WINDOWS AND SHADING

WINDOWS – TO LOOK OUT

TO ALLOW NATURAL DAY LIGHT TO ILLUMINATE

TO HEAT UP BUILDING

TO PROVIDE NATURAL VENTILATION

SOLAR HEAT

DIRECT FROM WINDOW

INDIRECT FROM ROOF AND CEILING.

TO REDUCE SUMMER HEAT GAIN THROUGH WINDOWS

- ORIENTATE THE WINDOWS TO REDUCE SUMMER SUN PENETRATION
- DECREASING THE WINDOW SIZE
- SHADING WINDOWS AND WALLS.
- USE LIGHT COLOURED WALLS

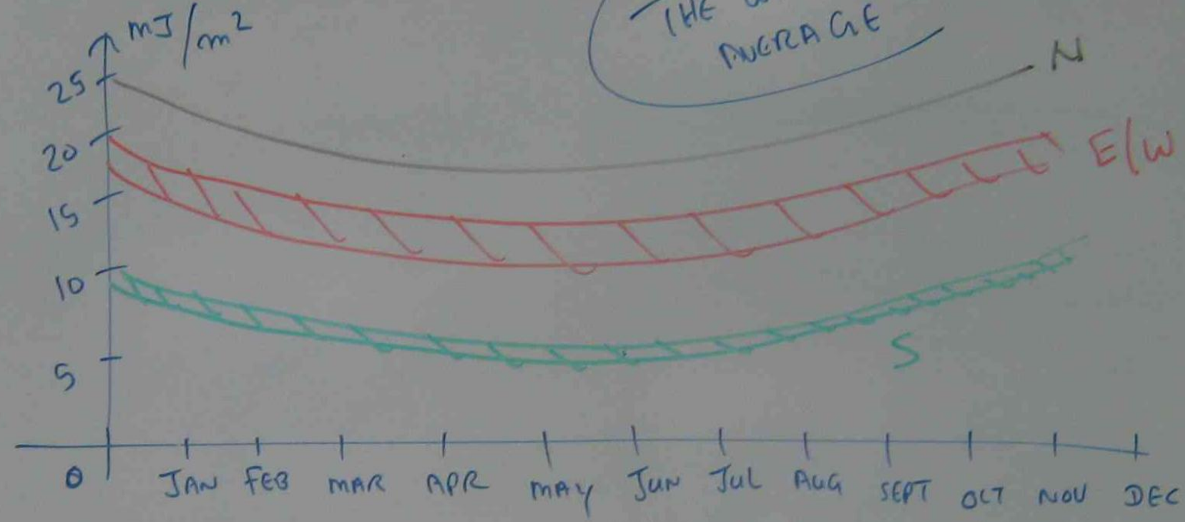
DIRECT

- DIRECT VENTING OF HEAT FROM APPLIANCES
- PROVIDE VENTING OF CEILING CAVITY, INSULATION, CONCRETE SLAB FLOORS.
- BETTER INSULATION OF INTERNALLY INSTALLED HOT WATER SYSTEM

INDIRECT

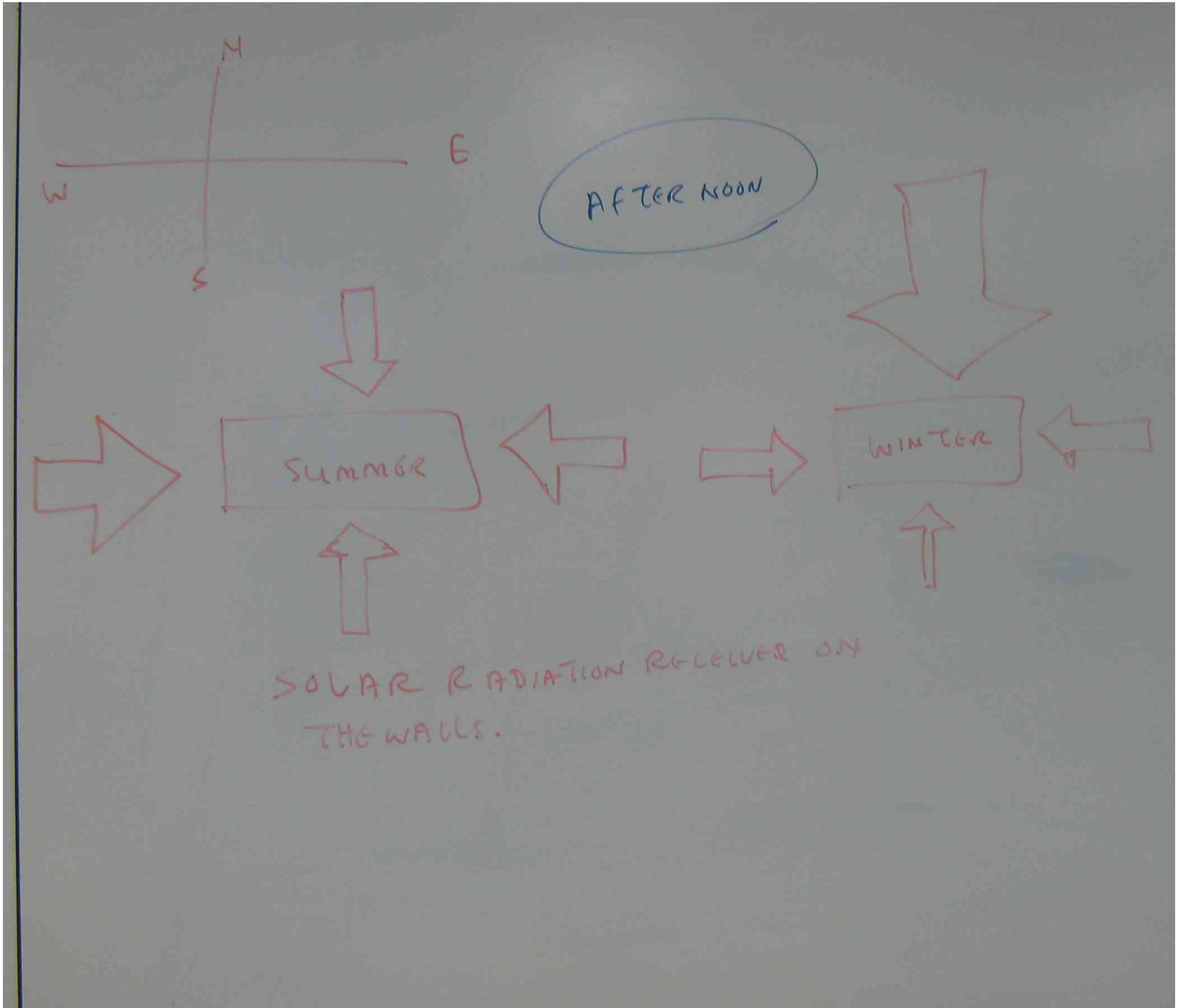
WINDOW ORIENTATION (SYDNEY)

THE WHOLE MONTH AVERAGE

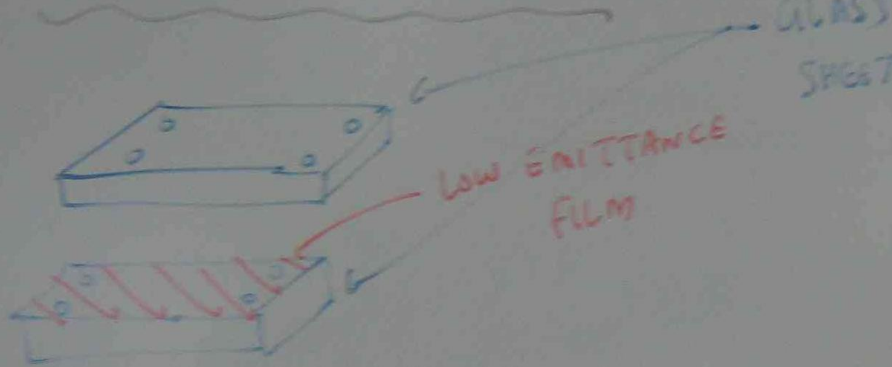


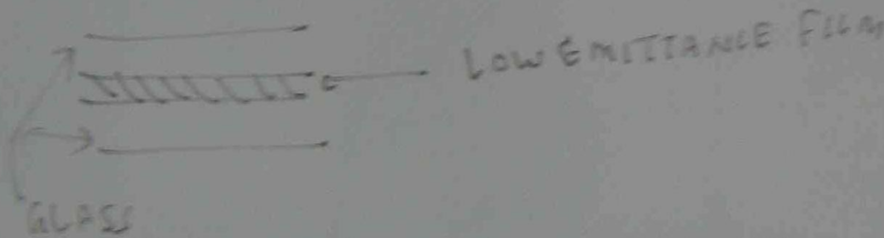
- NORTH FACE OF BUILDING RECEIVES TWICE AS MUCH SUN LIGHT IN WINTER AS EAST AND WEST SIDES.

- NORTH FACE OF BUILDING RECEIVES FIVE TIMES AS MUCH SUN LIGHT IN WINTER AS SOUTH SIDE.


N
W
E
S
AFTER NOON
SUMMER
WINTER
SOLAR RADIATION RECEIVED ON
THE WALLS.

TYPES OF GLAZING SYSTEMS





INSULATION

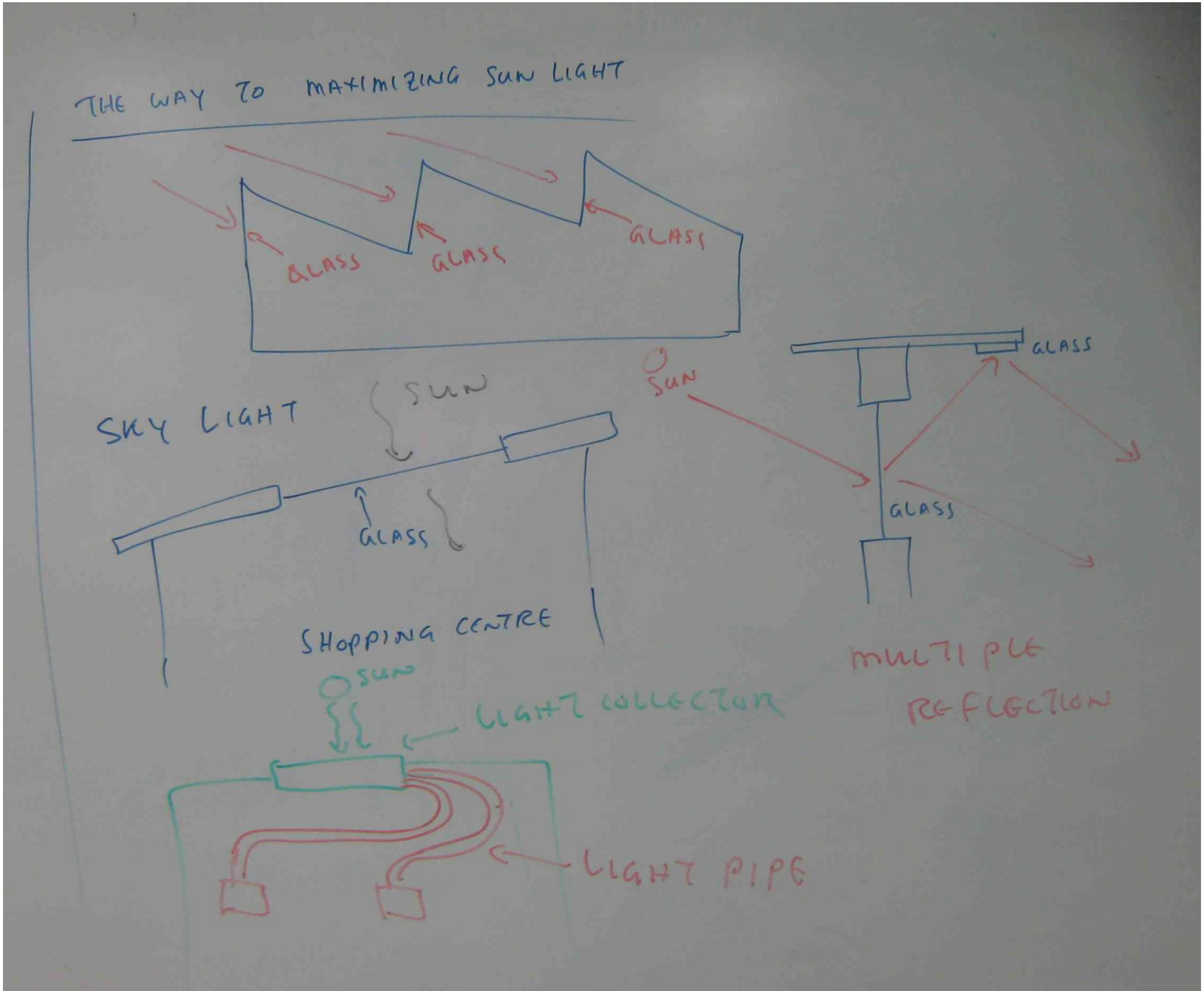
+

HEAT REFLECTING GLASS

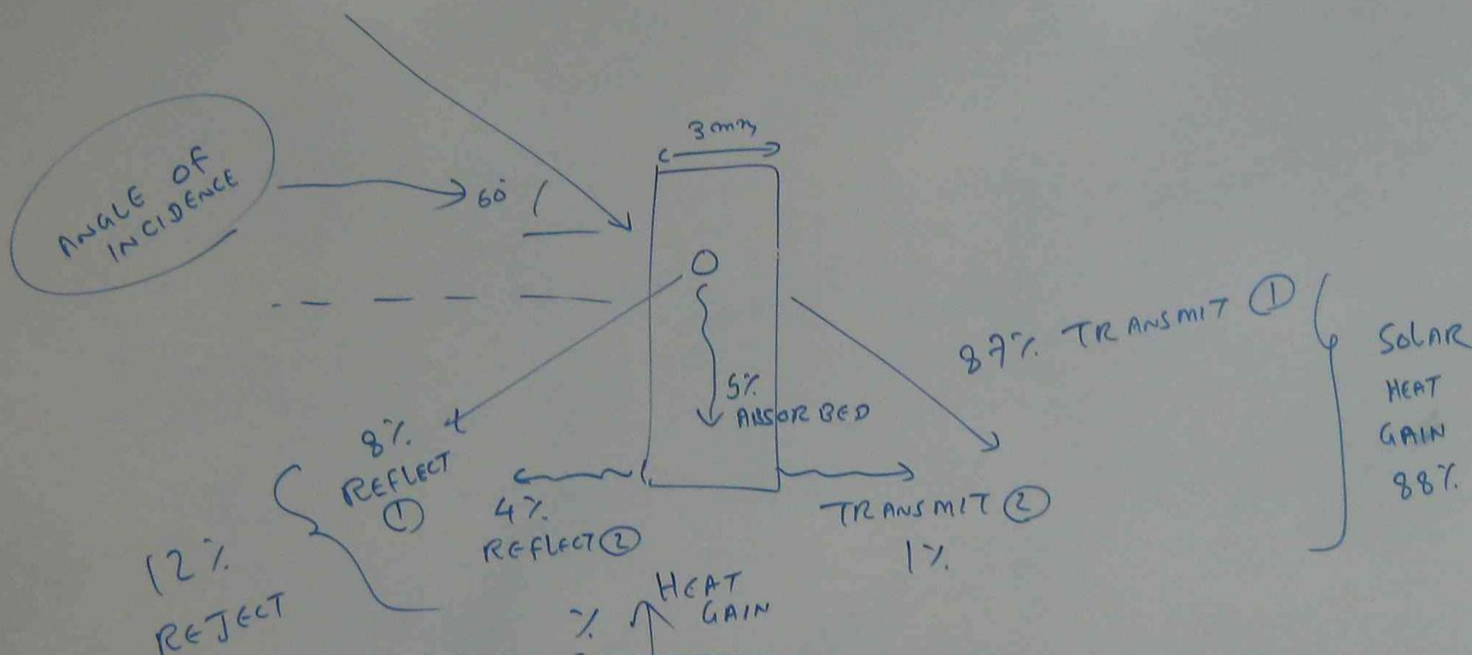
+

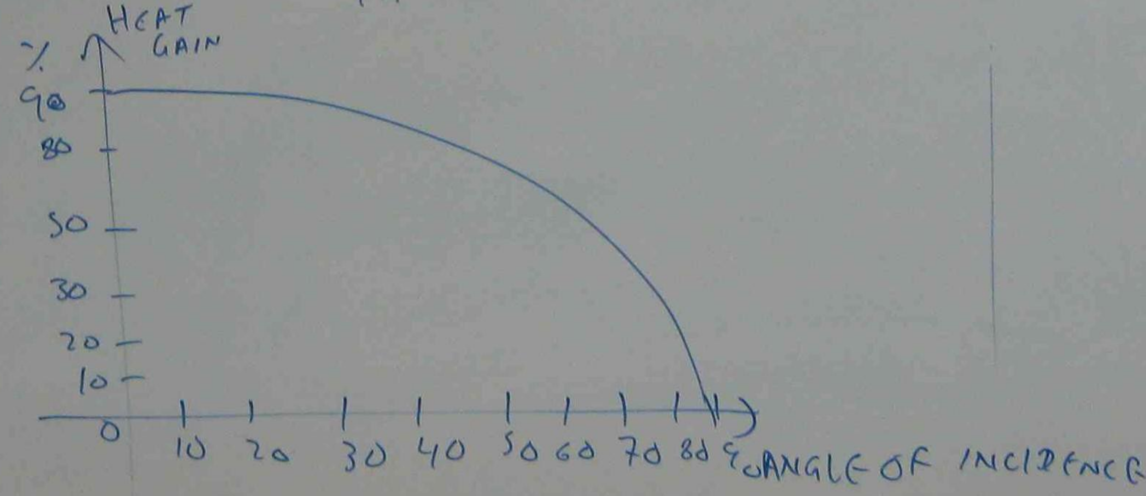
HEAT ABSORBING GLASS

- USE IN COMMERCIAL BUILDINGS.
- SUN PENETRATION = 15% OF SINGLE GLASS
- LOW EMITTANCE FILM EMITTANCE = 0.9


THE WAY TO MAXIMIZING SUN LIGHT
GLASS
GLASS
GLASS
SKY LIGHT
SUN
GLASS
SUN
GLASS
GLASS
MULTIPLE REFLECTION
SHOPPING CENTRE
SUN
LIGHT COLLECTOR
LIGHT PIPE

ENERGY BALANCE DIAGRAM OF STANDARD 3mm CLEAR GLASS





HEAT EXCHANGERS

HYDRONIC HEAT EMITTING EQUIPMENTS

$$\boxed{P_c = CA\,(T_s - T_a)^n}$$

P_c = RATE OF HEAT EMISSION (NATURAL CONVECTION) (J)

C_i = 2.5 HEAT FLOW UPWARD

1.3 HEAT FLOW DOWNWARD

1.9 HORIZONTAL HEAT FLOW

A = AREA OF EMITTING SURFACE

T_s = TEMPERATURE OF EMITTING SURFACE

T_a = AMBIENT AIR TEMPERATURE

INCIDENCE $n = 1.25$

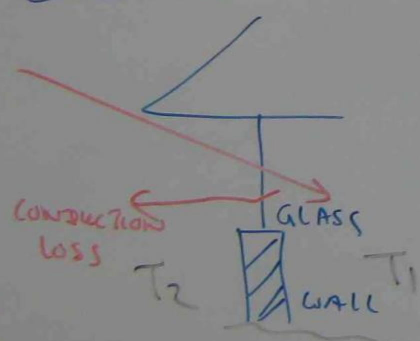
$$\boxed{P_r = \delta A \varepsilon \left(T_s^4 - T_a^4\right)}$$

P_r = HEAT EMISSION VIA RADIATION (J)

$\delta = 5.67 \times 10^{-8}$

ε = EMITTANCE = 0.9

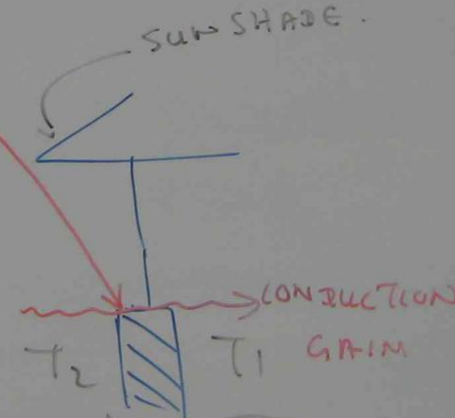
WINDOWS HEAT GAIN AND LOSSES



$T_1 > T_2$

WINTER

WINTER



$T_2 > T_1$

SUMMER

THE DESIGN OF SUN SHADE IS IMPORTANT FOR MAXIMIZING SUN ENTRY INTO BUILDIN IN WINTER AND MINIMIZING IT IN SUMMER.

pb CALCULATE THE NET GAIN OR LOSS OF HEAT THROUGH A NORTH FACING SINGLE GLAZED WINDOW FOR JULY IN SYDNEY. THE WINDOW IS 0.9 m HIGH AND 0.2 m FROM THE BOTTOM OF THE EAVES WHICH ARE 0.6 m WIDE. ASSUME FOR THE WINDOW THAT 90% OF IT IS GLASS. THE TRANSMITTANCE IS 0.76 AND U VALUE IS 6.4.

d = DAY

FOR JULY

DAILY IRRADIATION = 8.8 mJ/d-m²

VERTICAL WALL FACING NORTH => H_V = 12.87 mJ/d-m²

IF THE WALL IS SHADED H_{VS} = 12.67 mJ/d-m²

MAXIMUM TEMPERATURE FOR JULY = 16.8°C.

MINIMUM TEMPERATURE FOR JULY = 6.5°C

THE DAILY HEAT GAIN THROUGH WINDOW

$$\boxed{Q_{wg} = H_{VS} \times \%\,\text{GLASS} \times \text{TRANSMITTANCE}}$$

$$= 12.67 \times 0.9 \times 0.76$$

$$= 8.67\ \text{mJ}/\text{d-m}^2$$

HEAT LOSS

$$\boxed{Q_{WL} = U \times \Delta T \times 0.864}$$

$$\boxed{\Delta T = T_i - T_{avg}}$$

$$T_{avg\ July} = \frac{T_{MAX} + T_{MIN}}{2}$$

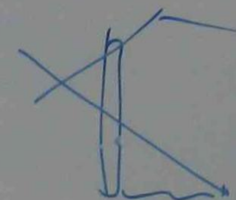
$$= \frac{16.8 + 6.5}{2}$$

$$= 11.7^\circ C$$

$$\boxed{T_i = 17.6 + 0.31 \times T_{AVG}}$$

$$T_i = 17.6 + 0.31 \times 11.7$$

$$= 21.2\,^{\circ}C$$



$$\delta T = T_i - T_{AVG}$$

$$= 21.2 - 11.7 = 9.5\,^{\circ}C$$

$$Q_{WL} = 6.4 \times 9.5 \times 0.864 = 5.04\ \mathrm{MJ/d\text{-}m^2}$$

$$\text{NET HEAT GAIN} = Q_{wg} - Q_{WL}$$

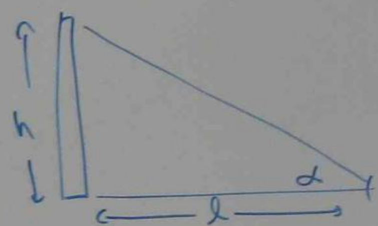
$$= 8.67 - 5.04$$

$$= 3.6\ \mathrm{MJ/d\text{-}m^2}$$

U = HEAT CONDUCTANCE

SHADING

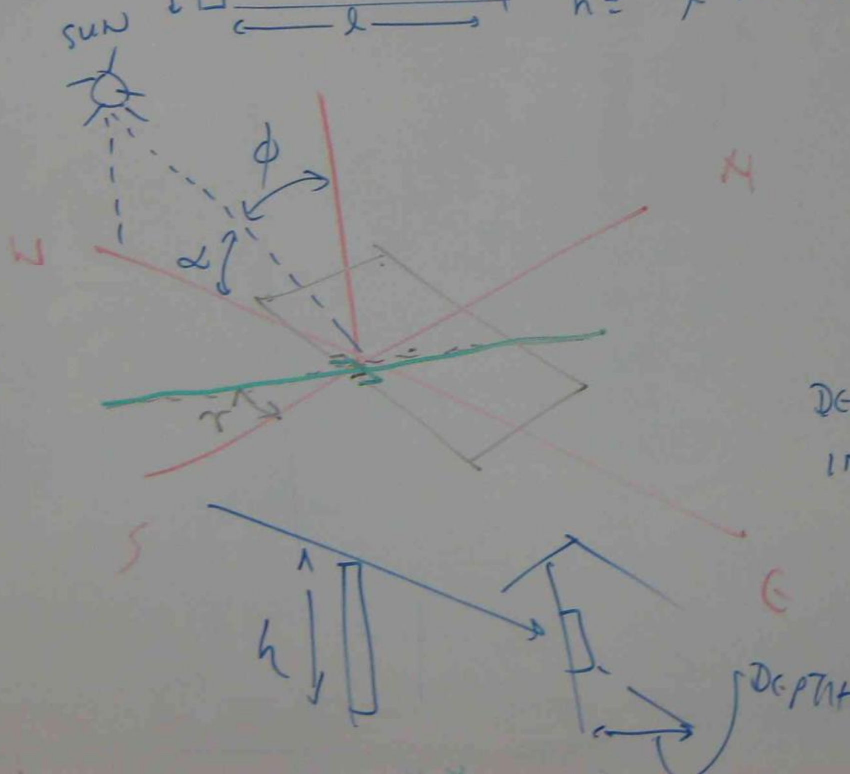
SHADING
- → OBSTRUCTIONS SUCH AS TREES
- → ADJACENT BUILDINGS



h = HEIGHT OF OBSTRUCTION

l = LENGTH OF SHADOW

$h = l \tan \alpha \longrightarrow l = \dfrac{h}{\tan \alpha}$



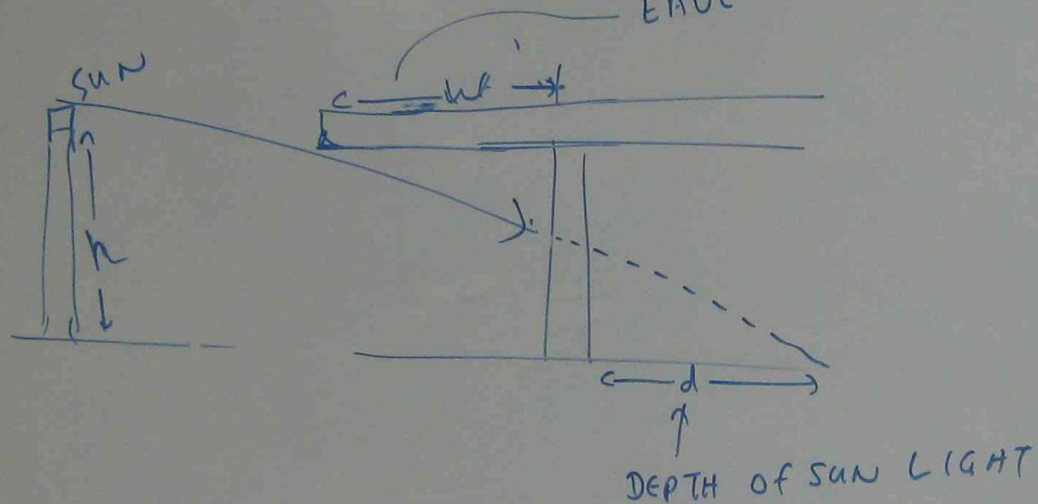
γ = ORIENTATION ANGLE

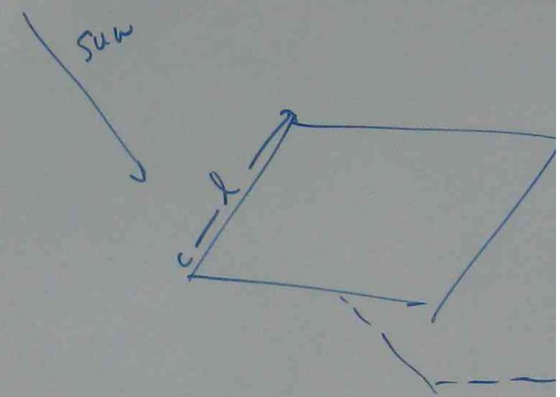
ϕ = AZIMATH ANGLE

α = ALTITUDE ANGLE

DEPTH OF SUN LIGHT INTO ROOM $= \dfrac{h \cos(\gamma + \phi)}{\tan \alpha}$

EFFECT OF EAVE AND HORIZONTAL AND VERTICAL SUN ANGLES





$$d = h\,\frac{\cos(\phi + \gamma)}{\tan \alpha} - w$$

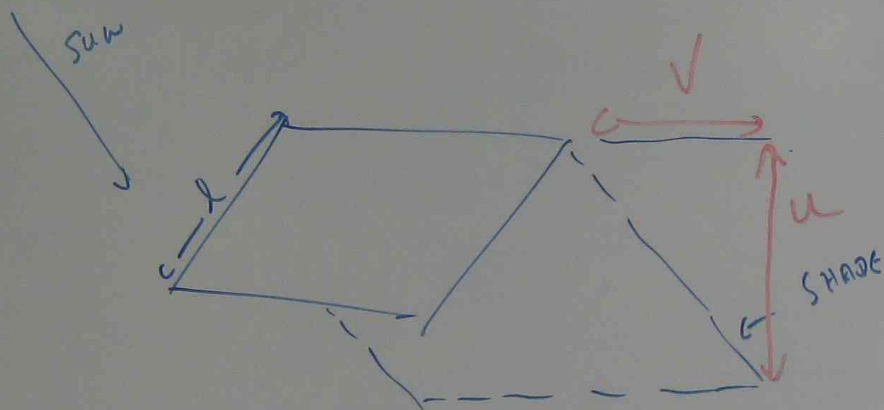
$u = l \tan HSA$

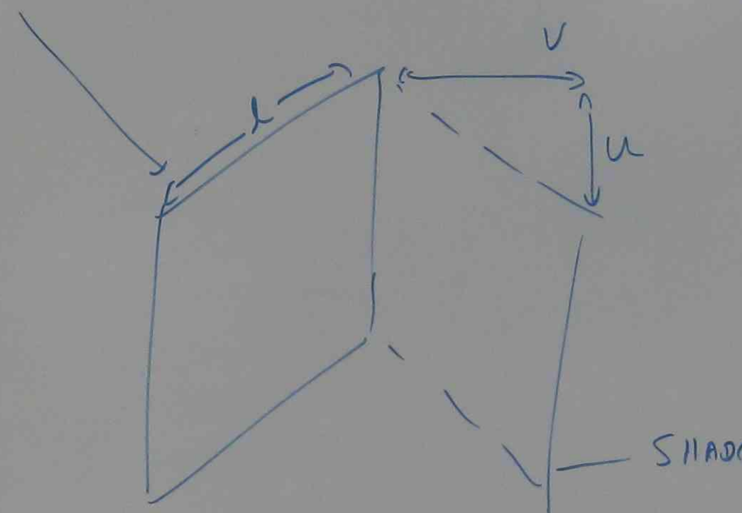
$v = l \tan V$

HSA = HORIZONTAL SU

VSA = VERTICAL SUN

VERTICAL SUN ANGLES





$$U = l \tan HSA$$

$$V = l \tan VSA$$

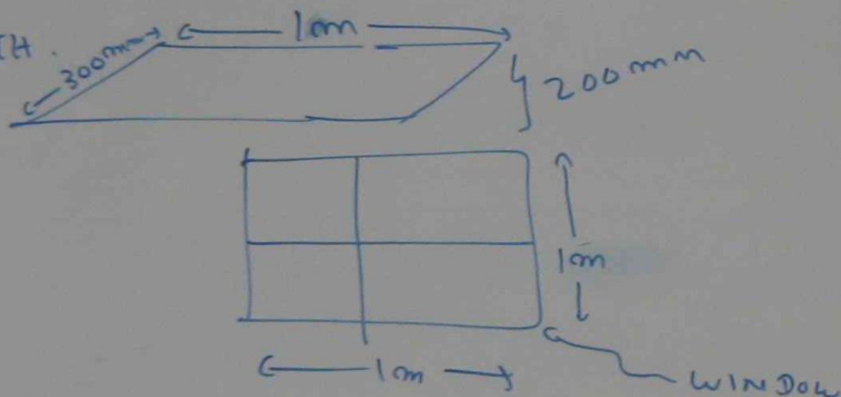
HSA = HORIZONTAL SUN ANGLE

VSA = VERTICAL SUN ANGLE

$$HSA = \phi + \gamma$$

$$\tan VSA = \frac{\tan \alpha}{\cos HSA}$$

pb CALCULATE THE SHAPE OF THE SHADOW FORMED ON A 1m × 1m WESTERN WINDOW IN BRISBANE AT 3pm SOLAR TIME ON NOVEMBER 1. IF SHADED BY A HORIZONTAL SUN BREAK OF WIDTH 300 mm ATTACHED 200 mm ABOVE THE WINDOW. THE LATITUDE OF BRISBANE IS 27.5° SOUTH.



from BRISBANE SOLAR CHART

ALTITUDE ANGLE $\alpha = 46.39°$

AZIMATH ANGLE $\phi = 82.49°$

γ = ORIENTATION ANGLE

EAST WALL $\rightarrow \gamma = 0°$	WEST WALL $\gamma = -90°$
NORTH WALL $\rightarrow \gamma = 90°$	SOUTH WALL $\gamma = 270°$

$$HSA = \phi + \gamma$$
$$= 82.49 + (-90)$$
$$= -7.51$$

$$\tan VSA = \frac{\tan\alpha}{\cos HSA}$$

$$\tan VSA = \frac{\tan 46.39}{\cos(-7.51)} = 1.059$$

$$u = L \tan HSA = 0.3 \times \tan(-7.51) = 0.04\,m$$

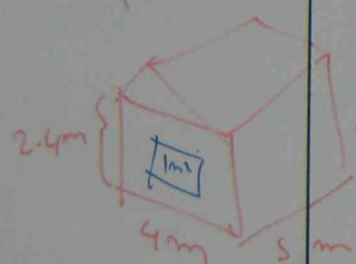
$$v = L \tan VSA = 0.3 \times 1.059 = 0.32\,m$$

T_{max} July $= 13.3$

T_{min} July $= 5.7$

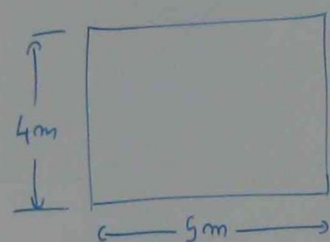
T_{max} Jan $= 25.6$

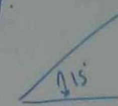
T_{min} Jan $= 14$

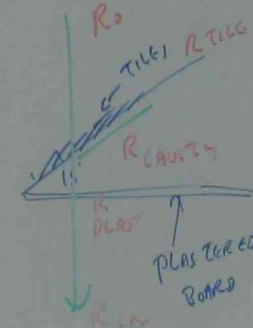


ph

CALCULATE THE TOTAL HEAT LOSS BY CONDUCTION FOR A SIMPLE ONE ROOM HOUSE IN MELBOURNE DURING THE MONTHS OF JANUARY AND JULY.







Roof

15°

THICKNESS OF TILE = 19mm

$k = 0.81$

THICKNESS OF PLASTERED BOARD = 13mm

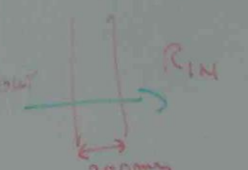
$K = 0.17$

WALL

AERATED CONCRETE (THICKNESS) = 200mm. $K = 0.13$

OUTSIDE AIR (R_{OUT}) = $0.12\ m^2K/W$

INSIDE AIR (R_{IN}) = $0.04\ m^2K/W$



THE HOUSE HAS 1m² WINDOW ON EACH WALL, AVERAGE CEILING, NO OPEN FIRE PLACE AND WEATHER STRIPPING AT THE BOTTOM OF EXTERNAL DOORS.

THE WINDOW IS 4m x 5m WITH A 2.4m CEILING HEIGHT.

Roof CAVITY RFL, $U_{summer} = 1.36$, $U_{winter} = 0.34$

- THE WINDOWS ARE SINGLE GLAZED.
- GLASS $U = 6.17$
- THE ROOF IS A DOUBLE PITCHED AND VENTED TILED ROOF WITH LAMINATE UNDER THE TILE. FLOOR IS CARPET ON A CONCRETE SLAB ON GROUND. ($U_{summer} = 0.41$, $U_{winter} = 0.4$

USE THIS

OUT SI

TIL

Roof C

VEN

PLASTERE

INSIDE

15

WALL

TOT

AREA

Ro

R

IN

EL R TILE

CAVITY

PLASTERED BOARD

USE THIS TABLE ↓ JAN ↓ JULY

ELEMENT	RESISTANCE (SUMMER)	RESISTANCE (WINTER)	SOURCE
OUTSIDE AIR FILM	0.04 R_o	0.04	TABLE 6
TILE 19mm	0.02 R_{TILE}	0.02	
ROOF CAVITY VENTED RFL	1.36 R_{CAVITY}	0.34	
PLASTERED BOARD 12mm	0.08 R_{PLAST}	0.08	
INSIDE STILL AIR IS ROOF	0.16 R_{IN}	0.11	

I WALL

$$\boxed{\text{TOTAL HEAT LOSS} = Q = \sum UA(T_i - T_a) \times N \times 0.0864}$$

$$\text{AREA OF WALLS} = (4 \times 2.4 - 1) \times 2 + [5 \times 2.4 - 1] \times 2 = 39.2\ m^2$$

$=0.34$ R

$R_{OUT} = 0.12\ m^2K/W$

$R_{IN} = 0.04\ m^2K/W$

R_{OUT} | R_{WALL} | R_{IN}

$\longleftarrow R_T \longrightarrow$

$$R_{WALL} = \frac{d}{k} = \frac{200 \times 10^{-3}}{0.13} = 1.538\ m^2K/W$$

$$R_T = R_{OUT} + R_{IN} + R_{WALL} = 0.12 + 0.04 + 1.538 = 1.699$$

$$U = \frac{1}{R_T} = \frac{1}{1.699} = 0.59\ W/m^2K$$

ATE UNDER

$U_{SUMMER} = 0.41$

D. $U_{WINTER} = 0.4$

II Roof

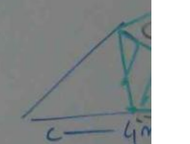
R_T SUMMER $= 0.04 + 0.$

$U_{SUMMER} = \frac{1}{R_T}$

R_T WINTER $= 0.04 + 0.02$

$U_{WINTER} = \frac{1}{R_T\ \text{WIN}}$

Roof AREA



$l_{COSIS} = 2 \longrightarrow$

AREA = 5 m ×

uly

(WINTER)	SOURCE)
	TABLE 6
2	

$T_a) \times N \times 0.0864$

$.4-1] \times 2 = 39.2\,m^2$

$R_T = R_{OUT} + R_{IN} + R_{WALL}$

$= 0.12 + 0.04 + 1.538$

$= 1.699$

$U = \frac{1}{R_T} = \frac{1}{1.699} = 0.59\,W/m^2K$

II Roof

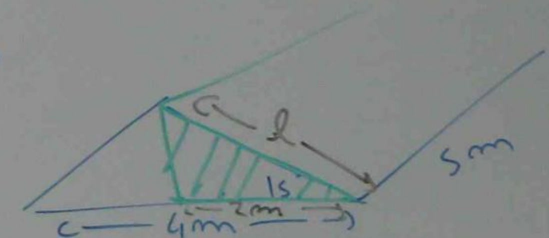
R_T SUMMER $= 0.04 + 0.02 + 1.36 + 0.08 + 0.16 = 1.66$

$U_{SUMMER} = \frac{1}{R_T \text{ SUMMER}} = \frac{1}{1.66} = 0.6\,W/m^2K$

R_T WINTER $= 0.04 + 0.02 + 0.34 + 0.08 + 0.11 = 0.59$

$U_{WINTER} = \frac{1}{R_T \text{ WINTER}} = \frac{1}{0.59} = 1.69\,W/m^2K$

ROOF AREA



$l \cos 15 = 2 \longrightarrow l = \frac{2}{\cos 15} =$

$AREA = 5\,m \times l \times 2 = \frac{2}{\cos 15} \times 5 \times 2 = 20.7\,m^2$

III FLOOR

AREA OF FLOOR = 5 × 4 = 20 m^2

$U_{SUMMER} = 0.41$

$U_{WINTER} = 0.4$

IV WINDOW

TOTAL WINDOW AREA = 4 m^2

$U = 6.17$

$T_i = ? \Rightarrow T_i = 17.6 + 0.31 \times T_{avg}$

T_{avg} July = $\frac{T_{MAX} + T_{MIN}}{2} = \frac{13.3 + 5.7}{2} = 9.5c$

T_i July = 17.6 + 0.31 × 9.5 = 20.55c

T_{AV}

$$T_{AVG\ JAN} = \frac{T_{MAX} + T_{MIN}}{2} = \frac{25.8 + 14}{2} = 19.9^\circ C$$

$$T_{i\ JAN} = 17.6 + 0.31 \times 19.9 = \underline{\underline{23.77^\circ C}}$$

N = NO. OF DAYS IN PARTICULAR MONTH

TOTAL HEAT LOSS IN JULY

$$Q_c = \sum UA\,(T_i - T_{Avg})\,N \times 0.0864$$

$$= \left(U_{WALL} \times A_{WALL} + U_{Roof} \times A_{Roof} + U_{FLOOR} \times A_{Floor} + U_{WINDOW} \times A_{WINDOW}\right) \times \left(20.55 - 9.5\right) \times 31 \times 0.0864$$

$$= \left(0.59 \times 39.2 + 1.69 \times 20.7 + 0.4 \times 20 + 6.17 \times 4\right)\left(20.55 - 9.5\right) \times 31 \times 0.0864$$

$$= 2687.08\ mJ$$

9.5 C

TOTAL HEAT LOSS IN JANUARY

$$Q_c = \sum UA\,(T_i - T_{Avg}) \times N \times 0.0864$$

$$= \left(U_{WALL} \times A_{WALL} + U_{Roof} \times A_{Roof} + U_{Floor} \times A_{Floor} + U_{WINDOW} \times A_{WINDOW}\right)\left(23.77 - 19.9\right) \times 31 \times 0.0864$$

$$= \left(0.59 \times 39.2 + 0.6 \times 20.7 + 0.41 \times 20 + 6.17 \times 4\right)\left(23.77 - 19.9\right) \times 31 \times 0.0864 = 709.28\ mJ$$

$$T_{AVG\ JAN} = \frac{T_{MAX} + T_{MIN}}{2} = \frac{25.8 + 14}{2} = 19.9^{\circ}C$$

$$T_{i\ JAN} = 17.6 + 0.31 \times 19.9 = \underline{\underline{23.77^{\circ}C}}$$

N = No. of DAYS IN PARTICULAR MONTH

TOTAL HEAT LOSS IN JULY

$$Q_c = \sum UA\,(T_i - T_{Avg})\,N \times 0.0864$$

$$= \left(U_{WALL} \times A_{WALL} + U_{Roof} \times A_{Roof} + U_{FLOOR} \times A_{Floor} + U_{WINDOW} \times A_{WINDOW}\right) \times (20.55 - 9.5) \times 31 \times 0.0864$$

$$= (0.59 \times 39.2 + 1.69 \times 20.7 + 0.4 \times 20 + 6.17 \times 4)(20.55 - 9.5) \times 31 \times 0.0864$$

$$= 2687.08\ mJ$$

9.5c

TOTAL HEAT LOSS IN JANUARY

$$Q_c = \sum UA\,(T_i - T_{Avg}) \times N \times 0.0864$$

$$= \left(U_{WALL} \times A_{WALL} + U_{Roof} \times A_{Roof} + U_{Floor} \times A_{Floor} + U_{WINDOW} \times A_{WINDOW}\right)(23.77 - 19.9) \times 31 \times 0.0864$$

$$= (0.59 \times 39.2 + 0.6 \times 20.7 + 0.41 \times 20 + 6.17 \times 4)(23.77 - 19.9) \times 31 \times 0.0864 = 709.28\ mJ$$

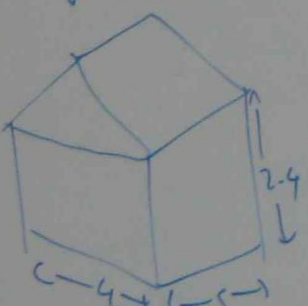
pb(2) IN ABOVE PROBLEM, CALCULATE INFILTRATION HEAT LOSS / HEAT GAIN IN THIS BUILDING. GLASS WINDOW, NO OPEN FIRE PLACE.

$$Q_V = AC \times V \times (T_i - T_{avg}) N \times 0.0286$$

Q_V = INFILTRATION HEAT LOSS / GAIN (mJ)

AC = AIR CHANGE PER HOUR (AC = 1.5 FOR NATURAL AIR CHANGE)

V = VOLUME OF THE HOUSE / ROOM)



$V = 2.4 \times 5 \times 4$

JANUARY

$T_i = 23.77$

$T_{avg} = 19.9$

$$Q_V = 1.5 \times (2.4 \times 5 \times 4) \times (23.77 - 19.9) \times 31 \times 0.0286$$

$$= 247.0\ mJ$$

July

$T_i = 20.55$

$T_{avg} = 9.5$

$$Q_V = 1.5 \times (2.4 \times 5 \times 4) \times (20.55 - 9.5) \times 31 \times 0.0286$$

$$= 705.4\ mJ$$