Fundamentals of Building Science: Moisture Flow

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Energy Code Resources

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Energy Code Resources

Missouri Residential Building Energy Code Construction Practices Study:
https://energy.mo.gov/energy-codes/missouri-residential-building-codes-study
For additional information on other DOE Field Studies and participating states, please visit https://www.energycodes.gov/compliance/energy-code-field-studies.
Additional education resources are available at www.southfaceonlinetraining.org.

www.southface.org => Resources => GA Energy Code Resources

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Who are you?

A. Weatherization
B. HERS Rater
C. Code official
D. Designer/Engineer
E. Contractor/Builder/Sub
F. Utility
G. Manufacturer/Product Rep
H. Policy / Government
I. Facilities
J. Home Inspector

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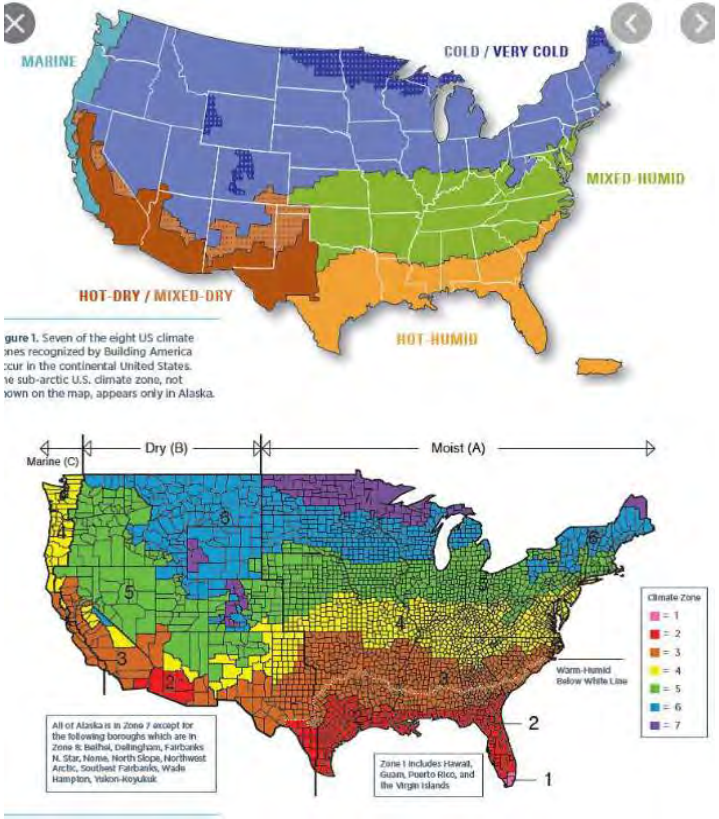
Why building science?

- Employ scientific principles from a variety of fields that govern building performance
- Optimize building performance and understand, prevent and correct building failures
- Systems approach to houses
- Physics of Heat, Air & Moisture



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The house as a system

- A house is a system made up of interrelated parts:
- The building thermal envelope
- The weather barrier
- Space conditioning
- Ventilation
- Lighting & appliances & plumbing
- The site and neighboring homes

The human factor

- It’s not just about energy efficiency
- Many efficiency measures also improve comfort, health and reduce maintenance
- All efficiency measures should take occupants into account (e.g., air sealing & ventilation)

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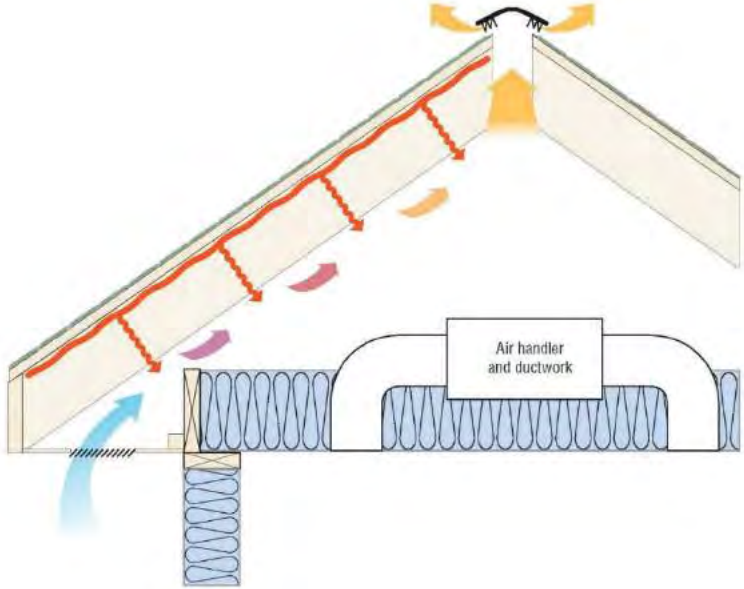
Building Science: Heat transfer

- Heat is a form of energy
- Heat moves from hot to cold
- 3 methods of heat transfer:
  - **Radiation:**
    Sun to shingles; underside of decking to other attic surfaces
  - **Conduction:**
    Through shingles and decking
  - **Convection:**
    Soffit vents through attic to ridge



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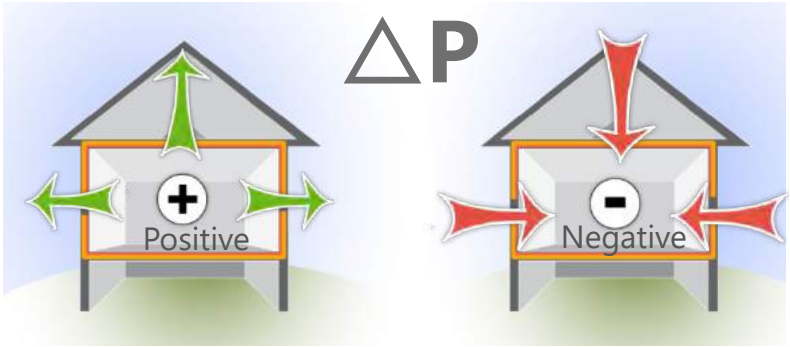
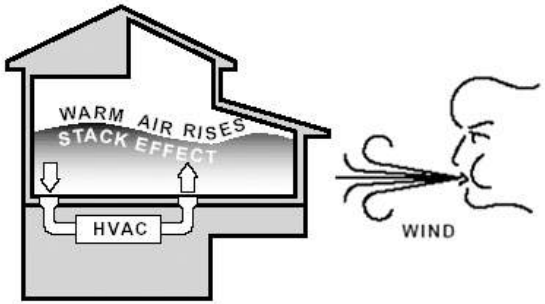
Building Science: Air movement

- Air moves from high pressure to low
- $CFM_{out} = CFM_{in}$
- Air leakage requires a pressure difference and a leak pathway (hole)
- 3 Driving forces:
  - **Wind:**
    Positive on windward side
  - **Stack Effect:**
    Warm air rises, cold air sinks
  - **Mechanical Fans:**
    Supply, exhaust, circulating





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Building Science: Moisture transport

- Moisture moves from wet to dry
- Liquid **water flows downhill** (but can be **wicked** up)
- Water **vapor diffuses** from high concentration to lower concentration
- **Air movement** can carry lots of humidity

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Challenges with Moisture

- What's your story with water problems?

Matt: Midwest home in Peoria, IL ☹

Mike: "All my life I've lived in houses with vented crawls" ☹

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Forms of Moisture flow

Forms of Moisture flow

LIQUID and **VAPOR**

Bulk

Liquid water (rain, drainage, plumbing leaks)

Capillarity

Wicking through porous materials (concrete, wood, paper drywall, fiberglass and cellulose insulation)

Diffusion

Molecules of water moving through porous materials

Infiltration

Moisture laden air brought into the house

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Managing Bulk Moisture

- Foundation waterproofing
- Proper site drainage
  - Gutters channel water away from foundation
- Drainage planes with proper flashing in walls allows water to escape (e.g. behind brick)

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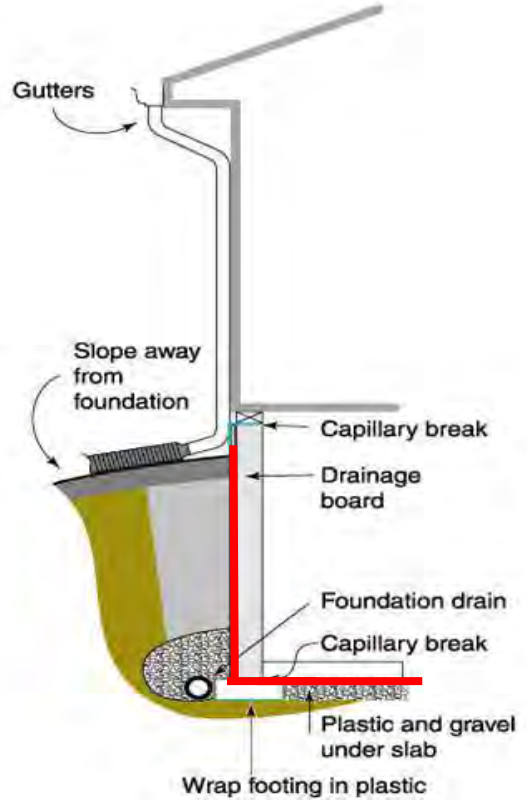
Encountering Bulk Moisture

Managing Bulk Moisture

Foundation waterproofing

- Plastic under slab
  - Gravel base under plastic
- Waterproofing foundation wall
  - Drainage mat, dimpled with filter, then backfill
- Footing
  - Wrap footing in plastic –tie into other plastic and waterproofing
  - OR waterproof top of footing before stem wall is poured
- Foundation drain tile
  - Adjacent to footing (better than on top)
  - Routed to daylight or sump pump
- Positive exterior drainage
  - Gutters, downspouts, grading slopes away from foundation
- Capillary break at top of stem wall



Bulk Moisture – foundation waterproofing

Dimpled drainage mat with filter

Drainage system

Spray on water-proofing plus drainage board

Plastic wrapped beneath footing

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Managing Bulk Moisture

- Proper site drainage is crucial

Bulk Moisture Control

- Proper site drainage
  - Swales
  - Positive slope grading
  - French drains

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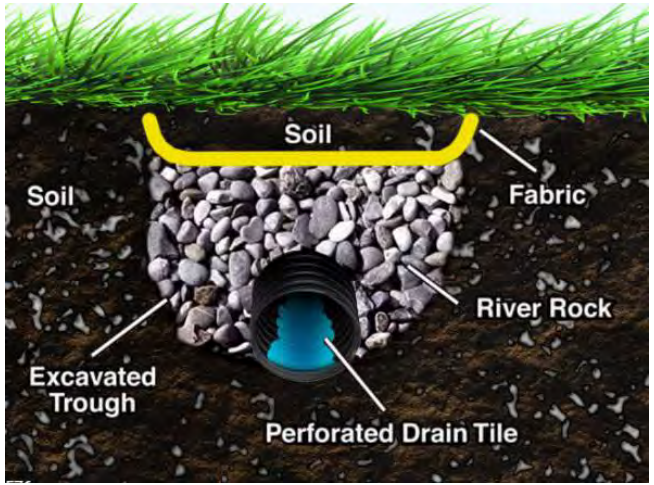
Bulk Moisture Control

- Proper site drainage
  - Swales
  - Grading with positive slope
  - French drains



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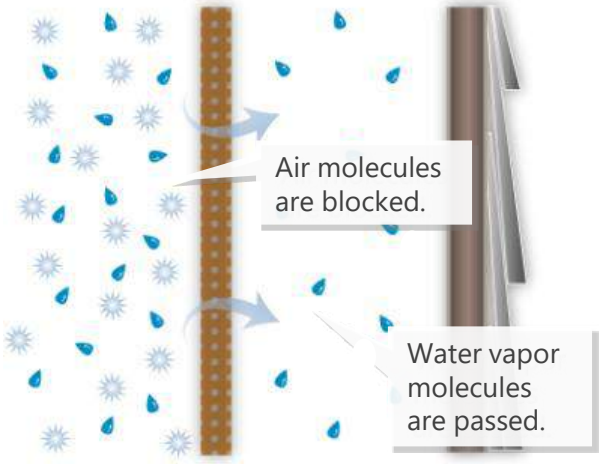
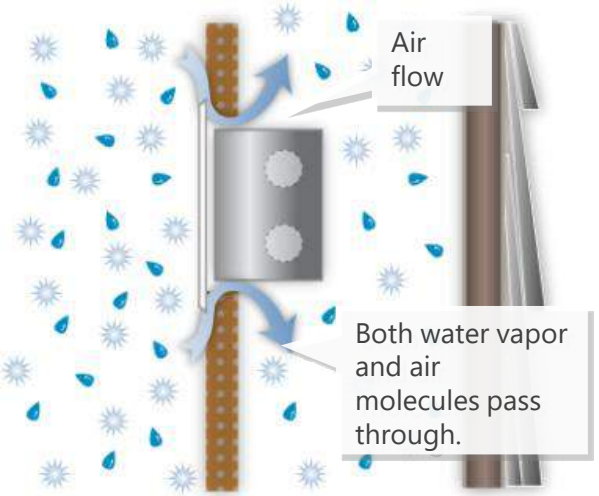
Encountering Water Vapor

Managing Water Vapor

Water Vapor Movement



Diffusion Through Surface



Convection Through Holes

The measurement of the permeability of a material is its **Perm Rating**

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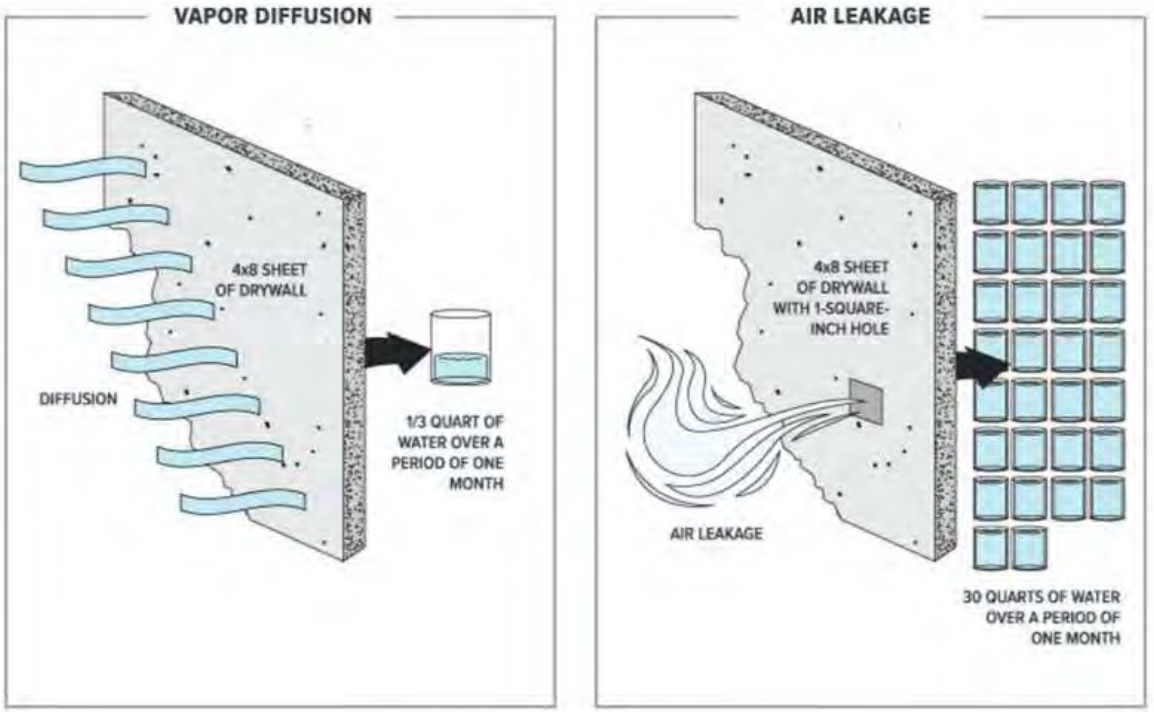
Vapor Diffusion vs. Air Leakage



VAPOR DIFFUSION VS. AIR LEAKAGE

INTERIOR TEMPERATURE = 70° F
RELATIVE HUMIDITY = 40%

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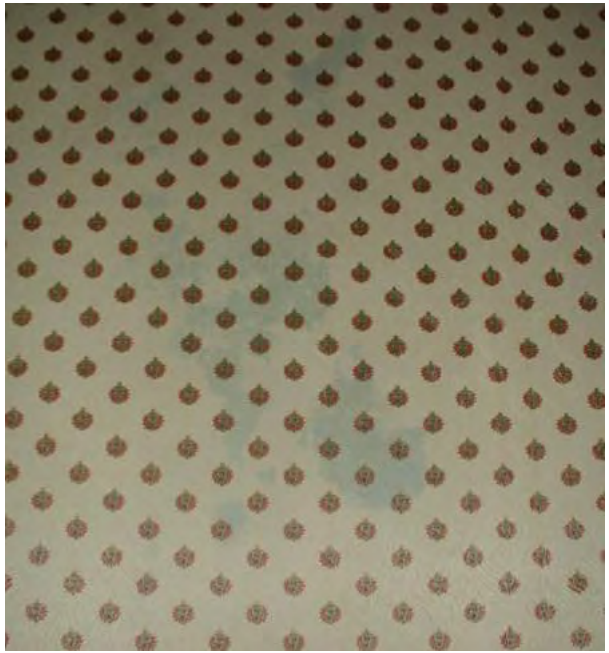
Vapor Diffusion retarders

Appropriate measures for moisture control are essential!



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Moisture question

- Which of these is not one of the four forms of moisture transport?

1. Bulk
2. Capillarity
3. Air Movement
4. Diffusion
5. Flux Capacitance

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Psychrometrics

Moisture: Some Definitions

- **Psychrometrics*:*** The measurement of water vapor and heat in an air sample
- **Absolute humidity*:*** The ratio of the mass of water vapor to the mass of dry air in a given volume of air at a given temperature - the amount of moisture in the air (grains)
- **Relative humidity*:*** is the percent of moisture absorbed in the air compared to the maximum amount possible (the amount of moisture in the air in relation to the amount of moisture the air could hold at that temperature)
- **Dew Point*:*** The temperature at which water vapor condenses into liquid (related to absolute humidity)

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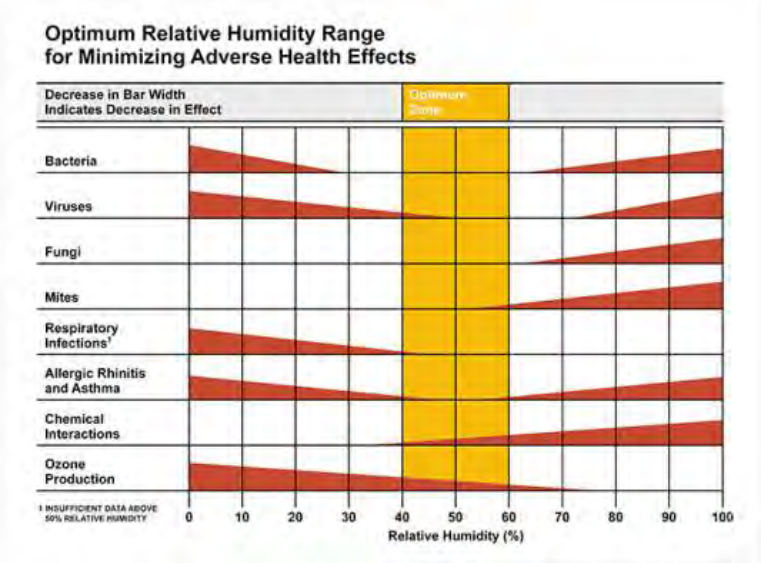
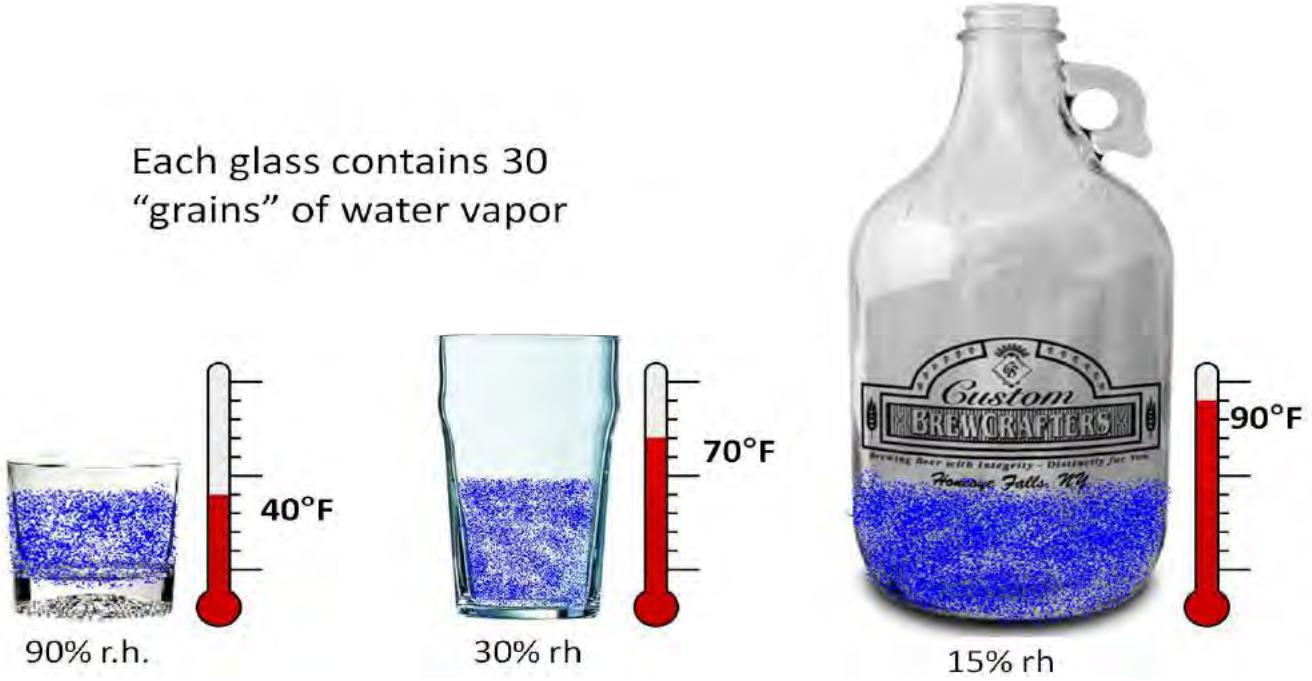
Moisture Vapor content

- Ideal Health & Comfort is **~50% RH** at room temperature (~72°F)

• Building decay	100% RH
• Interior Mold	RH > 70%
• Dust Mites	RH > 50%
• Viruses	RH < 40%
• Static electricity, dry sinus	RH < 25%



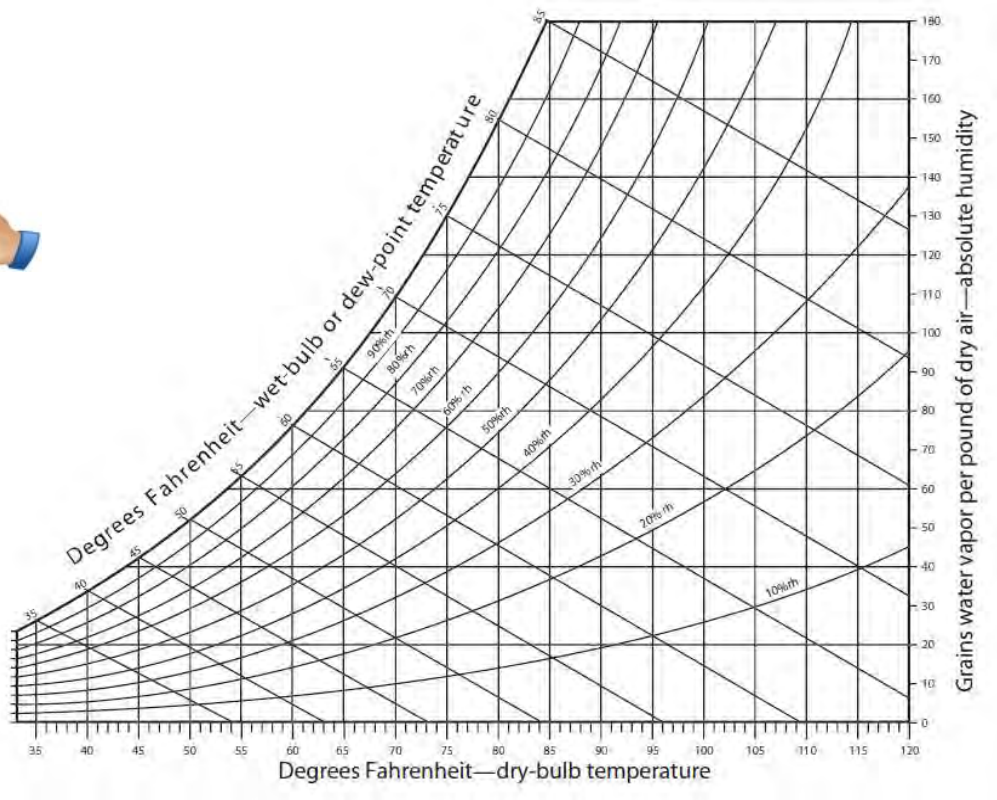
Temperature and Relative Humidity



Warm air can hold more moisture than cold air

Psychrometric Chart

- As temperature goes up, 👍
- RH goes down 👎



Room Temperature Example

Find 75°F and 50% Relative Humidity.

Record the grains: 63

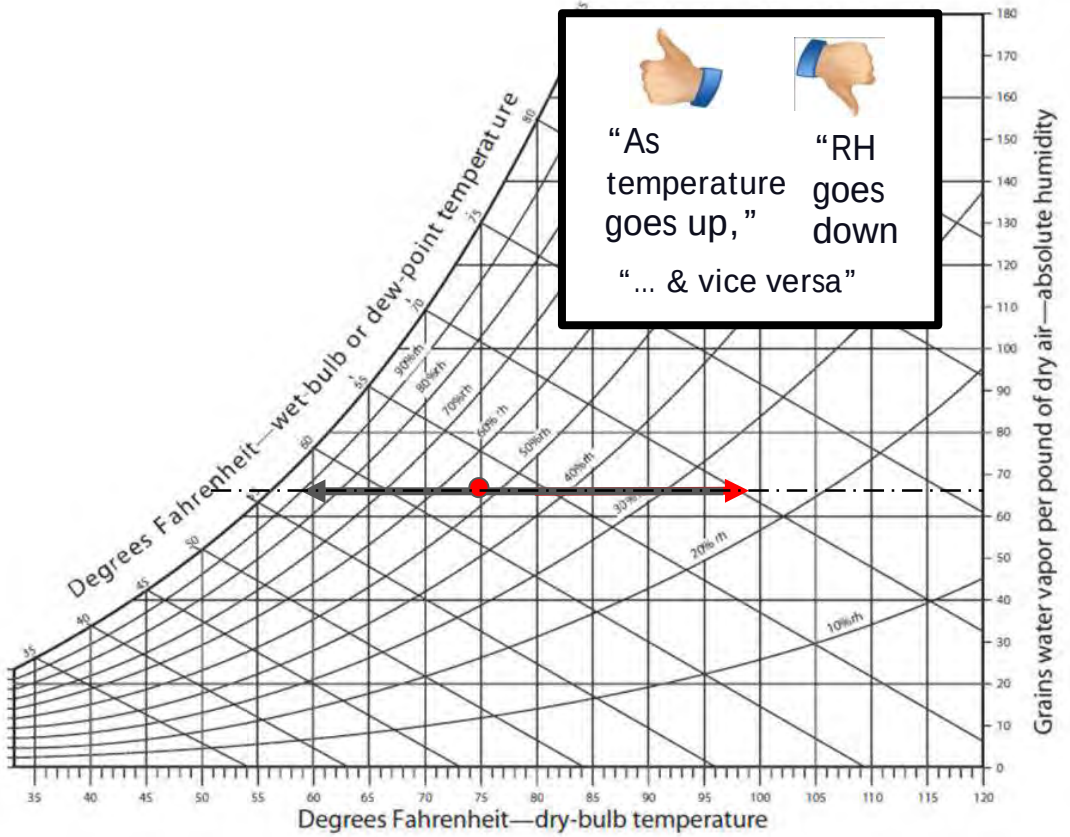
What is the Dew Point? 55 °F

This air is then heated to 90°F. What happens to the relative humidity? ↓

What is the RH? 30 %

This air is now cooled to 60°F. What happens to the relative humidity ↑?

What is the relative humidity? 85 %



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Example Problem – Winter

Find 40°F and 90% Relative Humidity.

Record the grains: 30

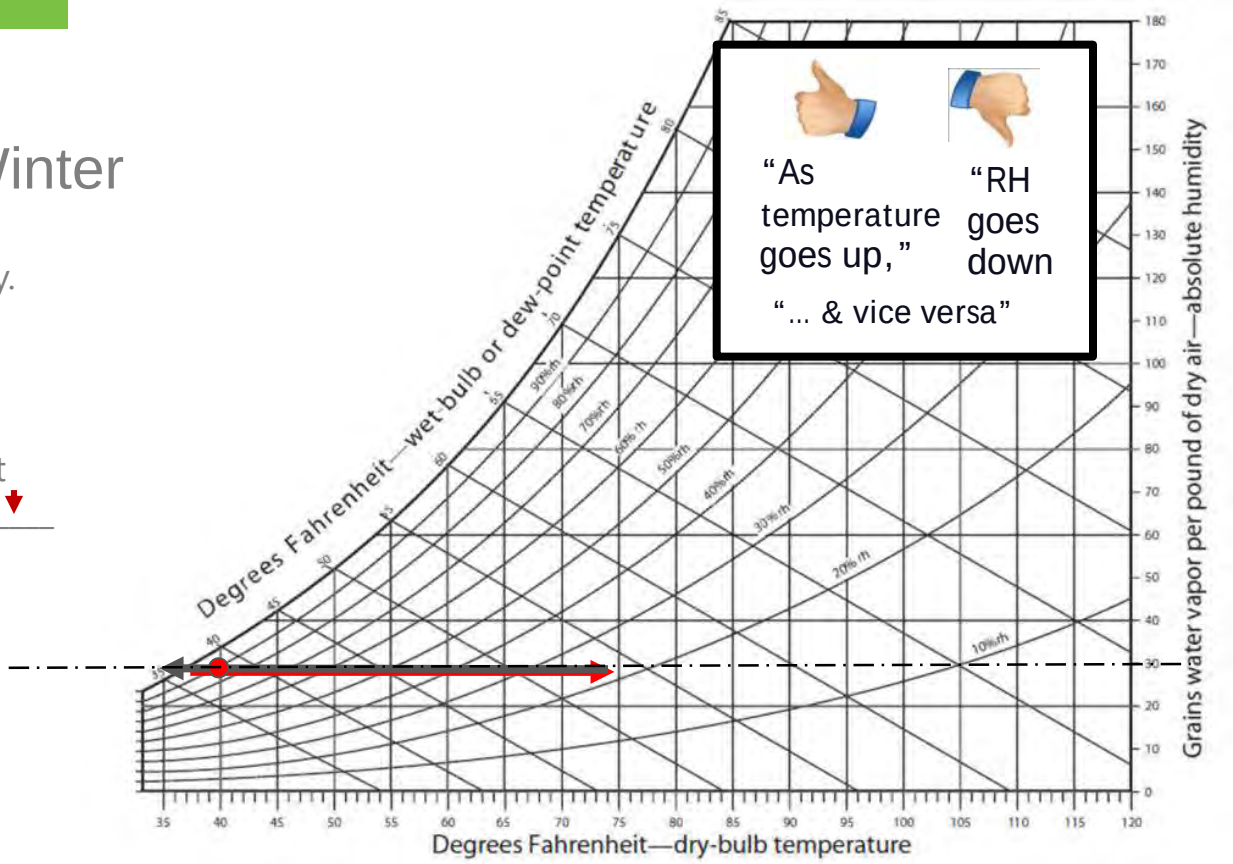
What is the Dew Point? 38 °F

This air is then heated to 70°F. What happens to the relative humidity? ↓

What is the RH? 28 %

This air is now cooled to 38°F. What happens to the relative humidity ↑?

What is the relative humidity? 99 %



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Summer Temperature Example

Find 80°F and 80% Relative Humidity.

Record the grains: 123

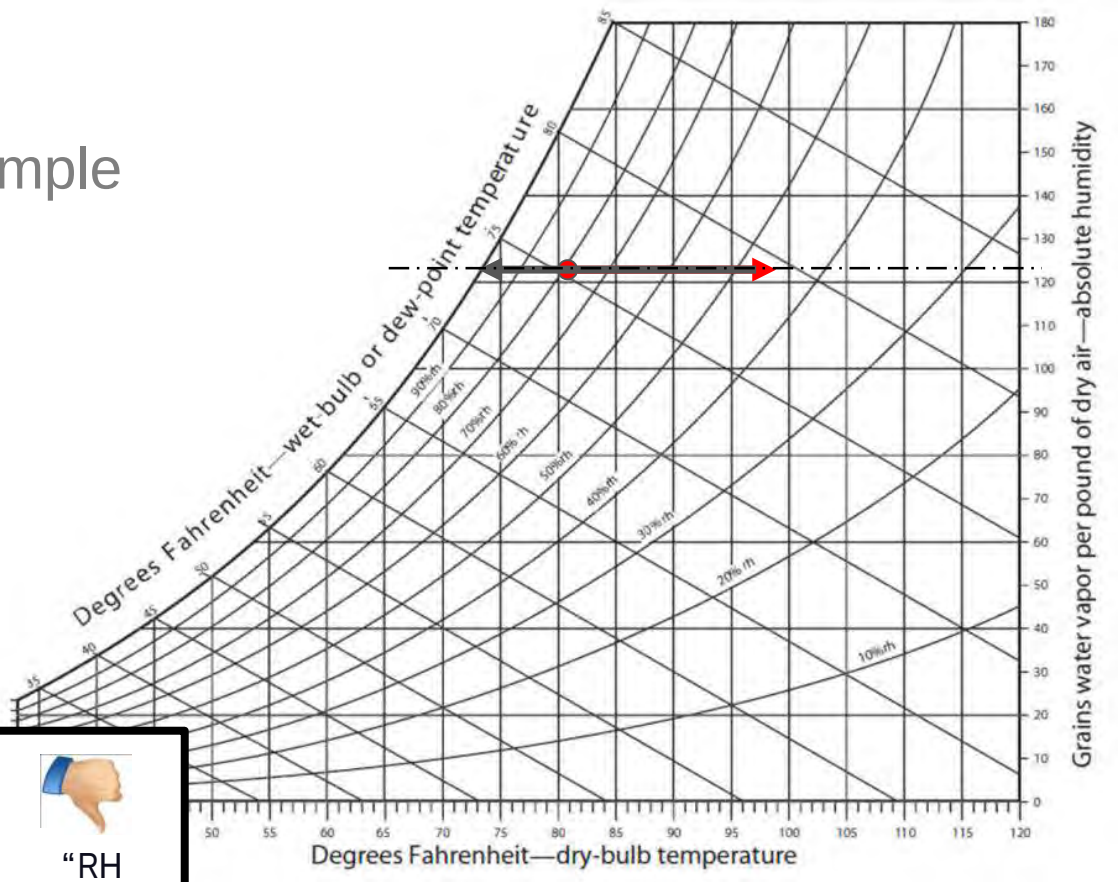
What is the Dew Point? 73 °F

This air is then heated to 95°F. What happens to the relative humidity? ↓

What is the RH? 50 %

This air is now cooled to 75°F. What happens to the relative ↑

What is the relative humidity? 95 %



"As temperature goes up," "RH goes down

"… & vice versa"

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Questions - Psychrometrics

"As temperature goes up," "RH goes down

"… & vice versa"

"Cold air is very dry air"

Which can hold more moisture, warm air or cold air? warm

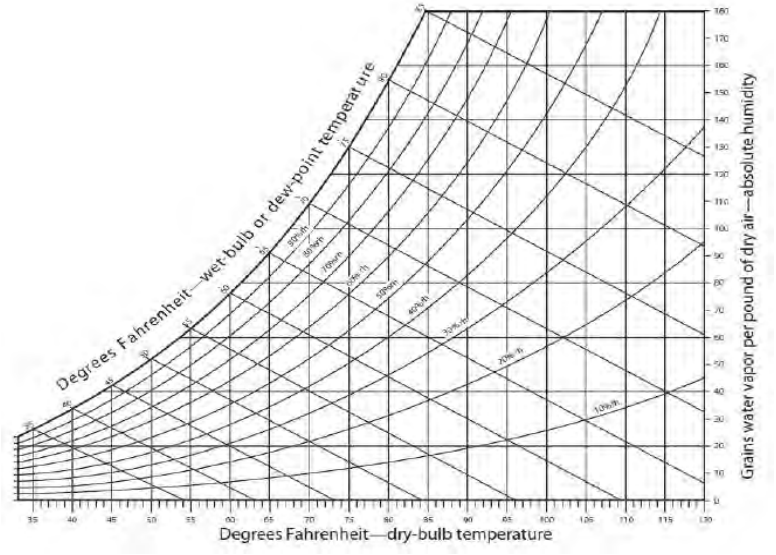
If a cubic foot air is heated, what happens to the RH ? ↓

If a cubic foot of air is cooled, what happens to the relative humidity? ↑

Without changing the moisture content, heating air will cause the relative humidity to ↓?

Misting 75F water vapor into 75F air will cause the RH to ↑?

Adding a desiccant to a humid closet will cause the RH to ↓?



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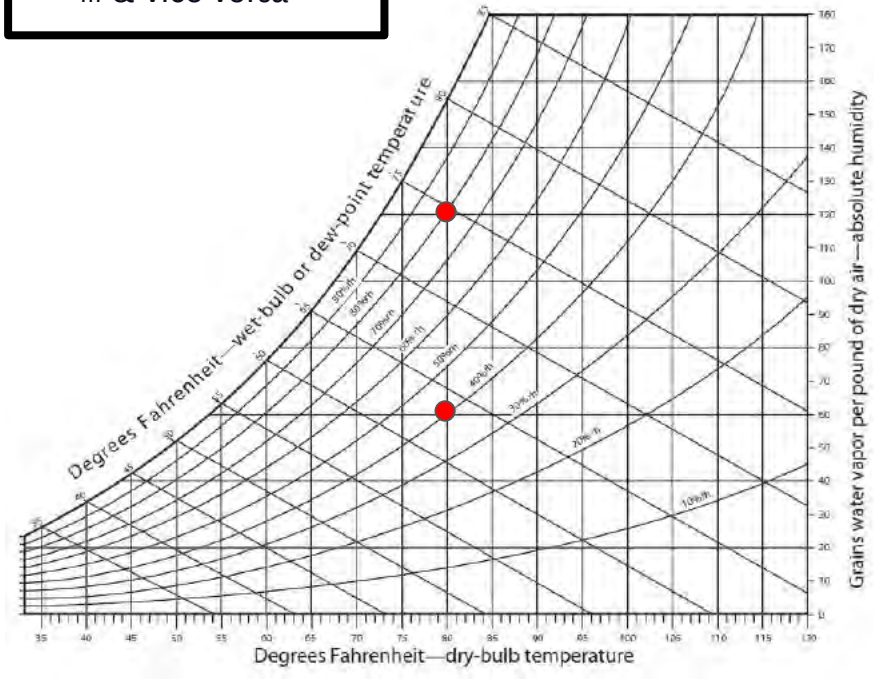
"As temperature goes up," "RH goes down

"… & vice versa"

Questions – Psychrometrics



If a cubic foot of air held exactly half of the water vapor that it theoretically could hold, the relative humidity would be? 50 %

If a cubic foot of air held exactly 1/3 of the water vapor that it theoretically could hold, the relative humidity would be? 33 %

Because a person's body cools via sweat evaporation, humid air generally feels less comfortable in the summer.

Air that is too dry (cold) in the winter is uncomfortable and can lead to chapped lips, nosebleeds, and static electricity.

Mold generally starts to grow at 70 % RH

Air at 80F and 40% RH contains 60 grains; if the amount of moisture is increased to 120 grains, the new RH will be 80 % RH

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