



Seattle 2-hour temperatures

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
12 midnight	37	40	42	45	50	56	60	60	56	49	42	38
2	37	39	40	43	49	54	58	58	54	48	42	37
4	36	38	39	42	47	53	56	57	53	47	41	36
6	35	37	39	41	46	52	55	56	52	46	40	35
8	36	39	40	43	48	54	57	58	54	47	41	37
10	41	44	47	51	57	62	67	67	62	54	46	41
12 noon	44	48	51	55	61	67	72	72	67	58	49	44
2	45	50	53	57	64	70	75	75	69	60	51	45
4	44	48	52	56	62	68	74	74	68	59	50	44
6	42	46	48	52	59	64	69	69	64	55	47	42
8	40	43	45	48	54	60	64	64	60	52	45	40
10	38	41	43	46	52	57	61	62	57	50	43	38

Balance Point = 55° F
Change-over Temperature = 75° F

CLOSED/Heating: 66.0%
OPEN/“Sailing”: 32.6%
CLOSED/Cooling: 1.4%







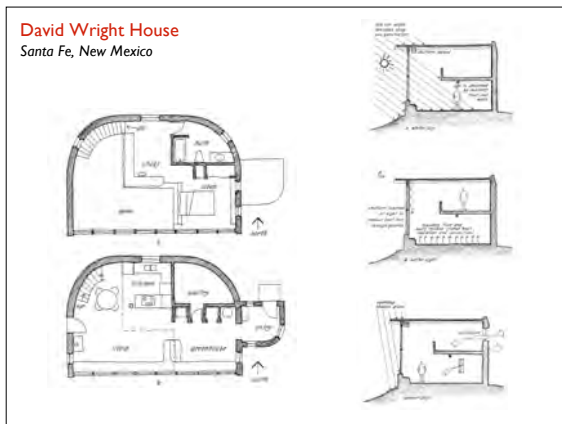
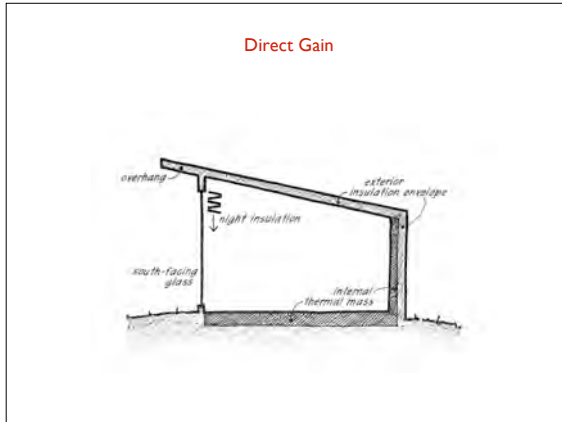
Passive Solar Systems

DIRECT GAIN

•Trombe Wall

•Sunspace

•Roof Pond



Quiz 5 Slide 1 answers

1. Name the three fundamental criteria for **Passive Solar Design**.


- 1. Insulation**
 - Keep the Heat In and Cold Out
- 2. Glass**
 - Window Area and Solar Access
- 3. Mass**
 - Heat Capacity and Quantity of Materials
 - Location and Distribution of Materials

Slide 2 answers

Material	Specific Heat BTU/lb °F	Density lb/ft ³	VHC BTU/ft ³ °F
Water	1.0	62.0	62.0
Concrete	0.20	120.0	24.0
Steel	0.12	489.0	58.7
Wood	0.50	27.0	13.5

4. **T** For a given temperature change, a **cubic foot** of water will store (or liberate) more energy than a **pound** of concrete.
 TM of 1 ft³ water = **62** BTU/°F; TM of 1 ft³ concrete = **24** BTU/°F
5. **F** For a 10°F temperature increase (or loss), a **pound** of steel will store (or liberate) more energy than a **pound** of concrete.
 TM of 1 lb steel = **1.2** BTU; TM of 1 lb concrete = **2.0** BTU
6. **T** **1 cubic foot** of water contains more thermal mass (TM = BTU/°F) than 100 **pounds** of concrete.
 TM of 1 ft³ water = **62** BTU/°F; TM of 100 lbs concrete = **20** BTU/°F

Slide 3 answers



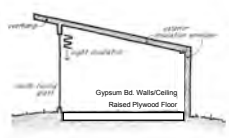
7. What is the Thermal Mass inside small "test" room having the following materials?
 Floor: 6" concrete (40 ft³)
 Walls: 4" concrete (60 ft³)
 Thermal Mass (TM) = 24 BTU/ft³ °F x 100 ft³
 = 2,400 BTU/°F

8. How much energy is stored in this room when the temperature of the entire room rises by 10°F?
 Q = 2,400 BTU/°F x 10°F = 24,000 BTU

Mass
 Thermal Mass = SH x Density x Volume Q = TM x dT
 VHC

Material	Specific Heat BTU/lb °F	Density lb/ft³	VHC BTU/ft³ °F
Concrete	0.20	120.0	24.0
Air	0.24	.075	.018

Direct Gain
 Example 1.1



How hot does it get inside a small "test" room (9' deep x 16' wide x 8' high) located in Seattle on a typical day in July:

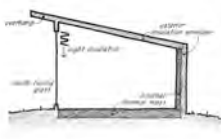
Thermal Mass contained inside this building:
 Floor: 3/4" plywood 80 BTU/°F
 Walls/Ceiling: 1/2" gyp. bd. 150 BTU/°F
 Air: (1152 ft³) x (.018 BTU/ft³ °F) 21 BTU/°F
 Thermal Mass (TM) = 251 BTU/°F

Incoming solar energy through a south window in July:
 Q_{sun} (July - Table C.15, "VS") 1299 BTU/ft²
 Shading Coefficient x .86
 Window Area (8' x 16') x 128 ft²
 Q_{in} (energy entering room) = 142,993 BTU

Q = TM x dT
dT = Q / TM

dT = 142,993 BTU / 251 BTU/°F = 570 °F

Direct Gain
 Example 1.2



Replace raised plywood floor with a slab-on-grade, and replace the back wall with concrete:

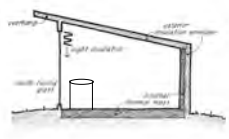
Thermal Mass contained inside this building:
 Concrete floor and walls 2,400 BTU/°F
 Walls/Ceiling: 1/2" gyp. bd. 120 BTU/°F
 Air: (1152 ft³) x (.018 BTU/ft³ °F) 21 BTU/°F
 Thermal Mass (TM) = 2,541 BTU/°F

Incoming solar energy through a south window in July:
 Q_{sun} (July - Table C.15, "VS") 1299 BTU/ft²
 Shading Coefficient x .86
 Window Area (8' x 16') x 128 ft²
 Q_{in} (energy entering room) = 142,993 BTU

Q = TM x dT
dT = Q / TM

dT = 142,993 BTU / 2,541 BTU/°F = 56 °F

Direct Gain
 Example 1.3



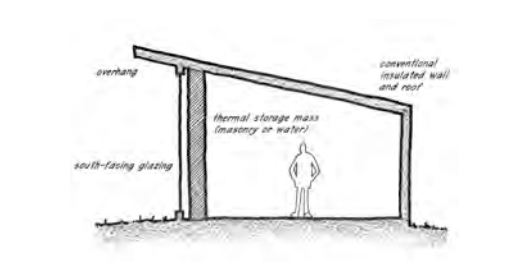
Add 6 - 50 gallon barrels of water:

Thermal Mass contained inside this building:
 6 x 50 gal. x 8 lb/gal x 1 BTU/lb °F 2,400 BTU/°F
 Concrete floor and walls 2,400 BTU/°F
 Walls/Ceiling: 1/2" gyp. bd. 120 BTU/°F
 Air: (1152 ft³) x (.018 BTU/ft³ °F) 21 BTU/°F
 Thermal Mass (TM) = 4,941 BTU/°F

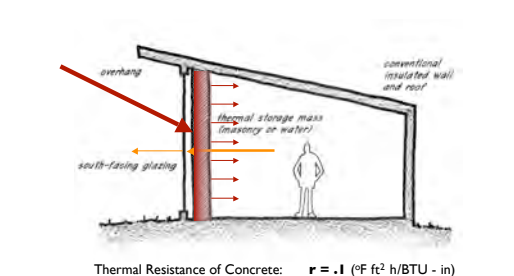
Incoming solar energy through a south window in July:
 Q_{sun} (July - Table C.15, "VS") 1299 BTU/ft²
 Shading Coefficient x .86
 Window Area (8' x 16') x 128 ft²
 Q_{in} (energy entering room) = 142,993 BTU

dT = 142,993 BTU / 4,941 BTU/°F = 30 °F

Indirect Gain
 Mass Wall



Indirect Gain
 Mass Wall



Thermal Resistance of Concrete: **r = .1** (°F ft² h/BTU - in)
 10-inch thick concrete wall: **R = 1** (°F ft² h/BTU)

