Unit 3 ~ Learning Guide Name: _____

Instructions:

Using a pencil, complete the following notes as you work through the related lessons. Show ALL work as is explained in the lessons. You are required to have this package completed BEFORE you write your unit test. Do your best and ask questions if you don't understand anything!

Relative Velocity in 2D:

1. Use your own words to explain the difference between 1D, 2D, and 3D motion (dimensions). Provide examples of each. You may use diagrams that include x, y, and z axis to help illustrate.

2. Convert the following into vertical and horizontal components. Show all steps and include units.

a)

b)

c)

3. A canoe is crossing a river. Describe how the landing position (distance downstream) is impacted by both the river current and the canoe speed.

4. Break the following vectors into components (remember directions). **Show work** by sketching each vector, labeling the angle, and showing components! Remember – components also have direction

   a) 25 [35° N of E]

   x_____

   y_____

   b) 373 [12.0° E of N]

   x_____

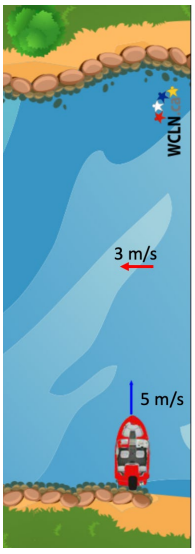
   y_____

   c) 126 [22.0° N of W]

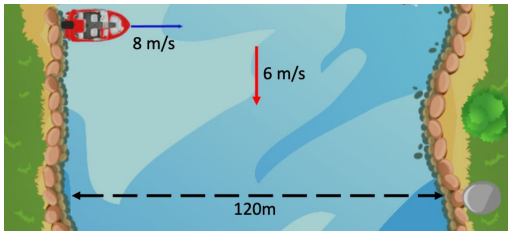
   x_____

   y_____

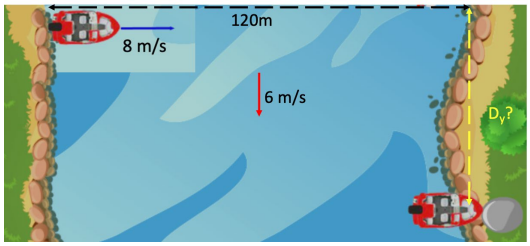
5. A boat travels north at 5.0 m/s across a river which is flowing west at 3.0 m/s. What is the resulting velocity as viewed from shore?



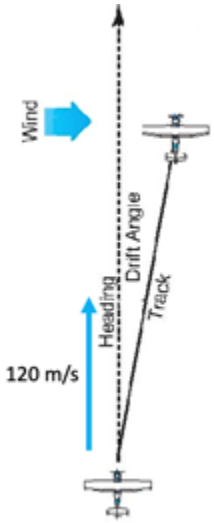
6. A boat aims straight across a river with velocity 8.0m/s to the east. If the river flows south at 6.0m/s and is 120m wide, how long will it take to cross?



7. Using the boat and river from the previous example, how far downstream, D_y, is the boat when it lands on the far bank?



8. An airplane aims directly north with an airspeed of 120 m/s. However, a wind is blowing **<u>from</u>** the west causing the plane to track at 122 m/s relative to the ground. What is the wind velocity? Also, provide the direction of the plane in 'degrees east of north'. **Show all work**.



9. A ping pong ball is smashed straight down the centre line of the table at 60.0 km/h. However, the game is outdoors and a crosswind of 25.0 km/h sweeps across the table parallel to the net. How many degrees off centre will the ball end up? What is the ping pong ball's speed overall? **Show all work**.

10. The still water velocity of a rower is 5.0 m/s. At what angle must this rower point upstream to be able to land directly across the river? The current is moving at 3.0 m/s.
    a. Draw a fully labeled vector diagram of this scenario and solve.

    b. A common incorrect answer for (a) is 31 degrees. What mistake results in that answer?

11. The kinematic equation ***d = vt*** is used in conjunction with relative velocity questions. Explain why the other kinematic equations are not useful for most relative velocity questions.

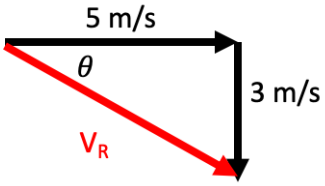
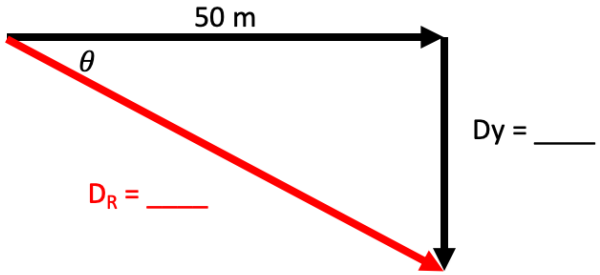
12. Two rowers of identical ability want to race across the river above. The goal is to touch the other side first (anywhere along the bank). Both rowers can row at a rate of 5.00 m/s in still water. The river's current is 3.00 m/s. Rower A points upstream so that she ends up travelling straight across the river along a line perpendicular to the point on the shore where she started. Rower B points directly across and ends up downstream due to the river's current.

    a. Which rower makes it across first? Why do you think this is so?

    b. If the river is 50.0 m wide determine the time it takes for each rower to cross.

Rower A (time to cross) – show work	Rower B (time to cross) – show work

c. Using Rower B above solve for the following: Construct the equivalent **displacement vector diagram** and label all sides and angles with correct **displacement** values. Use the equation **d** = **v**t and solve for **d** in each direction (i.e., displacement downstream and diagonally).

Velocity Diagram: (solve for angles)	Displacement Diagram (determine sides and angles)
	

d. Discuss the similarities and differences between these two vector diagrams:

Projectiles:

1. Describe (in your own words) what a projectile is. Provide examples.

2. What is the biggest difference in the behaviour of a projectile's horizontal and vertical motion? Discuss the phenomenon that causes this difference. Be sure to state why one dimension is affected while the other is not.

3. Summarize the (often) surprising result of shooting a gun horizontally and dropping a bullet at the same time from the same height. Why is this true (explain in terms of horizontal and vertical components of motion)?

4. Try the "Falling Monkey" simulation.
    a. Where must you aim the rifle to hit the falling monkey? Why?

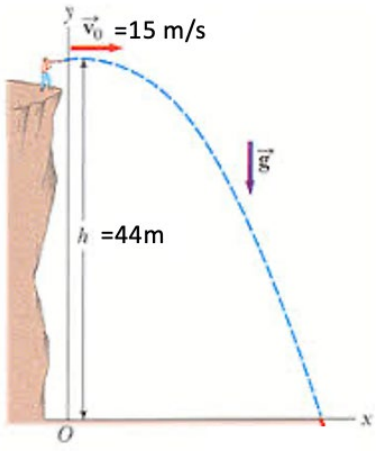
    b. If you increase the monkey's initial height, where do you aim the rifle? Why is this true?

    c. If you had a rifle with a higher muzzle-velocity, where do you aim the rifle? Why is this true?

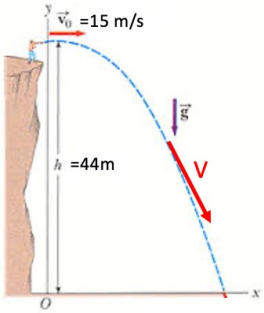
Projectile Problems – Type 1:

1. What characteristics make a projectile problem a “Type 1” problem?

2. A rock is thrown horizontally at 15 m/s from the top of a cliff 44 m high.
   a. How far from the base of the cliff does the rock hit the ground?



   b. What is the velocity of the rock after 2.0 seconds?



3. Legolas shoots an arrow horizontally from the top of Helm's Deep at a speed of 15 m/s and hits an Orc on the ground with a speed of 25 m/s. Calculate the height of Helm's Deep. *(hint: “speed” is the overall magnitude, v_x and v_y combined)*

4. A jet aircraft is travelling at 850 km/hr at an altitude of 11 km – when an engine falls off!
   a. Neglecting air resistance, determine the speed of the engine when it hits the ground.

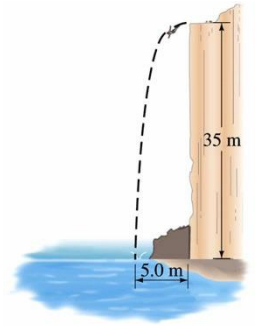
   Is this realistic? Discuss how assumptions made in the calculations might not reflect the reality of the engine's impact speed. Would the impact speed actually be higher or lower and why?

   b. Determine the horizontal range of the engine (measured from where the jet was located when the engine fell off).

   c. Reality – Would the engine land at this point in reality? Why or why not? Under what conditions would your solution be valid? Would it actually land closer or further from this point?

5. A water bomber flying with a horizontal speed of 85 m/s at a height of 3.0×10^3 m drops a load on a fire below. How far in front of the where the target fire starts should the load be released for maximum coverage?

6. A cliff diver wishes to clear some rocks extending 5.0 m from the base of a 35 m high cliff. What is the lowest horizontal velocity that she could safely leap from the cliff?

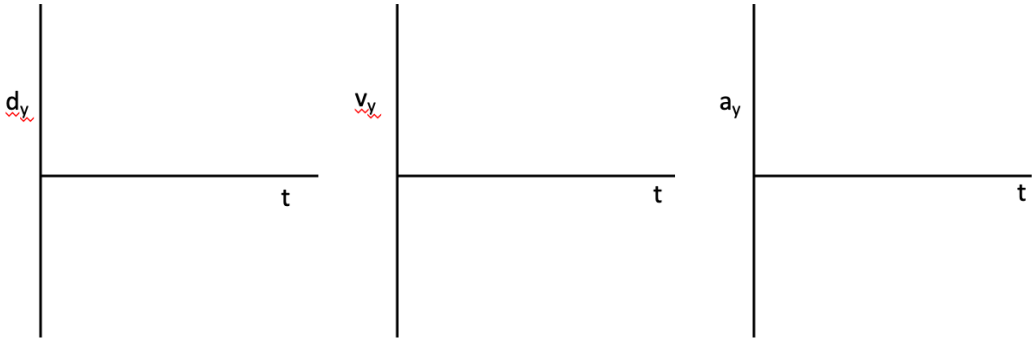


7. You are exploring a newly discovered cave in the Andes in South America. Peering over the edge of a cliff in the cave, you can't see the bottom. Wondering if you have enough rope to rappel to the ground, you drop a rock off the top, and hear the sound of it hitting the bottom 4.2 seconds later. Find the height of the cliff ignoring the time that the sound takes to travel back to you from the bottom. **Show all work** as done in lessons.

8. 0.30 s after seeing a puff of smoke rise from the starter's pistol, the sound of the firing of the pistol is heard by the track timer 100. m away. What is the velocity of sound? Hint: treat the speed of light as instantaneous. Sound does not accelerate. It travels at a constant speed.

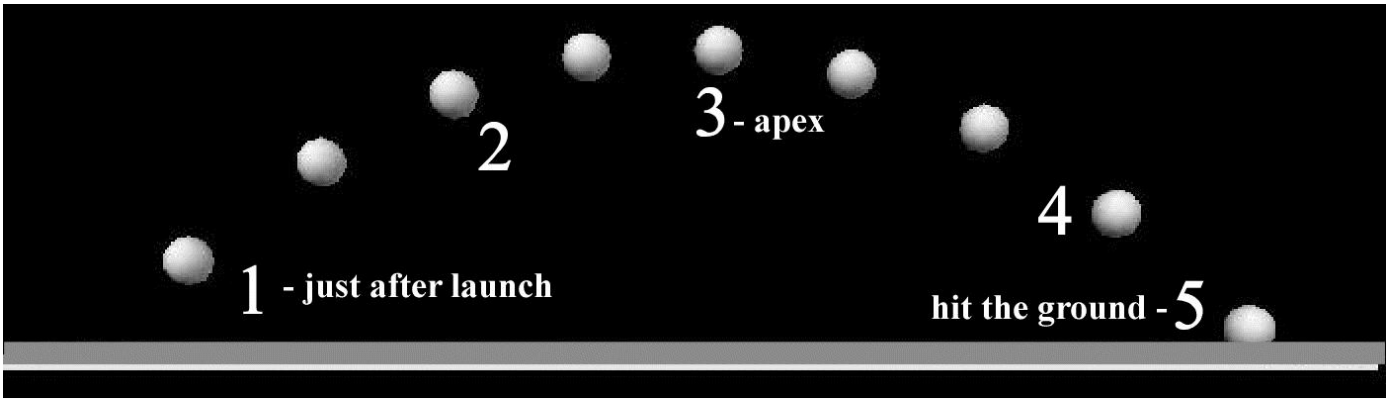
9. A boy throws a rock **straight** up into the air. Explain the changes taking place through the flight in terms of velocity and acceleration.

10. Sketch the general shapes of d_y vs t, v_y vs t, and a_y vs t graphs for Type 1 projectiles. Use arrows and wording to explain how the various characteristics of these graphs change (or don't change) depending on the problem.



Projectile Problems – Type 2:

1. The photograph below shows a basic projectile at several locations on its trajectory.



a) List the location(s) where the **vertical component** of the velocity would be zero.

_____

b) What is the acceleration at location #3? _____

c) What is the horizontal acceleration of the projectile? _____

d) Identify the location where the vertical displacement would be zero. _____

e) Identify the location with the maximum vertical displacement. _____

f) Rank each location in terms of the projectile's speed (highest to lowest). _____

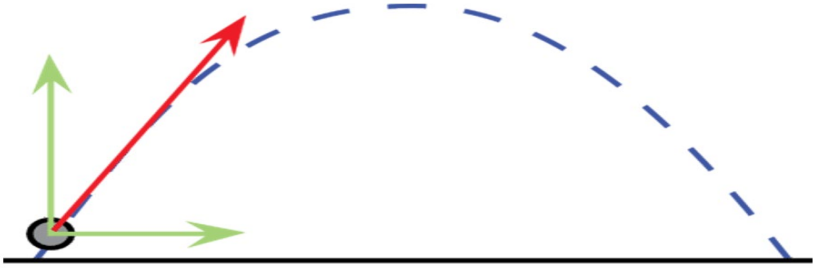
The above projectile is classified as a Type 2 projectile. What characteristics make a projectile problem a "Type 2" problem?

2. A water cannon ejects water at a 40. degree angle with an initial speed of 35 m/s. How far (horizontally) does it travel before it hits the ground? (you may assume the water strikes at approximately the same height it was fired from).

3. A golf ball is struck and leaves the ground at 48 m/s on a 60. degree angle.
   a. How long will it be in the air before bouncing?

   b. How far will the ball travel in the air before the first bounce?

   c. The overall velocity of the ball at any point in time is a vector tangent to the path (parabola) at this point. It consists of both $\boldsymbol{v_x}$ and $\boldsymbol{v_y}$ components.



   I. Draw the velocity vector at the highest point on the diagram above. Determine the magnitude velocity at this point.

   II. What is the maximum height reached by the ball?

   III. Label the velocity vector 2s into its flight directly on the diagram above. *Hint: Consider your answer to (a).*

   d. Determine the ***velocity*** of the ball 2.0 seconds after it was struck.

   e. The most common incorrect answer for this question is 22m/s. What has actually been calculated if this is the answer?

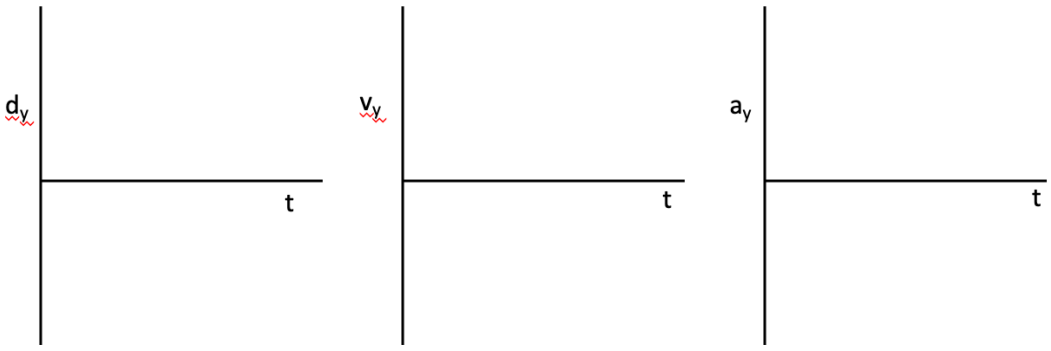
4. Discuss the degree of danger involved in firing an “celebration gun” straight up into the air from a crowd on Earth compared to the same “gun-firing celebration” on the moon. *Hint: while this is dangerous on Earth, there are some limiting factors not accounted for in our kinematic equations.*

5. What is the maximum height of a rock launched by a sling shot at 50. m/s on an angle of 80. degrees?

6. Christine Sinclair kicks a ball from ground level at 27 m/s at an angle of 30. degrees above the horizontal.
   a) What is the "hang time" (time in the air) of the ball? **Show all work** as done in lessons.

   b) How far does the ball travel before hitting the ground? **Show all work** as done in lessons.

7. Sketch the general shapes of d_y vs t, v_y vs t, and a_y vs t graphs for Type 2 projectiles. Use arrows and wording to explain how the various characteristics of these graphs change (or don’t change) depending on the problem.



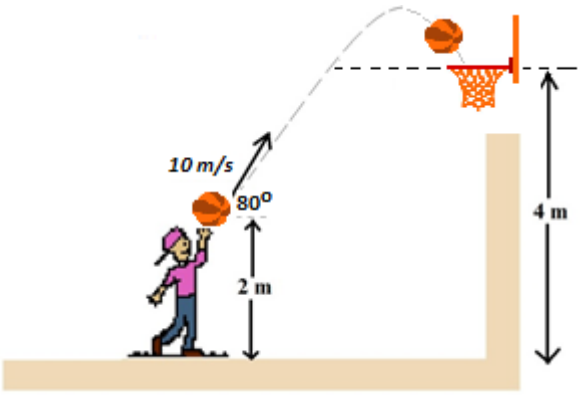
8. You are sitting in the back seat of a car that is going 100 km/hr and decide to flip a coin. You flip the coin straight up. What happens? Does the coin bang you in the chest? Does it land in your hand, which is now in a different place? How does the trajectory (path) of the coin look to someone on the side of the road as you pass by?

9. Newton's Second Law states the objects will accelerate in the direction of the unbalanced force. For projectiles, this force is the force of gravity. Explain the ballistic cart demonstration in your own words. Describe how this demonstration still illustrates the validity of Newton's Second Law (analyze both components of the motion with this law in mind).

Projectile Problems – Type 3:

1. A ball is kicked from the top of one building towards another building that is 15.24 m away. The initial velocity of the ball is 6.1 m/s 40.° above the horizontal. How far above or below its original level will the ball strike the opposite wall?

2. A grade 12 Physics student shoots a basketball from the ground at a hoop which is 2.0 m above her release. The shot was at a velocity of 10. m/s and at an angle of 80.° to the ground.



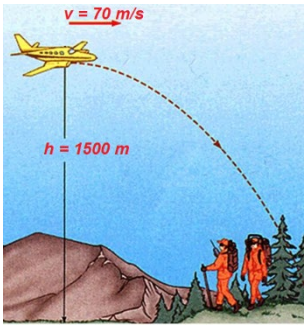
   a. Determine the vertical velocity of the ball when it is at the level of the net. You should get two answers.

   b. Using your answer to (a) determine the times of flight for the ball (from release to the 2.0m vertical displacement of the basket).

   c. When solving projectiles, you will often get two possible times for solutions. Sometimes a time will be negative and can be rejected. Other times both times will be positive and therefore possible. **Explain** why both times above make sense in the context of the given information used. Which time will you ultimately choose and why? Use the diagram to label where the ball is at the two times found above. Label the heights at these points with a dotted, horizontal line. Explain why both times are valid.

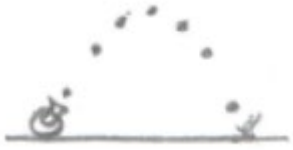
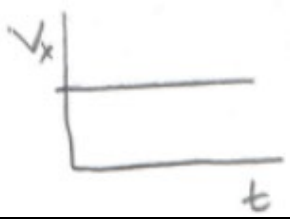
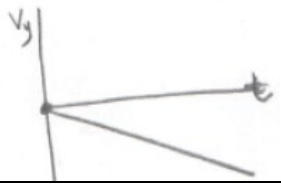
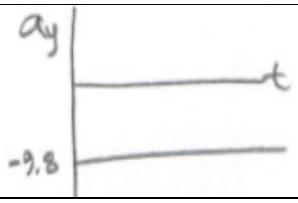
3. Emergency rations are to be dropped from a plane to some stranded hikers. The search and rescue plane is flying at an altitude of 1500 m at 70. m/s.

   a. Determine where the ideal drop point would be (measured horizontally from the hikers).



   b. The pilot notices (too late!) that they have passed the ideal drop point; the supplies now need to be launched vertically in order to land near the hikers. Calculate the vertical launch velocity required, given that the plane is now 1.0 km away (horizontally) from the hikers.

Sketch the basic graph shapes (and add values where appropriate) for the various projectile problems. Some have been done for you – make sure you understand them.

	Type 1	***Type 2***	***Type 3***
Example Situation (cannon)			
special	V_{yo} = _____	d_y = _____	$V_{yo} \neq$ ___, $d_y \neq$ ____
d_x vs t			
d_y vs t			
v_x vs t			
v_y vs t			
a_x vs t			
a_y vs t			

Answers:

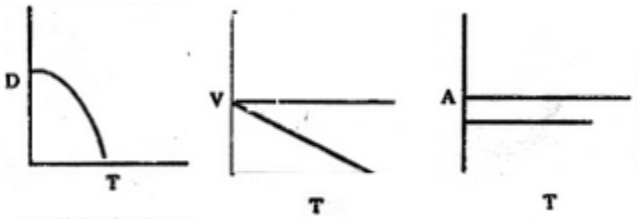
Relative Velocity in 2D:

2)a) v_x=27 m/s, v_y=22 m/s b) v_x=180 m/s, v_y=-59 m/s c) v_x=-0.33 m/s, v_y=1.2 m/s 4)a) 20.E, 14 N b) 77.6 E, 365 N c) 117 W, 47.2 N 5)5.8 m/s[31°WofN] 6)15 s 7)90m 8) 22m/s, plane[10.°EofN] 9) 22.6°off, 65.0km/h 10)a) 37 degrees b) calculated from a line perpendicular to the shore 11)no acceleration, so stay simple 12)a)B, explain b) 12.5s,10.0s c) 30.0m, 58.3m, 31.0 degrees below horizontal

Projectile Problems-Type 1:

2) a) 45m b)25 m/s, 37˚ E of S 3) 20.m 4) a. 520m/s,1900kph b. 11 km away 5) 2100 m 6) 1.9 m/s 7)86 m 8) 330 m/s

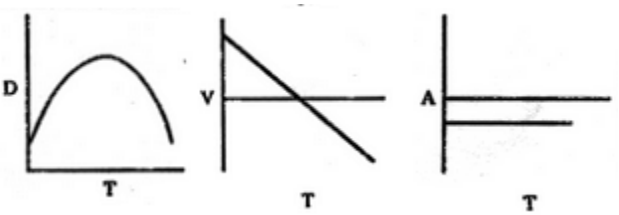
11)



Projectile Problems -Type 2:

2) 120 m 3) a) 8.5 s b) 2.0x10^2 m c)I 24m/s, II 88m d)33m/s, 42˚ above horizontal e)v_y 5)120 m 6) 2.8 s, 64 m

7)



Projectile Problems -Type 3:

1) 39 m below 2) a) ±7.6m/s b) 1.8s and 0.23s 3. a) 1.2 km, b) 35m/s [down]