SPH4U: Projectile Problem Solving

Recorder: ___________________
Manager: ___________________
Speaker: __________________
0 1 2 3 4 5

The key idea which allows us to solve projectile problems is the relationship between the horizontal and vertical motions. Since the vertical physics does not affect the horizontal physics, we can treat a single projectile problem as two related kinematics problems – one for each direction.

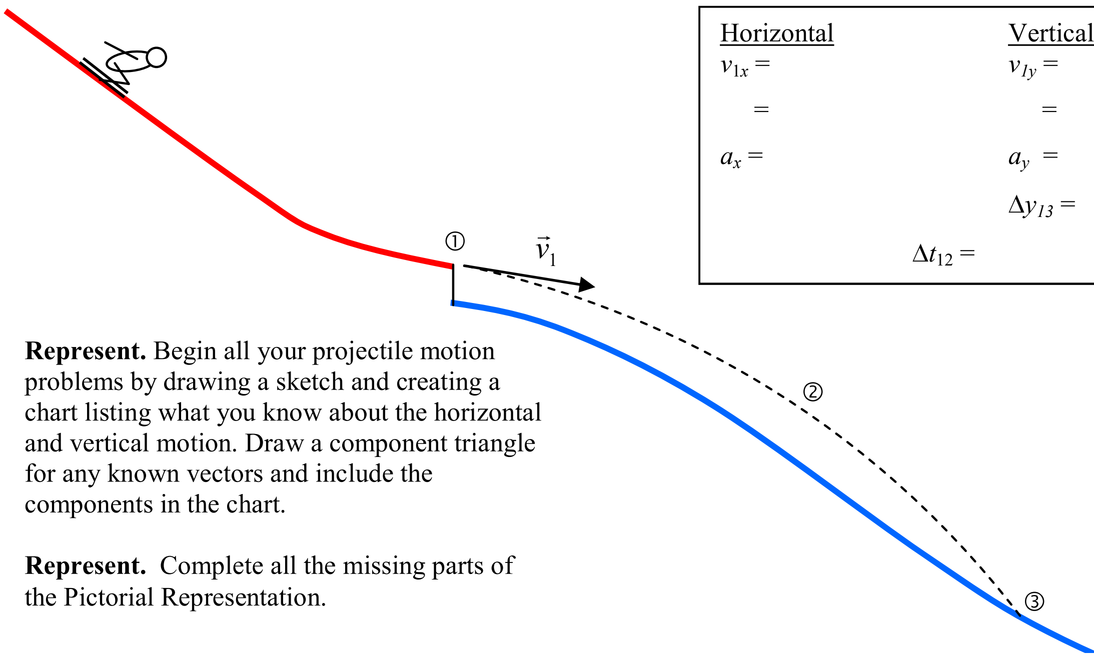
A convenient way to show the direction of the velocities used to describe projectile motion is to simply indicate the angle and use a sign convention with positive for above the horizontal and negative for below. For example: 12 m/s [32°] or 150 km/h [-12°].

The Ski Jump – One Giant Leap …

The ski jump is an exciting and death-defying event that turns human beings into projectiles! Let's study the physics of the craziest winter sport as featured at the Vancouver Winter Olympics in 2010. A typical ski jumper will be launched with a velocity of 26.1 m/s [-11.25°]. What is hard to notice from TV and photos is that the launch angle is **below** the horizontal (downwards)! A jumper makes her leap and we note three events: (1) leaving the ramp, (2) part way down after 1.8 s, and (3) just before landing, 35.8 m below the starting position.

A: Pictorial Representation

Sketch, coordinate system, label givens & unknowns, conversions, describe events



Horizontal	Vertical
v_{1x} =	v_{1y} =
=	=
a_x =	a_y =
	Δy_{13} =

Δt_{12} =

1. **Represent.** Begin all your projectile motion problems by drawing a sketch and creating a chart listing what you know about the horizontal and vertical motion. Draw a component triangle for any known vectors and include the components in the chart.

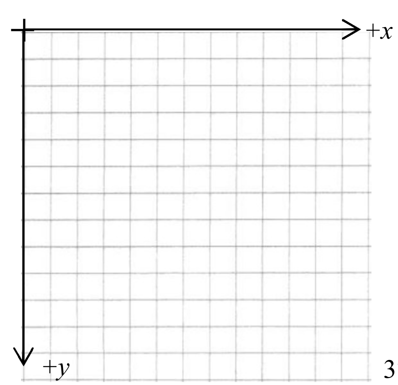
2. **Represent.** Complete all the missing parts of the Pictorial Representation.

B: Physics Representation

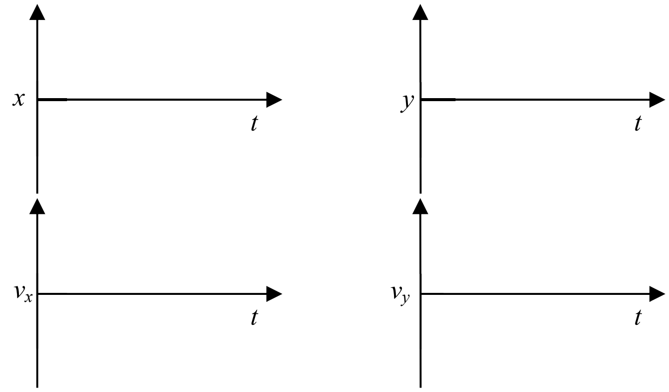
Motion diagram, motion graphs, velocity vectors, force diagram, events

For two-dimensional motion we will draw a special kind of motion diagram. Start by drawing a motion diagram along the *x*-axis for the motion in the *x*-direction.Next, do the same for the *y*-axis. Finally, use the two motion diagrams to help draw a third one using the grid which shows the complete, two-dimensional path of the object.

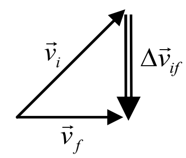
3. **Represent.** Complete the 2-D motion diagram for the ski jumper. Be sure to label events 1, 2 and 3. Don't worry about being too precise, as long as the correct ideas are shown. Describe how you chose to draw the dot patterns along the *x*- and *y*-axes.



4. **Represent.** Complete motion graphs for the *x*- and *y*-components of the ski jumper's motion.



A velocity vector diagram shows the relationship between a pair of velocity vectors and shows how the velocity has changed. This is summarized by the equation: $\Delta\vec{v}_{if} = \vec{v}_f - \vec{v}_i$. Draw the vectors v_f and v_i **tail-to-tail** in order to subtract them. The change in velocity, $\Delta\vec{v}_{if}$, points from the tip of v_i to the tip of v_f. When drawing your 2-D velocity vectors, make sure that both the lengths and directions seem right for the moments in time you are considering.



5. **Represent**. Draw the velocity vector diagram for events 1 and 2. Draw a force diagram for the ski jumper.

6. **Reason.** How do the directions of Δv, a and F_{net} compare? Why?

Vectors $\Delta\vec{v}_{12} = \vec{v}_2 - \vec{v}_1$
Force Diagram

7. **Represent.** Complete the word representation describing the physics below.

C: Word Representation

Describe motion (no numbers), explain why, assumptions

8. **Solve.** Find her complete velocity vector (magnitude and direction) at moment 2. Complete the math representation below.

D: Mathematical Representation

Describe steps, complete equations, algebraically isolate, substitutions with units, final statement

9. **Evaluate.** Imagine you erased all the math in part D above. Would your descriptions of the steps be good enough to help a struggling student work their way through this problem? If not, go back and improve them! Then complete part E, the evaluation, below.

E: Evaluation

Answer has reasonable size, direction and units? Why?

*** Call your teacher over to check your work. Then you are ready to check your results against the simulation***

10. **Solve.** How far has the skier travelled horizontally between moments 1and 3? Answer this in Part D below.

D: Mathematical Representation

Complete equations, describe steps, algebraic work, substitutions with units, final statement

11. **Reason.** Emmy says, "I was wondering about this. Imagine I toss a blob of playdoh which lands on the floor. When it hits the floor its final velocity is zero. Do you think I could use $v_2 = 0$ in my BIG 5 equation?" Can she? Explain.

The Great Jumper

Sondre Norheim (1825 – 1897) was a ski jumping champion and the designer of the modern ski used for ski jumping. The modern ski acts like a wing, providing the jumper with an upwards lift force. In gr. 12, we ignore all effects of the air and this upwards force. The story goes that Sondre wowed a group of spectators by jumping over a very tall rock. Let's explore the physics of this daredevil event. We will suppose that he launched from a ramp with a speed of 18.0 m/s at an angle of 28° above the horizontal. The edge of the ramp was 1.5 m above the ground level. The tallest point of the rock was located 13.8 m horizontally from the edge of the ramp and was 5.0 m above the ground. The ground in this area is quite level. Complete the three parts of the solution below.