HVAC FUNDAMENTALS – ESSENTIAL TIPS & RULES OF THUMB

Feeling lost in the world of HVAC? This course is your foundation.

This introductory course serves as your gateway to mastering the fundamentals of HVAC systems. In this comprehensive 8-hour course, you will gain a solid understanding of:

a. Core Systems: Distinguish between various HVAC systems, gaining insight into their unique characteristics, and their strengths and weaknesses.
b. Application Expertise: Explore how different HVAC systems are best deployed across diverse settings, ranging from residential to commercial and beyond, optimizing comfort and efficiency in each environment.
c. Foundational Knowledge: Grasp the fundamental principles of thermodynamics, heat transfer, and fluid dynamics that underpin the operation of HVAC systems.
d. Heat Transfer Hacks: Explore core principles governing air and fluid behavior for efficient heat transfer and for optimal comfort control without complex equations.
e. Fluid Flow Fundamentals: Grasp fluid flow principles affecting airflow and pressure in HVAC systems.
f. Energy Efficiency Essentials: Understand key factors impacting HVAC performance and cost savings.

Embedded within the course are essential metrics, practical tips, and handy rules of thumb to accelerate your learning journey and help you make well-informed decisions.

Let's get started with essential metrics and rules of thumb.

ACRONYM FOR HVAC

a. H: Heating
b. V: Ventilation
c. AC: Air conditioning

FUNCTIONS OF HVAC

	Subjects	*Rules of Thumb*
	Air conditioning	*Comfort Standard: ASHRAE 55* *a. Temperature: 75±2°F* *b. Relative humidity (RH): 50±5%* *c. Air quality: Adequate ventilation and filtration.*
	Ventilation	*Ventilation Standard: ASHRAE Standard 62.1.* *a. Typical ventilation rates: 15 to 20 cubic feet per minute (CFM) outdoor air per person.* *b. CO_2 levels between 600-1000 ppm. Above 1000 ppm is considered poor air.*
	Filtration	*Filtration Standard: ASHRAE 52.1.* *a. MERV 8 for pre-filters* *b. MERV 13 for final filters*
	Heating system	*Comfort Standard: ASHRAE 55* *a. Temperature: 68 to 70°F* *b. Relative humidity (RH): 30% and 50% to avoid condensation and mold.* *c. Freeze control: above 32°F.*

HVAC Capacity

	Description	*Rules of Thumb*
	Air-conditioning Capacity	*HVAC systems rated in tons of refrigeration (TR): 1 TR = 12,000 BTU/hr. or about 3.5 kW (Thermal).*

Relationship of Tons, BTU, and KW

	Main Unit (Ton)	*Equivalent BTU*	*Equivalent kW*
	**1 Ton**	***12,000 BTU***	***3.51 kW***
	**1.5 Ton**	*18,000 BTU*	*5.27 kW*
	**2 Ton**	*24,000 BTU*	*7.03 kW*
	**2.5 Ton**	*30,000 BTU*	*8.79 kW*
	**3 Ton**	*36,000 BTU*	*10.55 kW*

Classification of Refrigeration Systems

	Refrigeration Type	***Rules of Thumb***
	Low temperature refrigeration	*Systems at 32°F or lower: Refrigerators, freezers, ice makers.*
	Medium temperature refrigeration	*Systems between 30°F and 45°F: Display cases, beverage coolers.*
	High temperature refrigeration	*Systems between 45°F and 60°F: HVAC systems (air-based or hydronic).*

HVAC Systems

	System Type	***Rules of Thumb***
	Air-based HVAC systems	*Air circulation for heating and cooling: examples, Split and package units, furnaces.*
	Hydronic HVAC Systems	*Chilled or hot water for heat transfer: example, Hydronic systems.*

HVAC Control

Higher heat in a room requires more sensible heat removal capacity. Higher moisture in a room requires more latent heat removal capacity.

	Parameters	***Rules of Thumb***
	Air conditioner capacity (Total load)	*AC capacity in tons (1 ton = 12,000 BTU/hr); 80% sensible, 20% latent load.*
	Sensible load	*Sensible heat (ΔT) alters temperature, not moisture; calculated using Q = m * Cp * ΔT.* *Where, m is mass of air, Cp is specific heat of air and ΔT is the temperature difference.*
	Latent load	*Latent heat handles moisture changes; standard ACs focus more on sensible cooling.*
	Temperature Control	*Adjust air quantity or supply air temperature for desired heating or cooling.*
	Humidity Control	*In hot, humid regions, customized HVAC with deep coils or dehumidifiers effective for moisture control. Increasing AC capacity alone may not resolve high humidity.*

Type of HVAC systems

	HVAC Types	***Rules of Thumb***
	Window AC	*Capacity: 0.5 - 2 tons; Individual room cooling in residential and small offices.*
	Portable AC	*Capacity: 0.5 - 2 tons; Movable cooling solution for various spaces.*
	Single Split AC	*Capacity: 0.75 - 3 tons; Cooling for individual rooms or zones.*
	Multi-Split AC	*Capacity: 1.5 - 5 tons; Multiple indoor units connected to one outdoor unit.*
	VRF Systems	*Capacity: 5 - 30 tons; Precise control for large buildings with multiple zones.*

	HVAC Types	*Rules of Thumb*
	Package System	*Capacity: 3 - 15 tons; Self-contained unit for rooftop or ground-level installation.*
	Package Through Wall	*Capacity: 1 - 5 tons; Through-wall installation for localized cooling.*
	Rooftop Units: Capacity	*5 - 25 tons; Commercial buildings with rooftop installation.*
	Air-Source Heat Pump	*Capacity: 1 - 5 tons; Heating and cooling for single spaces.*
	Ground-Source Heat Pump	*Capacity: 2 - 10 tons; High efficiency using ground temperature.*
	Water-Source Heat Pump	*Capacity: 1 - 10 tons; Efficient heating/cooling with water source/sink.*
	Air-Cooled Chiller	*Capacity: 10 - 300 tons; Commercial cooling using air for heat rejection.*
	Water-Cooled Chiller	*Capacity: 100 - 5000 tons; Commercial cooling using water for heat rejection.*
	District Cooling System	*Capacity: 10000 – 100000 tons; Centralized cooling for multiple buildings.*
	Furnaces (Air-based): Capacity	*20,000 - 150,000 BTU/h; Residential, commercial, industrial space heating.*
	Boiler (Hydronic): Capacity	*Varies; Heats water for radiator, underfloor heating, or commercial use.*

Thermodynamics

	Fundamental Principles of Thermodynamics	*Rules of Thumb*
	First Law	*Energy conservation: Energy is neither created nor destroyed, only transferred.*
	Second Law	*Heat transfer: Moves from higher entropy to lower entropy, hotter to cooler areas.*
	Boyle's Law	*Pressure and volume relationship: At constant temperature, pressure and volume are inversely related - pressure up, volume down, and vice versa.*

	Fundamental Principles of Thermodynamics	***Rules of Thumb***
	Charles's Law	*Temperature impacts air volume: Heating expands air, cooling contracts it.*
	Cooling and Heating	*In HVAC, heat quantity is determined by temperature difference (ΔT), mass (m), and specific heat (Cp) and is given by equation m*Cp*ΔT.*
	Water or Air	*Water has much higher specific heat (about 4 times) than air, making it much more efficient in heating and cooling systems.*

Refrigeration Cycles

	Type of Refrigeration	***Rules of Thumb***
	Vapor Compression Cycle	*Uses mechanical compressors and refrigerant phase change for cooling in residential and commercial buildings.*
	Absorption Cycle	*Employed in industrial settings, achieve cooling through absorption principles using lithium bromide (LiBr) as an absorbent, and heat sources like gas or steam. No compressors, minimal power use.*

Components of Vapor Compression Cycle

	Air conditioner Components	***Rules of Thumb***
	Compressor	*Compressors raise refrigerant pressure, consuming 0.6 KW to 1.2 KW per ton, depending on type and heat rejection method. During compression:* a. *Pressure – increase* b. *Temperature – increase* c. *Refrigerant state is gas*
	Condenser	*Condensers release indoor heat to the outdoor*