GUIDED NOTES

Unit 2: Newtonian Mechanics – Kinematics in Two Dimensions

OBJECTIVES:

There are no AP Physics 1 or AP Physics 2 learning objectives that focus *solely* on the topics covered in this unit. However, both concepts, vectors and projectiles, weave into other themes in the AP Physics 1 and AP Physics 2 curricula. Our objectives in this unit are therefore …

> 1. …to lay a foundational understanding of vector operations and projectile motion so that when these arise in contexts we will encounter later in the course, we are prepared.
> 2. ……to reinforce every learning objective from the previous unit by practicing kinematic analysis of motion in the context of projectile motion.

There is this objective, which is embedded in other more complex topics. For now, we can focus on it in simple terms:

> Essential Knowledge 3.E.1 …
>
> c. The component of the net force exerted on an object perpendicular to the direction of the displacement of the object can change the direction of the motion of the object without changing the kinetic energy of the object. This should include uniform circular motion and projectile motion.

NOTES

I. Two-Dimensional Motion

   A. Two-dimensional motion is confined to a _____.
   B. Examples of two-dimensional motion include _____, _____, and _____.

II. Vectors

   A. Vectors are measurements that have magnitude (quantity) and direction.
   B. Vectors symbols are written with an arrow over the top. If only the magnitude is being calculated, the arrow is omitted.
   C. Vector models: Arrows represent the vector such that…
      1. The _____in a way that represents the _____ of the vector.
      2. The _____ of the arrow represents the _____ of the vector.
   D. Vector parts
      1. Vector _____: When more than one vector of the same type is involved in a situation, these vector "parts" are called components.
      2. _____ vector: The vector that results from the combination of the components.
   E. _____allow mathematical analysis of vector values.
      1. Vector _____ must be drawn _____.
      2. Vector _____ must be drawn _____.

F. Vector addition/subtraction uses trigonometry to determine the resultant from given components. (This is also called "vector operations.")

- <u>Example 1</u>: A boat's captain steers a ferry straight across the Hudson River from Hoboken to Manhattan with the engines running in such a way that if there were no current, the ferry would travel at 15m/s. However, the current is flowing at 12m/s. The average river width is 4.125km. How fast and at what angle downstream will the ferry actually travel? Represent your answer both mathematically and graphically (with a vector diagram.)

G. Vector resolution uses trigonometry to determine the components from a given resultant.

- <u>Example 2</u>: Carry the river problem further...
    - First predict: Do you think the boat will make it to the dock faster with or without the current?
    - Now show all the steps you could use to solve for the angle the ferry boat captain could aim upriver so that she arrives at a dock straight across the river. Also show how you could find how long the trip will take. Assume she can run her engines to move the boat no faster than 15m/s under its own accord and that the river current continues to flow at 12m/s.
    - Solve using both mathematical and graphical methods. Be sure to create vector diagrams *and* one graph. Compare your answer to your prediction.

GUIDED NOTES

II. _____ under the influence of _____ [1]

    A. Projectiles involve an object _____. In the
       absence of air resistance, the path a projectile takes is a _____.

    B. Rule: The _____are _____ of each other.

      1. Horizontal:

          • There is _____naturally occurring on Earth, so there is
           _____. [2]

          • Therefore in the absence of significant air resistance, the horizontal velocity is constant,
           and _____.

      2. Vertical:

          • The force of _____ causes the object to _____
           at a rate of _____. Therefore the _____.

          • Note that the _____ it takes for the object to land _____ on its
           _____components.

This chart is a helpful way to organize your calculations.

	Vertical Component	Horizontal Component
x_0 (m)		
x (m)		
v_0 (m/s)		
v (m/s)		
a (m/s^2)		
t (s)		

    C. Horizontally-Launched Projectiles: There is no initial vertical velocity component.
    D. Vertically-Launched Projectiles: There *is* an initial vertical velocity component.

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[1] We will examine projectile motion created by electric charges moving in electric, magnetic, and/or gravitational fields later.
[2] Newton's second law proves that force (a push or pull) is required to accelerate an object or system.

E. Examples

1. <u>Example 3</u>: A pebble is kicked horizontally with a velocity of 2m/s off of a bridge that is 9 m high. Fully describe its motion using...

- Mathematical representations...
- Graphical representations...
- Narrative representations...

2. <u>Example 4</u>: A rowdy physicist uses a trebuchet to launch a pumpkin so that the pumpkin leaves the trebuchet at an angle θ with a velocity v at a height $x_{0,y}$ above the ground. Using formulas, descriptions, and principles, answer the following questions.

     a. How fast is the pumpkin moving vertically when it leaves the trebuchet?

     b. How fast is the pumpkin moving horizontally when it leaves the trebuchet?

     c. Describe what happens to the vertical velocity as the pumpkin travels upward and then downward to the ground below. Then explain why this happens using physics principles. Include vector diagrams to compliment your explanation.

     d. Describe what happens to the horizontal velocity as the pumpkin travels upward and then downward to the ground below. Then explain why this happens using physics principles. Include vector diagrams to compliment your explanation.

3. <u>Example 5</u>: The NFL doesn't officially record the distance of actual throws during passing plays. However, it is widely accepted that in 1966 Cowboys quarterback Don Meredith tossed the longest actual throw: 83 yards! (That's 75 m!) Typical NFL quarterbacks can throw the ball between 50-60 miles per hour (22-27 m/s,) so let's say he threw it a little faster than that at 28 m/s at an angle of 55.5°. Don Meredith was 6'3" (1.88 m) tall, so let's say the ball left his hand when it was 2.0m above the ground and that the receiver caught it at a chest height of 1.45 m above the ground. Fully describe the ball's motion from its launch to its reception using…

- Mathematical representations, being sure to confirm that the ball really would have gone the full 75 m.
- Graphical representations…
- Narrative representations…
- Finally, besides throwing faster, how could he make the ball go farther? Justify your answer.

4. <u>Example 6</u>: A zookeeper needs to shoot a banana to a monkey in a tree, but the monkey has the bad habit of dropping from the tree limb as soon as the banana canon is fired. Where should the zookeeper aim? Justify your answer using physics principles.