



announcements 4/15/08

A3: Envelope Heat Transfer

Available on Thursday, 4/17

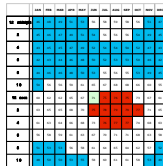
Due: week 5

Quiz 2: Tuesday 4/22

Climate Analysis

II. Analysis and Graphic Articulation

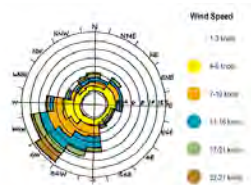
1. Temperature: 2-hour temperature map



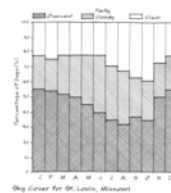
2. Temperature + Rel. Humidity: Psychrometric Chart



3. Wind Direction & Velocity Wind rose



4. Sun & Shade Sky Cover Chart



Climate Analysis

Additional Metrics

- **Temperature:** monthly normal high & low
- **Relative Humidity:** monthly normal high & low
- **Wind:** normal monthly normal velocity and direction
- **Sky Conditions:** clear, partly cloudy, cloudy
- **Climate Narrative:** description of climate
- **Character/Sense of Place:** images
- **Solar Radiation:** energy incident on a surface
- **Heating & Cooling Degree Day:** cumulative intensity and duration of heating and cooling periods
- **Seasonal Design Temperatures:** summer and winter temperatures (for sizing mechanical equipment)


Solar Radiation: Horizontal and Vertical Surfaces

Solar radiation

thermal energy measured in

Btu/h sf
or
Watts/m²

both direct + diffuse sunlight



Solar Radiation: Horizontal and Vertical Surfaces

MEEB 10th Appendix C: Solar Data

TABLE C.15

			Seattle	Phoenix	Denver
Heating Degree Days			4684	1552	6016
January	Solar Insolation BTU/day ft ²	HS	262	1021	840
		VS	378	1462	1465
July		HS	2248	2486	2273
		VS	1299	964	1053
Year (avg.)		HS	1056	1371	1570
		VS	857	1326	1334

HS = Horizontal Surface
VS = Vertical South

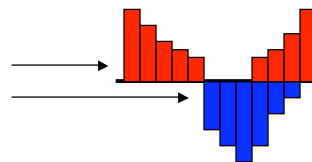
Additional Metrics: Heating and Cooling Degree Days (HDD & CDD)

Heating Degree Day and Cooling Degree Days

Intensity of heating + cooling patterns

heating and cooling degree days:

HDD base 65°F (18 °C) or lower
 CDD base 74°F (18 °C) or higher



Additional Metrics: Heating and Cooling Degree Days (HDD & CDD)

Heating and Cooling Degree-Days

	HDD65	CDD74
Seattle, WA	4684	37
Dawson Creek, BC	11,212	18
San Juan, PR	0	2,301

Additional Metrics: Seasonal Design Temperatures

Seasonal Design Temperatures

	Winter	Summer
Seattle, WA	27 °F	82/66 °F
Dawson Creek, BC	-33 °F	79/63 °F
San Juan, PR	68 °F	88/80 °F

- **Winter Design Temperature**
(99.0% or 97.5% condition)
- **Summer Design + Mean Coincident Wet Bulb Temp**
(1% or 2.5% condition)

Additional Metrics: Outside Design Conditions - Summer & Winter

Outside Design Conditions **Seattle**

Climate: Table B.1 MEEB 10th edition:

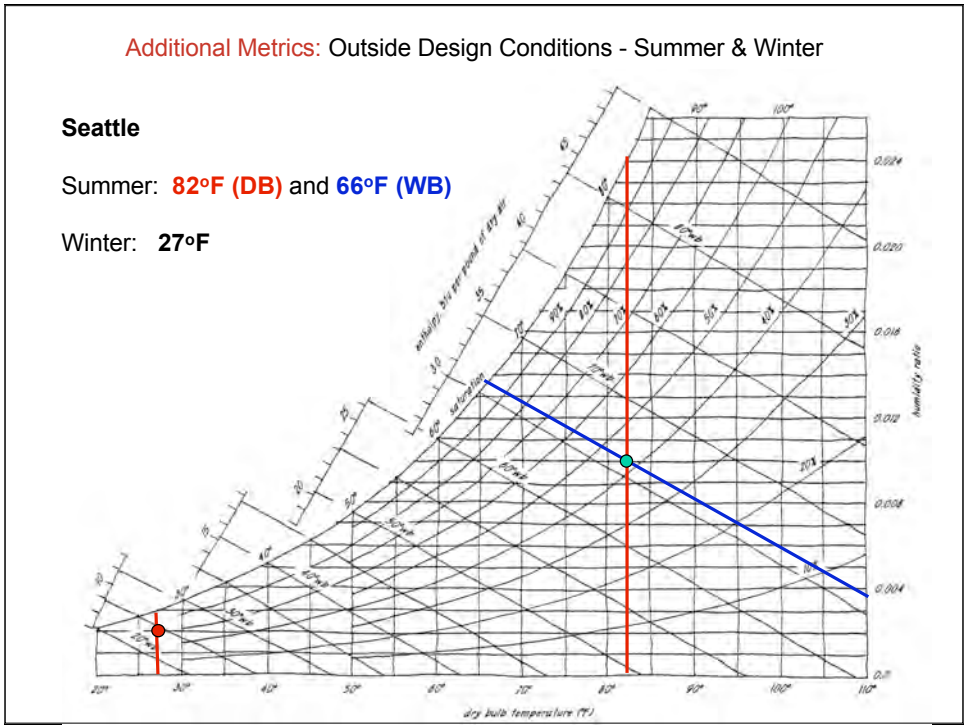
HDD65:	4684 (heating degree days)
Winter:	27°F
Summer:	82°F (DB) and 66°F (WB)
Mean daily range:	19°F

Additional Metrics: Outside Design Conditions - Summer & Winter

Seattle

Summer: **82°F (DB)** and **66°F (WB)**

Winter: **27°F**



Thermal Comfort



Thermal Comfort

A Condition of Body

- A state of equilibrium between internally generated energy and energy loss to the environment.

- The lack of discomfort

THERMAL NEUTRALITY

A Condition of Mind

“... that condition of mind which expresses satisfaction with the thermal environment”

ASHRAE

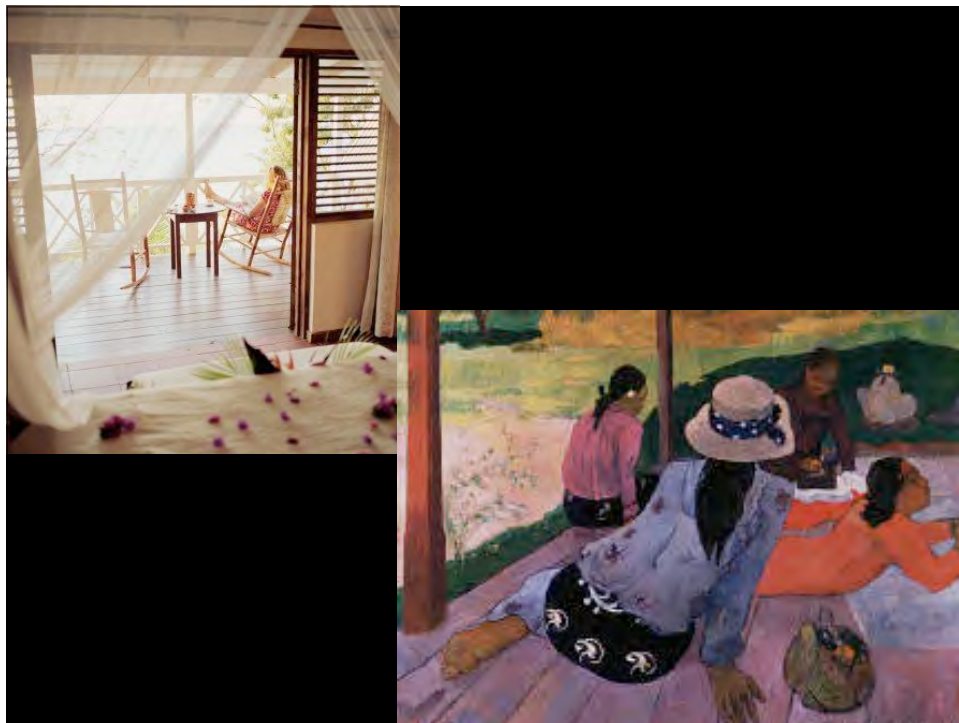
THERMAL DELIGHT



Experiential Goals/Intentions

Thermal Neutrality or Thermal Delight?

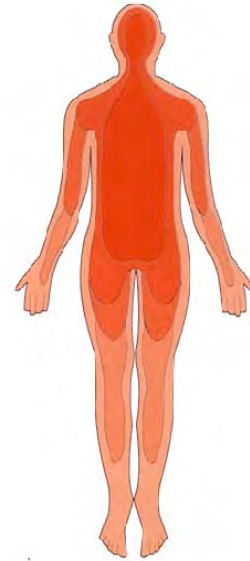




Human Body

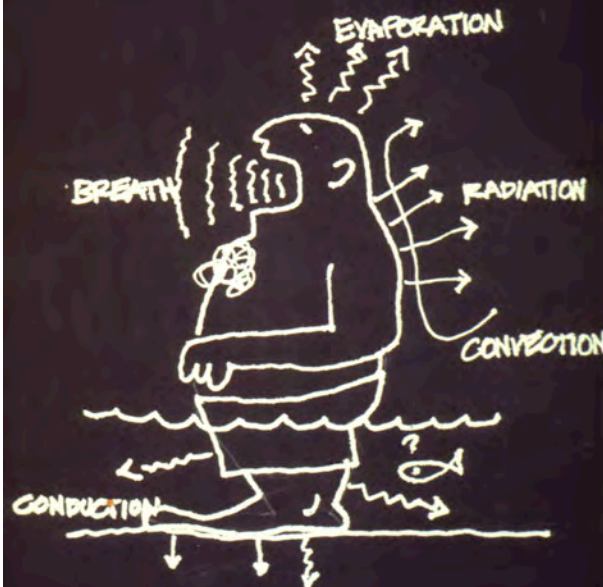
- *The human body is always producing heat.*
- *At best our “motors” are 20% efficient in converting food into mechanical energy (movement)*
- *80% or more of our energy is released as heat.*
- *We must constantly discard energy not needed to keep us at a core body temperature of 98.6oF.*

What really determines thermal comfort is the rate at which we lose heat to the environment



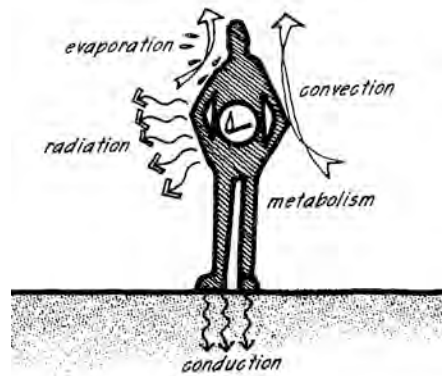
Heat Transfer Mechanisms:

- CONDUCTION
- CONVECTION
- RADIATION
- EVAPORATION (Phase Change)



Thermal Balance & Thermal Comfort

$$Q_{in} = Q_{out}$$



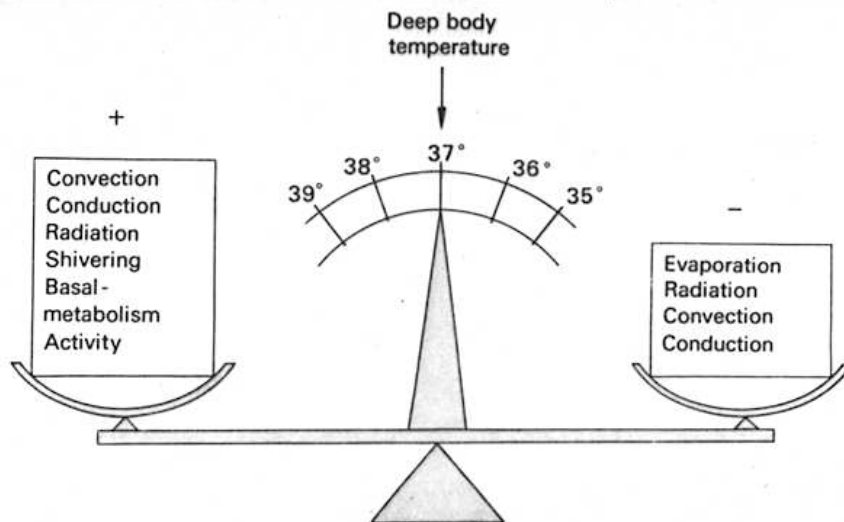
Q_{in} = Metabolism (food)
+ Environmental

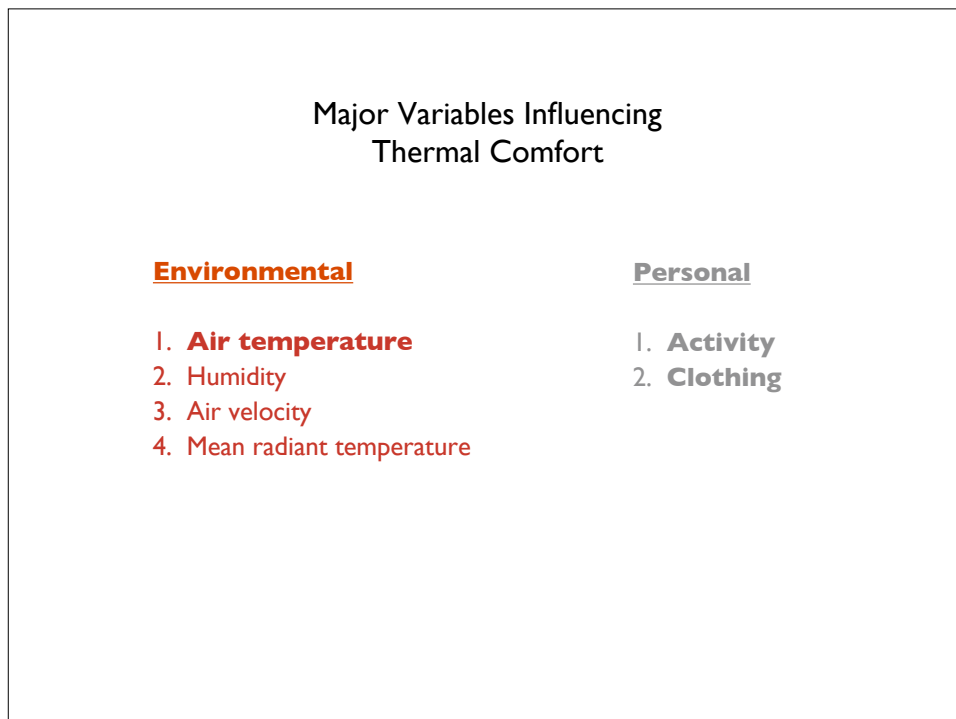
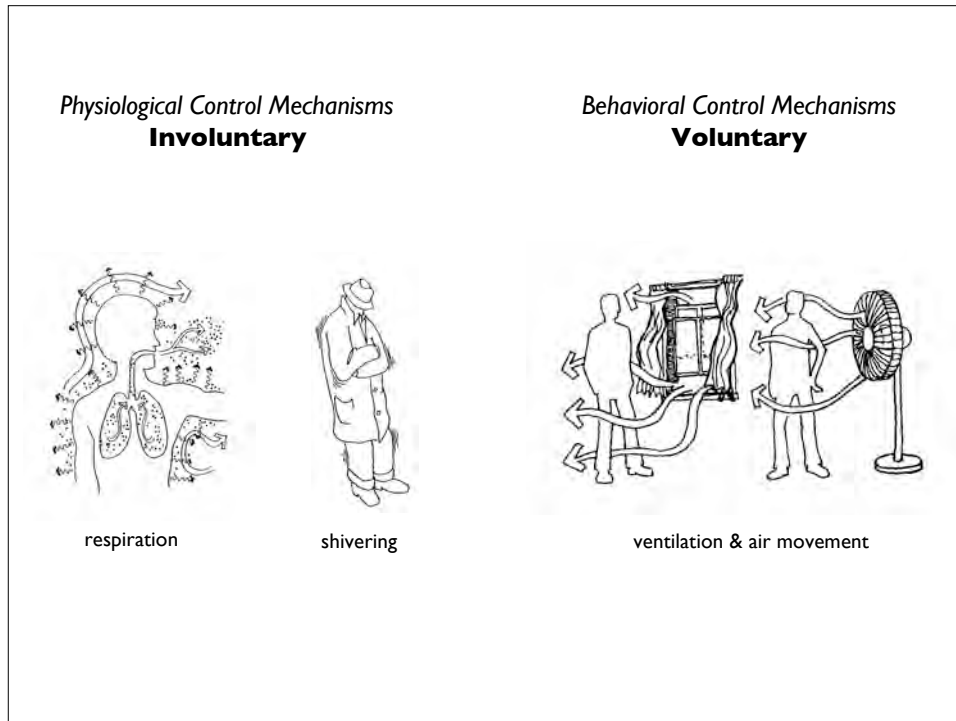
Q_{out} = Sweat
Wind/Breeze
Contact
Breathing
Warmth

evaporation
convection
conduction
convection
radiation

Heat Gains & Losses

37 °C = 98.6 °F





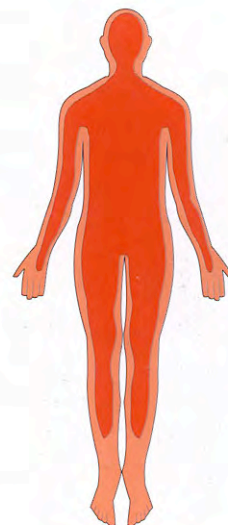
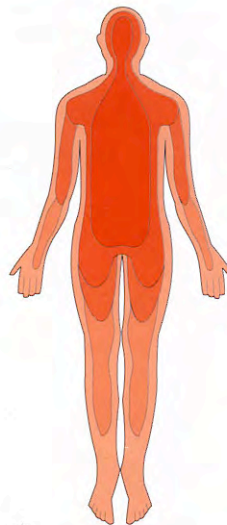
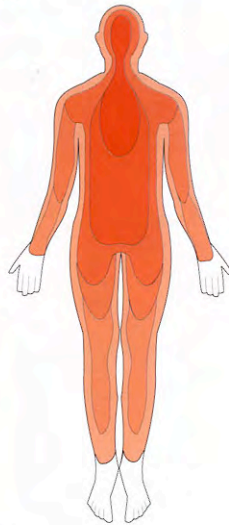
Air Temperature



Air Temperature

Body Heat and External Temperature

Core Temperature



Room Temperature

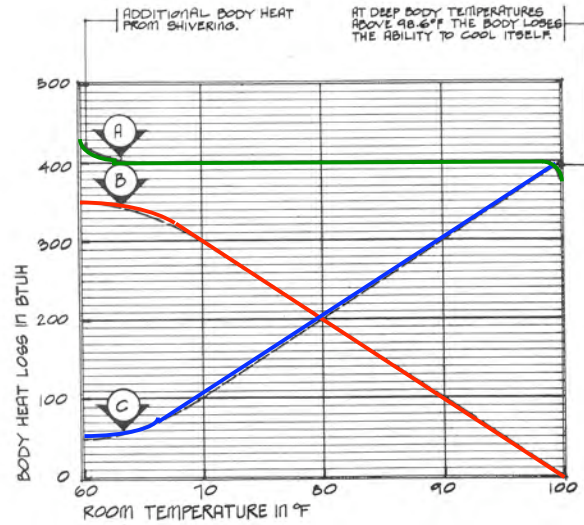
0° C

20° C

35° C

Effect of Air Temperature & Heat Loss

- A = Total Body Heat Loss
- B = "Dry" Heat Loss (convection + radiation)
- C = "Wet" Heat Loss (evaporation)

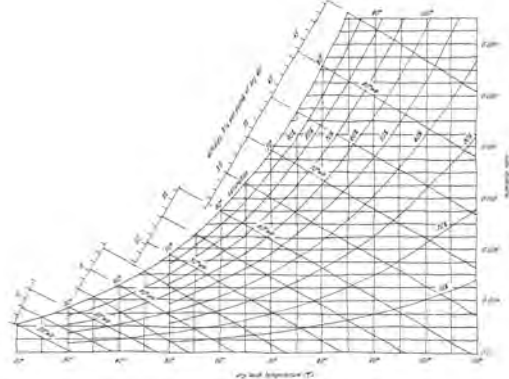


Humidity

Measures of Humidity



- RH Relative Humidity (%)
- DP Dew Point temperature (°F)
- WB Wet-Bulb temperature (°F)
- W Humidity ratio (lb,water / lb,air)

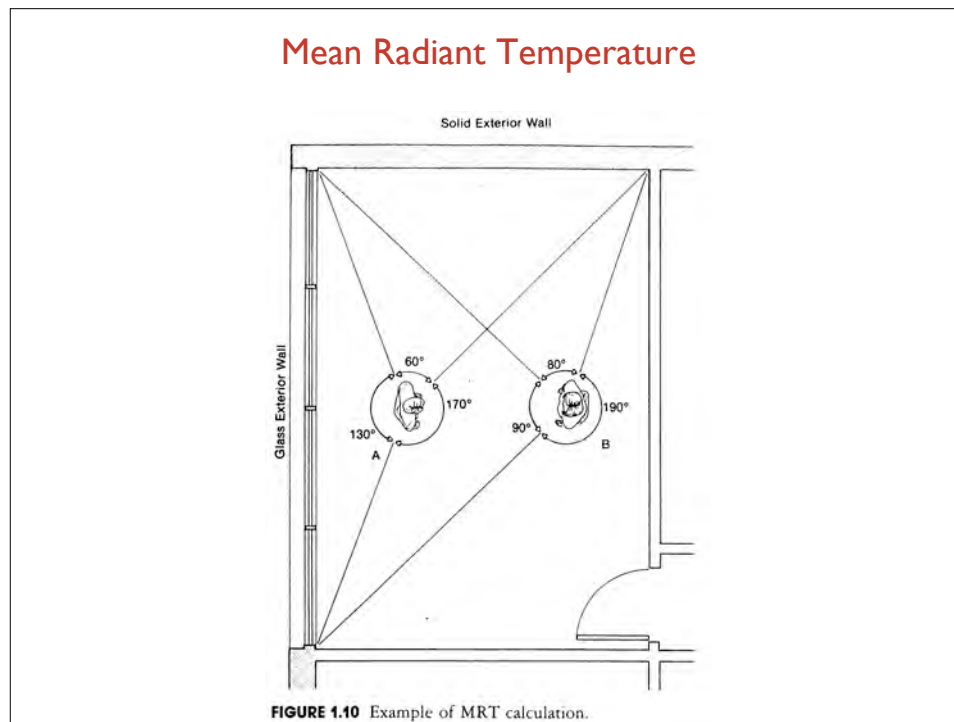


Air Velocity



Mean Radiant Temperature





Major Variables Influencing Thermal Comfort

Environmental


1. **Air temperature**
2. Humidity
3. Air velocity
4. Mean radiant temperature

Personal

1. **Activity**
2. **Clothing**

clothing level
activity level

- 1.0 clo = heavy slacks, light sweater, shirt, and jacket for women and men
- 0.5-0.7 clo = light office clothing



activity level
clothing level

METS
↓

Activity	Met units	Kcal/hr	Watts	Btu/h
Sleeping	0.7	64	74	253
Drafting	1.2	109	127	433
Sawing	4.4	400	466	1588

