

ME 491 THERMAL SYSTEMS DESIGN

Final Exam

ENG 1B77, December 12, 2002 (Time: 3 hours)

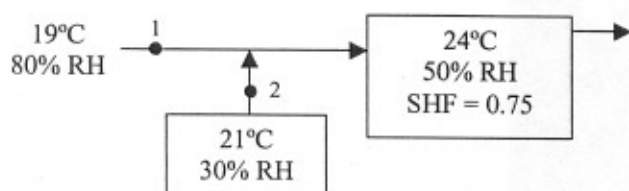
This is an **open book** exam (text, notes and any other relevant material are allowed). Answer **all 6 questions** using the attached psychrometric charts (sea level) as needed. State all **assumptions** and justify, where possible.

Reference all data used.

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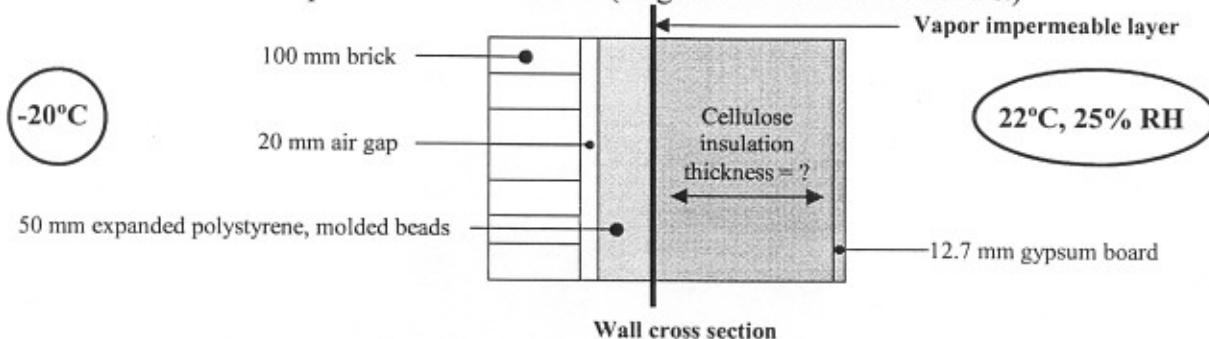
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1. To conserve energy, exhaust air from a cooler space in an office building is mixed with outdoor air to condition a warmer space. The cooler space is at 21°C and 30% RH and the warmer space is to be maintained at 24°C and 50% RH. The warmer space has a SHF of 0.75. (a) When the outdoor conditions are 19°C and 80% RH, what mixing ratio of outdoor air to exhaust air (\dot{m}_1 / \dot{m}_2) is required to maintain the space conditions? (b) What is the maximum cooling load that can be met under these conditions, if the exhaust rate from the cooler space (\dot{m}_2) is 1.5 kg/s?



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2. Commercial wooden buildings typically include a moisture impermeable membrane between the cavity insulation and an external insulation board as shown below. If the outdoor temperature is -20°C and the indoor conditions are 22°C and 25% RH, what is the maximum thickness of cellulose fiber insulation that can be used in the stud cavity of the wall without causing condensation on the impermeable membrane. (Neglect the effect of the studs.)



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3. You are part of the design team for a new building in Saskatoon that is will soon be constructed. The building owner has read a recent research paper that describes the advantages of natural daylighting and wants to increase the window area on the south side of the building without decreasing the window area on the other sides. Since the design and tendering process has advanced, it would be prohibitively expensive to choose cooling equipment with a greater cooling capacity to accommodate the new windows. The owner asks you to determine the maximum window area that could be used with the current cooling equipment. Based on your calculations, you determine that the maximum instantaneous transmitted solar heat gain from the windows must be less than 10 kW. During the original design, you calculated the maximum solar irradiation on the south windows to occur at 1:00 pm when the angle of incidence is 60°. The maximum direct solar irradiation (G_D) is 480 W/m² and the maximum diffuse solar

irradiation (G_d) is 65 W/m^2 . **(a)** What is the largest window area you can select, if the windows have a Shading Coefficient of 0.85? **(b)** If the owner wants 50% more window area than you calculate in (a), what would you recommend the owner do to keep the heat gain below 10 kW, but allow the greater window area?

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4. A new gambling casino is to be built in Saskatoon with a floor area of 800 m^2 and your company has been contracted to design the cooling system. Since the peak loads will occur in the evening, you have decided to neglect the heat gains through the building envelope (walls, windows, etc.). You also expect the equipment in the casino to generate 50 W/m^2 of sensible heat and 10 kW of latent heat. Determine the maximum space cooling load (not including ventilation) considering that the Casino is open from 6:00 pm to 12:00 am (midnight). The radiant time series factors for the casino are given below.

	r_0	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8
Non-solar	0.3	0.2	0.15	0.1	0.05	0.05	0.05	0.05	0.05
Solar	0.25	0.2	0.2	0.15	0.04	0.04	0.04	0.04	0.04

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1. You are selecting a cooling system for a large office building ($20,000 \text{ m}^2$) in Cleveland, Ohio with a 750 kW sensible and 250 kW latent design cooling load. You have the choice of 4 manufacturers that provide cooling equipment in increments of 10 tons (i.e., you can choose a 20 ton or 30 ton unit, but not a 25 ton unit) and provide different SHFs as shown in the following table. **(a)** Select a manufacturer and specify the size of the cooling equipment required for the office building with and without air-to-air energy recovery **(b)** Would you recommend the owner to install an air-to-air energy recovery system? Why or why not?

Manufacturer	A	B	C	D
SHF	0.4	0.5	0.6	0.7
Cost per ton	\$1,500	\$1,400	\$1,200	\$1,000

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2. Select and locate supply diffuser(s) and return grille(s) for an internal room in an office building that is supplied with a variable air volume system. The room has a total cooling load of 35 kW and a maximum airflow rate of 1000 L/s and a minimum airflow rate of 600 L/s.

