the object.

As you can see from the velocity time graph, object travels 5h distance during 2t-3t which is the distance between the points B and C.

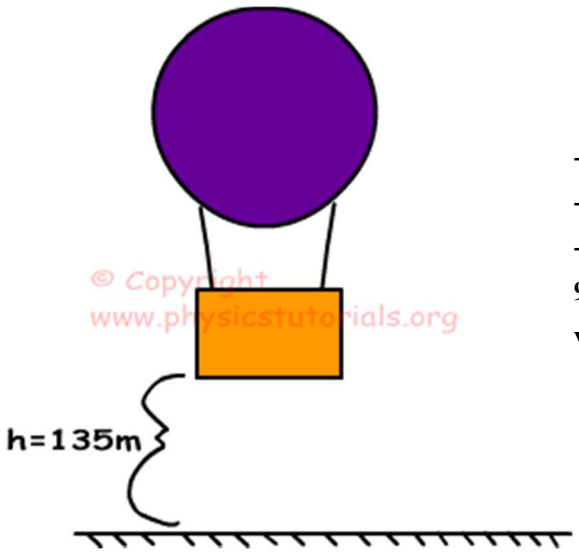
All distance traveled is 36h

144m=36h

h=4m

Distance between B-C=5h=5.4m=20m

4. A hot- air balloon having initial velocity v_0 rises. Stone dropped from this balloon, when it is 135 m height, hits the ground after 9 s. Find the velocity of the balloon.



$-h=v_0.t_{fligth}-1/2.g.t_{fligth}^2$

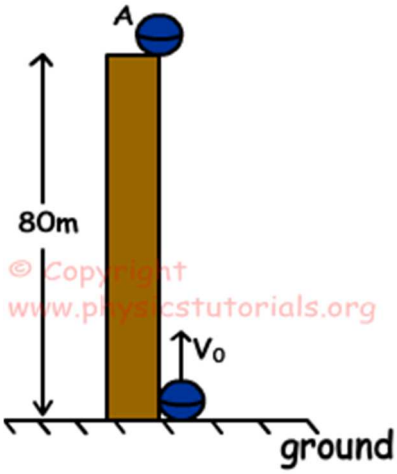
$-135=v0.9-1/2.10.(9)^2$

$-135=9v_0-405$

$9v_0=270$

$v_0=30m/s$

5. Look at the given picture below. Object K does free fall motion and object B thrown upward at the same time. They collide after 2s. Find the initial velocity of object B. (**$g=10m/s^2$**)



Object A does free fall motion

$h_A=1/2.10.2^2=20m$

$h_L=v_0.t-1/2.g.t^2$

$h_L=v_0.2-1/2.10.2^2$

$h_L=2v_0-20$

$h_K+h_L=80m$

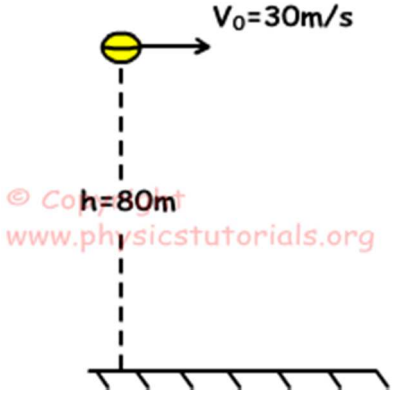
$20m+h_L=80m$

$2v_0-20=60m$

$v_0=40m/s$

Kinematics Exam3 and Problem Solutions

1. As you can see from the given picture, ball is thrown horizontally with an initial velocity. Find the time of motion. ($g=10m/s^2$)



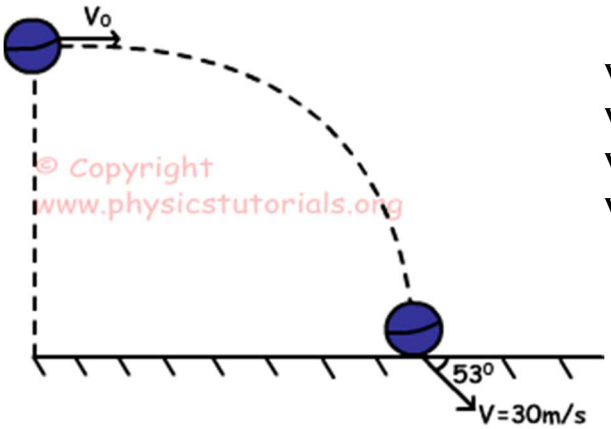
Ball does projectile motion in other words it does free fall in vertical and linear motion in horizontal. Time of motion for horizontal and vertical is same. Thus in vertical;

$h=1/2g.t^2$

$80=1/2.10.t^2$

$t=4s$

2. An object hits the ground as given in the picture below. Find the initial velocity of the object.



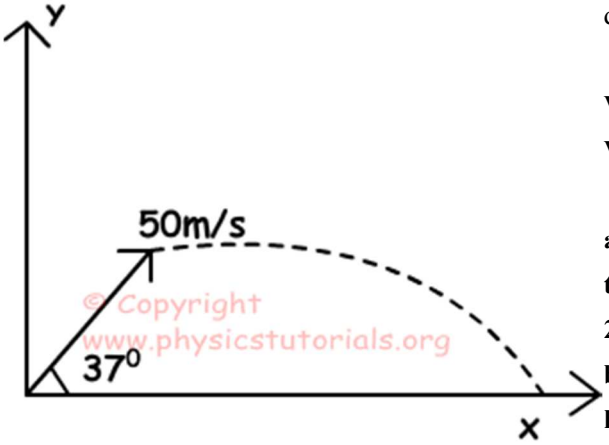
Velocity of horizontal motion is constant. So;

$V_0=V_x=V\cos53^0$

$V_x=V_0=30m/s.0,6$

$V_0=V_x=18m/s$

3. An object is thrown with an angle 37^0 with horizontal. If the initial velocity of the object is 50m/s, find the time of motion, maximum height it can reach, and distance in horizontal.



$V_{0x}=V_0\cos53^0=50.0,8=40m/s$

$V_{0y}=V_{0y}.\sin53^0=50.0,6=30m/s$

a) $V-V_{0y}=0-g.t$ at the maximum height

t=30/10=3s

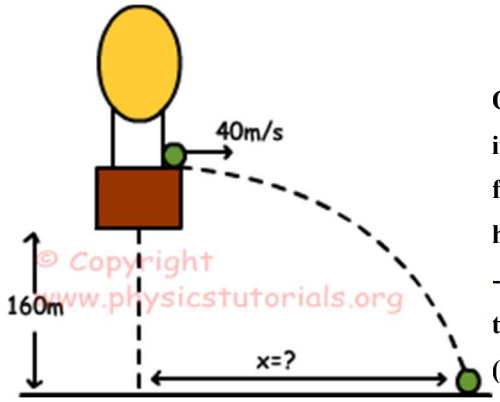
2.t=time of motion=2.3=6s

b) $V_{0y}^2=h_{max}.2.g$

$h_{max}=302/2.10=45m$

c) $X=V_{0x}.t_{total}=40.6=240m$

4. A balloon having 20 m/s constant velocity is rising from ground to up. When the balloon reaches 160 m height, an object is thrown horizontally with a velocity of 40m/s with respect to balloon. Find the horizontal distance travelled by the object.



Object has velocity 40m/s in horizontal, 20m/s in vertical and its height is 160m. We can find time of motion with following formula;

$h=V_{0y}.t-1/2.g.t^2$

$-160=20.t-1/2.10.t^2$

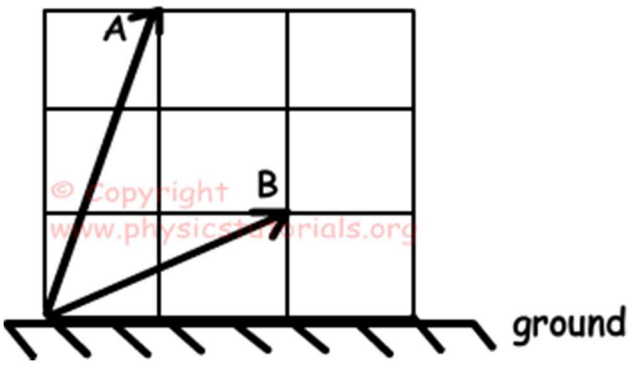
$t^2=4t-32$

(t-8).(t+8)=0

t=8s

$X=V_{0x}.t=40.8=320m.$

5. Objects **A** and **B** are thrown with velocities as shown in the figure below. Find the ratio of horizontal distances taken by objects.



Time of flight is directly proportional to vertical component of velocity. Vertical velocity component of A is three times bigger than vertical velocity component of B.

$t_A/t_B=3$ $t_B=t_A/3$

Horizontal distance traveled by the object is found by the following formula;

$X_A=V_A.t_A$

$X_B=V_B.t_B$

Horizontal component of V_A is half of V_B, so we can write following equation;

$V_A=V_B/2$

$V_B=2.V_A$

$X_A=V_A.t_A$

$X_B=2.V_A.t_A/3$

$X_A/X_B=3/2$