

Unit 4 Notes – Physics I

Two Dimensional Motion Projectiles and Vectors – Textbook Ch. 3

I. The nature of physical quantities: scalars and vectors

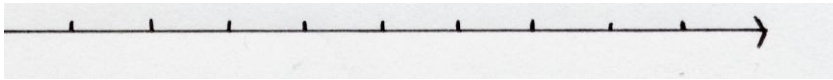
- **Scalar** — quantity that describes only magnitude (how much), **NOT** direction; e.g., mass, temperature, time, volume, distance, speed, etc.
- **Vector** — describes magnitude and direction; e.g., displacement, velocity, force, etc.
 - speed is the magnitude of velocity; velocity must include both magnitude (speed) and direction
 - on diagrams, arrows are used to represent vector quantities; the direction of the arrow gives the direction of the vector and the magnitude of the vector is proportional to the length of the arrow

Frames of reference — standard for comparison

- Any movement of position, distance, or speed is made against a frame of reference; “with respect to Earth” is most common; measurements may differ in different frames of references.

Vector Representation

- 100 km/hr in an easterly direction

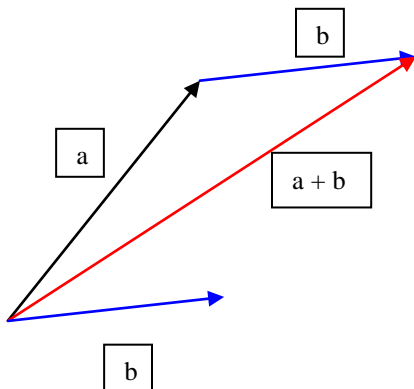


- 50 N of force pushing down:



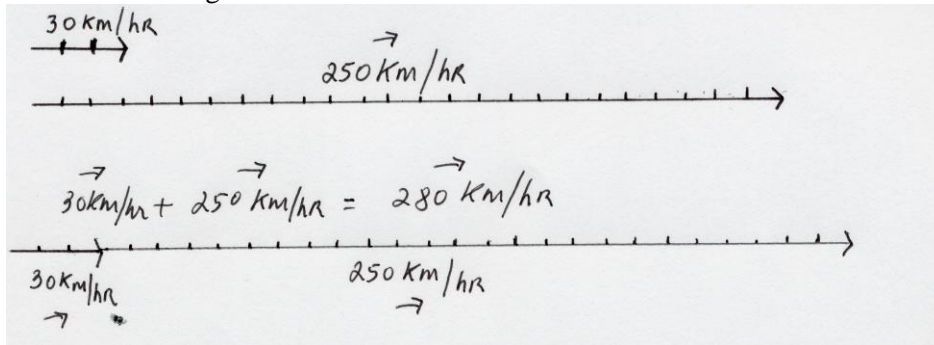
II. Addition of vectors

- **To add vectors**, add x- components to find total displacement in x direction, then add y components to find total displacement in the y direction; use Pythagorean theorem to find the magnitude of the resultant and inverse tangent to find the angle of the resultant
 - Two methods we can use to add vectors:
1. **Graphical Method** (ruler and protractor required for precise results). Notice that to find the vector sum of a and b, you arrange vectors a and b “head-to-tail” and then draw the resultant (a+b) from the origin of the first vector to the tip of the “head-to-tail” arrangement.

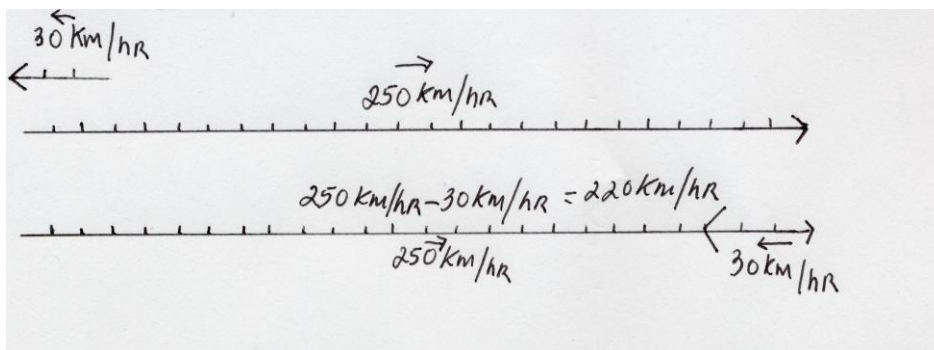


Example 1 – An airplane flies straight east at 250 km/hr. In addition, the same airplane encounters a tailwind of 30 km/hr. What is the total airplane velocity?

Solution: Use a ruler and draw two vectors representing the airplane's velocity and the wind velocity to scale. To add the two vectors, place the tail of one vector at the head of the other vector. When adding the two vectors, the order in which the vectors are represented does not matter. However, the direction and the length of each vector must not be changed when drawn.



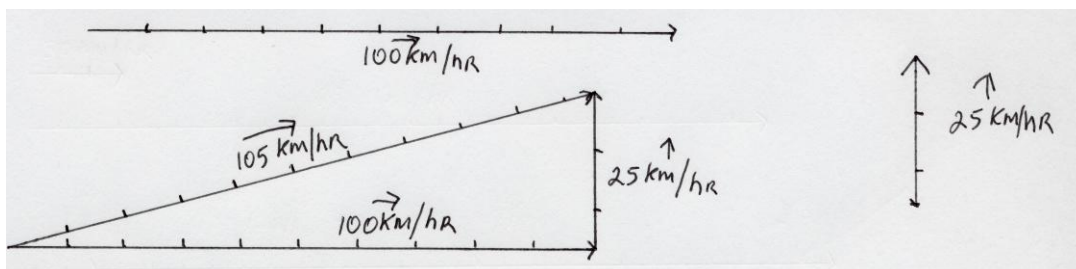
Example 2 – Another airplane is flying straight west at 250 km/hr and encounters a headwind of 30 km/hr. Use the graphical method of vector addition and subtraction to determine the total velocity of the airplane. The difference in this case is that the directions are opposite to each other.



Vector Addition in Two Directions

When vectors in two directions are added, the tail of one vector is placed at the head of the other vector. The final vector (called the **resultant** vector) is drawn from the tail of the first vector to the head of the second vector. The direction of the resultant is expressed as an angle measured between the resultant and the largest component vector.

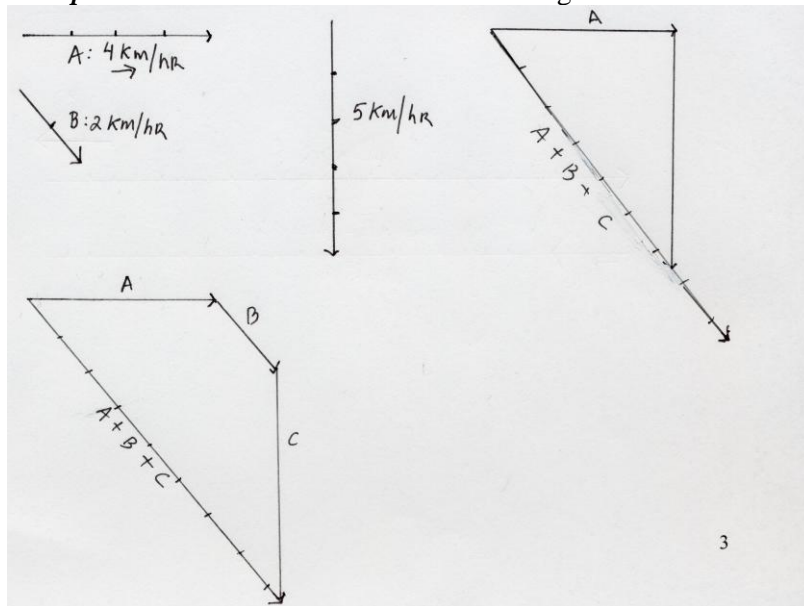
Example 3 – An airplane is flying east at 100 km/hr but it encounters a 25 km/hr crosswind in a straight northerly direction. What is the final velocity of the airplane?



Addition of Several Vectors

The length and direction of each vector are important. However, the order in which they are added is not important.

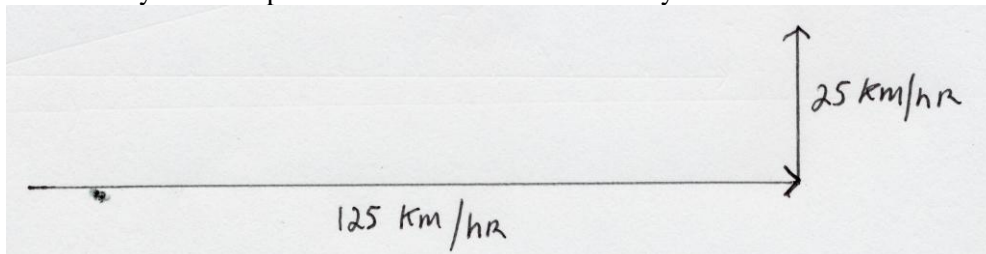
Example 4 – Find- the resultant of the following vectors:



Mathematical / Analytical Method of Vector Addition

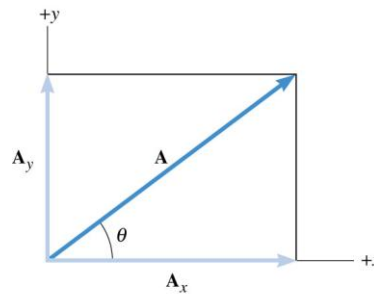
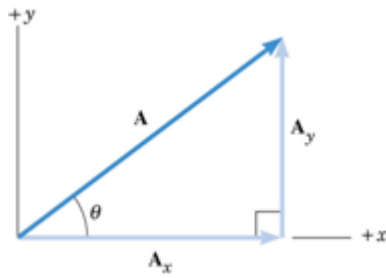
When two vectors are perpendicular, the vector diagram produces a right triangle, in which the resultant vector is the **hypotenuse** of the triangle. In this case you have an opportunity to use what you have learned in your geometry class and apply your knowledge of the Pythagorean Theorem to calculate the length of the resultant vector. The relations between the sides and angles of the triangle can be used to calculate the direction of the resultant.

Example 5 – An airplane is flying at 125 km/hr and encounters a 25 km/hr crosswind to the north. What is the true velocity of the airplane? Use the mathematical analytical method.

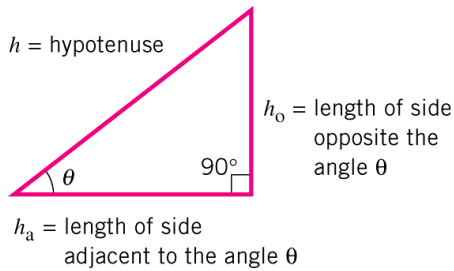


2. Component Method: Addition using components of vectors

You will soon learn that motion in the x direction (horizontal) is independent of motion in the y direction (vertical). Vectors are often described by using only their x (or horizontal) and y (or vertical) components. A **vector component** is the portion of the vector along the x - or y -axis. **Negative of a vector**—has the same magnitude but opposite direction. The diagrams below show two alternative ways to graphically show components.



- Determine x and y component for each vector; $\cos \theta$ for x and $\sin \theta$ for y
- Add the components to determine the components of the resultant
- Use Pythagorean Theorem to find the magnitude of the resultant and use trig functions to get the angle. The angle is necessary because you must give direction for a vector quantity.
- For example: $\tan \theta = y/x$ so use $\tan^{-1}(y/x)$ to calculate angle θ
- The same procedure will work for other trig functions to get the angle when the sides are known.



$$\sin \theta = \frac{h_o}{h}$$

$$\cos \theta = \frac{h_a}{h}$$

$$\tan \theta = \frac{h_o}{h_a}$$

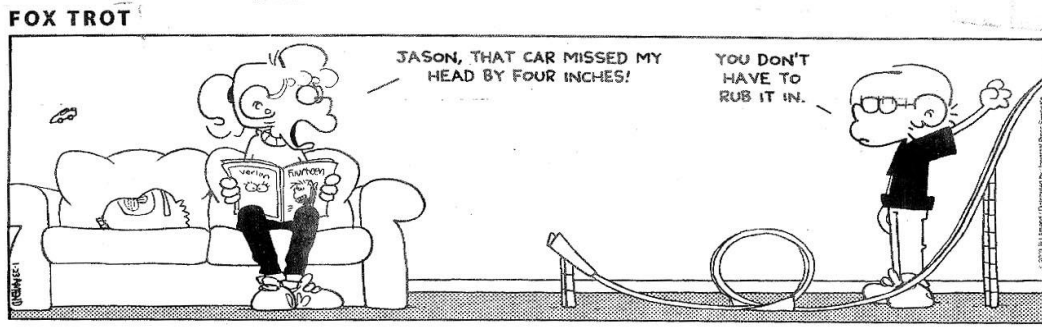
$$c^2 = a^2 + b^2$$

$$h^2 = h_o^2 + h_a^2$$

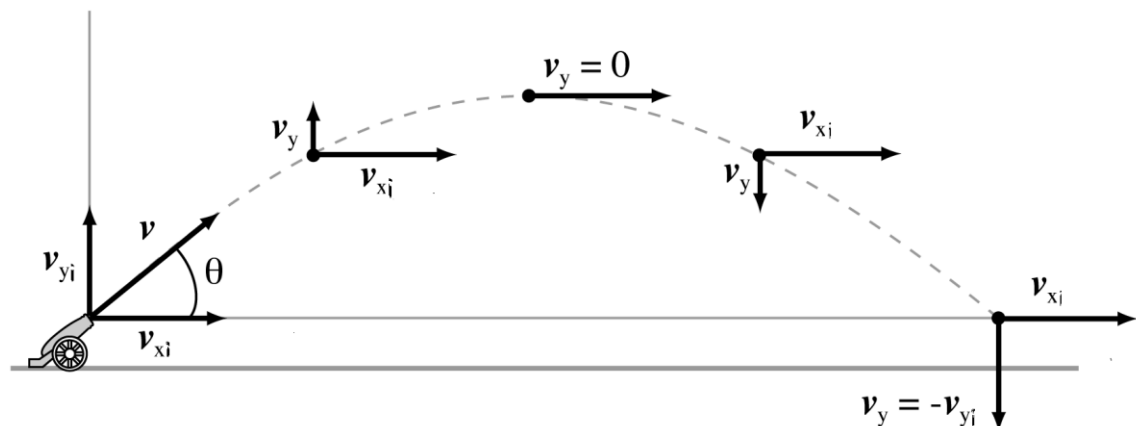
- **Example 6** – A hiker begins a trip by first walking 25.0 km due east from her base camp. On the second day she walks 40.0 km north, at which point she discovers a forest ranger's tower. Determine the displacement from the camp to the tower.
- **Example 7** – A plane whose airspeed is 200.0 km/h heads due north. But a 100.0 km/h east wind (wind blowing to the East) suddenly begins to blow. What is the resulting velocity of the plane with respect to the ground?

- **Example 8** – The speed of a boat in still water is 1.85 m/s. If the boat is to travel directly across a river with a current of 1.20 m/s, at angle must the boat head with respect to the bank upstream?

III. Projectile Motion



- Projectile motion – refers to objects that are thrown or launched into the air and are subject to gravity. ***Motion in the x direction (horizontal) is independent of motion in the y direction (vertical)***
- When solving projectile problems, motion in the horizontal is analyzed independently of motion in the vertical (vector analysis).
- Since air resistance is ignored, there is ***no acceleration in the horizontal direction so the x-component of velocity remains constant for the entire time of flight. The vertical motion is not constant velocity...IT IS ACCELERATED! It is the same as a free falling object with the acceleration of gravity.***
- Time is the key that ties the motions together! ***Time of flight for vertical and horizontal component is the same.*** To play with some numbers and try them out on a virtual projectile lab go to: http://galileoandeinstein.physics.virginia.edu/more_stuff/Applets/ProjectileMotion/jarapple.t.html



The table below lists the equations used to solve projectile problems

<i>X Component Equation</i>	<i>y Component Equations</i>
$\Delta x = v_{ix}t$	$\Delta y = v_{iy}t + \frac{1}{2}gt^2$ $v_{fy} = v_{iy} + gt$ $v_{fy}^2 = v_{iy}^2 + 2g \Delta y$

FoxTrot

BILL AMEND

