Build a Better House

Foundations Part II



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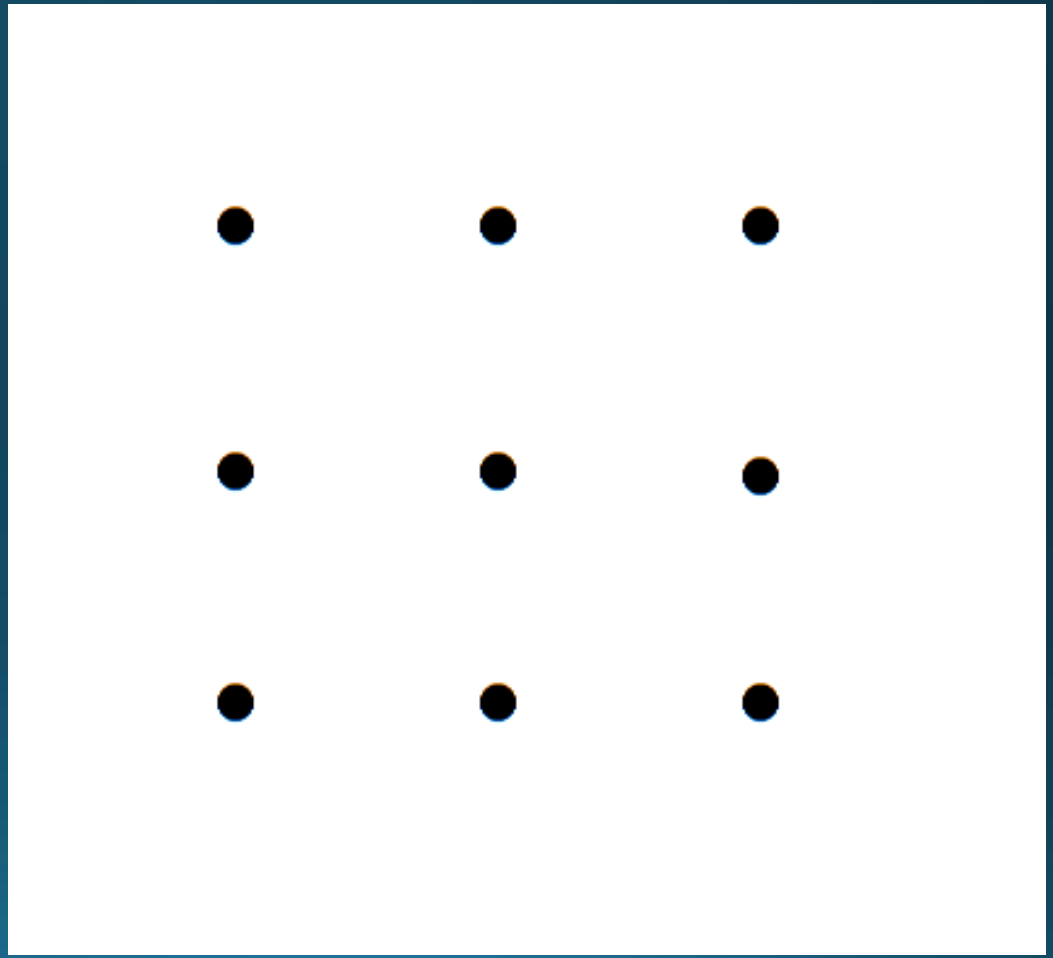
Connect the nine points with four lines without retracing

How about three lines?



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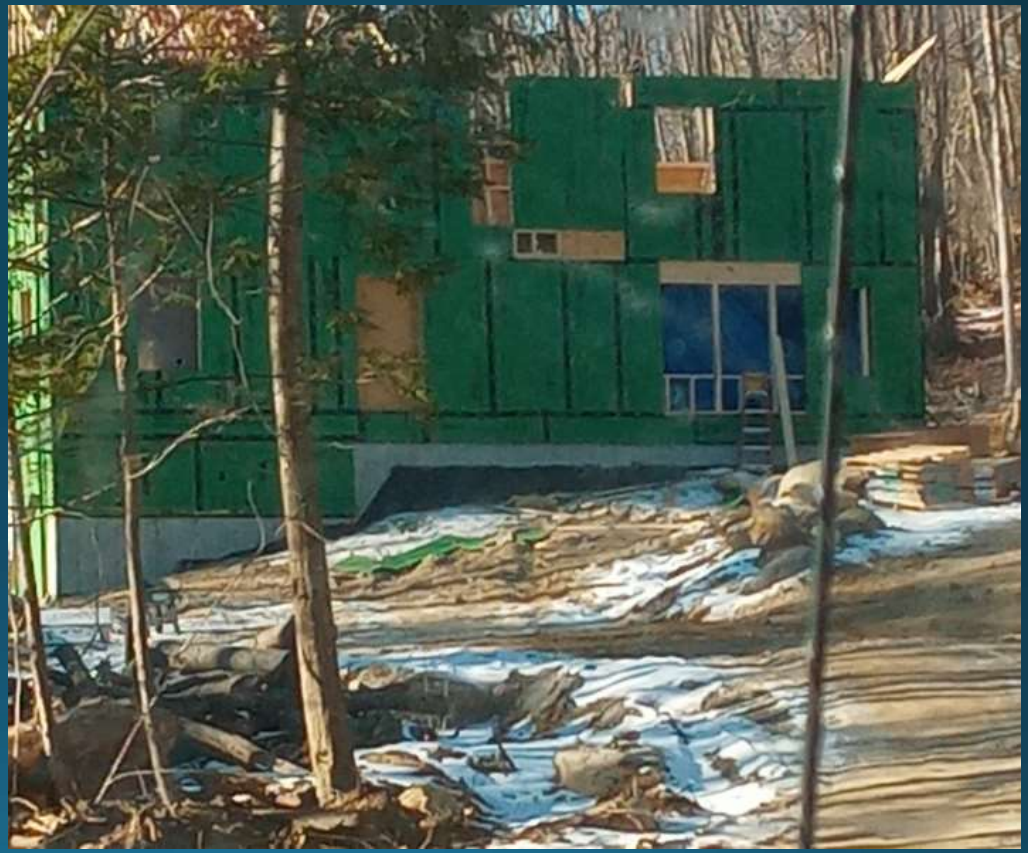

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Physics



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

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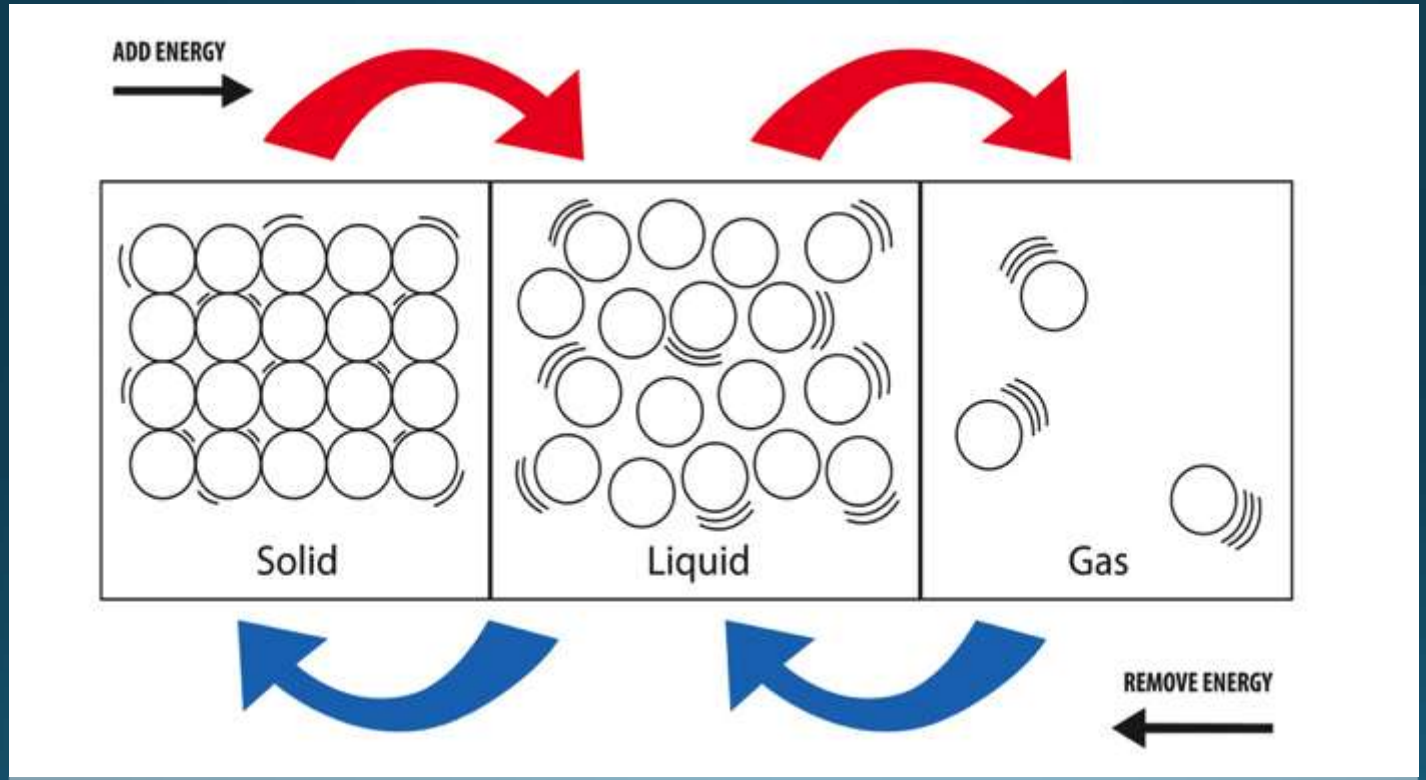
Matter



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Energy



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All energy comes from the Sun…

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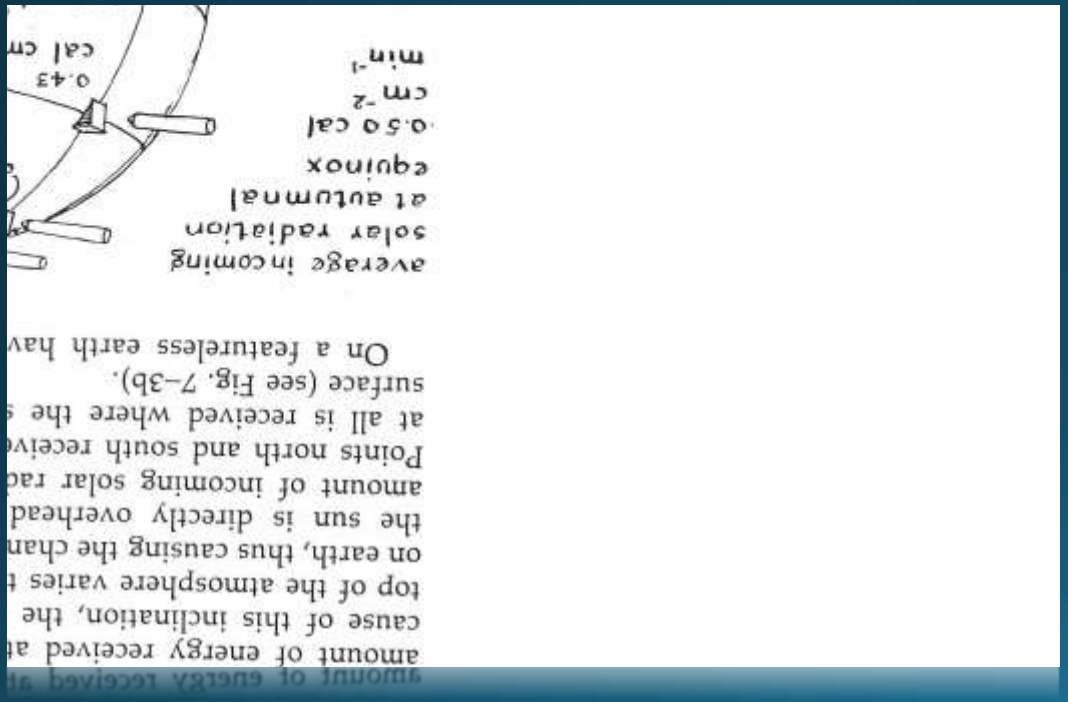
Available Solar Energy



Assume 30% loss to atmosphere…

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

M. Grant Gross

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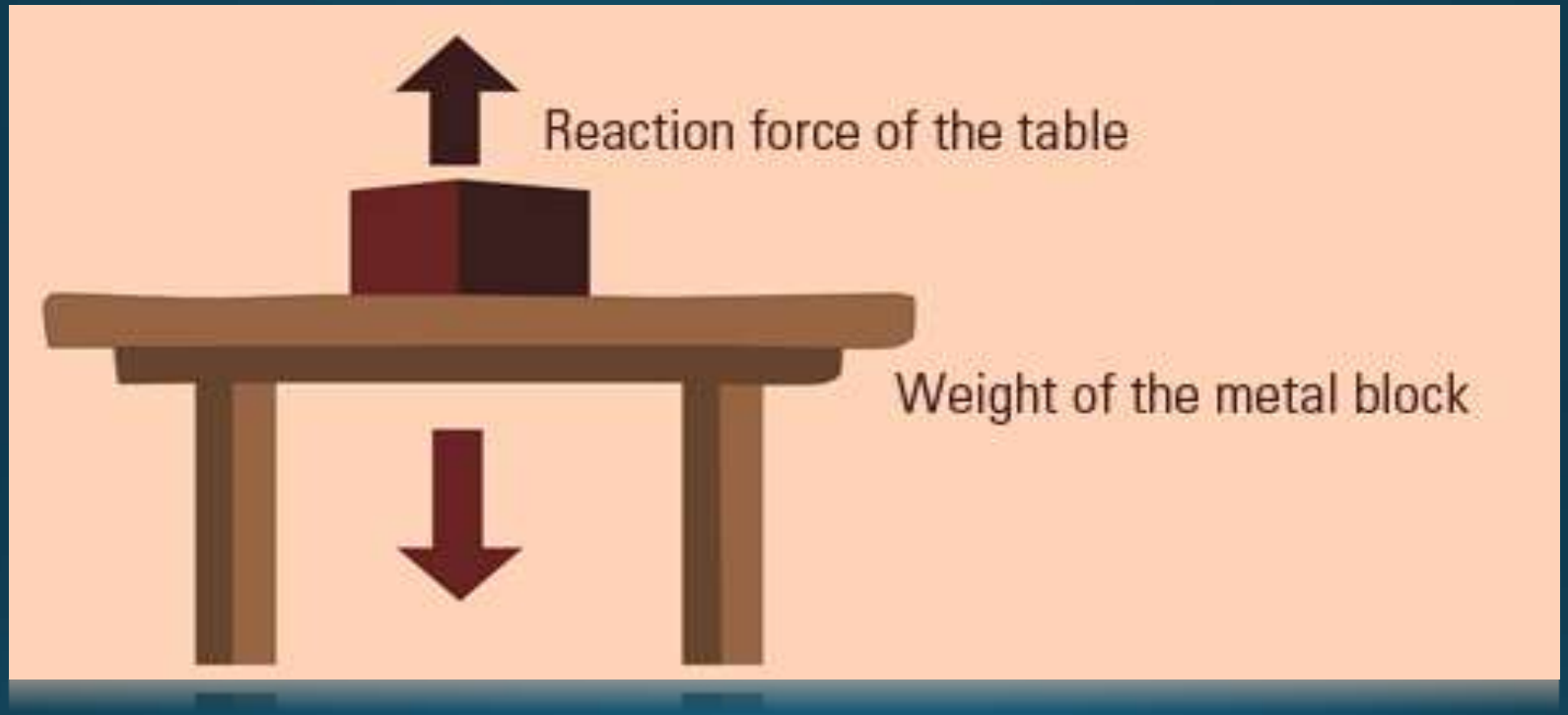

Structure and Force

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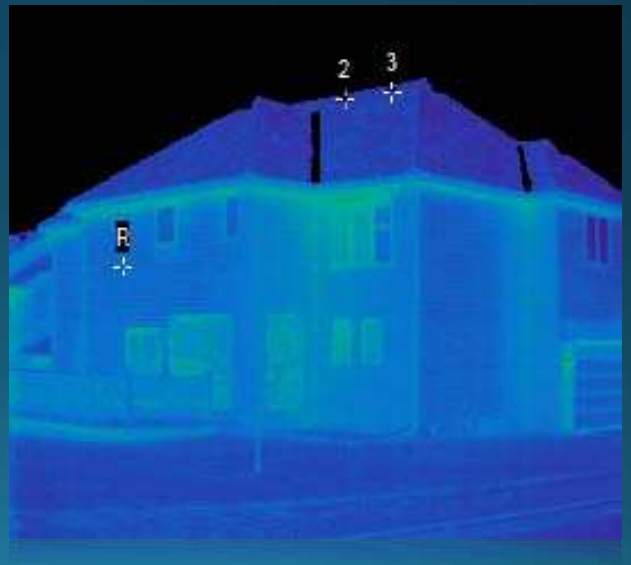
Structure and Thermal Performance



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



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What would this look like 150 years ago…?



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Post and Beam Construction

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

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Thermodynamics

A branch of physics dealing with heat and temperature

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Thermodynamics



Energy moves from place to place

Energy changes from one form to another

Energy cannot be created or destroyed

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Potential energy… energy of position





Kinetic energy… energy of motion

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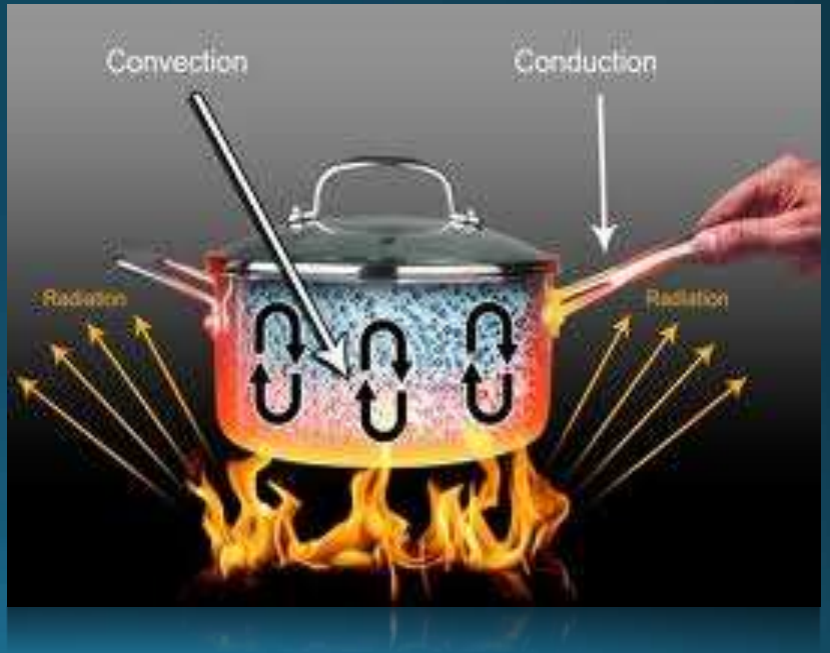
Heat transfer mechanisms

Conduction… molecular excitation without molecular movement

Convection… fluid movement of excited molecules

Radiation… electromagnetic motion of charged particles



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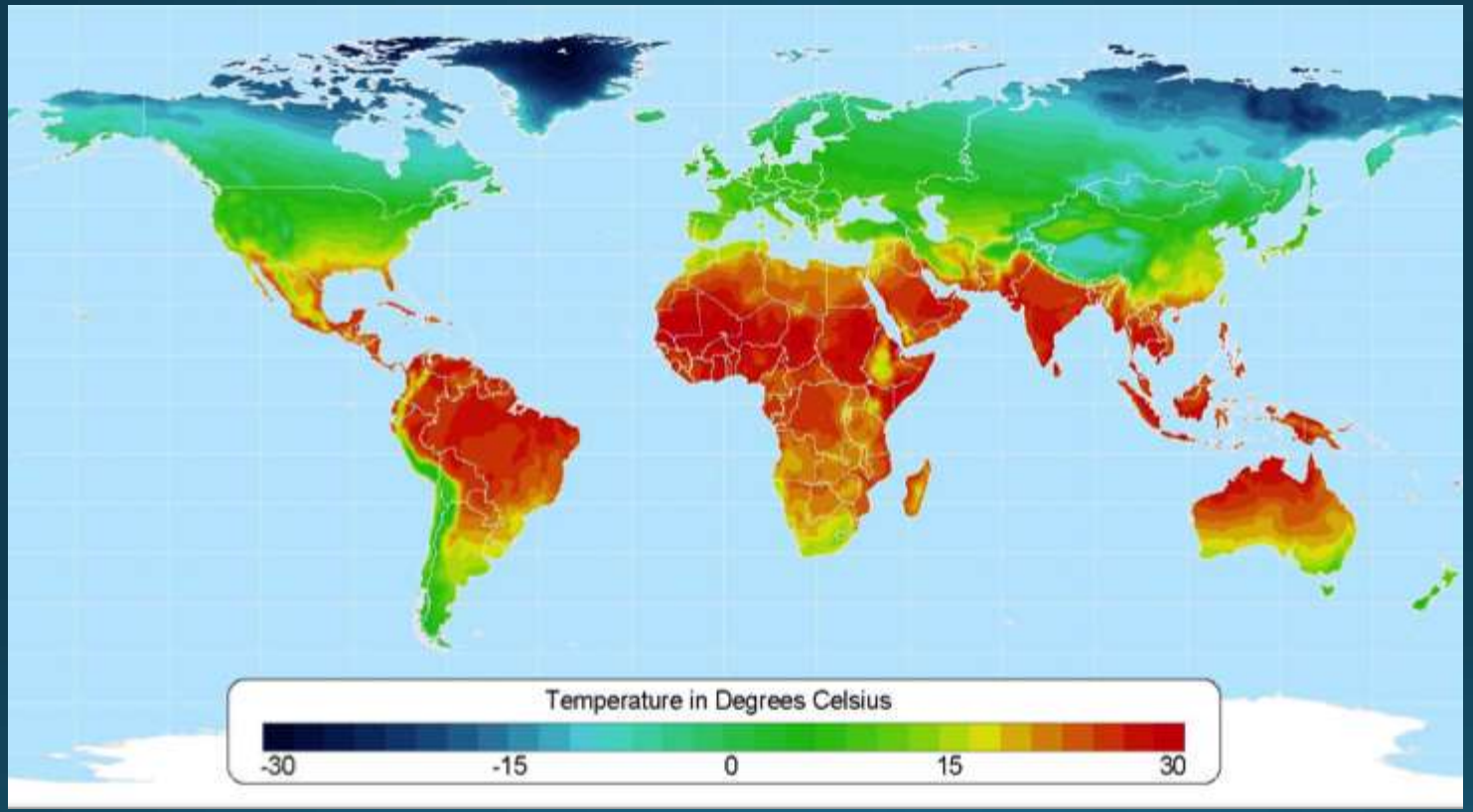

Temperature

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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

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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

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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?

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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°

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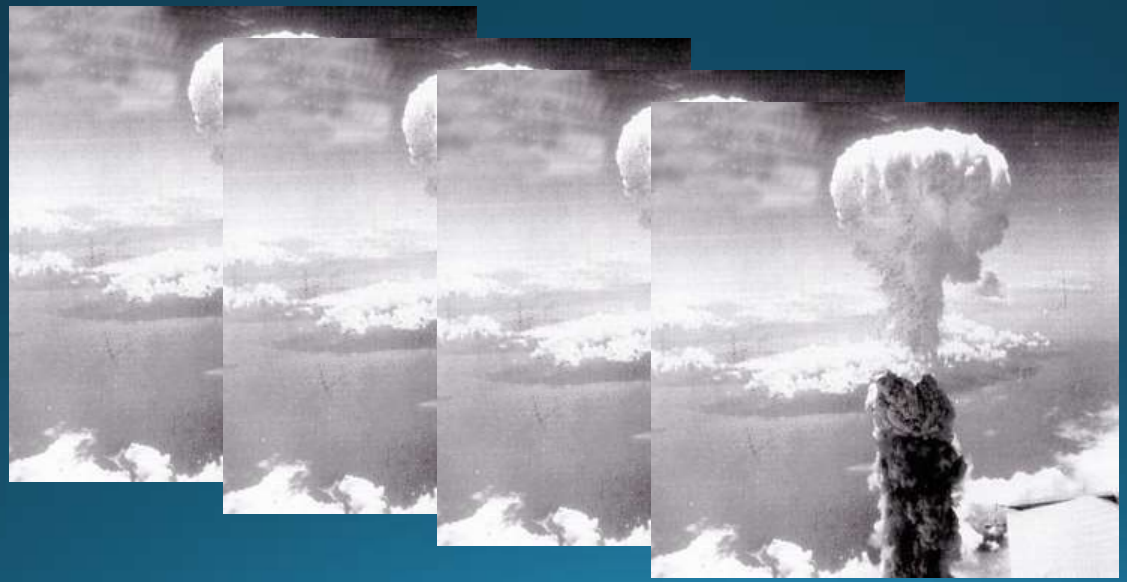
That’s approximately 1.5 quadrillion BTU’s!

Or 24 Hiroshima bombs…



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

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



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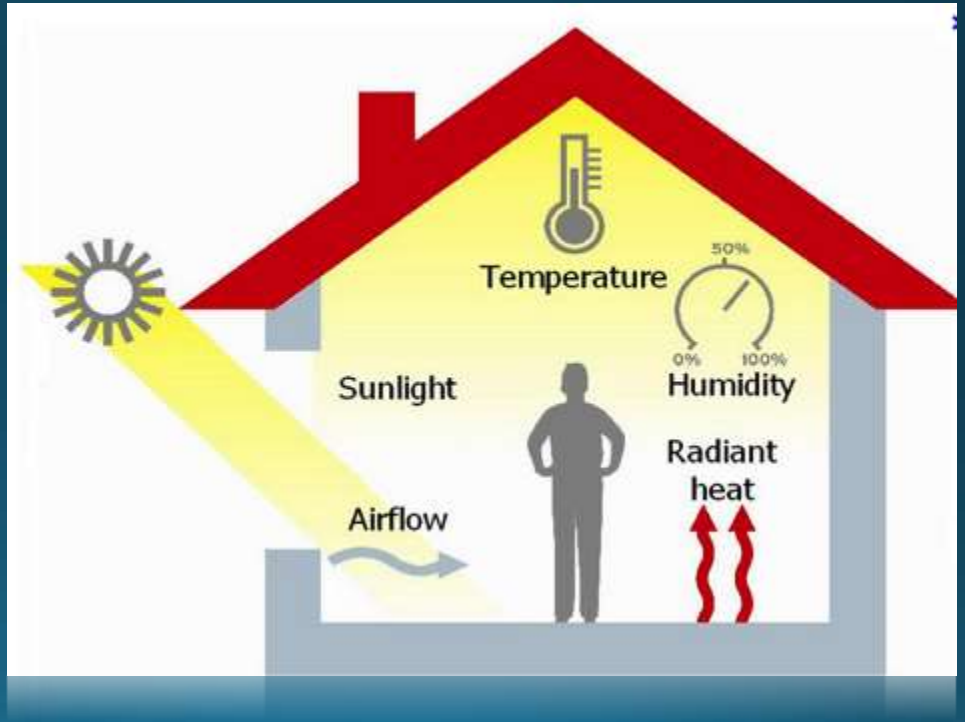
Human Comfort Factors

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



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Achieving Thermal Comfort

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

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Alex Toth

RST Thermal/Renewaire

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Alex Khomoutov









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

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Building Envelope Specialists

Guaranteed heat loss

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Building Envelope Specialists

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Building Envelope Specialists

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Insulation versus photovoltaics

Energy conservation first, photovoltaics second… up to a point





Courtesy BuildingGreen.com

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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

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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

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Dew Point Calculation

Temperature scale

◉ Celsius ○ Fahrenheit ○ Kelvin

	Value	Accuracy
Temperature	20	
Relative Humidity [%]	50	± 3
Dew Point Temperature	9.27	± 0.87
Saturation Vapor Pressure [kPa]	2.3392	

Compute

www.decatur.de

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Simple Approximation

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

For example… $T_{db} = 60°$ RH = 50%

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

41.33° using Decatur.de calculator

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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)

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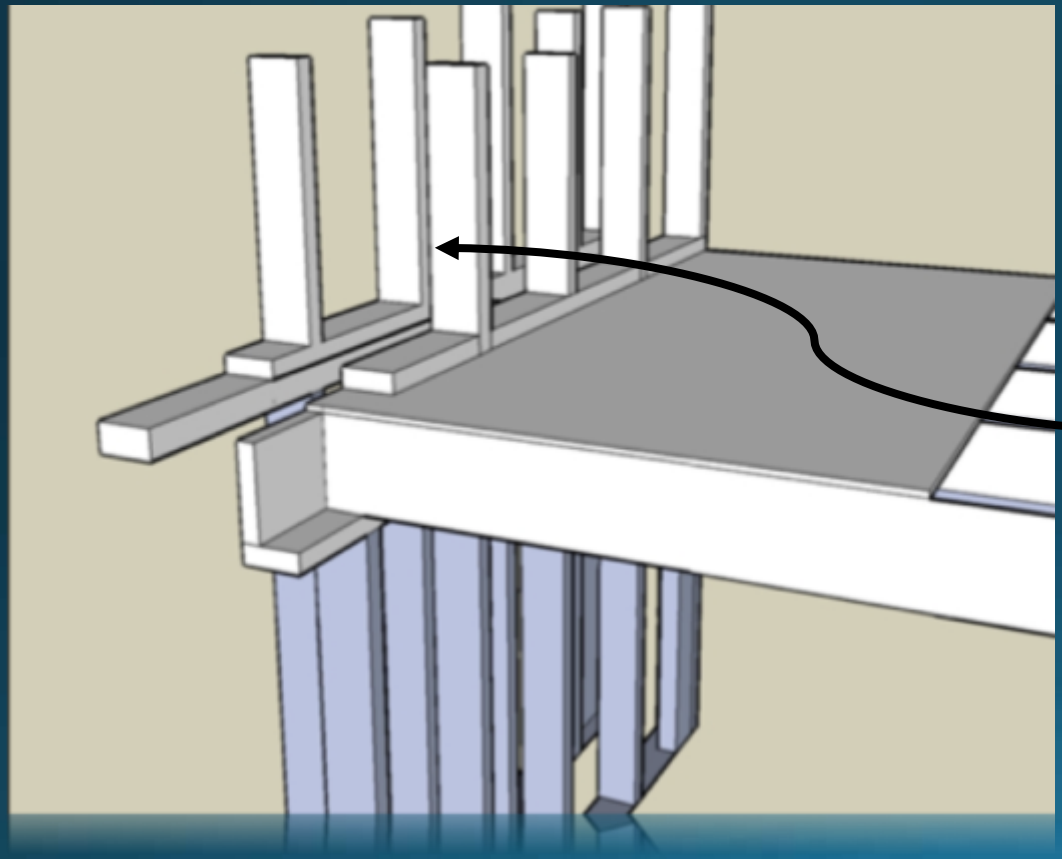

Double Wall System

What temperature here?

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Total R value = R26 + R11 = 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

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Dew-Point Temperature (°F)															
Relative Humidity	Design Dry Bulb (Interior) Temperature (°F)														
	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
100%	32	35	40	45	50	55	60	65	70	75	80	85	90	95	100
90%	30	33	37	42	47	52	57	62	67	72	77	82	87	92	97
80%	27	30	34	39	44	49	54	58	64	68	73	78	83	88	93
70%	24	27	31	36	40	45	50	55	60	64	69	74	79	84	88
60%	20	24	28	32	36	41	46	51	55	60	65	69	74	79	83
50%	16	20	24	28	33	36	41	46	50	55	60	64	69	73	78
40%	12	15	18	23	27	31	35	40	45	49	53	58	62	67	71
30%	8	10	14	16	21	25	29	33	37	42	46	50	54	59	62
20%	6	7	8	9	13	16	20	24	28	31	35	40	43	48	52
10%	4	4	5	5	6	8	9	10	13	17	20	24	27	30	34

Adapted from ASHRAE Psychrometric Chart, 1993 ASHRAE Handbook—Fundamentals.

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A visualization of vapor permeability and bulk water impermeability



Courtesy Parksite

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Air Flow Management

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Why stop air leakage?



Moisture and rot
Energy and health
IAQ
Sound
Fire Codes

Who's responsible?

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Liquid Air Barriers



Masoncontractors.org

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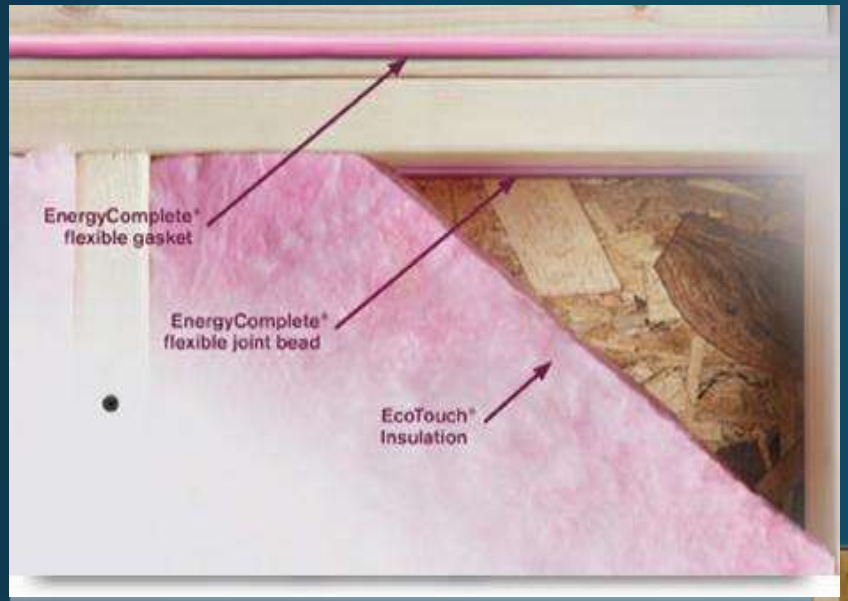
Systems for air sealing open wall cavities



Owens Corning





Knauf Ecoseal

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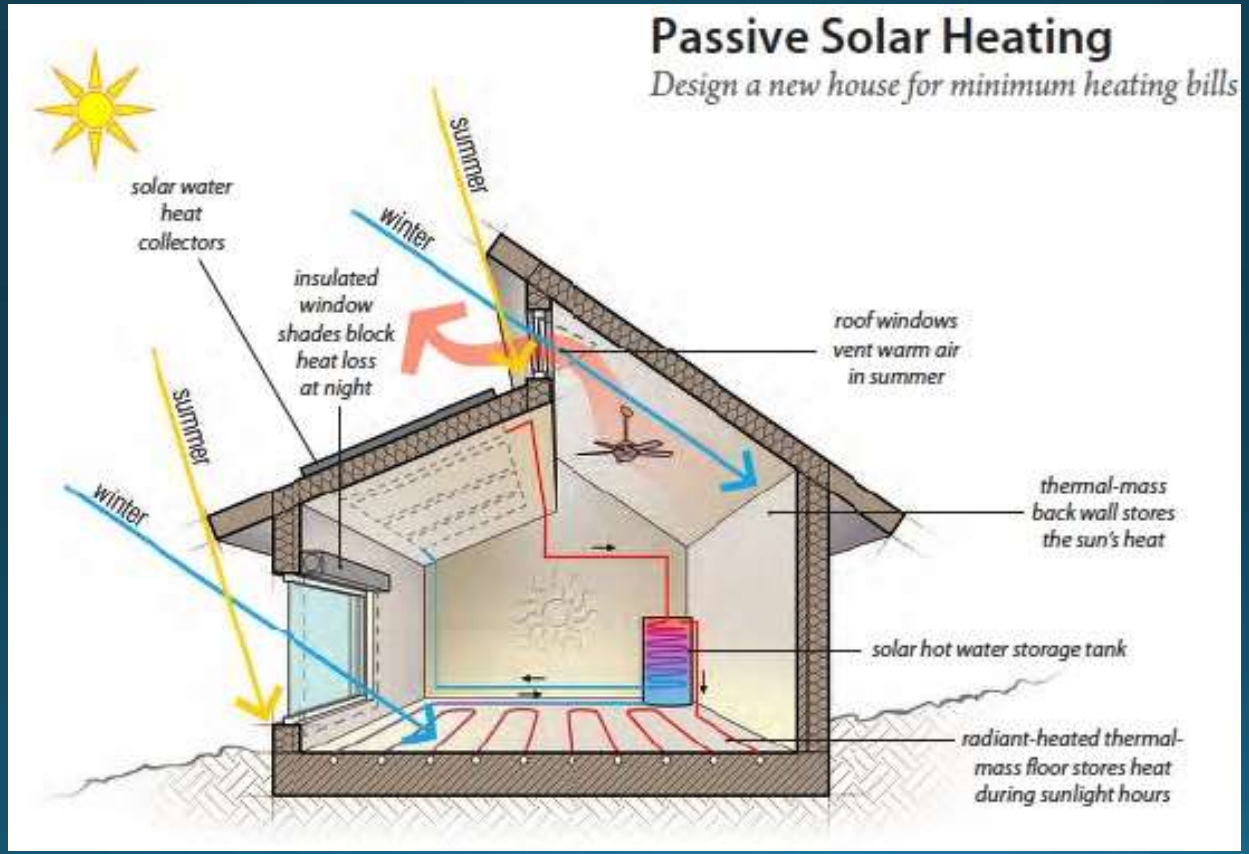
Roof overhangs can manage radiant energy



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

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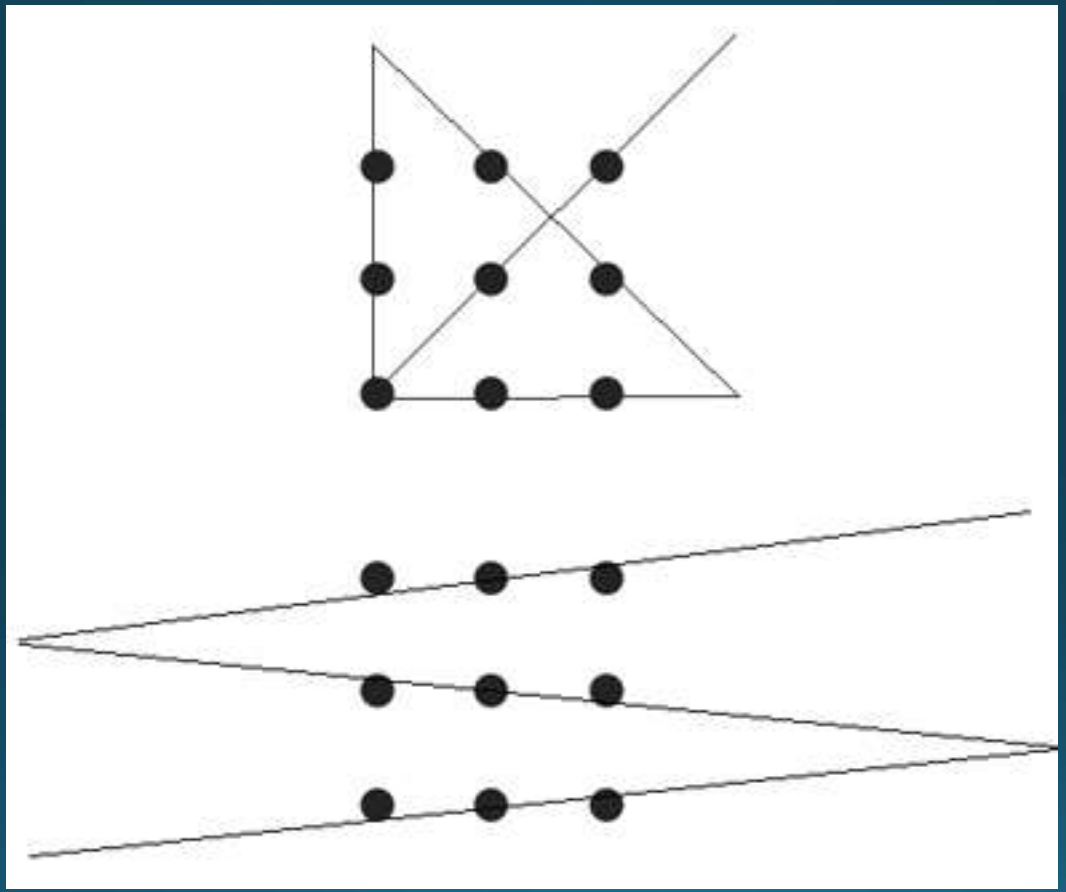

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Fifteen minute break

Inter-active quiz comes next