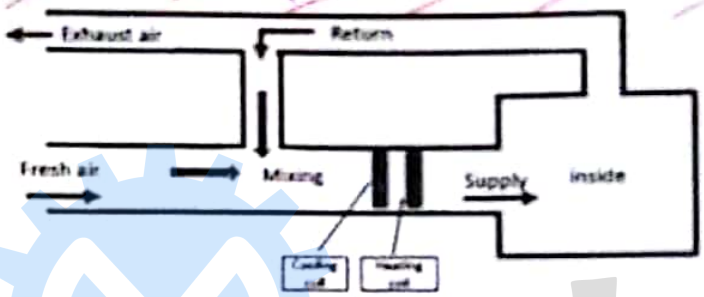
ME 0934445: HVAC		الاسم:
Mid exam, 2nd semester, 10/4/2017 Dr. Osama Ayadi	A	الرقم التسلسلي: 12 الرقم الجامعي: 0125371

Question 1 SHOW YOUR SOLUTION AND (Write the symbol of the correct answer) [25points]

1	2	3	4	5	6	7	8	9	10
d	b	c	a	d	c	c	b	b	b



1. A 100 m² auditorium is to ventilated, the required ventilation air volume flow rate is:
   a. 100 l/s b. 150 l/s c. 800 l/s d. 1200 l/s

$\dot{V} = 8\ l/s/person \times 150\ person = 1200\ l/s$

2. Two air streams are mixed adiabatically, the first is the return from the space at 22 °C and 50% RH, the second is fresh air at 35 °C and 40 % RH, if the ratio of the mass flow rates is 4:1 respectively, then the enthalpy of the mixture is:
   a. 66 kJ/kg b. 49 kJ/kg c. 57 kJ/kg d. 71 kJ/kg

Let $\dot{m}_1 = 1$, $\dot{m}_1 = 0.8$, $\dot{m}_2 = 0.2$

$0.8 h_1 + 0.2 h_2 = h_3$

$\Rightarrow h_2 = 49.8\ kJ/kg$

3. 1 m³/s of outside air is saturated at 2 °C is heated in a heating and humidification device to 25 °C and 40% RH. Calculate the mass of water vapor that must be added per second.
   a. 2.5 g/s b. 25 g/s c. 4.5 g/s d. 45 g/s

$\dot{m}_w = \dot{m}_a(\omega_2 - \omega_1)$

$= 4.58\ g/s$

$\omega_1 = 0.0044\ kg/kg$

$\omega_2 = 0.008\ kg/kg$

4. A cooling coil of a fresh Air Handling Unit is supplied with a chilled water flowing at 1.5 kg/s, and a fresh air entering at 1000 l/s and 35 °C and 40% RH and exiting at 22 °C at 50 %, the total capacity of the cooling coil is:
   a. 32 kW b. 13 kW c. 14.6 kW d. 42.75 kW

$\dot{V} = 1\ m^3/s$, $T_o = 35$, $\phi_o = 40$, $v_o = 0.89\ m^3/kg$

$T_i = 22$, $\phi = 50$, $h_i = 43.5$

$\dot{m} = \frac{1}{0.89} = 1.123\ kg/s$

$\dot{Q} = \dot{m}(h_o - h) = 32.5\ kW$

$\omega_1 = 0.0119$ kg/kg dry air ↑ $\omega_2 = 0.007$ ↑

5. 2 kg/s of mixing air at 28 °C and 50% RH is cooled and dehumidified to 12 °C and 80% RH. The mass of water condensing each hour is:

a. 1.8 kg/h b. 3.6 kg/h c. 18 kg/h d. 36 kg/h

$\dot{m}_\omega = \dot{m}_a(\omega_1 - \omega_2) = 35.28$ kg/h.
$* 3600$

6. 500 l/s of cold air at 5 °C, 50% RH is sensibly heated up to 30 °C by a heating coil receiving hot water from the boiler at 85 °C and return it at 75 °C, the mass flow rate of the necessary hot water in the hot coil is:

0.5 m³/s. $\rho_a = 0.79$ $\dot{m} = \frac{0.5}{0.79} = 0.63$ kg/s

a. 0.63 kg/s b. 1.26 kg/s c. 3.7 kg/s d. 7.4 kg/s

$\dot{Q} = \dot{m} c_p \Delta T = 0.63 * 1 * (30-5) = 15.75$ kW

$15.75 = \dot{m}_h c_p (85-75) \Rightarrow \dot{m}_h = \frac{15.75}{10 \times 4.187} \rightarrow \dot{m}_h = 3.7$ kg/s

7. A basement house is located in the city of Irbid, it measures 9.7 m wide and 10 m long, 3 m height from the basement ceiling to the floor, 0.9 m of the walls is below grade. The inside design temperature is 22 °C, the outside design conditions to be obtained from table A-7.

$T_g = 11.8$ $U_g = 3.9$

The total heat loss rate from the basement floor:

a. 299.6 W b. 403 W c. 135 W d. 196 W

$Q_f = U_f A_f (T_i - T_g) = 134.5$ W

$A_f = 9.7 \times 10 = 97$ m²

$U_f = 0.136$

8. For the previous question, all walls are constructed with 20 cm concrete, and uninsulated, the heat loss rate from the below grade walls:

a. 268 W b. 553 W c. 351 W d. 821 W

U: 0.0 - 0.3 → 2.328; 0.3 - 0.6 → 1.261; 0.6 - 0.9 → 0.88

$A = 11.82$ m²

$\Rightarrow Q = (U_1 + U_2 + U_3) \times A \times \Delta T = 552$

9. 9. a business office is occupied by 15 persons doing very light work. The working hours are from 8:00 to 17:00. The total heat gain rate due to the occupants at the 15:00 hour:

a. 1000 W b. 1540 W c. 1725 W d. 1950 W

$n = 15$ CLF ≈ 0.825

$\dot{Q}_{occ} = n(\dot{q}_{sen} * CF + \dot{q}_{lat}) = 15((70 * 0.825) + 45) = 1541.5$ W

10. Five persons occupy an office with exterior door and windows on two sides of the office, the office has overall dimensions of 6m x 5m x 3m height, the inside and outside temperatures are 20 °C and 5 °C, respectively. The sensible heating load due to infiltration is:

a. 467 W b. 700 W c. 1350 W d. 2025 W

$n = 5$

$N = 1.5$.

$\dot{Q}_{s,f} = \frac{1250}{3600}(N * V_{room}) c_p (20-5) = 703$ W

$T_{dp} = 10^{\circ}C$

Question 2. (5 Points)

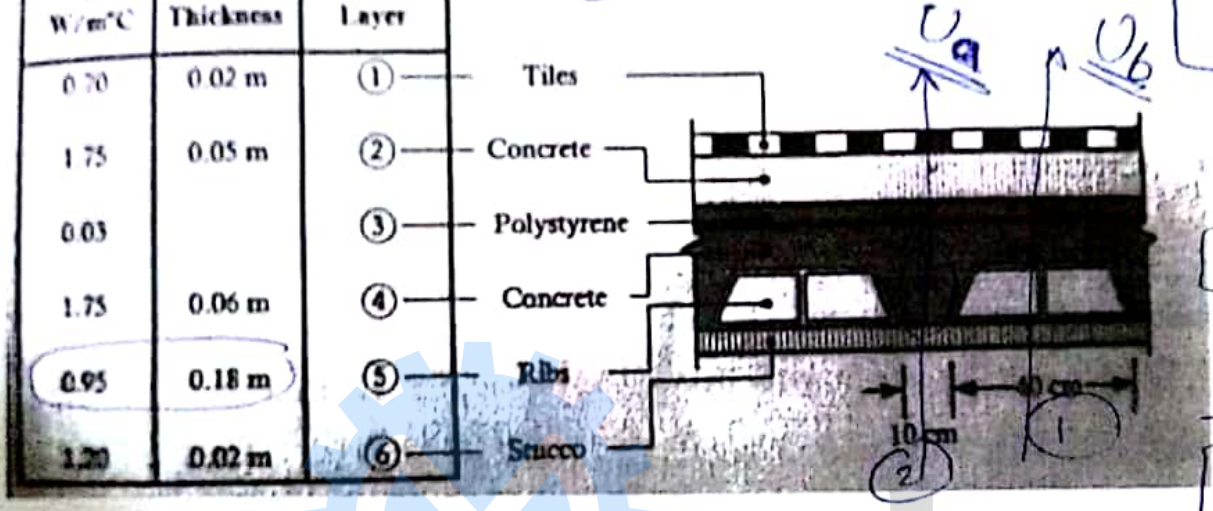
The ceiling construction of a house is as shown, the design inside and outside air temperatures are (21 °C, 50% RH) and 0 °C respectively, calculate the following:

$\begin{bmatrix} T_i = 21 \\ T_o = 0 \end{bmatrix}$ $\Delta T = 21$

$R_i = 0.1$

$R_o = 0.04$

k W/m°C	Thickness	Layer	
0.70	0.02 m	①	Tiles
1.75	0.05 m	②	Concrete
0.03		③	Polystyrene
1.75	0.06 m	④	Concrete
0.95	0.18 m	⑤	Ribs
1.20	0.02 m	⑥	Stucco



$a + b = 1$

$b = 4a$

$a = \frac{1}{5}$ $b = \frac{4}{5}$

$b = 0.4$ m

$a = 0.1$ m

$\frac{a}{b} = \frac{1}{4}$

a. The U value of the ceiling if there is NO insulation.

$U = \frac{1}{R_t} \Rightarrow R_{t_1} = 0.1 + 0.04 + \frac{0.02}{0.7} + \frac{0.05}{1.75} + \frac{0.06}{1.75} + \frac{0.18}{0.95} + \frac{0.}{1.}$

$R_{t_1} = 0.437$ m²·K/W $\Rightarrow$ $U_b = 2.285$ W/m²·K ✓

$U_c = U_b \cdot \frac{4}{5} + U_a \cdot \frac{1}{5}$

$= 2.398$ W/m²·K

$R_{t_2} = 0.1 + 0.04 + \frac{0.02}{1.2} + \frac{0.05}{1.75} + \frac{0.02}{1.2} + \frac{0.24}{1.75} = 0.35$ m²·K/W

$U_a = 2.85$ W/m²·K

b. Inner ceiling surface temperature, will condensation occur on the surface? Why?

$h_i = \frac{1}{0.1} = 10$ W/m²·C. $\frac{U_c}{h_i} = \frac{T_i - T_s}{T_i - T_o} \Rightarrow \frac{2.398}{10} = \frac{21 - }{21 -}$

$T_s = 15.96$ °C, No, because $T_s > T_{dp}$.

c. The insulation layer is increased to 10 cm.

$R_{t_1} = 0.437 + \frac{0.1}{0.03} = 3.77 \Rightarrow U_b = 0.265$ W/

$R_{t_2} = 0.35 + \frac{0.1}{0.03} = 3.68 \Rightarrow U_a = 0.271$ W/m²·K

$U_c = U_b \cdot \frac{4}{5} + U_a \cdot \frac{1}{5} =$ 0.2662 W/m²·K

d. Inner ceiling surface temperature, will condensation occur on the surface? Why?

$\frac{0.2662}{10} = \frac{21 - T_s}{21 - 0} \Rightarrow T_s = 20.44$ °C ✓

No, because $T_s > T_{db}$