EGR343 Green
Architectural Engineering
Lecture Notes
Chapter 3

Chapter 3

1) Sensible Heat + Conduction + Temperature

- Sensible Heat = Motion of Molecules
  - Motion → Heat
  - Quantity of Heat Stored = \( \int \text{Temp} \times \text{Mass} \)
  - Temperature = Measure of this "Motion"

Conduction = Heat Transfer

- Heat flow from hot to cold along a temperature gradient
- In solids, molecular agitation without motion of material
- In gases, molecules collide
- In vacuum, no conduction possible

- "Cold" is just the relative absence of heat

- Resist heat conduction in buildings with insulation, double panes
  - More in Ch. 15

2) Latent Heat

- Amount of heat needed to change "state" (phase)
  - Solid
  - Liquid
  - Gas

- Elements and molecules have 3-phase diagrams

  ![Diagram](image)

  - Normal melting point
  - Critical point
  - Normal boiling point
  - Triple point

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**Ex 1 H\(_2\)O**

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**Diagram:**

- **Atmospheres**
- **At Sea-Level**
- **Solid (Ice/Snow)**
- **Liquid (Water)**
- **GAS** (WATER VAPOR, STEAM)
- **Freeze**
- **Boil**

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- **Sublimation** (Go directly from a solid to a gas)
- **This is why dry snow at high altitudes (lower atmospheric pressure) is better for skiing**
- **Better "comfort" (Ch. 4)**
- **Relate to low relative humidity**

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**Note:**

- Can use H\(_2\)O in ARCH. to store heat (e.g., water columns for thermal mass)
- But H\(_2\)O not compressible...
- Refrigerants better for storing heat, especially when compressed (life for air is...)
EVAPORATIVE COOLING

- Evaporation is from a surface
- Boiling is within the entire volume

SWEAT

- Body cooling itself via heat transfer through H₂O
- Into water vapor in air
- If high humidity body can't do this well because air more saturated

- Air movement over surface helps with cooling
- Tall windows and ceilings in humid climates
- And use ceiling fans
- South Pacific
- South-East US
CONVECTION

GAS OR LIQUID: TEMP $\rightarrow$ DENSITY

$\Rightarrow$ LESS DENSE GAS OR LIQUID RISES

$\Rightarrow$ CONVECTION CURRENTS CREATED

$\Rightarrow$ CAN MAKE USE OF

$\Rightarrow$ FOR ENERGY GENERATION

$\Rightarrow$ IN OCEANS

$\Rightarrow$ STRATIFICATION OF AIR

WHEN HOT AIR RISES

$\Rightarrow$ MAY WANT THIS IN HOT CLIMATES TO GET RID OF HEAT

$\Rightarrow$ TALL CEILINGS

$\Rightarrow$ MAY NOT WANT THIS IN COLD CLIMATES

$\Rightarrow$ LOW CEILINGS TO KEEP HEAT NEAR TO PEOPLE

$\Rightarrow$ USE INFILTRATION BARRIERS IN WALLS, AND "WEATHER STRIPPING" AROUND DOORS AND WINDOWS TO PREVENT UNDESIRABLE HEAT LOSS OR GAIN

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Heat in CONDUCTION is via elastic collisions between molecules.
Heat in CONVECTION is via motion by the flow of the medium.

E.M. RADIATION
→ TRAVELS LIKE A WAVE → # (GRAVITY)
→ INTERACTS WITH MATTER LIKE A PARTICLE (i.e., PHOTON)
→ WITH EFFECTIVE MASS
→ TYPES OF INTERACTIONS
1. TRANSMITTANCE → JUST PASSES THROUGH MAY BEND (REFRACTION)
2. ABSORBION → CONVERT INTO SENSIBLE HEAT
3. REFLECTANCE → EX/ REFLECTIVE PAINTS ON EXTERIOR WALLS
4. EMITTANCE → EX/ THERMAL MASS FLOOR AT NIGHT

NOTE: This definition is somewhat debatable.
GREEN HOUSE EFFECT

EXhaust GAS TRANSMITS MOST SUNLIGHT BUT REFLECTS MOST HEAT

FENESTRATION
- Design of openings in buildings
- Windows

EXhaust HEAT rises, then heat is released but is reflected back by window

EXhaust EARTH

GREEN HOUSE GASES CHARGE ATMOSPHERE:
- Global Warming
- Ice melts, oceans rise
- Ecosystems unbalanced

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EQUILIBRIUM TEMPERATURE

\[ T = \mathcal{F}(\text{Absorbance}, \text{Emittance}) \]

EX: FOUR BLOCKS OF SAME MATERIAL
EACH COATED DIFFERENTLY

- WHITE PAINT
  - Absorbance: L
  - Reflected (Emittance): H
  - Equilibrium Temp: Cool
  - Good for exterior paint in not climate

- CHROME
  - Absorbance: H
  - Reflected: L
  - Equilibrium Temp: Warm

- BLACK PAINT
  - Absorbance: H
  - Reflected: H
  - Equilibrium Temp: Hot
  - Not much good for building

- SPECIAL COATING
  - Absorbance: L
  - Reflected: L
  - Equilibrium Temp: Very hot
  - Good for solar collectors

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Assume all other interior surface are at 35 Degrees Fahrenheit

\[ M_R T_A = \frac{1}{360} \sum_{i=1}^{n} (T_i \times 310) \]

\[ M_R T_A = (1000 \times 310) + (20 \times 310) \]

\[ M_R T_A = \frac{360 \times 4}{360} + \frac{360 \times 4}{360} \]

\[ = 87 \text{ Degrees Fahrenheit} \]

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NOTE: SOME CH 3 SECTIONS DISCUSSIONS EXPANDED + MOVED INTO LATER, MORE-ADVANCED LECTURES:

3.14 "HEAT SINKS" ➔ CH 10 "PASSIVE COOLING"

3.15 "HEAT CAPACITY" ➔ CH 7 "PASSIVE"

3.16 "THERMAL RESISTANCE" (R-VALUES, ETC.) ➔ CH 15 "THERMAL ENVIRONMENT"

3.17, 3.18, 3.19 ➔ C15
3.20 "Energy Conversion"

- Nuclear is very efficient but hazardous!
- Fossil fuel is very wasteful

- Approximately 70% of original energy lost:
  - Heat loss
  - Steam loss
  - Electro-mechanical loss (turbines)

- Power loss current in constant resistance of transmission lines

- This is why it's better to transmit high voltages

I.e., since \[ P = I^2 R \]

- If \( V \uparrow \), \( I \downarrow \)

- This is also a factor, but to much lesser degree, in home heating
  - Ex: 220V heater
  - Ex: 220V water heaters

- Much of the world uses 220V instead of 110V (used in U.S.)
- But dangerous

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To understand hydrogen fuel cells, first research how batteries work. Then research how hydrogen fuel cells use hydrogen and electricity to create hydrogen to create electricity and yield water as a byproduct. Make sure you understand the ‘batteries do not need a fuel’ reminder that a hydrogen fuel cell NEEDS hydrogen to generate electricity (as opposed to generating electricity from a battery). A few hydrogen sources can be recharged by providing electricity to them; however, a hydrogen fuel cell NEEDS a source of hydrogen to generate electricity.

https://www.youtube.com/watch?v=819172JhWkc
https://www.youtube.com/watch?v=IguMuDZkd8I

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3.21

Our friends at Phoenix Controls USA doing THIS now.

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OUR FRIENDS AT PHOENIX CONTROLS USA DOING THIS.
3.23 "EMBODIED ENERGY"

U.S. ENERGY USE

BUILDINGS

Industry

Most of this is maintenance and construction.

But ~1/4 is in construction.

Also, consider the energy used to create these materials.

All "ventricular" design lectures moved to later case-study examples (e.g., using local materials, methods, etc.).

Note: LEED credits awarded for green construction methods.

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