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CONFIDENTIAL

SET A

# UNIVERSITI KUALA LUMPUR

## MALAYSIA FRANCE INSTITUTE

## FINAL EXAMINATION

## JANUARY 2014 SEMESTER

| | | |
|---|---|---|
| SUBJECT CODE | : | FCB 20603 |
| SUBJECT TITLE | : | HEATING & COOLING LOAD |
| LEVEL | : | BACHELOR |
| DURATION | : | 9.00 am - 12.00 noon (3 HOURS) |
| DATE / TIME | : | 29 MAY 2014 |

### INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. Please write your answers on the answer booklet provided.
4. Answer should be written in blue or black ink except for sketching, graphic and illustration.
5. Use documentation for Cooling Load (Diploma) and Heating and Cooling Load (Bachelor) provided.
6. Answer all questions in English.
7. Formulae is appended.

THERE ARE 4 PRINTED PAGES OF QUESTIONS.

**INSTRUCTION: Answer ALL questions.**

**Please use the answer booklet provided.**

**Question 1**

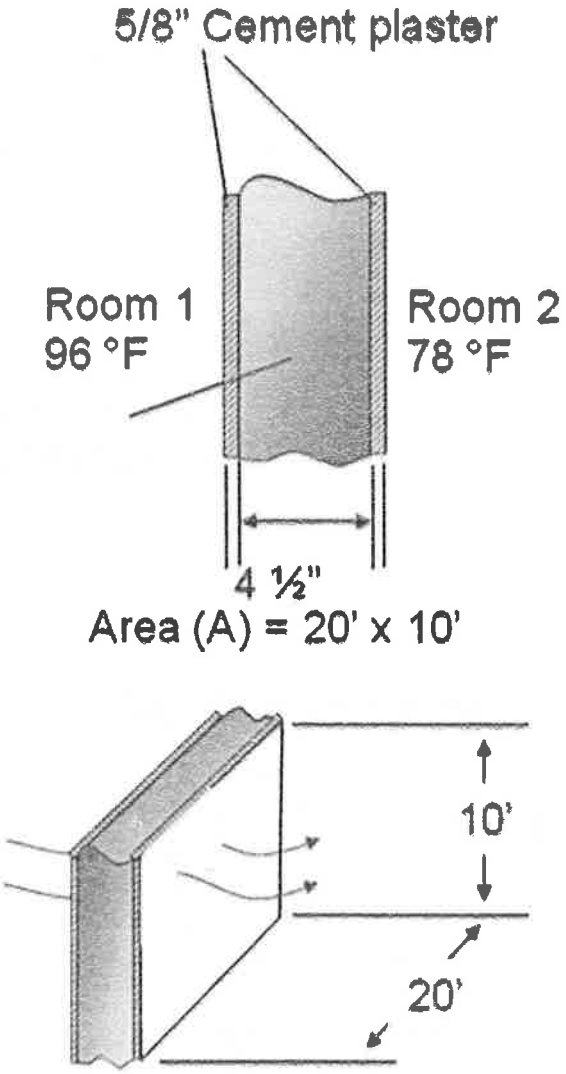



Figure Q1: Roof construction

The diagram above shows a wall construction of an office building. Calculate the heat loss, Q.

(25 marks)

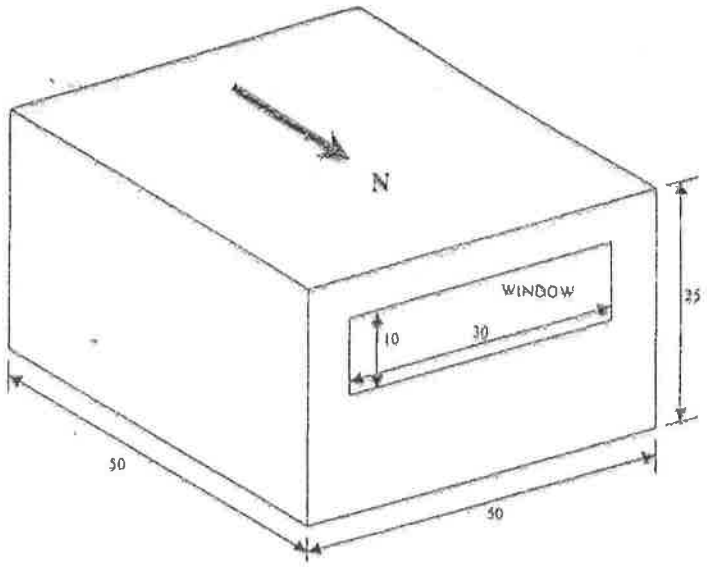
## Question 2.

Calculate the total radiation for a horizontal surface at 2:00 pm on 21 July in Bangi. Neglect reflected radiation. (Longitude (Bangi) = 101° 48' E, latitude (Bangi) =2 ° 56' N).

| | | |
|---|---|---|
| 2.1 | Solar time, $t_{sol}$ | (2 Marks) |
| 2.2 | Hour angle, h | (2 Marks) |
| 2.3 | Solar altitude, β | (2 Marks) |
| 2.4 | Solar azimuth, Φ | (2 Marks) |
| 2.5 | Angle of incidence, θ | (2 Marks) |
| 2.6 | Direct normal radiation, $G_{ND}$ | (3 Marks) |
| 2.7 | Direct radiation, $G_b$ | (3 Marks) |
| 2.8 | Diffuse radiation, $G_d$ | (4 Marks) |
| 2.9 | Total radiation, $G_t$ | (5 Marks) |

**Question 3.**

(50 Marks)




Note: Units for dimension is in ft.

Figure Q1. A single-zone building

A single-zone building in Kuala Lumpur is shown in Figure Q1.

The roof is made of 4-in lightweight concrete, while the walls are made of 4-in concrete. The roof comes with a suspended ceiling. The window is made of green, low-emissivity, single glazed glass pane and is internally shaded. The window is not setback. The floor is made of 75 mm concrete floor and is not carpeted. The interior furnishing is basically functional for office use. The date is July 21.

The outdoor condition is taken to be 1% dry-bulb temperature 32.2 °C, and a mean wet-bulb temperature of 25.9 °C. The daily dry-bulb temperature range is 6.3 °C. The building interior is maintained at 25 °C and 50% RH from 6:00 am to 5:00 pm solar time. The building is designed for office use, and houses 30 occupants from 8:00 am to 4:00 pm. There is no significant infiltration into the building.

The mechanical ventilation rate is considered to be medium. The heat gain from suspended fluorescent (unvented) lights is 1.5 W/ft$^2$ and lasts from 8:00 am to 4:00 pm. For the same time period, the heat gain from computers and other office equipment (appliances) is 1 W/ft$^2$. For most of the occupied period, the occupants are expected to be seated and performing light office work.

i. Identify the shading coefficient and the U-value of the glazing used,

ii. Identify the U-values of the roof and walls,

iii. Identify the sensible and latent heat gains from all the occupants,

iv. Determine the instantaneous latent load of the conditioned space for 10:00 am and 2:00 pm,

v. Determine the hourly instantaneous sensible load in the conditioned space due separately to the walls, roof, glazing, occupant, lightings, and equipment for 10:00 am and 2:00 pm,

vi. Hence, determine the hourly instantaneous total load of the conditioned space for 10:00 am and 2:00 pm, and

vii. From the specified time given in the question i.e 10:00 am and 2:00 pm which one carries higher load.

viii. Show all your calculations in the answer booklet and fill in your answers in Table 1 in Appendix. **(TO BE RETURNED)**

**END OF QUESTIONS**

# APPENDIX

## USEFUL FORMULAE

1. $t_{sol} = t_{std} - (L_{std} - L_{loc})\ 4 + E_t$
2. For Bangi, $L_{std} = 120$, $L_{loc} = 101° 48'$, $l = 2° 56'$, $h = t_{sol} - 12:00$
3. $\sin \beta = \cos l \cos h \cos d + \sin l \sin d$
4. $\cos \phi = (\sin \beta \sin l - \sin d) / (\cos \beta \cos l)$
5. $\cos \theta = \cos \beta \cos \gamma$
6. $\gamma = \phi - \psi$
7. $G_{ND} = A / \exp (B/ \sin \beta)$
8. $G_D = G_{ND} \cos \theta$
9. $G_d = C\ G_{ND}$
10. $G_R = G_{th}\ \rho\ F_{wg}$
11. $F_{wg} = (1 - \cos \Sigma) / 2$ where $\Sigma = 90 - \alpha$ ($\alpha = 0$ for horizontal)
12. For horizontal surface, $\cos \theta = \sin \beta$
13. $G_t = G_D + G_d + G_R$
14. $q = - kA \frac{dt}{dx}$
15. $R = \frac{dx}{k} = \frac{1}{C}$
16. $C = \frac{1}{R} = \frac{k}{dx}$
17. $U = 1/\Sigma R$
18. $q = UAdt$
19. $Q_{c,cond,t} = UA$ **CLTD**
20. $CLTD_{corr} = (CLTD + LM)K + (25.5°C - T_i) + (T_{o,av} - 29.4°C)$
21. $Q_{c,glass,t} = UA$ **CLTD** $_{glass,t}$
22. $Q_{c,sol,t} = A \times SC \times SHGF_{max} \times$ **CLF**$_t$
23. $Q_{lit,t} = Q_{lit\ or\ app}$ **CLF**$_{lit\ or\ aoo,t}$
24. $Q_{occ,t} = Q_{occ}$ **CLF**$_{occ,t}$

## USEFUL FORMULAE. (Additional)

1. $t_{sol} = t_{std} - (L_{std} - L_{loc})\ 4 + E_t$
2. For Bangi, $L_{std} = 120°$, $L_{loc} = 101°\ 48'$ E, l = 2° 56' N
3. For Pulau Pinang, $L_{std} = 120°$ E, $L_{loc} = 100°\ 16'$ E, l = 5° 25' N
4. For Kota Kinabalu, $L_{std} = 120°$ E, $L_{loc} = 116°\ 5'$ E, l = 5° 59' N
5. $\sin \beta = \cos l \cos h \cos d + \sin l \sin d$
6. $\cos \phi = (\sin \beta \sin l - \sin d) / (\cos \beta \cos l)$
7. $\cos \theta = \cos \beta \cos \gamma \sin \alpha + \sin \beta \cos \alpha$
8. $\gamma = \phi - \psi$
9. $q = - kA \frac{dt}{dx}$
10. $R = \frac{dx}{k} = \frac{1}{C}$
11. $C = \frac{1}{R} = \frac{k}{dx}$
12. $U = 1/\Sigma R$
13. $q = UAdt$

⇒ For vertical surface ($\alpha = 90°$)

$\cos \theta = \cos \beta \cos \gamma$

⇒ For horizontal surface ($\alpha = 0°$)

$\cos \theta = \sin \beta$

**Table 1 (TO BE RETURNED)**

| | | | | | | |
|---|---|---|---|---|---|---|
| | Month = July | 5.678 W/m².K | | | Solar time | |
| | 1 m = 39.37 in. (3.28 ft)<br>1 m² = 10.76 ft² | light office work=45 W | | | 10:00 a.m. | 2:00 p.m. |
| Latent loads | | | | | | |
| | Occupant | | | | | |
| Sensible loads | | U (W/[m².K]) | A (m²) | | | |
| | North-facing wall | | | | | |
| | South-facing wall | | | | | |
| | East-facing wall | | | | | |
| | West-facing wall | | | | | |
| | Roof | | | | | |
| | Glazing (conduction) | | | | | |
| | | SC | A (m²) | $SHGF_{max}$ | | |
| | | | | | | |
| | Glazing (solar) | | | | | |
| | Appliances | | | | | |
| | Lights | | | | | |
| | Occupants | | | | | |
| | | | | | | |
| Total load | | | | | | |
| | | Window is north facing | | | | |