Build a Better House
Foundations Part II

Maine Indoor Air Quality Council

©2021

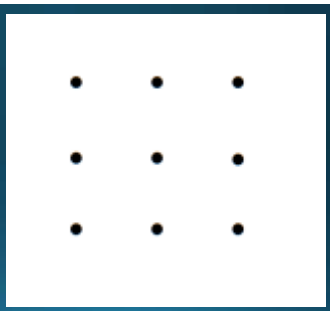
Thank you, program sponsors...

Northeast Laboratory Services
TURNER GROUP
RenewAire
TC Halford Basement
MITSUBISHI ELECTRIC
Fresh Air
PERFORMANCE BUILDING SUPPLY
DUPONT

©2021

Connect the nine points with four lines without retracing

How about three lines?



©2021



©2021



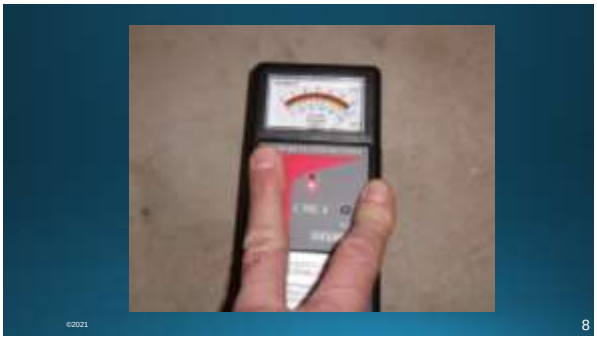
©2021



©2021



©2021 7



©2021 8



©2021 9





©2021 10



©2021 11

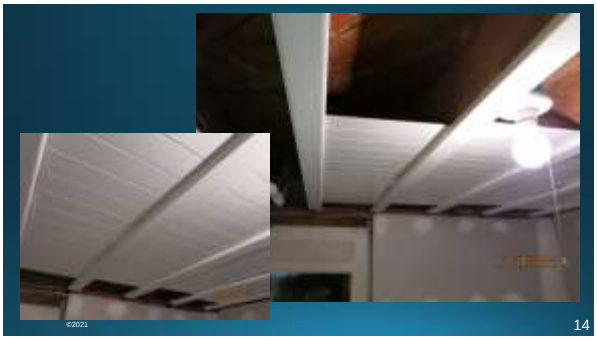




©2021 12



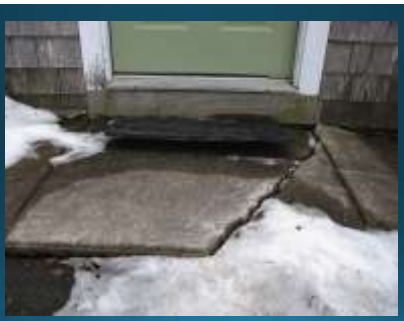
©2021 13



©2021 14



©2021 15



©2021 16



©2021 17

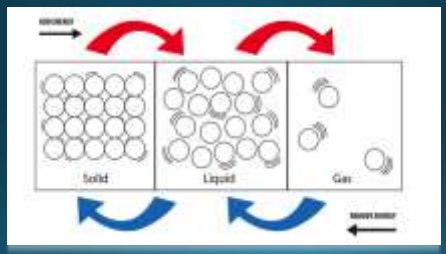
Physics



A natural science studying matter, motion, energy, and force

©2021 18

Matter



©2021 19

Energy



©2021 20



All energy comes from the Sun…

©2021 21

Available Solar Energy

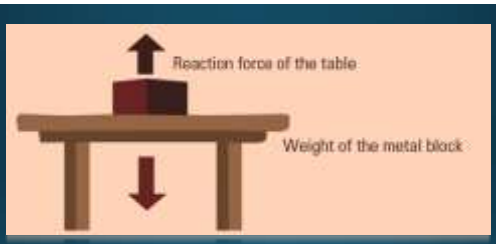


M. Grant Gross

Assume 30% loss to atmosphere…

2.88 kWh/day/m^2 for a 6 hour day

©2021 22



Structure and Force

©2021 23

Structure and Thermal Performance

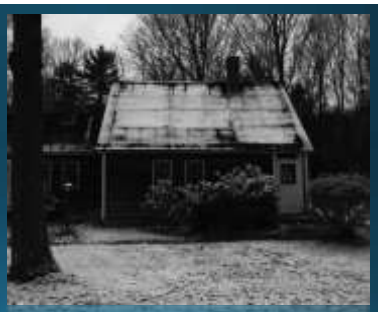


Structural choices directly affect how and how well a building can be insulated



©2021 24

What would this look like 150 years ago…?



©2021 25



Post and Beam Construction

Green timbers shrank away from infill walls, up to ½" for 8"x8"

©2021 26

Thermodynamics

A branch of physics dealing with heat and temperature

©2021 27

Thermodynamics



Energy moves from place to place

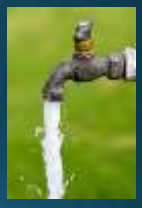
Energy changes from one form to another

Energy cannot be created or destroyed

©2021 28

Potential energy… energy of position





Kinetic energy… energy of motion

©2021 29

Heat transfer mechanisms

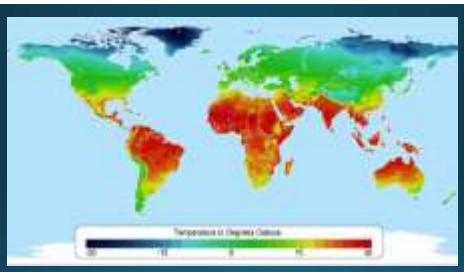
Conduction… molecular excitation without molecular movement

Convection… fluid movement of excited molecules

Radiation… electromagnetic motion of charged particles



©2021 30



Temperature

©2021 31

Sensible Heat and Latent Heat

Sensible… energy added (or subtracted) that causes a change in temperature

A gas flame under a pot of cold water will raise the temperature

Latent… energy absorbed (or released) by a substance changing state

Once the water above reaches 212ºF temperature remains constant… water changes from liquid to gas

©2021 32

British Thermal Unit

The amount of energy needed to raise one pound of water one degree Fahrenheit

A wooden kitchen match burned completely generates one BTU

©2021 33

Gulf of Maine in Distress

Portland Press Herald October 2015

…The uppermost layers of the Gulf of Maine have risen in temperature more than one degree Fahrenheit in a few years

Big deal! One degree?

©2021 34

Gulf of Maine surface area = 167,000 square miles

Let's take the uppermost five feet

$167{,}000 \times 5280^2 \times 5 = 23{,}278{,}464{,}000{,}000$ CF

1 cubic foot of water weighs 62.43 pounds

It took 1,453,274,507,520,000 BTU's to raise the T°

©2021 35

That's approximately 1.5 quadrillion BTU's!

Or 24 Hiroshima bombs…



©2021 36

Comfort… when the rate at which a body creates heat metabolically is matched by the rate at which a body loses heat environmentally

©2021 37

Comfort…a state of mind, a sense of physical and psychological ease



©2021 38

Human Comfort Factors

- Metabolic rate
- Clothing levels
- Air temperature
- Radiant temperature
- Air velocity
- Relative humidity



©2021 39

Achieving Thermal Comfort

- Maintain temperature
- Optimize relative humidity
- Control air movement and drafts
- Minimize radiational losses and gains

©2021 40

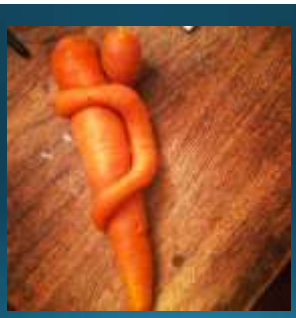
Alex Toth

RST Thermal/Renewaire

©2021 41



42



43



44



45



46

Heat Flow Management

Reduce conductive losses by placing resistive material in the path of heat flow

Reduce convective heat losses by disrupting fluid motion

Reduce radiational losses by maintaining warm interior surfaces

©2021

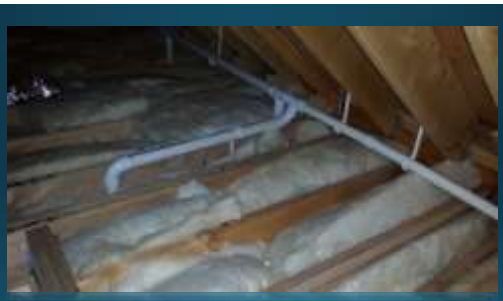
47



Guaranteed heat loss

©2021

48







Insulation versus photovoltaics

Energy conservation first, photovoltaics second… up to a point





Courtesy BuildingGreen.com

Relative humidity is the ratio of the current absolute humidity to the highest possible absolute humidity

Relative Humidity

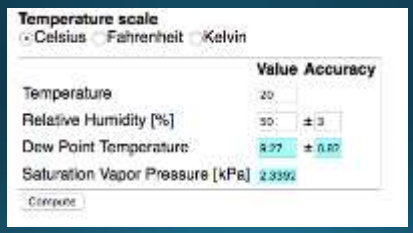
A reading of 100 percent relative humidity means that the air is totally saturated with water vapor and cannot hold any more

Dew Point

The temperature at which water vapor condenses into liquid water

100% RH implies that the dew point is equal to the current temperature of the air

Dew Point Calculation



www.decatur.de

©2021

©2021

Simple Approximation

In F° … $T_{dp} \approx T_{db} - 9/25(100\text{-}RH)$

For example… T_{db} = 60° RH = 50%

$T_{dp} \approx 60° - (9x50/25) \approx 60° - 18° \approx 42°$

41.33° using Decatur.de calculator

©2021

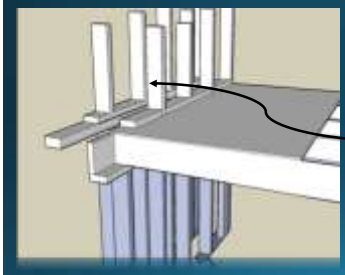
©2021

Temperature Calculation
within the wall

1. Determine total R-value
2. Determine ΔT across the wall
3. Starting from outside… $T_{interface} = T_{outside}$ + (percent of total R value x ΔT)

©2021

©2021



Double Wall System

What temperature here?

©2021

©2021

Total R value = R26 + RII = R37

ΔT = 68º (68º interior, 0° exterior)

Step One

Ext. cavity R-value % = 70.3%

.703 x 68° = 47.8º

0º + 47.8° = 47.8º

Step Two

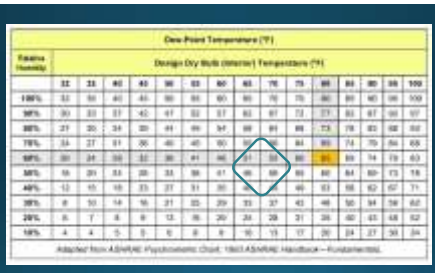
Int. cavity R-value % = 29.7%

.297 x 68° = 20.2º

0º + 47.8° + 20.2º = 68º

©2021

©2021



©2021

A visualization of vapor permeability and bulk water impermeability



Courtesy Parksite

©2021

61

Air Flow Management

©2021

62

Why stop air leakage?



Moisture and rot
Energy and health
IAQ
Sound
Fire Codes

Who's responsible?

©2021

©2021

63



Building Envelope Specialists

©2021

64

Liquid Air Barriers

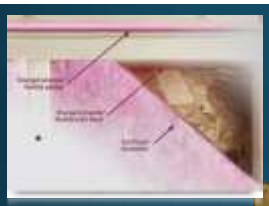


Masoncontractors.org

©2021

65

Systems for air sealing open wall cavities



Owens Corning

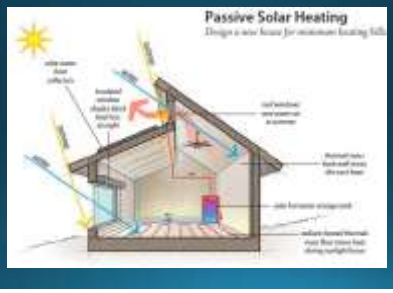


Knauf Ecoseal

©2021

66

Roof overhangs can manage radiant energy

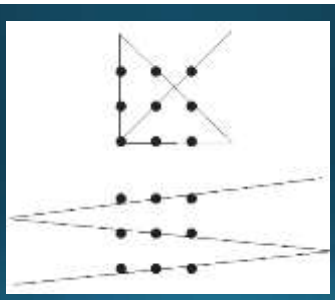


©2021
67



A reaction to the Oil Embargo of the mid 1970's

©2021
68



©2021
69



Fifteen minute break

Inter-active quiz comes next

70