LESSON PLAN

Subject : Physics

Class/Semester : XI/1

Time Allocation : 1 x 45 minutes

Standard Competencies : 1. Analyze symptom of nature and its regularity in term of point particle

Basic Competency : Analyze motion in straight line, circular motion and parabolic motion by using vectors

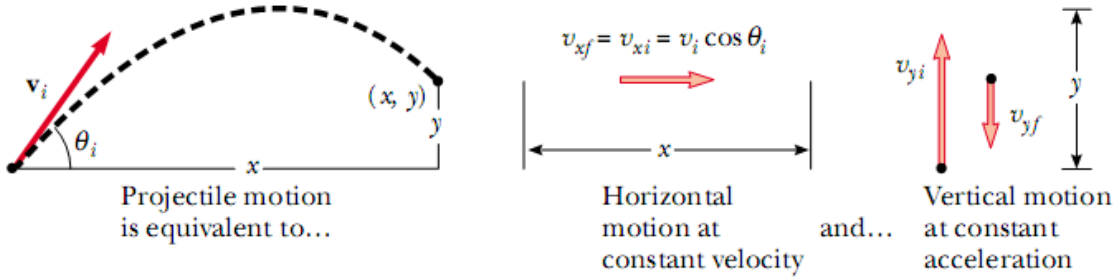
Indicator : Analyze displacement and velocity in parabolic motion by using vector analysis

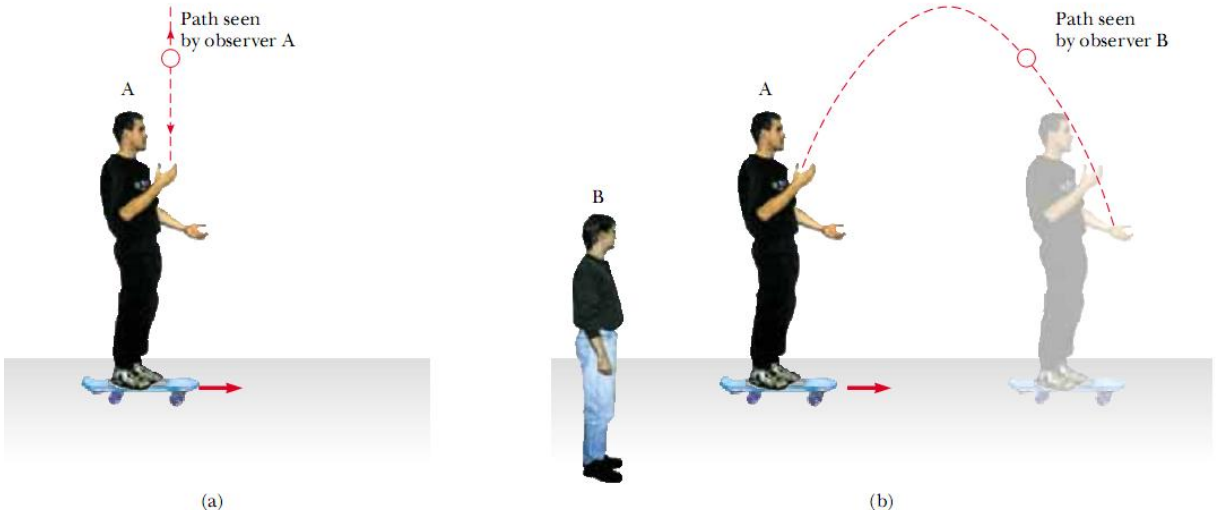
Learning Objectives :

- Students are able to apply the concepts of vectors to explain the displacement of a projectile that undergo a parabolic motion
- Students are able to determine maximum height that can be reached and the maximum range of a projectile by using vector analysis

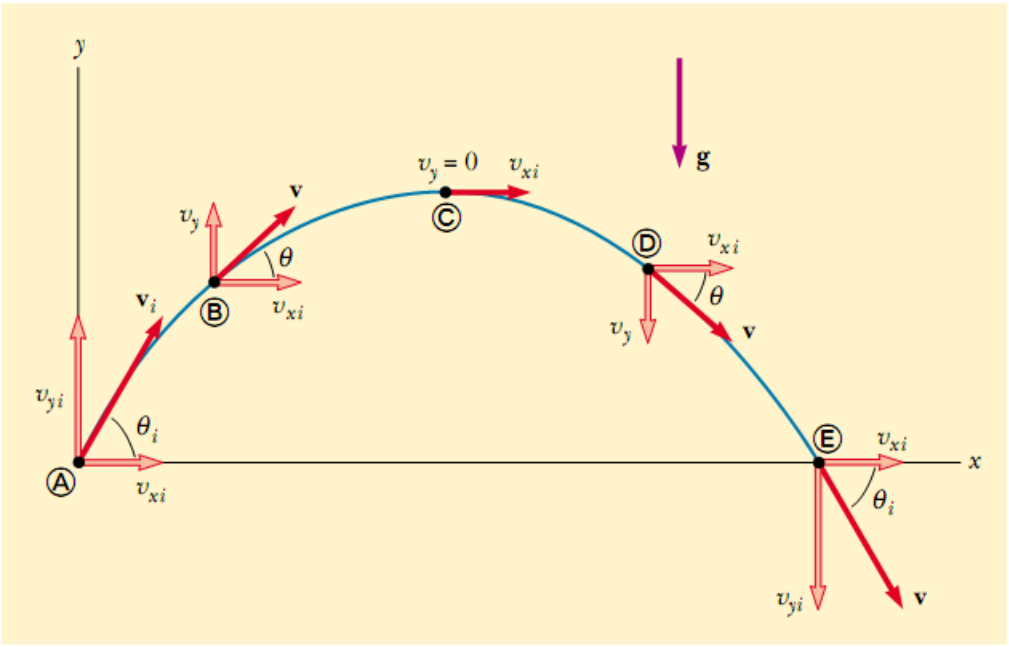
Learning Material:

Projectile motion or sometimes called parabolic motion is one type of two-dimensional motion under constant acceleration, where and It is useful to think of projectile motion as the superposition of two motions: (1) constant-velocity motion in the x direction and (2) free-fall motion in the vertical direction subject to a constant downward acceleration of magnitude g = 9.80 m/s2. You should be able to analyze the motion in terms of separate horizontal and vertical components of velocity





The vector of its velocity is shown in the picture below:



By using vector analysis we can find that the maximum height that can be reached by the projectile is :

$$h_{\max} = \frac{v_0^{\,2} \sin\theta}{2g}$$

And the horizontal range of the projectile is:

$$x = \frac{v_0^{\,2} \sin 2\theta}{g}$$

Learning Approach : Cooperative Learning

Media :

- Video of parabolic motion
- Media of Presentation (Pesona Edukasi)

Learning Activities:

1. Check the presence
2. Recall students understanding for the concept of linear motion (including accelerated motion)
3. Settle the class into some groups
4. Show the students the video about projectile motion
5. Distribute students worksheet
6. Students discuss the worksheet to find the solution
7. One of the group present the result of their discussion
8. Teacher leads a class discussion, to give feedback and to find the best solution for the problem given in the worksheet. In this discussion teacher will use the media from Pesona Edukasi, to assist him in explaining the vector analysis of parabolic motion
9. Check students' understanding by giving them some exercise problems
10. Students summarize their learning

Learning Resources/material

Marthen Kanginan (2007). Physics. Jakarta: Erlangga

Haliday, Resnick, and Walker. (2001). Fundamental of Physics. Sixth Edition. New York: John Wiley & Sons, Inc. (Optional)

Acknowledgement

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Assignment

1. A bullet is shot at initial of velocity *40 m/s*, and elevation angle of 60^0 from a flat ground, air friction in neglected and gravitational acceleration $g = 10\ m/s^2$.
   Determine:

   a. The time needed by the bullet to reach the highest point H
   b. The maximum height reached by the bullet
   c. The greatest distance reached by the bullet.
2. An object is thrown at initial of velocity of 20 m/s from point A to the ground with elevation angle 30^0. If gravitational acceleration g = 10 m/s^2 and air friction is neglected, determine:
   a. The initial velocity vector
   b. The object velocity vector after 0,5 s
   c. The object position vector after 0,5 s
3. A ball is thrown horizontally at initial velocity of 4 m/s from a place 20 m above a plain ground. Air friction is neglected, g = 10 m/s^2. Determine the time required by the ball to fall to the ground, and where it lands measured from the base of where it was thrown to the ground.

OBSERVATION SHEET

STUDENTS' COGNITIVE COMPETENCE

Subject : Science-Physics Meeting : ……… meeting

Grade : XI Day/date : ……………………

Semester : 1 Subject Matter : …………………….

Group	No.	Name	Aspects	
			Worksheet	Assignment

OBSERVATION SHEET

STUDENTS' AFFECTIVE COMPETENCE

Subject : Science-Physics
Meeting : ……… meeting

Grade : XI
Day/date : ……………………

Semester : 1
Subject Matter : …………………….

Group	No	Name	The assessment item *)				Score	Mark
			(1)	(2)	(3)	(4)		

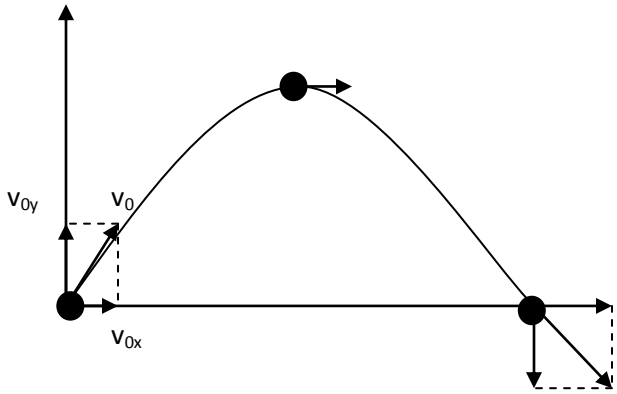
STUDENTS WORKSHEET

PROJECTILE MOTION

We next consider a special case of two dimensional motions: a particle moves in a vertical plane with some initial velocity but its acceleration is always downward. Such particle is called a **projectile**.

In projectile motion, the horizontal motion and vertical motion are independent of each other, neither motion affects each other

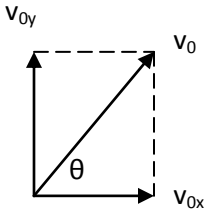
Let us now take a look at the graph bellow



1. If the angle between v_0 and x axis is θ, define the initial velocity of the motion in y axis and the velocity in x axis in the term of v_0 and θ!

   Answer :

   To determine the velocity in x and y axis, we have to draw the vector of the initial velocity. Then by using the theorem of trigonometry we can determine the value of the initial velocity in x and y axis.



   From the vectors we found that $v_{0x} = v_0 \cos\theta$ and $v_{0y} = v_0 \sin\theta$

2. As there is only acceleration in the motion, that is acceleration of gravity, so the motion in x axis is a motion with uniform velocity and the motion in y axis is an accelerated motion. Find the expression for the position of a projectile in x and y axis!

   X = …….

   Y = …….

   Is the equation for Y in the form of $Y = ax - bx^2$ (this is the equation of parabola)? What does it mean?

   Answer :

   $X = v_0 \cos\theta\, t$

   $Y = v_0 \sin\theta\, t - \frac{1}{2} gt^2$

   As we can see that the equation of y is in the form of $Y = ax - bx^2$. It means that the trajectory of the projectile is parabola (this motion is parabolic motion)

3. Determine the expression for vector position (**r**) of the projectile as a function of time (t)!

   Answer :

   The vector position of the projectile is given by

   $\mathbf{r} = (v_0 \cos\theta\, t)\mathbf{i} + (v_0 \sin\theta\, t - \frac{1}{2} gt^2)\mathbf{j}$

4. What happen to the magnitude of vertical velocity of the projectile when it goes upward, when it reaches the highest point, and when it goes downward?

   Answer :

   When the projectile goes up the acceleration is in opposite direction with the velocity. It makes the velocity of the projectile getting smaller. When it reaches the highest point, the projectile

stop (the velocity in this position is zero), then when it goes down the projectile's velocity is getting higher (the acceleration is in the same direction with the velocity)

5. What happen to the magnitude of horizontal velocity of the projectile when it goes upward, when it reaches the highest point, and when it goes downward?

   Answer :

   As it was explained, the acceleration is in vertical direction only. There is no acceleration in horizontal direction. It means that the velocity in horizontal direction remains constant.

6. Based on your answer to question number 4, determine the time that is needed to reach the highest point!

   Answer:

   We know that the velocity of a projectile in vertical direction is zero when it reaches the highest point.

   $$v_y = v_0 \sin\theta - gt$$
   $$t = \frac{v_0 \sin\theta}{g}$$

7. Find the highest point that is reached by the projectile!

   Answer:

   By substituting the equation which we get in question number 6 to the equation for position in y axis ($y = v_0 \sin\theta\, t - \frac{1}{2} gt^2$) we get

   $$h_{\max} = \frac{v_0^2 \sin^2\theta}{2g}$$

8. Let R be the horizontal range of the projectile. Considering that R is the horizontal distance the projectile has traveled when **it returns to its initial height** (y = 0), find the equation for R in the term of v_0, θ, and g!

   Answer:

   To find the equation for R, we have to determine the time that is needed to reach the horizontal distance. This can be gained by using the condition y =0. Then we can yield :

$$t = 2\frac{v_0 \sin\theta}{g}$$

   After having the formula for t, we now substitute t into the equation of

   x = vcos θ t

   we get :

$$R = \frac{v_0^2 \sin 2\theta}{g}$$

9. Based on the equation of R, what is launch angle that can give maximum horizontal range!

   Answer:

   Considering the equation that we get in the question number 8, the value of R is changed as the value of sin2θ is changed. So, maximum value of R is reached when the value of sin2θ is maximum.

   Thus

   $\sin 2\theta = 1$

   $\sin 2\theta = \sin 90^0$

   $\theta = 45^0$