Most Confusing Stuff
Units!!!!!

• How to convert units (Get the 1 the right way up)
• Always carry units around in problems!
• Your answer to a question should always include units!
• Use dimensional analysis to make sure you’ve solved a problem correctly – do the units make sense?
• Distance = meters (m), Time = seconds (s), Mass = kilograms (kg) ALWAYS!!!
Vectors

- Have magnitude (numerical value) and direction
- Add by graphical method: put tail of B at head of A, draw sum from tail of A to head of B
- Component method
  - YOU MUST REMEMBER YOUR TRIG!!
    - \( \sin \theta = \frac{Ax}{A}, \cos \theta = \frac{Ay}{A} \)
    - \( A^2 = Ax^2 + Ay^2 \)
  - Choose your coordinate system wisely, helps to draw your problem with coordinate system
1. Glenda and Harold are attempting to cross a river in a kayak. The river flows due east at 1.9 m/s. Glenda and Harold head the kayak due north and row at 2.4 m/s (relative to the water).

Determine the resultant velocity of the boat - both magnitude and direction.

Purpose: more flexibility with trig functions (see review for Exam 1: pushing box across floor, with and without frictional forces)
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This is a right triangle! \( A^2 = A_x^2 + A_y^2 \)

\((\text{resultant } v)^2 = (\text{rowing speed})^2 + (\text{current})^2\)
2. Glenda and Harold are attempting to cross a river in a kayak. The river flows due east at 1.9 m/s. Glenda and Harold head the kayak 14 degrees east of north, and row at 2.4 m/s (relative to the water).

Determine the rowing speed if they had chosen instead to row directly across the river (due north)

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Use trig functions! \( \cos 14 = \frac{\text{Resultant v}}{\text{River current}} \)
Know Your Powers of 10!

- $10^{-2} = \text{centi (c)}$
- $10^{-3} = \text{milli (m)}$
- $10^{-6} = \text{micro (μ)}$
- $10^{-9} = \text{nano (n)}$
- $10^{-12} = \text{pico (p)}$
Special case of motion: constant acceleration

- **a in terms of velocity and distance**
  - Solve $d = \frac{(\text{initial } v + \text{final } v)}{2} \times t$ for time
  - substitute into $a = (\text{final } v - \text{initial } v) / \text{time}$
  - Get $a = \frac{(\text{final } v^2 - \text{initial } v^2)}{2 \times d}$

- distance in terms of velocity, time, and a
  - Solve $a = (\text{final } v - \text{initial } v) / \text{time}$ for final velocity
  - Substitute into $d = \frac{(\text{initial } v + \text{final } v)}{2} \times t$
  - Get $d = (\text{initial } v \times t) + (\frac{1}{2} \times a \times t^2)$
Special case of motion: **constant acceleration** (ex: Falling Bodies)

- Galileo: **In the absence of air resistance, all bodies fall with the same acceleration, a**
  - ex: drop a sheet of paper vs crumpled sheet of paper, which falls faster?
- **This constant acceleration is due to gravity**
- **a due to gravity = g, \( g = 9.8 \text{ m/s}^2 \) towards the Earth’s surface**
Special case of motion: projectile motion (2D motion)

• Has some initial velocity!
• Curved path of motion, or trajectory
• Understand motion by splitting it into 2 independent parts, one for the x direction and one for the y direction
• x direction: no acceleration because $v_x$ always points in same direction and is constant because we assume a lack of air resistance.
  • $x = x_0 + v_{0x} \times t$
  • $x = \text{final position in x, } x_0 = \text{starting position in x, } v_{0x} = \text{starting velocity in x direction, } t = \text{total time of travel}$
Special case of motion: \textbf{projectile motion} (2D motion)

- \textit{y direction: constant acceleration downward due to gravity!}
  - $v_y = v_{0y} + a \cdot t \quad \Rightarrow \quad v_y = v_{0y} - g \cdot t$
  - $v_y = \text{final velocity in } y$, $v_{0x} = \text{starting velocity in } y \text{ direction}$, $a = \text{acceleration DOWNWARD due to gravity}$, $t = \text{total time of travel}$
  - $y = y_0 + (v_{0y} \cdot t) - \left( \frac{1}{2} \cdot g \cdot t^2 \right)$
  - $y = \text{final position in } y$, $y_0 = \text{starting position in } y$
Special case of motion: projectile motion (2D motion)

- Max range in x when object starts and returns to the same y position:
  \[ x = x_0 + \left( \frac{v_{0x} \times 2 \times v_{0y}}{g} \right) \]

- Max distance traveled in x is when starting angle is 45°

- Max height in y occurs when \( v_y = 0 \) (at top of trajectory)
  \[ y = y_0 + \left( \frac{1}{2} \times \frac{v_{0y}^2}{g} \right) \]

- Your ability to hit a target a certain x and y distance away from where you fire your object depends on BOTH the firing angle and the initial velocity
3. A plane is dropping a care package onto a village. The plane moves horizontally with a ground speed of 59.1 m/s. The package will be dropped a horizontal distance of 521 m from the intended target location. At what altitude must the plane be flying in order to successfully accomplish this feat?

Purpose: 2-D motion! Don’t forget that you often have to solve an equation in one dimension to get necessary information to allow you to solve in the other dimension
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- Plane is traveling at 59.1 m/s entirely in the x direction when it drops the package.

- Therefore $v_{0x}$ of the package is also 59.1 m/s.
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Use \( x = x_0 + v_{0x} \cdot t \) to find out how long it takes for the package to travel the 521 m.

Use \( y = y_0 + (v_{0y} \cdot t) - \left( \frac{1}{2} g t^2 \right) \) to calculate the height required, where \( y_0 = 0 \).
Conservation of Momentum

- Total momentum of a group of objects is the same before and after they interact, if no external forces act upon them
  - \( p_{\text{final}} = p_{\text{initial}} \)
- Momentum is a vector, so conservation law holds for magnitude AND direction
- Conservation of momentum means the momentum in the x direction and in y direction are separately conserved
  - \( p_{x, \text{initial}} = p_{x, \text{final}} \)
  - \( p_{y, \text{initial}} = p_{y, \text{final}} \)
4. The block and clay ball collide. What is the final velocity of the system?

Purpose: 2-D motion in conservation of momentum! Momentum is conserved separately in each dimension!!!
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Red block: $p_{ix} = 4.0 \text{ kg} \times (2.0 \text{ m/s} \times \cos 35)$
$p_{iy} = 4.0 \text{ kg} \times (2.0 \text{ m/s} \times \sin 35)$

Yellow ball: $p_{ix} = 0$
$p_{iy} = 5.0 \text{ kg} \times 10.0 \text{ m/s}$
4. The block and clay ball collide. What is the final velocity of the system?

\[ p_{ix} = p_{fx} \]
\[ 4.0 \text{ kg} \times (2.0 \text{ m/s} \times \cos 35^\circ) + 0 = (4.0 + 5.0)\text{kg} \times v_{fx} \]

\[ p_{iy} = p_{fy} \]
\[ 4.0 \text{ kg} \times (2.0 \text{ m/s} \times \sin 35^\circ) + 5.0 \text{ kg} \times 10.0 \text{ m/s} = (4.0 + 5.0)\text{kg} \times v_{fy} \]
Conservation of Energy

- Total Energy = $\frac{1}{2} k A^2 = \frac{1}{2} k x^2 + \frac{1}{2} m v^2$
  - $x = 0$ at equilibrium position, so $v$ is max

- $v_{\text{max}} = \pm A \sqrt{\frac{k}{m}}$

- period of simple harmonic oscillator
  - $T = 2\pi \sqrt{\frac{m}{k}}$
5. A spring with constant of $2.0 \times 10^3$ N/m is stretched by 6 inches when a 10 kg mass is attached to it. If the mass/spring is released, how fast will it be going 2 inches away from equilibrium? How fast will it be going when it passes the equilibrium position?

Purpose: conservation of E using springs
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This is the Amplitude of the oscillating system!
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Use $\frac{1}{2} k A^2 = \frac{1}{2} k x^2 + \frac{1}{2} m v^2$
and $v_{\text{max}} = \pm A \sqrt{k/m}$
Electricity

• Electric Force
  \[ F_{ele} = k \cdot \frac{q_1 \cdot q_2}{d^2} \]
  
  • k = 9 \times 10^9 \text{ N m}^2/\text{C}^2

• Electric field, \( E = F/q \) (vector!)
  \[ E_{ele} = \frac{k \cdot q}{d^2} \]
  
  • Points away from a + charge, toward a – charge

• Volt = electric potential
6. What is the strength of the electric field felt 10 m from a 200 C charge? What force will a 100 C charge feel if placed at this distance?

Purpose: *LOTS* of confusion over E and F equations, REMEMBER TO CHECK UNITS!!
6. What is the strength of the electric field felt 10 m from a 200 C charge? What force will a 100 C charge feel if placed at this distance?

Use

\[ E_{ele} = \frac{k \cdot q}{d^2} \]

and then: \( E = \frac{F}{q} \)

\( F = E \cdot q \)