BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
Second Semester (2022-2023)

ME F461 Refrigeration and Air Conditioning
End-Semester Examination – Open Book

May 20, 2023 **Max Marks = 80 (40% weightage)** **Duration: 180 min**

***Instructions*:**
- *Answer all the questions sequentially. Clearly underline the final answer.*

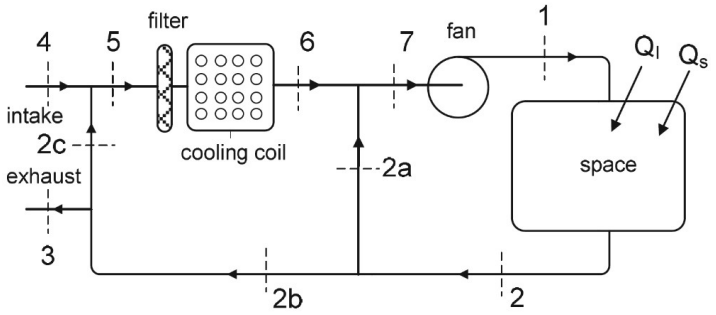
Comprehensive/Design Questions:

Q1. A R22 compressor with a bore of 0.1m and stroke of 0.08m runs at 750 rpm. The clearance volume is 0.04 and has 4 cylinders. It runs between the evaporator and condenser temperatures of -10°C and 45°C respectively working on a VCR cycle. The exit state of refrigerant from the compressor corresponds to a specific volume of specific volume of 0.0159 m^3/kg. Determine: **[15 M]**
(i) Index of compression and work of compression (kJ/kg).
(ii) Mass flow rate of the refrigerant R22 (kg/s)
(iii) Cooling load of the evaporator (kW)
(iv) COP of the CVR system.

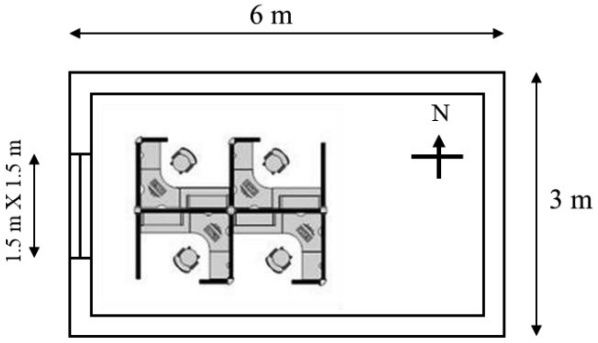
Saturation table for the R22:

T (°C)	P (bar)	v_g (m^3/kg)	h_f (kJ/kg)	h_g	s_g (kJ/kgK)
-10	3.55	0.0654	34.25	247.37	0.9473
45	17.209	0.0133	101.76	261.95	0.8697

Q 2. An air conditioning system supplying air to a space with a sensible heat load of 14 kW and a latent heat load of 9 kW has a cooling coil and a bypass path as shown schematically in Fig. The dry bulb temperature of the space is maintained at 26°C. The dry air mass flow rate of supply air is 1.2kg/s. Outdoor ventilation air at 34°C dry bulb temperature and 50% relative humidity is introduced into the system with a dry air mass flow rate of 0.26 kg/s. The air leaving the cooling coil is fully saturated at a dry bulb temperature of 6°C. The pressure is constant at 101.3 kPa.
Determine: **[15 M]**
(i) RSHF
(ii) Dry bulb temperature and relative humidity of the supply air to the space.
(iii) Wet bulb temperature of the space.
(iv) Temperature of the air entering the cooling coil.
(v) Refrigeration capacity of the cooling coil.



Q 3. An air conditioned office room that stands on a well ventilated basement measures 3 m wide, 3 m high and 6 m deep (as shown in Fig.) located at 32° N latitude. The walls are of D type and one of the two 3 m walls faces west and contains a double glazed glass window of size 1.5 m by 1.5 m, mounted flush with the wall with no external shading. There are no heat



gains through the walls other than the one facing west. Evaluate the following for the month of June at a solar time of 16 h. Some of the design data are given below and also refer to tables 1 and 2 for the CLTD and SHGF information.

(a) Evaluate Heat transfer rate through the walls, roof, floor, glass (in W)
(b) Evaluate the heat transfer through the infiltration (sensible and latent in W)
(c) Internal load due to occupants (sensible and latent in W)
(d) Load due to lighting and appliances (in W)
(e) Calculate the total sensible, total latent and total heat gains (i.e. required cooling capacity) on the room
(f) Evaluate the room sensible heat factor (RSHF) for the above data.from the following information for the month of June at a solar time of 16 h. What is the required cooling capacity?

[24 M]

- Inside conditions: 25^{o}C dry bulb, 50 percent RH
- Outside conditions: 43^{o}C dry bulb, 24^{o}C wet bulb
- U-value for wall: 1.78 W/m^{2}.K
- U-value for roof: 1.316 W/m^{2}.K
- U-value for floor: 1.2 W/m^{2}.K
- U-value for glass: 3.12 W/m^{2}.K
- Cooling Load Temperature Difference (CLTD) for roof: 30^{o}C
- Internal Shading Coefficient (SC) of glass: 0.86
- Occupancy: 4 (90 W sensible heat/person) and (40 W latent heat/person)
- Lighting load: 33 W/m^{2} of floor area
- Appliance load: 600 W (Sensible) + 300 W(latent)
- Infiltration: 0.5 Air Changes per Hour
- Barometric pressure: 101 kPa

Short answer/ Conceptual questions

Q 4. Calculate the direct solar radiation incident on a south facing vertical surface at solar noon on June 21st. Given that declination is 23.5^{o} on June 21st and latitude is 23^{o}. Use ASHRAE clear sky model. **[6 M]**

Q 5. Explain the Bubble Point Curve, Dew Point Curve and Glide Temperature for refrigerant mixtures with the help of temperature composition diagram. Sketch and represent the basic VARS system on a Dühring (P-T) plot**.** **[6 M]**

Q 6. Explain what is Dry Air Rated Temperature (DART). Show the variation of DART with aircraft speed for various air craft refrigeration cycles. Suggest your recommendations of various refrigeration cycle based on the above characteristic DART variation. **[7 M]**

Q 7. Distinguish between flooded and dry evaporator. Float Valve as an expansion device would be preferred with which of the above type of evaporator and why? **[7 M]**

Data tables:

Solar Time,h	Orientation							
	N	NE	E	SE	S	SW	W	NW
7	3	4	5	5	4	6	7	6
8	3	4	5	5	4	5	6	5
9	3	6	7	5	3	5	5	4
10	3	8	10	7	3	4	5	4
11	4	10	13	10	4	4	5	4
12	4	11	15	12	5	5	5	4
13	5	12	17	14	7	6	6	5
14	6	13	18	16	9	7	6	6
15	6	13	18	17	11	9	8	7
16	7	13	18	18	13	12	10	8
17	8	14	18	18	15	15	13	10
18	9	14	18	18	16	18	17	12
19	10	14	17	17	16	20	20	15
20	11	13	17	17	16	21	22	17
$CLTD_{max}$	11	14	18	18	16	21	23	18

Table 1: CLTD values (in K) for a D type wall (source: ASHRAE)

Month	Orientation of the surface					
	N/shade	NE/NW	E/W	SE/SW	S	Horizontal
December	69	69	510	775	795	500
Jan, Nov	75	90	550	785	775	555
Feb, Oct	85	205	645	780	700	685
Mar, Sept	100	330	695	700	545	780
April, Aug	115	450	700	580	355	845
May, July	120	530	685	480	230	865
June	140	555	675	440	190	870

Table 2: SHGF for sunlight glass located at 32^{o} N latitude (source: ASHRAE)

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