

BELLTES ACADEMY

Physics Calculations Breakdown

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Physics Calculations with Practical Analogies

A comprehensive field reference detailing core computational models in physics, supplemented with simplified intuition guides and worked walkthroughs.

1. Motion and Mechanics

Average Velocity

Calculates the clean rate of position change in a defined vector over a specific window of time.

Formula: $v = \Delta x / \Delta t$

Where: v = velocity (m/s), Δx = displacement (m), Δt = elapsed time (s)

Analogy: Imagine walking down a perfectly straight football field from end zone to end zone. If you move 100 meters in exactly 50 seconds, your velocity maps how much absolute forward ground you conquered with every tick of the clock.

Example: A delivery van drives straight North over a clean displacement of 200 meters inside 10 seconds.

Calculation: $v = 200 \text{ m} / 10 \text{ s} = \mathbf{20 \text{ m/s North}}$

Acceleration

Measures the precise rate at which an entity alters its traveling velocity.

Formula: $a = (v_f - v_i) / \Delta t$

Where: a = acceleration (m/s^2), v_f = final velocity, v_i = initial velocity

Analogy: Pressing down on a vehicle's gas pedal. Acceleration is how fast that dashboard speedometer needle climbs. If it ticks up leisurely, acceleration is low; if it snaps up instantaneously, acceleration is high.

Example: A stationary cheetah ($v_i = 0 \text{ m/s}$) targets prey and springs to 30 m/s (v_f) over exactly 3 seconds.

Calculation: $a = (30 - 0) / 3 = \mathbf{10 \text{ m/s}^2}$

Newton's Second Law of Motion

Determines how an un-balanced net force acts directly upon an item's mass to generate an acceleration.

Formula: $F_{net} = m \cdot a$

Where: F_{net} = net force (Newtons, N), m = mass (kg), a = acceleration (m/s^2)

Analogy: Shoving an empty wire supermarket trolley versus a trolley crammed with solid masonry bricks. Pushing both with identical muscular force will send the empty one flying forward effortlessly because there is less mass holding it back.

Example: You muscle a stalled 1,200 kg vehicle, causing it to roll forward with a steady acceleration of 1.5 m/s^2 .

Calculation: $F_{net} = 1200 \text{ kg} \cdot 1.5 \text{ m/s}^2 = \mathbf{1,800 \text{ N}}$

2. Work, Energy, and Power

Work Done

Quantifies the energy transfer when an external push or pull dislodges an object along a vector displacement.

Formula: $W = F \cdot \Delta x \cdot \cos(\theta)$

Where: W = work (Joules, J), F = force (N), Δx = displacement (m), θ = directional angle

Analogy: Shoving against a massive concrete structural pillar. You can strain your muscles and sweat for hours, but if the pillar remains unmoved, your scientific work output is exactly zero. Work demands a physical shift.

Example: A gym athlete drives a barbell perfectly vertical with 500 N of force, lifting it 2 meters high ($\theta = 0^\circ$).

Calculation: $W = 500 \text{ N} \cdot 2 \text{ m} \cdot \cos(0^\circ) = 500 \cdot 2 \cdot 1 = \mathbf{1,000 \text{ J}}$

Kinetic vs. Gravitational Potential Energy

Kinetic maps the live energetic state of an active mass in motion, while Potential maps stored structural energy drawn from elevation.

Formulas: $E_k = \frac{1}{2}mv^2$ | $E_p = mgh$

Where: E_k = kinetic energy (J), E_p = potential energy (J), g = gravity ($\approx 9.8 \text{ m/s}^2$), h = height (m)

Analogy: A classic amusement park roller coaster. As the mechanical chain slowly jerks the train cars to the apex of the primary drop, it hoards Potential Energy. The split second it builds momentum down the plunge, height converts instantly into raw Kinetic speed.

Example: A 0.5 kg educational textbook falls clean off an administrative storage shelf resting 2 meters up.

Calculation: $E_p = 0.5 \text{ kg} \cdot 9.8 \text{ m/s}^2 \cdot 2 \text{ m} = \mathbf{9.8 \text{ J}}$

Power

Expresses the precise time rate or speed at which work is actively dispatched or energy is consumed.

Formula: $P = W / \Delta t$

Where: P = power (Watts, W), W = work executed (J), Δt = time interval (s)

Analogy: Two identical twins scaling a staircase. Because they possess matching weights, they execute identical physical work to reach the summit. However, if Twin A sprints up in 5 seconds while Twin B strolls over 30 seconds, Twin A generates substantially higher Power.

Example: An automated industrial elevator hoist pulls a heavy cabin up by executing 60,000 J of work across 10 seconds.

Calculation: $P = 60,000 \text{ J} / 10 \text{ s} = \mathbf{6,000 \text{ W (6 kW)}}$

3. Waves and Electricity

The Universal Wave Equation

Establishes the constant operational relationship tying velocity, frequency, and physical spatial wavelength together.

Formula: $v = f \cdot \lambda$

Where: v = wave velocity (m/s), f = frequency (Hertz, Hz), λ = wavelength (meters, m)

Analogy: Picture a synchronized row of marching infantrymen. Wavelength is the geometric physical distance measured between one soldier's boots and the next man ahead. Frequency is how fast they cycle steps per minute. Velocity is the overall speed of the total column advancing down the avenue.

Example: A local radio mast broadcasts a signal pulsing at a frequency of 100 Hz with a physical wavelength of 3 meters.

Calculation: $v = 100 \text{ Hz} \cdot 3 \text{ m} = 300 \text{ m/s}$

Ohm's Law

Governs the electrical mechanics balances between driving pressure (Voltage), flow volume (Current), and restriction (Resistance).

Formula: $R = V / I$

Where: R = resistance (Ohms, Ω), V = potential difference (Volts, V), I = current flow (Amperes, A)

Analogy: Water coursing down a flexible garden hose. Voltage mimics the internal water pressure shoving the fluid forward. Current maps the literal volume of water passing a point per second. Resistance is a severe physical kink in the hose pipe choking the stream.

Example: A household appliance kitchen toaster drawing an active current of 10 A is plugged straight into a standard 230 V main wall outlet.

Calculation: $R = 230 \text{ V} / 10 \text{ A} = 23 \Omega$