WHOLE BUILDING DESIGN:

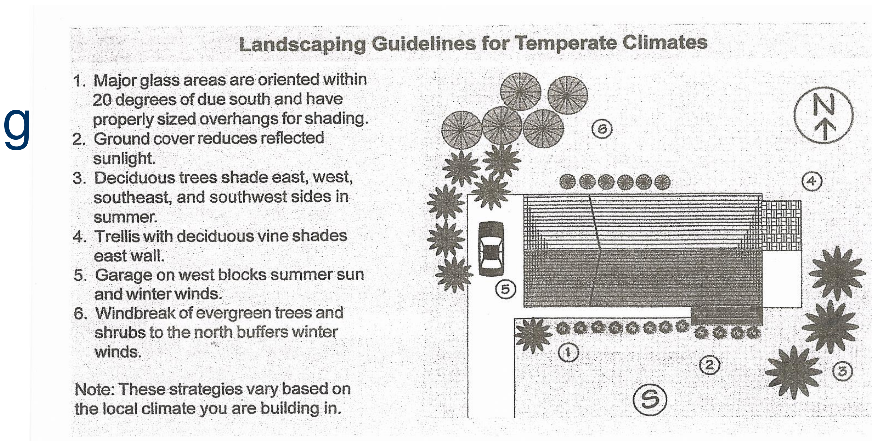
Site Selection
Building Envelope

Cabrillo College-

CEM 162 Spring 2012

Whole Building Design- Site Selection

- Building orientation to take advantage of solar effects
  - Thermal mass of building for passive solar
- Daylighting
- Landscaping- use of deciduous trees
- Site drainage


Landscaping Guidelines for Temperate Climates

1. Major glass areas are oriented within 20 degrees of due south and have properly sized overhangs for shading.
2. Ground cover reduces reflected sunlight.
3. Deciduous trees shade east, west, southeast, and southwest sides in summer.
4. Trellis with deciduous vine shades east wall.
5. Garage on west blocks summer sun and winter winds.
6. Windbreak of evergreen trees and shrubs to the north buffers winter winds.

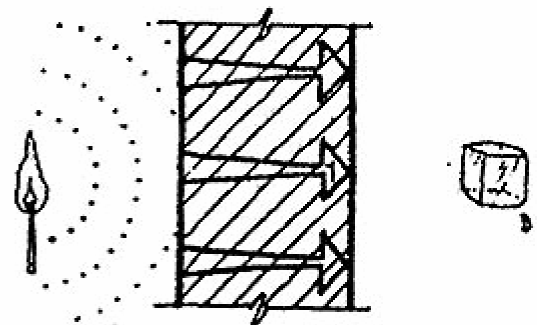
Note: These strategies vary based on the local climate you are building in.

WHOLE BUILDING DESIGN- Building Envelope

- <u>Heat energy fundamentals</u>

1st Law of Thermodynamics- “**Heat energy flows from hot to cold**”

  - Conduction
  - Convection
  - Radiation



- Units of heat energy

BTU- **B**ritish **T**hermal **U**nit

Amount of heat required to raise 1 lb of water 1 degree F

THERM= *100,000 BTU*

WATT = *3.41 BTU/HR*

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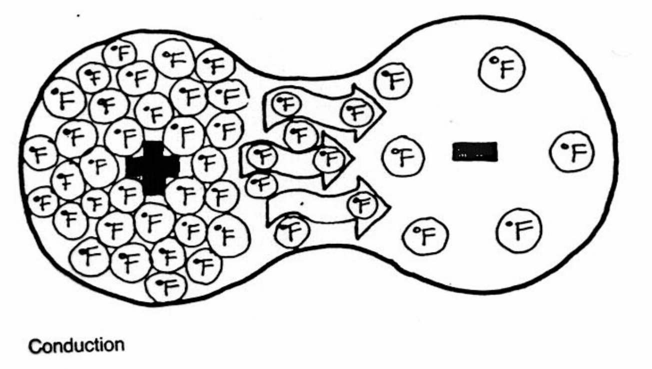
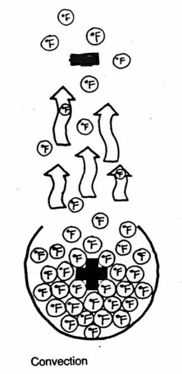
- Conduction
  - Heat transfer due to materials in contact and temp difference
- Convection
  - Heat transfer due to air motion and temp difference





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- Convection:
  - Forced convection- use of fans to assist airflow
  - Natural Convection- Stack effect- “passive convection”

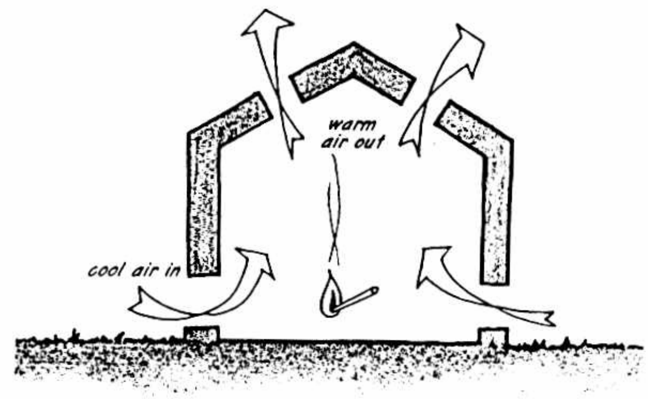
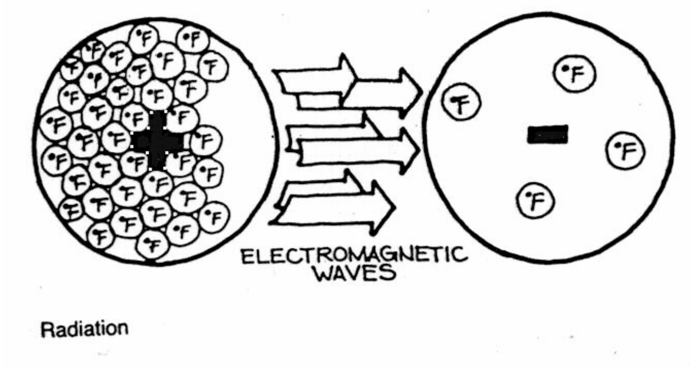
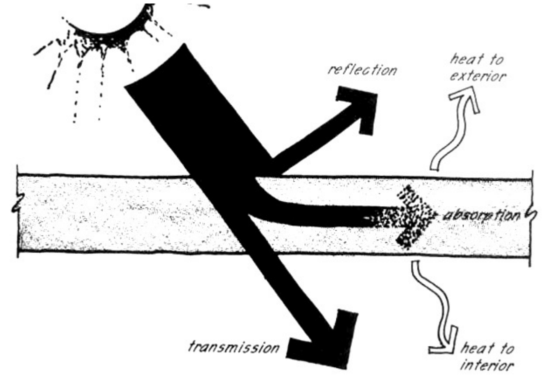


Figure 15.9: Ventilation principle #7 — The "stack effect" results when air in the building warms, becomes more buoyant than outside air, and rises to escape out of openings high in the building.

WHOLE BUILDING DESIGN- Building Envelope

- Radiation heat transfer:
  - Heat transfer due to temp difference and material properties





Building Envelope-

Heat Transfer Calculations

- Building Heat Transfer:
  - **R**- "resistance value" of building materials to heat flow
  - $\mathbf{R_T = R_{inside\ film} + R_1 + R_2 + \ldots\ R_{outsidefilm}}$
  - **U-value**: "overall heat transfer co-efficient"

    (NOTE: includes allowance for BOTH convection and conduction heat transfer.)

$$U = \frac{1}{R_T}$$

Building Envelope-

Heat Transfer Calculations

TABLE 4.2 **Thermal Properties of Typical Building and Insulating Materials (design values)**[a]

NOTE: The customary units for conductivity (k), [conductance (C), and resistance (R), either per inch ($1/k$)] or for thickness stated ($1/C$), are given in Table 4.1. Values are for a mean temperature of 75 F unless noted by an asterisk (*), which indicates that such a value has been reported at 45 F. The SI units for resistance (last two columns) were calculated by taking the values from the two resistance columns under Customary Unit, multiplying by the factor $1/k(r/\text{in.})$ and $1/C(R)$ for the appropriate conversion factor. Author's note: Actual (on-site) resistance values frequently are lower than the test-cell-determined "design" values listed in this table.

Description	Customary Unit						SI Unit	
	Density (lb/ft³)	Conductivity (k)	Conductance (C)	Resistance[b] (R) Per inch thickness ($1/k$)	Resistance[b] (R) For thickness listed ($1/C$)	Specific Heat, Btu/(lb)(deg F)	Resistance[b] (R) $\frac{(m \cdot K)}{W}$	Resistance[b] (R) $\frac{(m^2 \cdot K)}{W}$
BUILDING BOARD								
Boards, Panels, Subflooring, Sheathing								
Woodboard Panel Products								
Asbestos-cement board	120	4.0	—	*0.25*	—	0.24	1.73	
Asbestos-cement board . . . 0.125 in.	120	—	33.00	—	*0.03*			*0.005*
Asbestos-cement board . . . 0.25 in.	120	—	16.50	—	*0.06*			*0.01*
Gypsum or plaster board . . . 0.375 in.	50	—	3.10	—	*0.32*	0.26		*0.06*
Gypsum or plaster board . . . 0.5 in.	50	—	2.22	—	*0.45*			*0.08*
Gypsum or plaster board . . . 0.625 in.	50	—	1.78	—	*0.56*			*0.10*
Plywood (Douglas Fir)[o]	34	0.80	—	*1.25*	—	0.29	8.66	
Plywood (Douglas Fir) . . . 0.25 in.	34	—	3.20	—	*0.31*			*0.05*
Plywood (Douglas Fir) . . . 0.375 in.	34	—	2.13	—	*0.47*			*0.08*
Plywood (Douglas Fir) . . . 0.5 in.	34	—	1.60	—	*0.62*			*0.11*
Plywood (Douglas Fir) . . . 0.625 in.	34	—	1.29	—	*0.77*			*0.19*
Plywood or wood panels . . . 0.75 in.	34	—	1.07	—	*0.93*	0.29		*0.16*
Vegetable Fiber Board								
Sheathing, regular density . . . 0.5 in.	18	—	0.76	—	*1.32*	0.31		*0.23*
. . . 0.78125 in.	18	—	0.49	—	*2.06*			*0.36*
Sheathing intermediate density . . . 0.5 in.	22	—	0.82	—	*1.22*	0.31		*0.21*
Nail-base sheathing . . . 0.5 in.	25	—	0.88	—	*1.14*	0.31		*0.20*
Shingle backer . . . 0.375 in.	18	—	1.06	—	*0.94*	0.31		*0.17*
Shingle backer . . . 0.3125 in.	18	—	1.28	—	*0.78*			*0.14*
Sound deadening board . . . 0.5 in.	15	—	0.74	—	*1.35*	0.30		*0.24*
Tile and lay-in panels, plain or acoustic	18	0.40	—	*2.50*	—	0.14	17.33	
. . . 0.5 in.	18	—	0.80	—	*1.25*			*0.22*
. . . 0.75 in.	18	—	0.53	—	*1.89*			*0.33*
Laminated paperboard	30	0.50	—	*2.00*	—	0.33	13.86	
Homogeneous board from repulped paper	30	0.50	—	*2.00*	—	0.28	13.86	
Hardboard								
Medium density	50	0.73	—	*1.37*	—	0.31	9.49	

(continued)

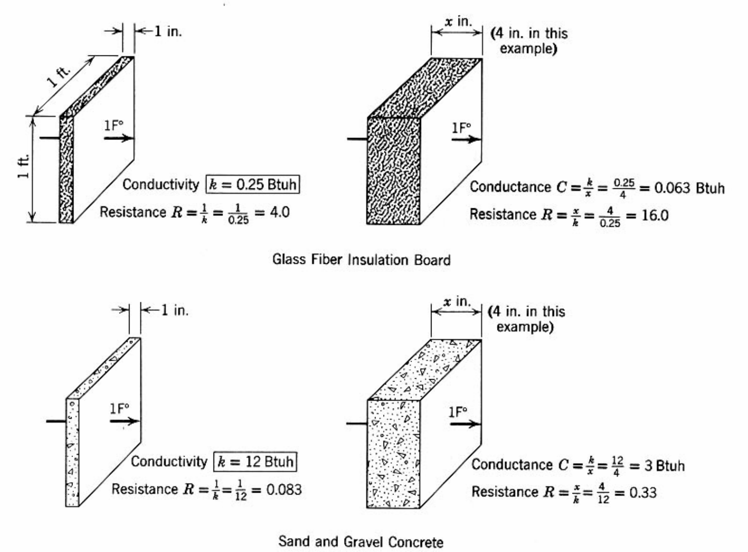


Fig. 4.2 Sample conductivities (k)

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Heat Transfer Calculations

- **Q = (U) x (A) x (delta T)**

where:

Q: heat transfer rate in Btu/hour

U: overall heat transfer co-efficient

A: surface area in square feet

delta T: temperature difference across surface; $T_{inside} - T_{outside}$

Building Envelope-
Heat Transfer Calculations

- Sample Calculations:

  For sample calculations- outside design = 30 F

  inside design = 70 F

  - **Walls:** wall area is 300 square feet

    wall is wood stud with R-11 insulation; approximate U = 0.08

    Q = U x A x delta T

    = 0.08 x 300 x (70 – 30) = 0.08 x 300 x 40

    = **960 Btu/hour**

Building Envelope-
Heat Transfer Calculations

- Sample Calculations:
  - **Windows:** window area is 300 square feet

    window is single pane; appx U = 1.10

    Q = U x A x delta T

    = 1.10 x 300 x (70 – 30) = 1.10 x 300 x 40

    = **13,200 Btu/hour**

NOTE THAT FOR SAME SURFACE AREA, SINGLE PANE GLASS HAS OVER 13 TIMES THE HEAT FLOW AS FOR R-11 INSULATED WALL !!

Building Envelope-
Heat Transfer Calculations

- Radiation heat gain thru windows

Q = (**A**) x (**SHGF**) x (**CLF**) x (**SC**)

where-

Q = heat transfer in BTU/HR

A = window area in ft2

SHGF= solar heat gain factor (dependent or orientation and globe location)

CLF = cooling load factor (dependent on shading and color of interior surface)

SC = shading coefficient (property of glazing; dependent on clear/tinted/mirror glass surface)

Other ratings- **SHGC** = solar heat gain coefficient = **SC x 0.86**

Building Envelope-
Heat Transfer Calculations

- Glazing selection
  - Single pane vs. dual/triple pane
    - Single pane- “U” = 1.10
    - Dual pane- “U” = 0.35
    - Triple pane- “U” = 0.22

    (NOTE effect of interior “films” at glass surfaces; insulation value increases due to air space and number of surface films)
  - Aluminum/wood/vinyl/fiberglass frames
  - “low E” glass→→ coating that allows light to get thru but not heat
  - High heat gain in winter vs. no heat gain in summer?
  - Use of different glazing on different exposures?

Building Envelope-
Glazing Selection

- **SHGC**- **S**olar **H**eat **G**ain **C**oefficient
  (% of ALL radiation (UV, visible and IR) that gets thru glass)
- **VT**- **V**isible **T**ransmittance
  (% of visible light that gets thru glass)

SOUTH FACING GLAZING:

- Cold climate: SHGC > 0.6; high VT; low “U”
- Moderate climate: SHGC < 0.6; high VT; low “U”
- Hot climate: SHGC < 0.4; medium VT; low “U”

- East/west facing: SHGC < 0.4; high VT; low “U”