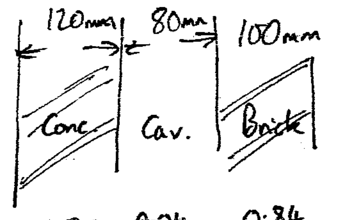
IIB 2011 4D11 - BUILDING PHYSICS

DR FA MCROBIE (Q1)
DR M OVEREND

4D11 Q1, 2010.

1 a)

internal.



external

0.20 0.04 0.84 W/mK

↑ 0.12 m²K/W ↑ 0.1 m²K/W

i).

Internal surface	R_i		0.12 m²K/W
Conc. block	R_c	0.12m / 0.2(W/mK)	0.60 m²K/W
Cav	R_w	0.08m / 0.04(W/mK)	2.00 m²K/W
Brick	R_b	0.10m / 0.84 (W/mK)	0.12 m²K/W
External surf.	R_e		0.10 m²K/W

$\sum R = 2.94$ m²K/W

$$U_{value} = \frac{1}{\sum R} = 0.34 \text{ W/m}^2\text{K}$$

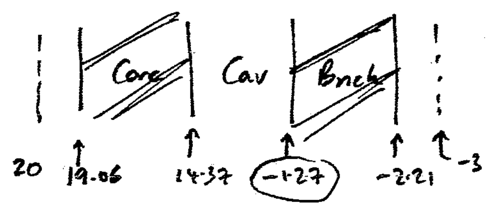
ii)

$$q = U \Delta T \rightarrow q = (0.34 \text{ W/m}^2\text{K})(23\text{ K}) = \underline{7.82 \text{ W/m}^2}$$

$$\Delta T_{tot} = \frac{q}{U} = (\sum R) q = \sum (Rq) = \sum \Delta T_{individual}.$$

		R	q	ΔT	T = 20 − ΣΔT
Int. surface	R_i	0.12 m²K/W	7.82 W/m²	0.94 °C	+19.06
Block	R_c	0.60 m²K/W	7.82 W/m²	4.69 °C	+14.37
Cav	R_w	2.00 m²K/W	7.82 W/m²	15.64 °C	−1.27
Brick	R_b	0.12 m²K/W	7.82 W/m²	0.94 °C	−2.21
Ext. surfa	R_e	0.10 m²K/W	7.82 W/m²	0.78 °C	−3.00

$\sum$ 23°C ✓.



Ans = −1.27°C

4D11 Q1 cont'd.

b) Marks will be awarded for correctly recognising the environmental node as a hypothetical concept, this being a point just off the internal surface of the internal layer of the wall at which all convective and radiative heat transfer is assumed to occur. Further marks will be awarded for descriptions of the true physics in this region, and of how the environmental node fits into the CIBSE Simple Model heat flow network.

c). Marks will be awarded for a description (plus sketch) of the basic axes and layout of a psychrometric chart, — moisture content against dry bulb temperature — with percentage saturation curves and wet bulb temperature curves. Further marks will be awarded for explaining how it may be used to examine and quantify phenomena such as condensation, evaporative cooling etc.

2a) i) LOW TEMPERATURE SOLAR COLLECTOR ⇒ 0 – 50°C

BOOKWORK : DESCRIBE UNGLAZED PANEL COLLECTORS.

OR GLAZED PANEL COLLECTORS OPEN LOOP

OR " " " CLOSED LOOP.

ii) HIGH TEMPERATURE SOLAR COLLECTOR ⇒ > 100°C

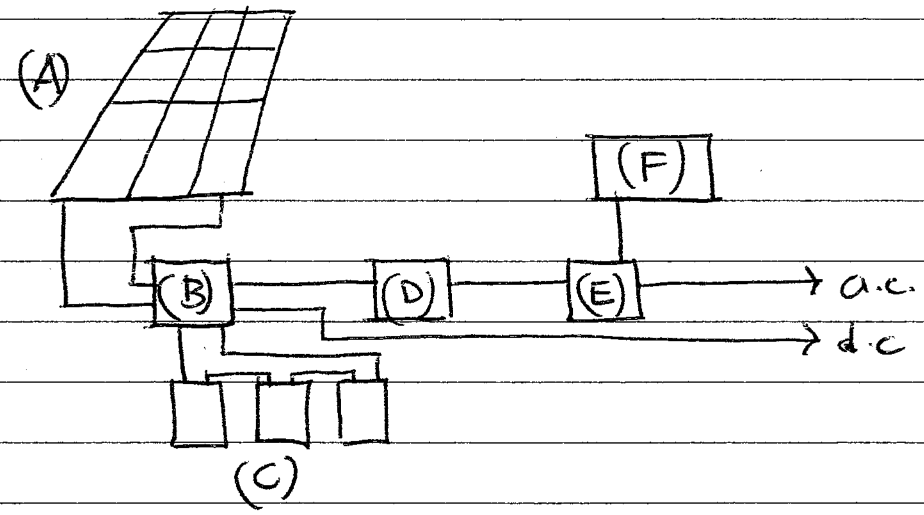
BOOK WORK : DESCRIBE EVACUATED TUBE COLLECTORS

OR PARABOLIC TROUGH CONCENTRATOR

OR PARABOLIC DISH CONCENTRATOR

OR SOLAR POWER TOWER

iii) OFF-GRID PV SYSTEM.



(A) - PV PANELS

(B) - CHARGE CONVERTOR

(C) - POWER STORAGE

(D) - INVERTER

(E) - SWITCH GEAR

(F) - BACK-UP POWER SUPPLY.

2b) LOAD = 8750 Wh/day

bi) FOR GRID CONNECTED SYSTEM CONSIDER ANNUAL IRRADIANCE

AT $\beta = 90°$ ⇒ 3.24 kWh/m²

AT $\beta = 0°$ ⇒ 4.15 kWh/m²

SOLAR IRRADIATION ON EARTH'S SURFACE ≈ $1 kW/m^2$

∴ PEAK SOLAR HOURS = 3.24 ($\beta = 90°$)

= 4.15 ($\beta = 0°$)

NOMINAL POWER REQUIRED TO MEET DAILY DEMAND:

$\beta = 90°$ P_o = 8750 Wh / 3.24 h = 2700 W

$\beta = 0°$ P_o = 8750 Wh / 4.15 h = 2108 W

∴ NO. OF PANELS REQUIRED:

$\beta = 90°$ ⇒ 2700 W / 200 W = 13.5

$\beta = 0°$ ⇒ 2108 W / 200 W = 10.5

∴ PROVIDE 14 × 200 W PV PANELS VERTICALLY OR

11 × 200 W PV PANELS HORIZONTALLY

bii) FOR OFF-GRID SYSTEM CONSIDER MONTH WITH LOWEST IRRADIANCE.

AT $\beta = 90°$ ⇒ JUNE = 2.51 kWh/m^2

AT $\beta = 0°$ ⇒ DEC = 1.70 kWh/m^2

∴ NO. OF PANELS REQUIRED:

$\beta = 90°$ ⇒ 8750 Wh / (2.51 × 200) = 17.4

$\beta = 0°$ ⇒ 8750 Wh / (1.70 × 200) = 25.7

∴ PROVIDE 18 × 200 W PV PANELS VERTICALLY OR

26 × 200 W PV PANELS HORIZONTALLY

c)

	$\beta = 90°$	$\beta = 0°$
• CAPITAL COST	18×800 = £14,400	26×800 = £20,800
• O&M COST	–	–
• POWER OUTPUT (LOAD) p.a.	8750 × 365 = 3.19 MWh	3.19 MWh

	$\beta = 90°$	$\beta = 0°$
• ANNUTISED COST OVER 20 YEAR SERVICE LIFE (5% DISCOUNT RATE).	$\frac{80}{1000} \times 14400 = £1152$	$\frac{80}{1000} \times 20800 = £1664$
• COST OF ELECTRICITY GENERATED	$\frac{1152 \times 10^2}{3.19 \times 10^3} =$	$\frac{1664 \times 10^2}{3.19 \times 10^3}$
	36.1p/kWh	52.2p/kWh

d) OPTIMUM ANGLE WOULD BE SELECTED AS FOLLOWS:

OFF GRID ⇒ $\beta = 65° - 70°$ (PSH = 3.51)

GRID CONNECTED ⇒ $\beta = 35°$ (PSH = 4.78)

∴ NO. OF PANELS FOR OFF GRID:

$(\beta = 65° - 70°) \Rightarrow 8750 / (3.51 \times 200) =$ 13 PV PANELS.

NO OF PANELS FOR GRID CONNECTED:

$(\beta = 35°) \Rightarrow 8750 / 4.78 \times 200 =$ 10 PV PANELS.

OFF-GRID COST OF ELECTRICITY GENERATED

$$= \frac{80}{1000} \times (10 \times 80000) \times \frac{1}{3.19 \times 10^3}$$

$$= 20.1 \text{ p/kWh}$$

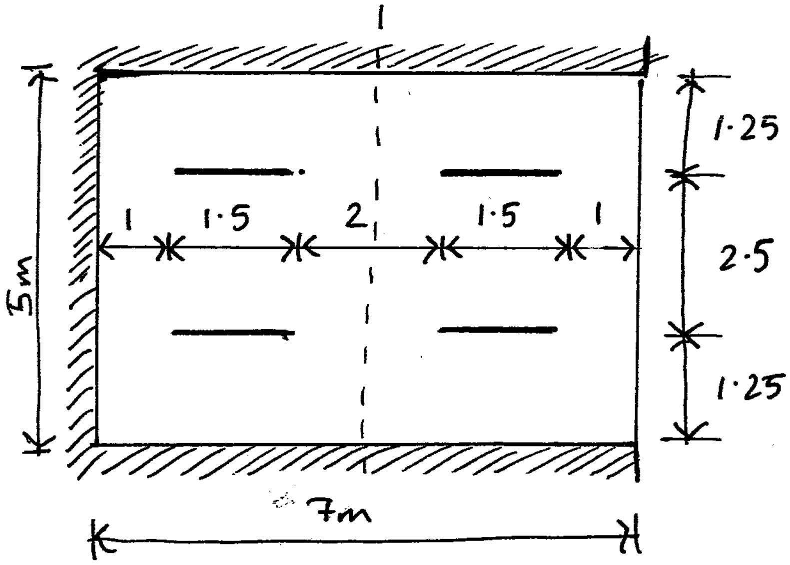
3(a) USEFUL OUTPUT PER LUMINAIRE $= 40W \times 85\, lm/W \times 0.78$

$= 2652\, lm$

REQUIRED ILLUMINANCE OF 300 lux $\Rightarrow 300 \times (5m \times 7m)$

$= 10,500\, lm$

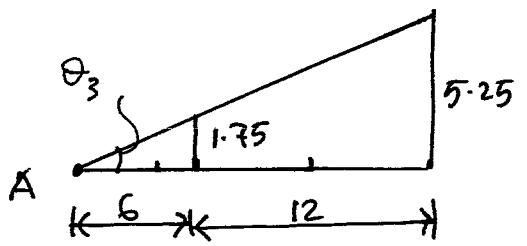
$\therefore$ NO. OF LUMINAIRES REQD. $= \frac{10,500}{2652} = 3.94$ SAY **4**



(b) D.F. = SC + ERC + IRC

POINT A

S.C.



$5.25m < 9.6m$ (HT. OF OBSTRUCTION)

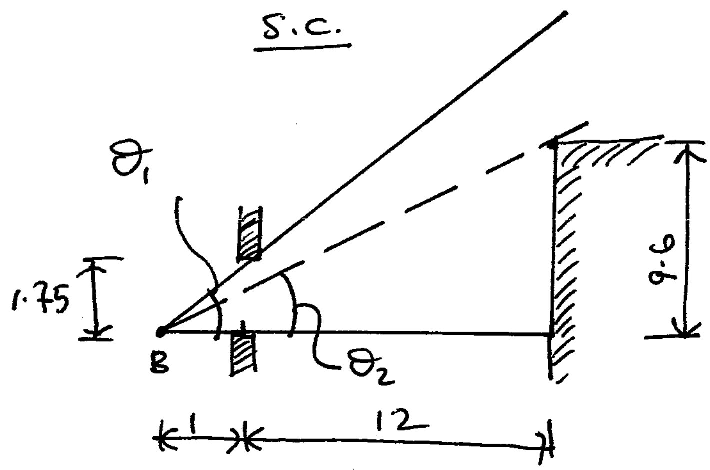
$\Rightarrow$ NO VISIBLE SKY

$\therefore$ SC = 0

$\theta_3 = 16.3°$

POINT B

S.C.



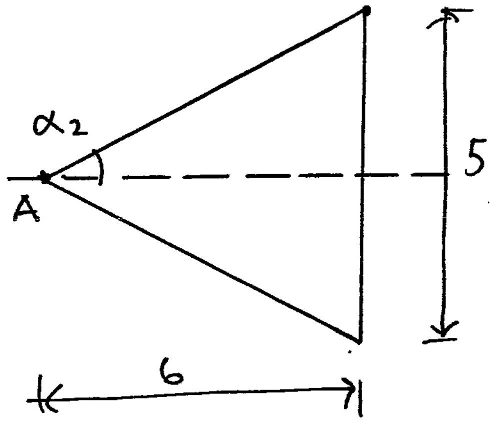
$\theta_1 = \tan^{-1} \frac{1.75}{1} = 60.3°$

$\theta_2 = \tan^{-1} \frac{9.6}{13} = 36.4°$

$\therefore$ FROM PROTRACTORS

SC = 18% − 6% = 12%

CORRECTION FACTOR NOT APPLICABLE FOR A AS THERE IS NO S.C. BUT CALCULATE ANGLE ON PLAN AS THIS WILL BE REQUIRED FOR ERC CALCULATIONS :



$\alpha_2 = \tan^{-1} \frac{2.5}{6} = 22.6°$

$\underline{\underline{SC = 0}}$

ERC

$\theta_3 = 16.3°$

ERC (FROM PROTRACTOR) = 1%

CORRECTION FACTOR FROM WINDOW WIDTH USING MEAN ANGLE OF ELEVATION $= \frac{16.3°}{2} = 8.2°$

AND $\alpha_2 = 22.6°$

⇒ CORRECTION FACTOR = 0.25 (FROM PROTRACTOR)

∴ FOR 2α = 0.5

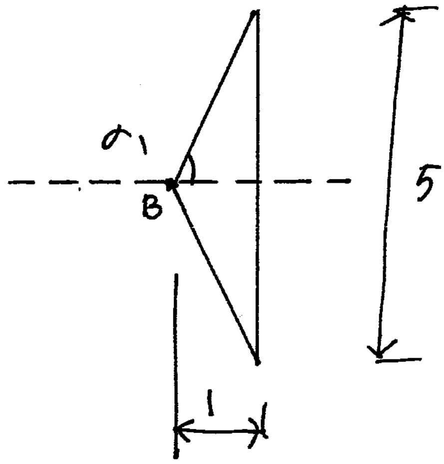
CORRECTED ERC = 1% × 0.5 × 0.75 × 0.6

= 0.23%

CORRECTION FACTOR FOR WINDOW WIDTH :

USE MEAN ANGLE OF ELEVATION $= \frac{60.3° + 36.4°}{2}$

$= 48.4°$



$\alpha_1 = \tan^{-1} \frac{2.5}{1} = 68°$

∴ CORRECTION FACTOR FROM PROTRACTOR ≏ 0.48

∴ FOR 2α = 0.96

CORRECTED SC = 12% × 0.96 × 0.75

= $\underline{\underline{8.64\%}}$

ERC

$\theta_2 = 36.4°$

ERC (FROM PROTRACTOR) = 5.8%

CORRECTION FACTOR FOR WINDOW WIDTH USING MEAN ANGLE OF ELEVATION $= \frac{36.4}{2} = 18.2°$

AND $\alpha_1 = 68°$

⇒ CORRECTION FACTOR = > 0.5 (FROM PROTRACTOR) ∴ NO CORRECT

CORRECTED ERC = 5.8% × 1 × 0.75 × 0

= [illegible]

4

a)
T = 0.16 V / A
Current A = 0.16 V / T = 0.16 x 12 x 17 x 3.3/4.5 = 0.16 x 673 / 4.5 = 23.5 m2
Required A = 0.16 x 673 / 1 = 108 m2
Additional A required = 108 - 23.5 = 84.5
Additional S required = 84.5 / 0.9 = 94 m2

b)
The absorbent material should be distributed around all four walls and the ceiling in patches so that, as far as possible, no parallel hard surfaces remain to cause flutter echoes and the effect of the absorption is maximised.

c)
In meetings the speech intelligibility will be increased to the extent that the speaker will be intelligible in the whole room.
During dinners it will be possible to take part in conversations with people not immediately next door.
The noise level due to sporting activities will be much lower in the hall.

d)
50 mm thick mineral wool is not a good absorber at low frequencies, with an absorption coefficient of 0.1. The room will sound boomy without additional low frequency absorption. This can not be a porous absorber such as mineral wool as it would have to be too thick to have a significant effect at low frequencies, therefore a panel absorber should be introduced. Placing a panel directly against the wall or ceiling will not produce an efficient absorber of low frequency sound and a significant air gap is required of at least 200 mm. This would make the ceiling unacceptably low if the panel absorber were to be installed horizontally. Therefore the panels will have to be placed on the walls, resulting in a smaller floor area.

e)
For meetings the background noise level should be no more than NR30. Speech will be less intelligible as a result of this high noise level, although the level will be reduced somewhat by the introduction of the additional absorption.