

Duct Math: Area, Velocity, and the Ductulator

YES Electric • Arc Workforce Academy HVAC Apprenticeship

Draft 1 (October 2026). This lesson is under review. Videos are made by other companies, not YES Electric; follow this lesson and your journeyman where they differ. Boxes marked "Shop photo coming" will get real photos from our shop in a later version.

Unit 2 • Trade Math for HVAC • RTI: Trade Math (26 hr) — feeds Comp 30 (Manual D, Lesson 10.14) Class time: ~3 hrs (1 classroom + 2 ductulator drills) — Unit 2 written exam follows this lesson

1. What you'll be able to do

- Use the airflow trinity: **CFM = Area (sq ft) × Velocity (ft/min)** — solve for any of the three.
- Spin a **ductulator** (the cardboard wheel that sizes the trade) to size round and rectangular duct from CFM + friction rate.
- Convert **round ↔ rectangular equivalents** correctly — and explain why a 10" round $\neq$ a 10×10 rectangle (it's better).
- Apply the residential velocity guardrails: supply trunks $\leq$ ~900 ft/min, branches ~600, returns lower — and say why quiet matters.
- Know what "0.1 friction rate" means well enough to use it as the default and to distrust it when static is tight (the Manual D bridge).

This is the math half of duct design. The full design method (effective length, friction-rate-from-static-budget) is Lesson 10.14; today the wheel and the trinity become reflexes.

2. Tools & materials

- Ductulator per student (theirs — tool list item; app version also installed)
- Drill sheets; tape measures; the shop's trunk lines (we'll measure and back-figure them)
- Anemometer for the demo (full airflow measurement = 11.2)

3. Watch first

Order	Video	Channel	Length	Why
1	How to Use a Ductulator?	Taddy Digest	8:08	The wheel, hands-on
2	How to Size Ductwork?	Taddy Digest	26:41	Sizing walked through on real jobs
3	Ductwork Too Small Causes Cooling Issues	Taddy Digest	6:13	What the math failure looks like in the field
4	Short 16 — Air Velocity Is Useful	HVAC School	16:46	Velocity as a diagnostic number
Preview	Reading Duct Velocity Pressure, CFM and Static w/ Pitot Tube	HVAC School	18:47	Where the trinity gets measured (11.2)

4. The idea

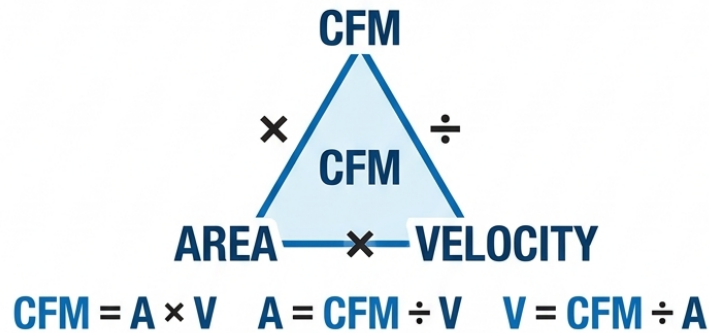
The airflow trinity

$$\text{CFM} = \text{Area} \times \text{Velocity} \text{ (cubic ft/min) } = \text{(square feet)} \times \text{(feet per minute)}$$

Same air, two knobs: a lot of air can move slowly through a BIG duct or fast through a small one. Fast = noisy + high friction; big = costs money + space. Duct design is negotiating between those two, forever.

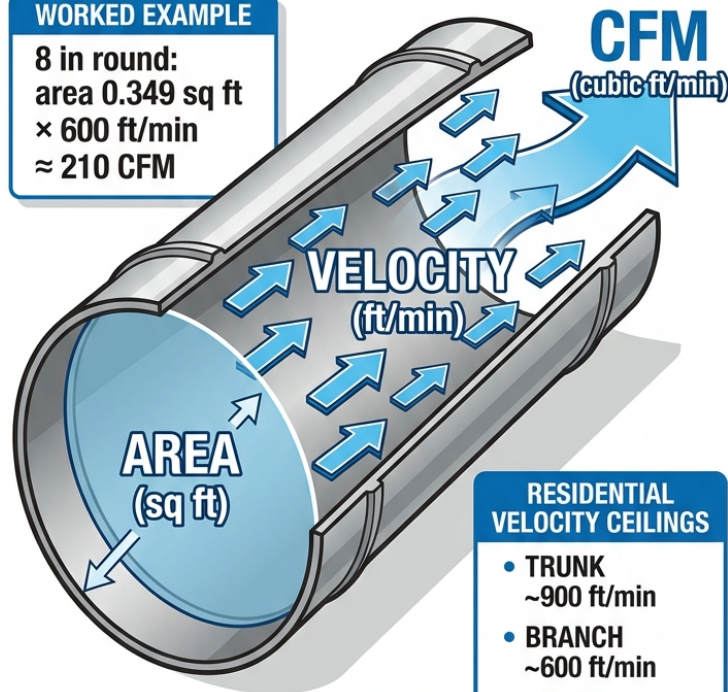
Worked example: an 8" round duct. $\text{Area} = \pi \times (4/12)^2 \approx 0.349 \text{ sq ft}$. At 600 ft/min: $\text{CFM} = 0.349 \times 600 \approx \mathbf{210 \text{ CFM}}$ — right at the classic "8-inch $\approx 200 \text{ CFM}$ " rule of thumb, which you now own instead of borrow.

THE AIRFLOW TRINITY: **CFM = AREA × VELOCITY**



WORKED EXAMPLE

8 in round:
area 0.349 sq ft
× 600 ft/min
≈ 210 CFM



RESIDENTIAL VELOCITY CEILINGS

- TRUNK
~900 ft/min
- BRANCH
~600 ft/min
- RETURN
~500–700 ft/min

— quieter is happier

The ductulator — friction rate in, sizes out

The wheel solves a harder equation (friction loss per 100 ft) so you don't have to. You set TWO things and read the rest:

1. **Set CFM** (what this run must carry — from the room load).
2. **Set friction rate** — the residential default is **0.1" WC per 100 ft** (a borrowed number until 10.14 teaches you to compute your own from the blower's static budget).

3. **Read:** round diameter, every rectangular equivalent, and velocity. **Check velocity against the guardrails before accepting any answer.**

Run type	Velocity ceiling (residential)	Why
Supply trunk	~900 ft/min	noise + friction climb fast past this
Branch	~600 ft/min	registers whoosh above it
Return	~500–700 ft/min	returns must whisper — they're in living space

Round vs rectangular — the aspect-ratio tax

Round is the most efficient shape per square inch (least metal touching the most air). Squash it and the perimeter grows while area doesn't: a 20×8 (aspect 2.5:1) carries like a 13.5" round, not the 14.3" its raw area suggests. Rules:

- Use the ductulator's equivalent scale, never raw area math, for rectangles.
- Keep aspect ratio $\leq 4:1$ (past that you're buying metal to make friction).
- Squashing is for joist bays and soffits — a constraint you pay for, not a preference.

Reality check both directions

The trinity runs backwards too: measure velocity in an existing duct (anemometer), multiply by area → CFM it's actually moving. That's how you audit a "it never cooled right" duct system with \$40 of tools (the Quality HVACR repair videos in Unit 10 do exactly this).

5. Drills & bench

1. **Trinity gauntlet (12 Qs):** solve for the missing leg. Include one backwards audit ("14×8 trunk, measured 720 ft/min — CFM?").
2. **Wheel drills:** size: 1,200 CFM trunk @0.1 → round + a $\leq 4:1$ rectangle; 150 CFM branch; 400 CFM return drop. For EACH: read the velocity window and pass/fail it aloud.
3. **Shop back-figure:** measure our shop's actual supply trunk, count its takeoffs, estimate its CFM job, and ductulate whether it's sized right. (It is — know WHY.)
4. **Aspect-ratio demo:** 10" round vs 10×10 vs 20×5 vs 40×2.5 — same nominal "area," ductulate each equivalent. Watch the skinny ones die.
5. **The 8-inch table:** build the team's own quick card — 6"/7"/8"/9"/10"/12" round at 0.1 friction → CFM each. Laminate it; it rides in the truck.

Checkout: unaided — size one trunk and one branch on the wheel with velocity verdicts; one backwards audit; state the residential default friction rate and ONE reason it can be wrong (tight static budget — see 10.14).

6. Field gotchas

- **The wheel assumes clean, sealed, hard duct.** Flex compressed = friction multiplies (10.13); the math was never the problem on those jobs.
- **0.1 is a default, not a law.** High-static equipment (media filters, long runs) can't afford it — Manual D computes the honest rate (10.14). Quoting wheel sizes on a complex job without the static budget is how "right-sized" ducts underperform.
- **Don't size to the equipment, size to the rooms.** The trunk carries the sum of room CFMs (Manual J → room loads → Manual D). "It's a 3-ton so 1,200 CFM trunk" skips the part where rooms differ.
- **Velocity sells the fix.** "Your return is moving 1,100 feet per minute — that's why it howls" lands better with customers than any friction-rate sermon.
- **Returns get undersized everywhere** — when in doubt, a size up on returns is cheap insurance (the #1 duct disease).

7. Competency link

- RTI Trade Math complete (Unit 2 exam after this lesson).
- Direct feed: **Comp 30** (Manual D, 10.14), Comp 29 (fab sizes), Comp 42 (airflow diagnosis, 11.2).

8. Check yourself

1. State the trinity and its units.
2. 12" round duct: area in sq ft? CFM at 700 ft/min?
3. Branch needs 160 CFM. Your wheel says 6" round at 640 ft/min. Accept?
4. Why does a 20×8 carry less air than its raw area suggests vs round?
5. What two inputs do you SET on a ductulator, and what's the residential default for the second?
6. Three velocity guardrails — trunk, branch, return.
7. Measured: 16×10 return at 500 ft/min. CFM? Enough for a 3-ton system?
8. Max sensible aspect ratio, and what gets worse past it?
9. When is 0.1"/100 ft the WRONG friction rate, and which lesson fixes it?
10. A bedroom register howls. Which trinity leg is too high, and what are the two fixes?

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