Prince of Songkla University
Faculty of Engineering

Final Examination **Semester 1/2556**

9 October 2013 **Time 9:00-12:00**

215-663 Energy Management in Buildings **Room:**

Directions

- A4 paper is allowed and can be written two sides of the A4 paper.
- All types of calculator are permitted.
- Attempt all 6 questions.
- The exam paper has 12 pages.

Juntakan Taweekun
Instructor

Problem	Marks	
1	20	
2	15	
3	15	
4	15	
5	20	
6	20	
Total	105	

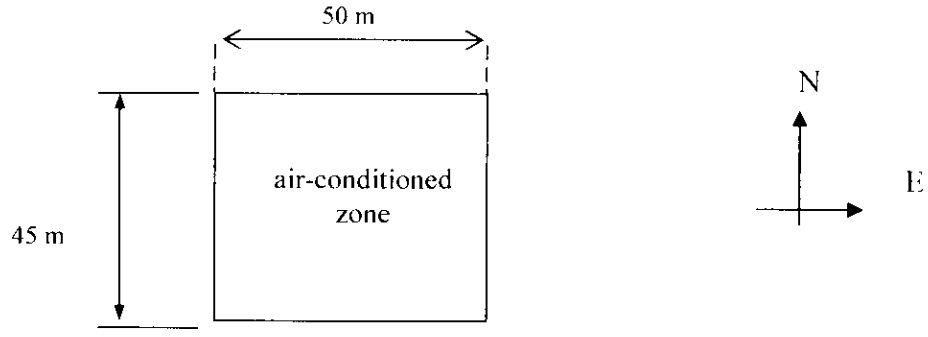
Name _____

ID _____

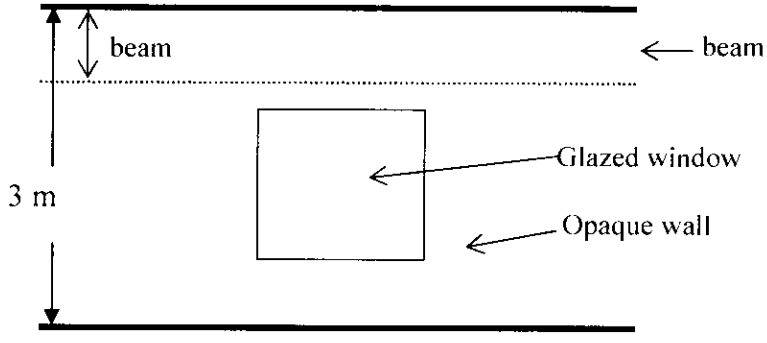
Name-Surname_____ID _____

Question 1 (20 points)

The arrangement of a typical floor in a office building is as shown.



A) Building plan



B) Details on the wall of a storey, WWR 0.25

The wall of the building comprises a beam, an opaque section, and a glazed window as shown. The height of each floor is 3.3 m and the ratio of window area to overall wall area (WWR) is 0.25. Material details of the beam, glazing and opaque wall are given in the following table.

Section	Details
Beam	Concrete slab, thickness 35 cm, width 55 cm, Medium-color exterior (α_b=0.5) k 0.78 $Wm^{-1}K^{-1}$, density 1,780 kgm^{-3}
Glazing	Single, reflective gray 6 mm, SC 0.6, U_f 5.85 $Wm^{-2}K^{-1}$
Opaque wall	Plaster-brick-plaster, 1-8-1 cm Medium-color exterior (α_w=0.5) Plaster: k 0.876 $Wm^{-1}K^{-1}$, density 1,750 kgm^{-3} Brick: k 0.685 $Wm^{-1}K^{-1}$, density 1,450 kgm^{-3}

Here, the columns are neglected. The value of h_o is 20 $Wm^{-2}K^{-1}$ and h_i is 8 $Wm^{-2}K^{-1}$. Use the following table for calculation.

Parameter	North	East	South	West
CF	0.7	1.12	1.11	1.03
SF	112	179.2	177.6	164.8

1.1 Calculate U value of each wall component

1.2 Calculate the wall OTTV of this building

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Question 2 (15 points)

Explain the following process in details and also draw the process in Psychrometric chart for each process.

2.1 Cooling without Condensation
2.2 Cooling with Condensation
2.3 Heating without Humidification
2.4 Heating with Humidification

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Question 3 (15 points)

A sedentary person (Met 1.2) generates CO_2 at a rate of 0.016 g/s. If the ventilation rate for a room in which the person resides is 10 L/s, and if the ventilation air contains:

- 0.8 g/m^3 of CO_2,
- 10 mg/m^3 of CO and
- 275 μg/m^3 of SO_2

What would be the concentration of CO_2, CO and SO_2 in the room? Assume 1 m^3 of air weighs 1.119 kg.

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Question 4 (15 points)

A room has length 5 m, width 4 m and height 3 m. The work plan is at 0.75 m from the floor and the fixtures are on the ceiling. Use LLF of 0.7. Task area and general area of this room is 8 m^2 and 9 m^2, remaining area is non-critical area. The value of Luminaire Coefficient of Utilization (CU) can be obtained from the following table.

Room Cavity Ratio	0	1	2	3	4	5	6	7	8	9	10
Luminaire Coefficient of Utilization	.55	.55	.50	.45	.40	.36	.32	.26	.26	.26	.26

The efficacy of lamp is 60 lm/W. If the uniform illuminance of visual task of 500 lux is required, calculate

a) Total electric power required (in unit of Watt) and power intensity for task area, general area and non-critical area
b) Power intensity for this room
c) Is the calculated power intensity for this room in the acceptable range? If the answer is "No", explain at least 3 methods how to minimize the power intensity of this room.

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Question 5 (20 points)

For a given time of a given day, the temperature and relative humidity of the air outside of an air-conditioning space are T_o = 33 °C and RH_o = 65%, respectively. The space houses 100 occupants. The space cooling load at the time is given in the followings.

Item	External Source (kW)		Internal Source (kW)		Total (kW)	
	Sensible, S	Latent, L	Sensible, S	Latent, L	Sensible, S	Latent, L
Space Cooling Load	22	-	20	15	42	15

The air-conditioning system is rated at 100 kW (thermal). It draws 0.35 kg/s of outside air for ventilation. The cooling effect provided by the air-conditioner varies with load. At a steady and balance condition it supplies cool air at 15°C (RH_s = 100%). At the outlet of the system the air is saturated and the flow rate supply air is 3 kg/s. Find

5.1 Ventilation load (sensible and latent ventilation load)

5.2 Condition of the air in the space.

5.3 Is the calculated total load exceeding the capacity of the air conditioner? If the answer is "Yes", explain how to do.

Also mark the values obtained in the Psychrometric Chart as attachment.

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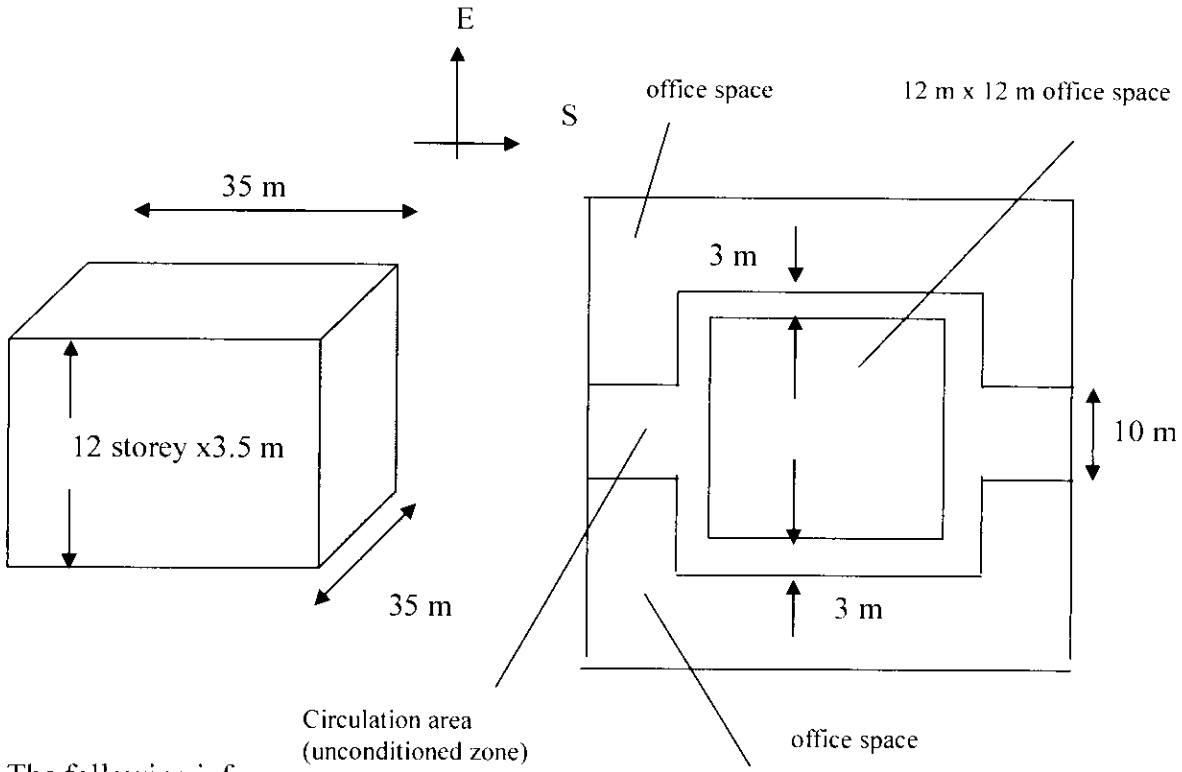
Question 6 (20 points)

A office building has a square shape as shown. The building comprises 12 floors.

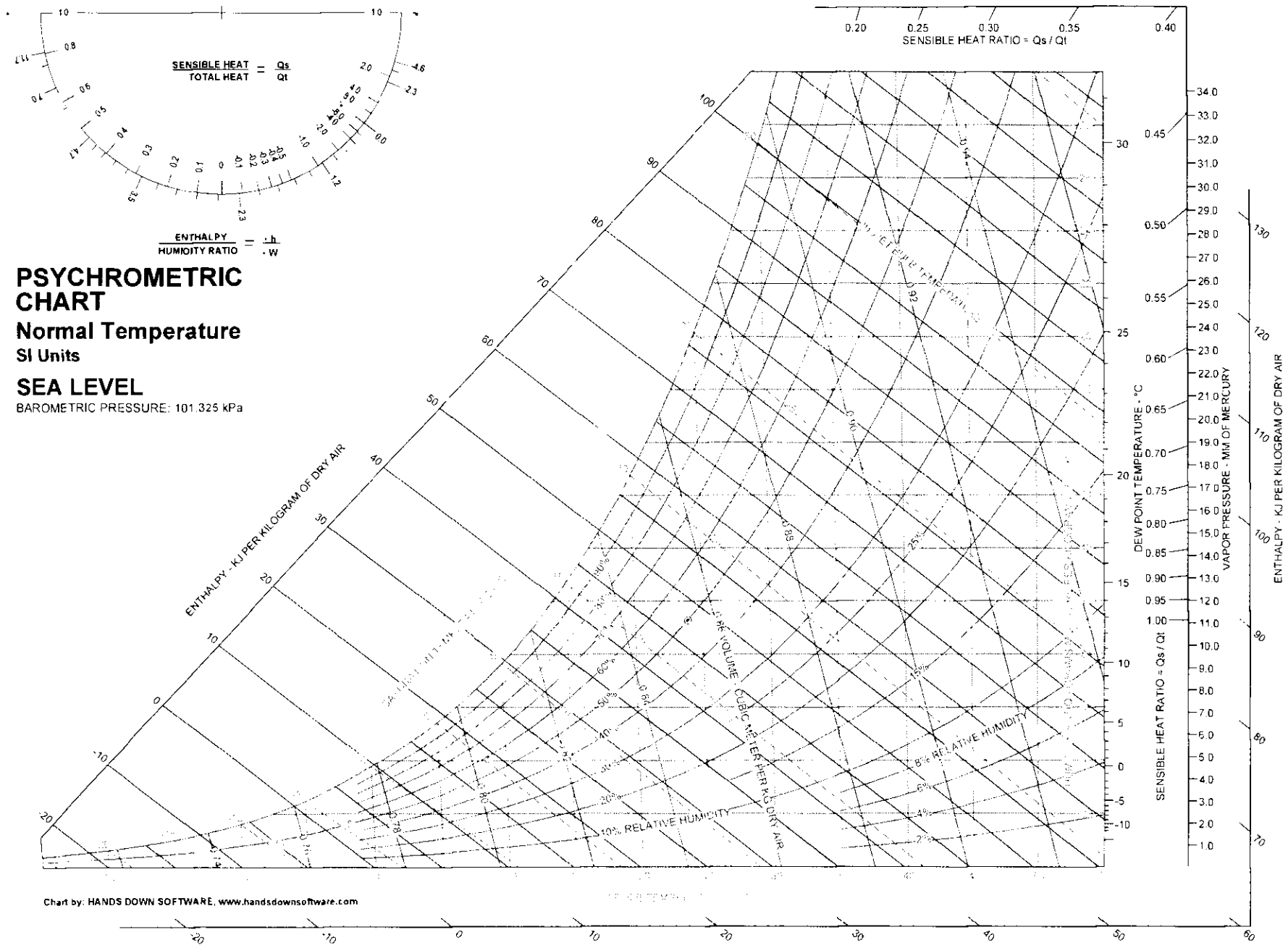


The following inform

- OTTV = 45 Wm^{-2}
- RTTV = 10 Wm^{-2}.
- Uniform lighting is used
    - Office space 18 Wm^{-2}
    - Circulation area 10 Wm^{-2}
- Office equipment 8 Wm^{-2}
- Number of people: 1 person/10 m^2 of office space
- Ventilation in office space 1 l/(s.m^2), 25 W/(l/s)
- Total average power taken by lifts are 65 kW during office hours.
- System COP of air-conditioning system is 2.5.
- Security lighting during night time totals 40 kW
- Day time operating hours 2,500 per annum
- Night time operating hours 4,200 per annum

Compute the followings

i) Average cooling load due to external factor (kW)
ii) Average cooling load of the building (kW)
iii) Average electrical power for day time (kW)
iv) Average electrical power for night time (kW)
v) Annual energy consumption ($kWhm^{-2}Yr^{-1}$)


SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = h / W
PSYCHROMETRIC CHART
Normal Temperature
SI Units
SEA LEVEL
BAROMETRIC PRESSURE: 101.325 kPa
SENSIBLE HEAT RATIO = Qs / Qt
ENTHALPY - KJ PER KILOGRAM OF DRY AIR
DEW POINT TEMPERATURE - °C
VAPOR PRESSURE - MM OF MERCURY
SENSIBLE HEAT RATIO = Qs / Qt
ENTHALPY - KJ PER KILOGRAM OF DRY AIR
10% RELATIVE HUMIDITY
80% RELATIVE HUMIDITY
CUBIC METER PER KILOGRAM DRY AIR
Chart by: HANDS DOWN SOFTWARE, www.handsdownsoftware.com