



**School of RAC Skills**

**Session: 2020-21 (Winter Semester)**

**B. Voc. 5th Semester**

**End-Sem. Examination**

**Course Code: HVA1501**

**Time: 2 Hours**

**Course Name: Heat Load Estimation**

**Max. Marks: 50**

**Instruction: Attempt all questions**

Calculator is allowed

**SET-A**  
**Section – A**

10X01 = 10 Marks

1. Which of the following is not a requirement for vapor barrier?  
a) Durability b) Strength c) Rigidity d) None of the above
  
2. The stack effect is caused by relative \_\_\_\_\_ of warmer air  
a) Temperature  
b) Buoyancy  
c) Humidity  
d) None of the above
  
3. The rated motor horsepower is multiplied by \_\_\_\_\_ to convert units to Btu/h.  
a) 2225  
b) 2125  
c) 2545  
d) 2625
  
4. Which of the following is not a part of building envelope?  
a) Floor  
b) Foundation  
c) Roof  
d) Pipes
  
5. Which of the following is not a heat gain source?  
a) Transmission  
b) Air leakage  
c) Equipment  
d) Pressure
  
6. The lighting use factor ( $F_{ul}$ ) is the ratio of the wattage actually in use at the time that the load estimate is being made to the total \_\_\_\_\_ wattage.  
a) Installed b) Consumed c) Overall d) all of the above.
  
7. Surfaces for which the properties are effectively independent of the wavelength are referred to as:  
a) Grey Surfaces  
b) Diffuse Surfaces  
c) Spectral surfaces  
d) None of the above
  
8. Average fan efficiency is about:  
a) 35% b) 40% c) 65% d) 90%
  
9. Which of the following causes both sensible and latent heat gain?  
a) Equipment  
b) Motors  
c) People  
d) Appliances
  
10. CTS stands for:  
a) Conduction Time Series  
b) Convection Time Series



- c) Commercial time series
- d) none of the above

**Section – B**

04X04 = 16 Marks

1. What are the different types of heat gains?
2. What is a thermal envelope for a building?
3. What are the different properties of radiation?
4. What are the few factors that are of utmost importance while calculating heat load?

**Section – C**

04X06 = 24 Marks

1. A 120 seat school band room is used continuously from 9:00 am until 5:00pm each day. For the first four hours, it is at 50% capacity; during the last two hours, it is at 80% capacity. Estimate the sensible heat gain from people at 12 pm, 2:00 pm, 4:00 pm and 6:00 pm.
2. What are conductive gains from opaque surfaces?
3. How is the U value for a wall is calculated?
4. What is effective leakage area method?

**Cooling Load Factors for People and Unhooded Equipment<sup>1</sup>**

Hours in Space	Number of Hours after Entry into Space or Equipment Turned On																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
<b>Zone Type A</b>																									
2	0.75	0.88	0.18	0.08	0.04	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.75	0.88	0.93	0.95	0.22	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.75	0.88	0.93	0.95	0.97	0.97	0.97	0.98	0.98	0.24	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00
8	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.25	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01
10	0.75	0.88	0.93	0.95	0.97	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.25	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01
12	0.75	0.88	0.93	0.95	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	0.25	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01
14	0.76	0.88	0.93	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.02	0.02	0.01	0.01	0.01
16	0.76	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.02	0.01	0.01	0.01
18	0.77	0.89	0.94	0.96	0.97	0.98	0.98	0.99	0.99	0.99	1.00	1.00	1.00	1.00	1.00	1.00	0.25	0.12	0.07	0.05	0.03	0.02	0.01	0.01	0.01
<b>Zone Type B</b>																									
2	0.65	0.74	0.16	0.11	0.08	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.65	0.75	0.81	0.85	0.83	0.17	0.13	0.10	0.07	0.06	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
6	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.31	0.22	0.17	0.13	0.10	0.08	0.06	0.05	0.04	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01
8	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.96	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
10	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.96	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
12	0.66	0.76	0.81	0.86	0.89	0.92	0.94	0.95	0.96	0.97	0.98	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
14	0.67	0.76	0.82	0.86	0.89	0.92	0.94	0.95	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
16	0.69	0.78	0.83	0.87	0.90	0.92	0.94	0.95	0.96	0.97	0.98	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
18	0.71	0.80	0.85	0.88	0.91	0.93	0.95	0.96	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.35	0.25	0.19	0.15	0.11	0.09	0.07
<b>Zone Type C</b>																									
2	0.60	0.68	0.14	0.11	0.09	0.07	0.06	0.05	0.04	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
4	0.60	0.68	0.74	0.79	0.23	0.18	0.14	0.12	0.10	0.08	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
6	0.61	0.69	0.74	0.79	0.83	0.86	0.89	0.91	0.32	0.26	0.21	0.17	0.14	0.11	0.09	0.08	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.01	0.01
8	0.61	0.69	0.75	0.79	0.83	0.86	0.89	0.91	0.92	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
10	0.62	0.70	0.75	0.80	0.83	0.86	0.89	0.91	0.92	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
12	0.63	0.71	0.76	0.81	0.84	0.87	0.89	0.91	0.92	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
14	0.65	0.72	0.77	0.82	0.85	0.88	0.90	0.92	0.93	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
16	0.68	0.74	0.79	0.83	0.86	0.89	0.91	0.92	0.94	0.95	0.96	0.96	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
18	0.72	0.78	0.82	0.85	0.88	0.90	0.92	0.93	0.94	0.95	0.96	0.97	0.97	0.98	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
<b>Zone Type D</b>																									
2	0.59	0.67	0.13	0.09	0.08	0.06	0.05	0.05	0.04	0.04	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
4	0.60	0.67	0.72	0.76	0.20	0.16	0.13	0.11	0.10	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.01	0.01
6	0.61	0.68	0.73	0.77	0.80	0.83	0.85	0.87	0.30	0.24	0.20	0.17	0.15	0.13	0.11	0.09	0.08	0.07	0.06	0.05	0.05	0.04	0.03	0.03	0.03
8	0.62	0.69	0.74	0.77	0.80	0.83	0.85	0.88	0.89	0.91	0.92	0.93	0.94	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
10	0.63	0.70	0.75	0.78	0.81	0.84	0.86	0.88	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
12	0.65	0.71	0.76	0.79	0.82	0.84	0.87	0.88	0.90	0.91	0.92	0.93	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
14	0.67	0.73	0.78	0.81	0.83	0.86	0.88	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
16	0.70	0.76	0.80	0.83	0.85	0.87	0.89	0.90	0.92	0.93	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
18	0.74	0.80	0.83	0.85	0.87	0.89	0.91	0.92	0.93	0.94	0.95	0.95	0.96	0.97	0.97	0.97	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98

**Heat Gain From Occupants of Conditioned Spaces<sup>1</sup>**

Degree of Activity		Total Heat, Btu/h		Sensible Heat, Btu/h	Latent Heat, Btu/h	% Sensible Heat that is Radiant <sup>b</sup>	
		Adult Male	Adjusted, M/F <sup>a</sup>			Low V	High V
Seated at theater	Theater, matinee	390	330	225	105		
Seated at theater, night	Theater, night	390	350	245	105	60	27
Seated, very light work	Offices, hotels, apartments	450	400	245	155		
Moderately active office work	Offices, hotels, apartments	475	450	250	200		
Standing, light work; walking	Department store; retail store	550	450	250	200	58	38
Walking, standing	Drug store, bank	550	500	250	250		
Sedentary work	Restaurant <sup>c</sup>	490	550	275	275		
Light bench work	Factory	800	750	275	475		
Moderate dancing	Dance hall	900	850	305	545	49	35
Walking 3 mph; light machine work	Factory	1000	1000	375	625		
Bowling <sup>d</sup>	Bowling alley	1500	1450	580	870		
Heavy work	Factory	1500	1450	580	870	54	19
Heavy machine work; lifting	Factory	1600	1600	635	965		
Athletics	Gymnasium	2000	1800	710	1090		

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School of RAC Skills  
Session: 2020-21 (Winter Semester)  
B. Voc. 5th Semester  
End-Sem. Examination

*Answer key*

Course Code: HVA1501  
Course Name: Heat Load Estimation  
Instruction: Attempt all questions  
Calculator is allowed

Time: 2 Hours  
Max. Marks: 50

SET-A  
Section – A

10X01 = 10 Marks

1. D
2. B
3. C
4. D
5. D
6. A
7. A
8. C
9. C
10. A

Section – B

04X04 = 16 Marks

1. Transmission
  - Internal gains
  - Solar gains
  - Air leakage
2. Separates interior and exterior of a building
  - Floor
  - Foundation
  - Walls
  - Ceiling
  - Roof
  - Components that penetrate the building
    - Windows
    - Doors
    - Vents
    - Electrical Boxes
    - Pipes
3. Properties of interest include the following:
  - Absorptance,  $\alpha$  the ratio of radiation absorbed by a surface to that incident on the surface.



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- Emittance,  $\epsilon$ , the ratio of radiation emitted by a surface to that emitted by an ideal "black" surface at the same temperature
- Reflectance,  $\rho$ , the ratio of radiation reflected by a surface to that incident on the surface
- Transmittance,  $\tau$ , the ratio of radiation transmitted by a translucent surface to that incident on the surface

4. While calculating the heat load for a building, first the direction and location of the building is considered. After that the ventilation rates of the people living in the building are calculated. Then solar gain through walls and windows is calculated and sensible heat is found out.

## Section – C

04X06 = 24 Marks

1. A Assuming the walls are concrete block with few windows and the floor is not carpeted, this could be a zone type C construction. The activity level might best be described as sedentary work, comparable to a restaurant. the total adjusted heat gain per person is 275 Btu/h sensible and 275 Btu/h latent. The CLF and sensible cooling loads are shown in

People	Heat Gain (each)	Hours/ Day	Start Time	CLF at			Cooling Load at		
				2:00	4:00	6:00	2:00	4:00	6:00
60	275	4	12:00	0.68	0.79	0.18	9350	10863	2475
36	275	2	2:00	0	0.68	0.11	0	5610	908
	275	(Latent)					13750	0	0
<b>Sensible Total, Btu/h</b>							9350	16473	3383
<b>Latent Total, Btu/h</b>							13750	0	0

thetable below. At 2:00 pm, there are 60 people in the room, with another 36 just entering. The energy the new class generates will not occur until 3:00 pm. Note that the latent load is always an instantaneous load.

2. Conductive heat gain is calculated for each wall and roof type with the use of a conduction time series (CTS). The 24 coefficients of the CTS are periodic response factors referred to as conduction time series factors (CTSFs). This formulation gives a time series solution to the transient, periodic, one-dimensional conductive heat transfer problem. For any hour, , the conductive heat gain for the surface is given by the summation of the CTSFs multiplied by the UA value multiplied by the temperature difference across the surface.

3. The U-factor is more commonly used to describe thermal conductivity in HVACR load calculations

A U-factor is assigned for a material of a given thickness



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For example 2" foam board has an u-factor of .1

The smaller the U-factor the lower the conductivity and the higher the R value The rate of heat loss via conduction for a given building panel is calculated by the

formula:  $Q = U\text{-factor} \times \text{Area} \times \Delta t$

Or just:  $Q = U \times A \times \Delta t$

In the previous problem  $Q = 0.2 \times 200 \times 60$

$Q = 2400 \text{ Btu/h}$

4. The second method to determine the rate of air infiltration is based on the effective leakage area of various construction components used in both residential and commercial buildings.

- To obtain the building's total leakage area, multiply the overall dimensions or number of occurrences of each building component by the Leakage related to them.
- Using the effective leakage area, the air flow rate due to infiltration is calculated according to:

where,

$$Q = L(A\Delta T + BV^2)^{0.5}$$

$Q$  = air flow rate, cfm

$L$  = effective leakage area, in.<sup>2</sup>

$A$  = stack effect coefficient, cfm<sup>2</sup>/(in.<sup>4</sup>·°F)

$\Delta T$  = average indoor-outdoor temperature difference, °F

$B$  = wind coefficient, cfm<sup>2</sup>/(in.<sup>4</sup>·mph<sup>2</sup>)

$V$  = average wind speed, mph

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**BHARTIYA SKILL DEVELOPMENT UNIVERSITY****School of Refrigeration & Air Conditioning Skills****Session: 2020-21 (Winter Semester)****B. Voc. Program, V Semester,****End-Sem. Examination**

Course Code: HVA1502

Time: **2 Hours**

Course Name: Cold Chain &amp; Cold Storage

Max. Marks: 50

SET-A

**Instruction:**

- All questions are compulsory.
- Section A is objective type.
- Section B is short answer type.
- Section C is long answer type.
- Scientific Calculator is allowed.

Section – A

10X01 = 10 Marks

- 1 Which of the following is true about fruits and vegetable processing?
  - a. They get spoil very fast and hence need to be consumed soon
  - b. They have high moisture content and should be kept in a cold, dark place
  - c. They're tender and hence get spoiled easily
  - d. All of the mentioned
  
2. Which of the following are Milk Processing Operations?
  - a. Clarification
  - b. Pasteurization
  - c. Homogenization
  - d. All of the mentioned
  
3. The horizontal line in psychrometric chart joining the change of state of air represents
  - a. humidification
  - b. sensible cooling or heating
  - c. sensible cooling or heating with humidification
  - d. sensible cooling or heating with dehumidification
  
4. Psychrometry is the study of-
  - a. moist air
  - b. stasis point
  - c. metrics in Canada
  - d. none of the above
  
5. The length of storage of fruits and vegetables is a function of \_\_\_\_\_
  - a. Resistance to attack by microorganisms
  - b. Composition
  - c. Gases in the environment
  - d. All of the mentioned

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6. Fats in frozen fish tissue tend to become rancid quicker than fats in frozen animal tissues.
  - a. True
  - b. False Provide customer satisfaction
  - c. Improve quality of a product
  - d. None of the above
7. Pork has a higher shelf life than beef.
  - a. True
  - b. False
  - c. Not Comparable
  - d. Services
8. Which of the following nutrients are lost in all steps of food engineering (including packaging and freezing)?
  - a. Minerals
  - b. Vitamins
  - c. Fats
  - d. Proteins
9. Evaporation, desiccation and dehydration all mean the same thing.
  - a. True
  - b. False
  - c. Both
  - d. None of the above
10. At 100% relative humidity, the wet bulb temperature is-
  - a. lower than the dew point temperature
  - b. higher than the dew point temperature
  - c. equal to the dew point temperature
  - d. none of the above

### Section – B

04X04 = 16 Marks

1. Explain postharvest physiology of fruits and vegetables through neat sketch.
2. Write down the importance of food preservation.
3. How multistage compressors are useful than single stage compressors?
4. Write a short note on cold store doors.

### Section – C

04X06 = 24 Marks

1. Write down the advantages of forced draft cooling towers.
2. Explain Drive-in drive-through pallet racking
3. What are the expansion devices? Explain the different types of it.
4. 39.6 m<sup>3</sup> /min of a mixture of re-circulated room air and outdoor air enters cooling coil at 31°C dry bulb temperature and 18.5°C wet bulb temperature. The effective surface temperature of the coil is 4.4°C. The surface area of the coil is such as would



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give 12.5 kW of refrigeration with the given entering air state. Determine the dry and wet bulb temperatures of the air leaving the coil and the by-pass factor.

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9/8/21





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School of Refrigeration & Air Conditioning Skills

Session: 2020-21 (Winter Semester)

B. Voc. Program, V Semester,

End-Sem. Examination

Course Code: HVA1502

Time: 2 Hours

Course Name: Cold Chain & Cold Storage

Max. Marks: 50

## ANSWER KEY -A

### Instruction:

- All questions are compulsory.
- Section A is objective type.
- Section B is short answer type.
- Section C is long answer type.

### Section – A

10X01 = 10 Marks

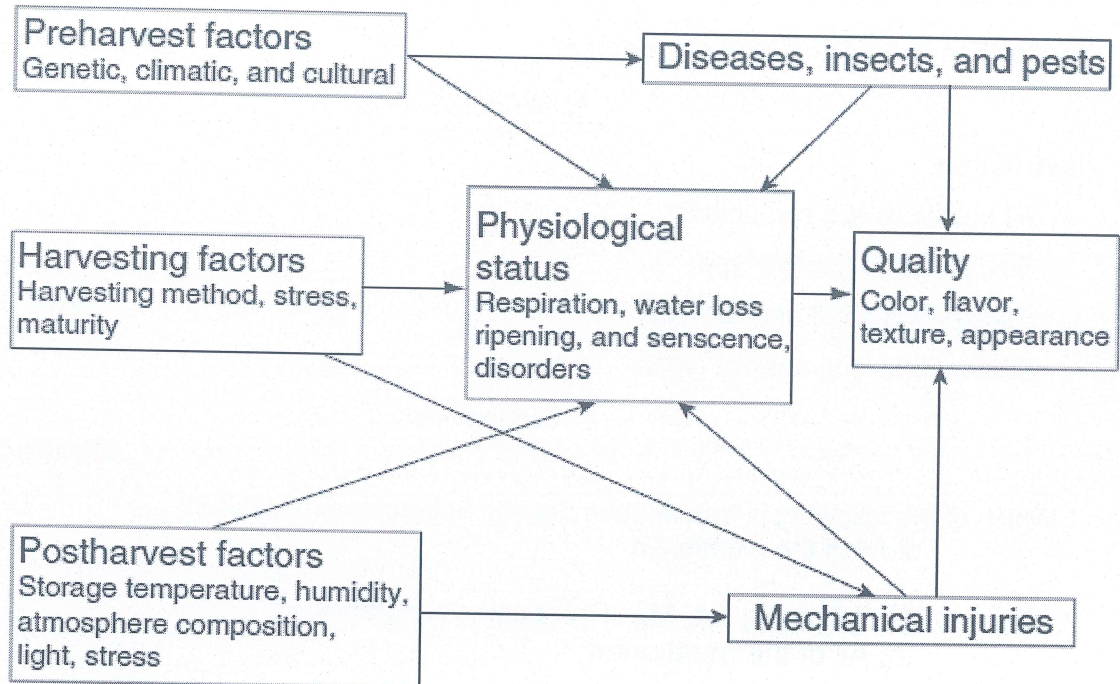
- 1 Which of the following is true about fruits and vegetable processing?  
d. All of the mentioned
2. Which of the following are Milk Processing Operations?  
d. All of the mentioned
3. The horizontal line in psychrometric chart joining the change of state of air represents  
b. sensible cooling or heating
4. Psychrometry is the study of-  
a. moist air
5. The length of storage of fruits and vegetables is a function of \_\_\_\_\_  
d. All of the mentioned
6. Fats in frozen fish tissue tend to become rancid quicker than fats in frozen animal tissues.  
a. True
7. Pork has a higher shelf life than beef.  
b. False
8. Which of the following nutrients are lost in all steps of food engineering (including packaging and freezing)?  
b. Vitamins
9. Evaporation, desiccation and dehydration all mean the same thing.  
b. False
10. At 100% relative humidity, the wet bulb temperature is-  
c. equal to the dew point temperature

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## Section – B

04X04 = 16 Marks

1. Explain postharvest physiology of fruits and vegetables through neat sketch.



2. Write down the importance of food preservation.

Answer: The main reasons for food preservation are to overcome inappropriate planning in agriculture, produce value-added products, and provide variation in diet. The agricultural industry produces raw food materials in different sectors. Inadequate management or improper planning in agricultural production can be overcome by avoiding inappropriate areas, times, and amounts of raw food materials as well as by increasing storage life using simple methods of preservation. Value-added food products can give better-quality foods in terms of improved nutritional, functional, convenience, and sensory properties. Consumer demand for healthier and more convenient foods also affects the way food is preserved. Eating should be pleasurable to the consumer, and not boring. particularly in underdeveloped countries to reduce reliance on a specific type of grain (i.e., rice or wheat).

3. How multistage compressors are useful than single stage compressors?

When the compression ratio required is considerably high, as in the case of low temperature refrigeration systems, the single-stage compression is highly uneconomical due to the following reasons.

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1. Very low volumetric efficiency
2. High frictional losses
3. Leakage problems
4. High running cost

In multistage compression, the compression of refrigerant from initial pressure to final pressure is carried out in more than one cylinder. A multistage compression with intermediate cooling is generally adopted for economical working.

#### 4. Write a short note on cold store doors.

When choosing a door system the following should be considered

- Is the track designed to give a good positive sealing action without undue wear to the sealing gaskets and will it be strong enough for its usage?
- Does it allow the door to be adjusted easily and accurately in all directions?
- Are the runners durable and will they allow free running?
- Will the handles, both inside and outside, allow easy opening of the door?
- Can the system be locked and does it have an emergency release facility?
- Do the moving parts require little maintenance and can they be easily replaced in the event of damage?

### Section – C

04X06 = 24 Marks

#### 1. Write down the advantages of forced draft cooling towers.

Answer:

1. Forced draft (FD) towers are more efficient than ID draft because some of the air velocity is converted into static pressure in the tower and recovered in the form of useful work.
2. The vibration and noise are minimal because mechanical equipment is set on solid foundations.
3. Because it handles dry air, problems of blade erosion are avoided.
4. It is safer because it is located on the ground level.

#### 2. Explain Drive-in drive-through pallet racking

Answer: This system uses a form of racking which allows each pallet to be supported individually but gives a similar cube utilization to block stacking. Drive-in dictates that the loads stored will be last in, first out (LIFO). Drive-through enables a first in, first out (FIFO) operation to take place. The system generally uses racking uprights fitted

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with pallet support rails cantilevered from the side of the uprights (Figure 9.11). These rails run from front to rear and form the required storage levels. The uprights are fixed to the floor and tied above the top pallet level. The structure is also braced above the top pallet level. Lanes are therefore formed down which a truck can be driven to access each level of pallets. All levels in each lane have to be filled or emptied at the same time, which, in turn, means that each lane must contain the same product. The difference between drive-in and drive-through is that with drive-in each block can only be accessed from one side, whereas drive-through can be accessed from both sides with no structural impediments in any of the lanes. As drive-through usually requires a higher level of strength to be derived from the steelwork above the top pallet, it is therefore less cost effective than drive-in. A simple solution is to place two drive-in installations back to back when access is required from both sides and FIFO is not important.

3. What are the expansion devices? Explain the different types of it.

An expansion device in a refrigeration system normally serves two purposes. One is the thermodynamic function of expanding the liquid refrigerant from the condenser pressure to the evaporator pressure. The other is the control function, which may involve supply of the liquid to the evaporator at the rate of which it is evaporated.

The different devices that are used to perform these functions include the following:

1. Capillary tube
2. Pressure control or automatic expansion valve
3. Thermostatic expansion valve
4. High-side float valve
5. Low-side float valve

4. 39.6 m<sup>3</sup> /min of a mixture of re-circulated room air and outdoor air enters cooling coil at 31°C dry bulb temperature and 18.5°C wet bulb temperature. The effective surface temperature of the coil is 4.4°C. The surface area of the coil is such as would give 12.5 kW of refrigeration with the given entering air state. Determine the dry and wet bulb temperatures of the air leaving the coil and the by-pass factor.

Solution: Given:  $v_1 = 39.6 \text{ m}^3 / \text{min}$ ;  $t_{d1} = 31^\circ\text{C}$ ;  $t_{w1} = 18.5^\circ\text{C}$ ;  $\text{ADP} = t_{d4} = 4.4^\circ\text{C}$ ;  $Q_c = 12.5 \text{ kW} = 12.5 \text{ kJ/s} = 12.5 \times 60 \text{ kJ/min}$

Dry and wet bulb temperature of the air leaving the coil Let  $t_{d2}$  and  $t_{w2}$  = Dry and wet bulb temperature of the air leaving the coil. First of all, mark the initial condition of air, i.e. 31°C

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dry bulb temperature and 18.5°C wet bulb temperature on the psychrometric chart at point 1, as shown in Fig. Now mark the effective surface temperature (ADP) of the coil at 4.4°C at point 4.

From the psychrometric chart, we find that enthalpy at point 1

$$h_1 = 52.5 \text{ kJ / kg of dry air}$$

Enthalpy at point 4,

$$h_4 = 17.7 \text{ kJ/kg of dry air}$$

Specific humidity at point 1

$$W_1 = 0.0082 \text{ kg / kg of dry air}$$

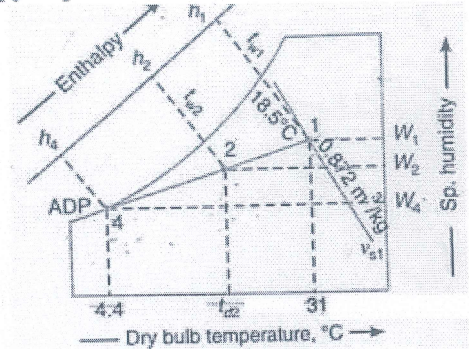
Specific humidity at point 4,

$$W_4 = 0.00525 \text{ kg / kg of dry air}$$

Specific volume at point

$$v_{s1} = 0.872 \text{ m}^3 / \text{kg}$$

We know that mass flow rate of dry air at point 1,



and cooling capacity of the coil,

$$m_a = \frac{v_1}{v_{s1}} = \frac{39.6}{0.872} = 44.41 \text{ kg/min}$$

or

$$h_1 - h_2 = \frac{Q}{m_a} = \frac{12.5 \times 60}{44.41} = 16.89 \text{ kJ / kg of dry air}$$

$\therefore h_2 = h_1 - 16.89 = 52.5 - 16.89 = 35.61 \text{ kJ / kg of dry air}$   
 The equation for the condition line 1-2-4 is given as

$$\frac{W_2 - W_4}{W_1 - W_4} = \frac{h_2 - h_4}{h_1 - h_4}$$

$$\frac{W_2 - 0.00525}{0.0082 - 0.00525} = \frac{35.61 - 17.7}{52.5 - 17.7}$$

$\therefore$

$$W_2 = 0.00677 \text{ kg / kg of dry air}$$

Now plot point 2 on the psychrometric chart such as enthalpy,  $h_2 = 35.61 \text{ kJ/kg}$  of dry air and specific humidity,  $W_2 = 0.00677 \text{ kg/kg}$  of dry air. At point 2, we find that

$$t_{d2} = 18.5^\circ\text{C}; \text{ and } t_{w2} = 12.5^\circ\text{C Ans.}$$

By-pass factor

We know that by-pass factor,

$$BPF = \frac{h_2 - h_4}{h_1 - h_4} = \frac{35.61 - 17.7}{52.5 - 17.7} = 0.5146 \text{ Ans.}$$





School of Refrigeration and Air-conditioning Skills

Session: 2020-21 (Winter Semester)

B. Voc. Program, 5<sup>th</sup> Semester,

End-Sem. Examination

SET - A

Course Code: HVA1503

Time: 2 Hour

Course Name: Chilled water supply system design

Max. Marks: 50

Section - A

10\*01 = 10 Marks

Note: Each question carries 01 mark.

Q. 1: The purge unit in a low-pressure chiller removes

- A. overcharge of refrigerant.
- B. excess oil.
- C. condensable refrigerant.
- D. non-condensable

Q. 2: The compressor used in low-pressure chillers is the

- A. Centrifugal
- B. Screw
- C. Rotary
- D. Reciprocating

Q. 3: When a chiller is used, the secondary refrigerant that circulates in the building is

- A. Air
- B. water
- C. barine
- D. glycol

Q. 4: A vapour absorption refrigeration system

- A. gives noisy operation
- B. gives quiet operation
- C. requires more power consumption
- D. have more wear and tear

Q. 5: In aqua-ammonia and Li-Br water absorption refrigeration system, the refrigerants are respectively

- A. water and water
- B. water and Li-Br
- C. ammonia and Li-Br
- D. ammonia and water

Q. 6: The commonly used refrigerant in ice plant is

- A. NH<sub>3</sub>
- B. CO<sub>2</sub>
- C. R-12
- D. none of these

Q. 7: Efficiency of Electric-drive air-cooled scroll chiller is

- A. 1.6
- B. 1.9



C. 3.25

D. 5.8

Q. 8: Chillers operate efficiently in range of

- A. 30% to 60% load
- C. 20% to 50% load

- B. 40% to 80% load
- D. 10% to 70% load

Q. 9: Pipe schedule 40 is used for

- A. Less than 18-inch pipe size
- C. Less than 10-inch pipe size

- B. Less than 20-inch pipe size
- D. Less than 14-inch pipe size

Q. 10: The wall thickness of copper tubing is indicated by

- A. Types K, L, and M
- C. Types J, K, and L

- B. Types A, B, and C
- D. Types D, E, and F

**Section – B**

04\*04 = 16 Marks

Note: Each question carries 04 mark.

Q. 1: Classified the HVAC chiller.

Q. 2: What are the differences between symmetrical and asymmetrical chiller?

Q. 3: Explain thermal energy storage system with classification.

Q. 4: Define the terms with respect to chiller:- off peak period, on peak period, charging and discharging.

**Section – C**

04\*06 = 24 Marks

Note: Each question carries 06 mark.

Q. 1: Explain the water-cooled HVAC system with neat sketch.

Q. 2: Explain primary and secondary parallel configuration with neat sketch.

Q. 3: Write down the various piping materials used in chiller plant.

Q. 4: Explain vapour absorption refrigeration cycle with neat sketch.

Shut  
Q



School of Refrigeration and Air-conditioning Skills

Session: 2020-21 (Winter Semester)

B. Voc. Program, 5<sup>th</sup> Semester,

End-Sem. Examination

Course Code: HVA 1503

Course Name: Chilled water supply system design

Time: 2 Hour

Max. Marks: 50

*Answer Key*

Section – A

10\*01 = 10 Marks

10 objective type questions, each question carries 01 mark.

- Q. 1: D
- Q. 2: A
- Q. 3: B
- Q. 4: B
- Q. 5: D
- Q. 6: A
- Q. 7: C
- Q. 8: B
- Q. 9: C
- Q. 10: A

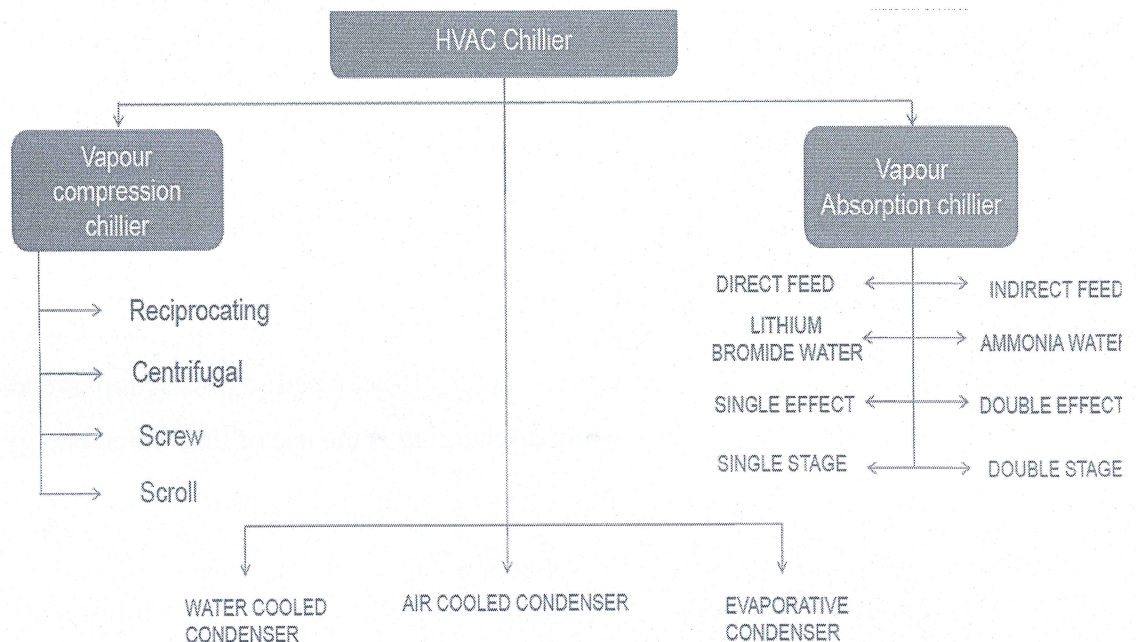
Section – B

4X4 = 16 Marks

4 short answer type questions, each question carries 04 marks.

Q. 1: Classified the HVAC chiller.

Ans.



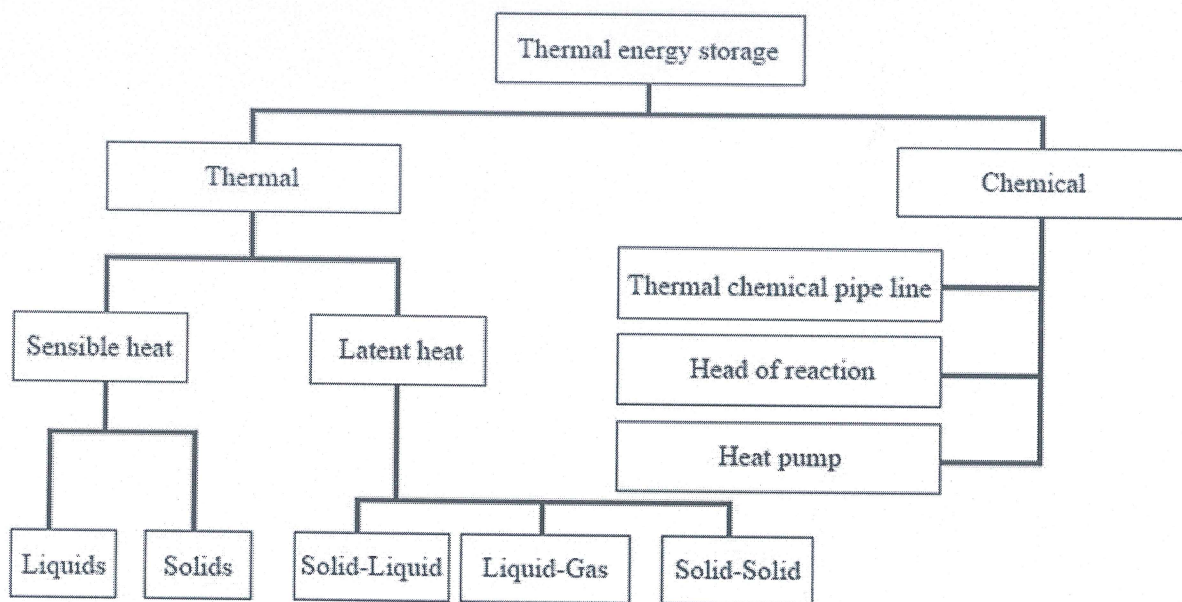
**Q. 2: What is the difference between symmetrical and asymmetrical chiller?**

**Ans.** Symmetrical chiller: With this approach, all of the chillers are sized for equal capacity. The number of chillers and, thus, the size of the chiller “module” are based on the minimum anticipated load.

Asymmetrical chiller: There is no engineering rule that says that all chillers in a multichiller system have to be of the same size. While there may be some maintenance advantages (common parts, etc.), different-sized chillers can be operated together.

**Q. 3: Explain thermal energy storage system with classification.**

**Ans.** Thermal energy storage (TES) allows the storage of heat and cold, which is used later. TES is also known as heat or cold storage. TES can aid in the efficient use and provision of thermal energy whenever there is a mismatch between energy generation and use. This mismatch can be in terms of time, temperature, power, or site. Different methods for TES are defined and discussed – sensible (air, water, and underground thermal energy storage) and latent (with phase change materials). Cool thermal energy storage (CTES) has recently attracted increasing interest in industrial refrigeration applications, such as process cooling, food preservation, and building air-conditioning systems.



**Q. 4: Define the terms with respect to chiller:- off peak period, on peak period, charging and discharging.**

**Ans.** Off peak period represent when the system is not in use while on peak period represent when system is working. Charging represents the off-peak period production of cooling energy by the chiller that is stored, while discharging is the use of that stored energy during the on-peak period.

**Section – C**

04X06 = 24 Marks

04 essay type questions, each question carries 06 marks.

**Q. 1: Explain the water-cooled HVAC system with neat sketch.**

**Ans.**

- Loop 1: Air system: Cold air is distributed by one or more air-handling units (AHUs) to the spaces within the building. The distributed air is returned to the air handling unit, mixed with the required quantity of outdoor air for ventilation.
- Loop 2: Chilled water system: The warmer-returned chilled water enters the water chiller where it is cooled to the desired chilled water supply temperature by transferring the heat extracted from the building spaces to a primary refrigerant.
- Loop 3: Condenser water system: The heat of compression must then be added to the heat load on the chilled water loop to establish the amount of heat that must be rejected by the condenser to a heat sink, typically the outdoor air.

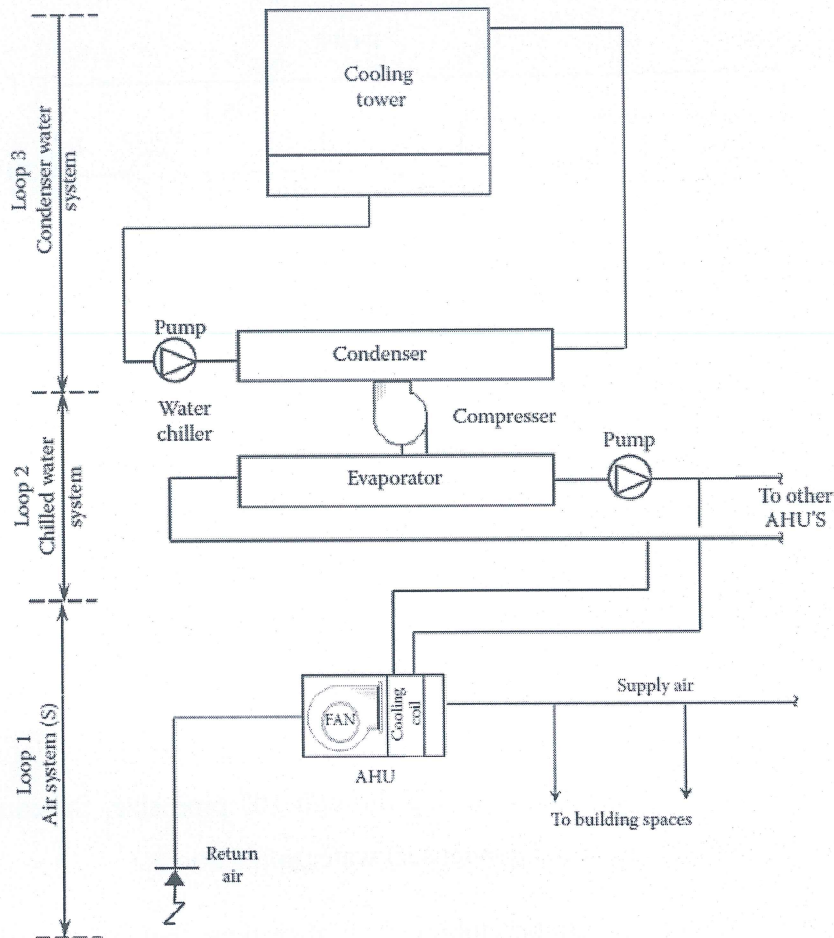
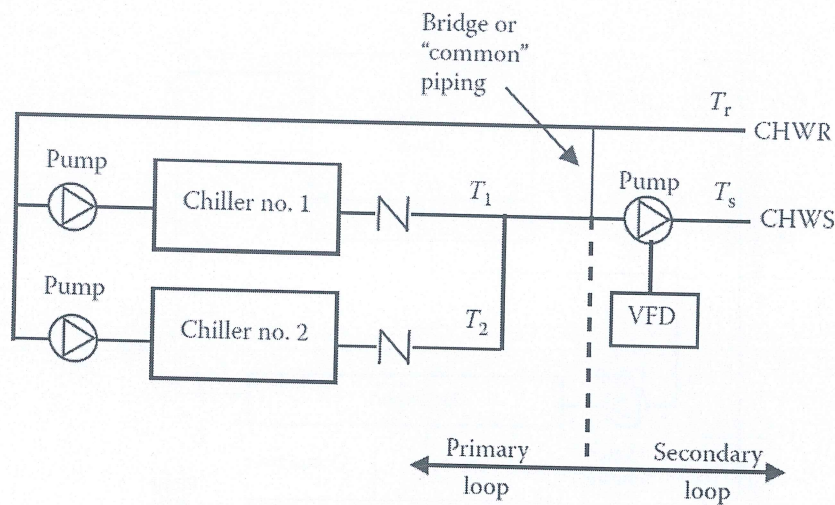


Fig. Water-cooled HVAC system

**Q. 2: Explain primary and secondary parallel configuration with neat sketch.**

**Ans.** In the primary–secondary variable flow piping arrangement, here, the production loop (primary loop) through the two chillers is hydraulically isolated from the distribution loop (secondary loop) by a piping bridge. The bridge is a short section of piping shared by both loops and designed to have little or no pressure drop. Thus, the flow in one loop is not affected by flow in the other. On the primary or production loop side, the system acts as multiple-pump parallel chiller installation, as described earlier. Flow in this loop varies in “steps” as the chillers are staged on or off and their respective pumps are started and stopped. However, in the secondary or distribution loop, the cooling coils utilize two-way control valves and the distribution pump(s) utilize a variable frequency drive(s) (VFD) so that the chilled water flow rate is modulated from 0% to 100% of peak design flow as a function of the imposed cooling load. Thus, this loop has fully variable flow, but maintains a constant temperature range.



**Q. 3: Write down the various piping materials used in chiller plant.**

**Ans.** Chilled water distribution systems are assembled from commercially available piping materials, most commonly steel and copper.

**Steel pipe:** This is the most common above-ground piping type and is defined by its wall thickness, called schedule, and its finish. Up through 10" pipe size, Schedule 40 piping is normally used for chilled water (and condenser) water applications.

**Copper tubing:** The cost of copper tubing is higher than that of a steel pipe, but the installation labor cost for smaller sizes, 2" and smaller, is much less than that of steel. Therefore, most designers will allow copper tubing to be used in water systems for these smaller sizes at the contractor's option.

The wall thickness of copper tubing is indicated by its *type*, defined as Types K, L, and M in decreasing order of wall thickness. Typically, Type K or L tubing can be used for chilled water piping, but Type M copper tubing is not rated as for pressure service and can be used only for drain lines or other atmospheric pressure applications.

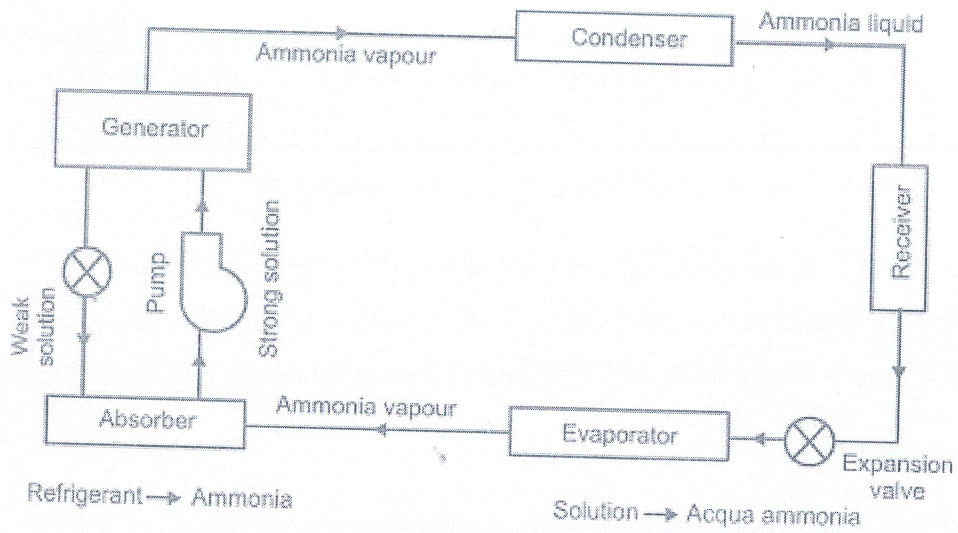
**PVC or CPVC:** As an alternative to iron piping for underground chilled water distribution, polyvinyl chloride (PVC) or chlorinated polyvinyl chloride (CPVC) piping can be used. PVC and CPVC piping wall thickness is defined in terms of schedules, much like steel pipe.

### Cast or ductile iron

- For underground piping, cast iron piping or ductile iron piping is routinely used.
- Iron piping is rated for application in terms of “pressure class”.
- for most chilled water systems, Class 350 is used up through 12" pipe size,
- Class 250 for 14–20" pipe, and
- Class 150 for piping 24" and larger.
- Fittings are cast gray or ductile iron and the fittings and piping are assembled with gasketed mechanical pressure joints.

### Q. 4: Explain vapour absorption refrigeration cycle with neat sketch.

**Ans.** In this system, the vapour refrigerant from the evaporator is drawn into an absorber where it is absorbed by weak solution of the refrigerant forming a strong solution. This strong solution is pumped to the generator where it is heated by some external source (waste heat or solar energy). During the heating process, the vapour refrigerant is driven off by the solution and enters into the condenser where it is liquified. The liquid refrigerant then flows into the evaporator and thus the cycle is completed. The vapour absorption system uses heat energy, instead of mechanical energy as in VCRC. In VARS, the compressor is replaced by an absorber, a pump, a generator and a pressure reducing valve. These components in VARS perform the same function as that of a compressor in VCRC system.



**Fig. Vapour absorption refrigeration system**

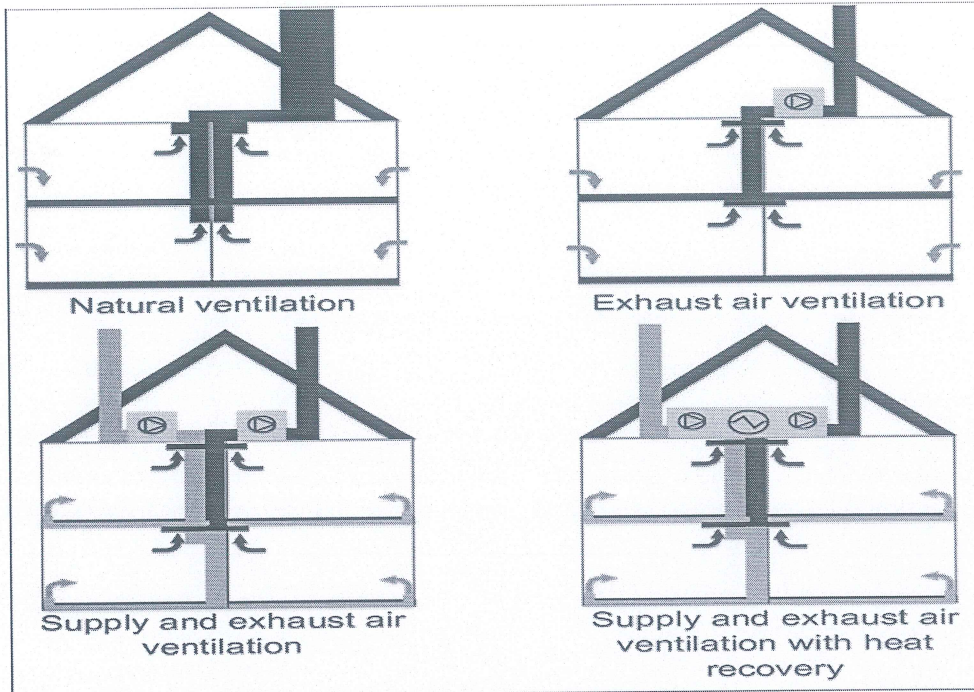
*Shruti*

➤ Forced ventilation.

1) positive pressure

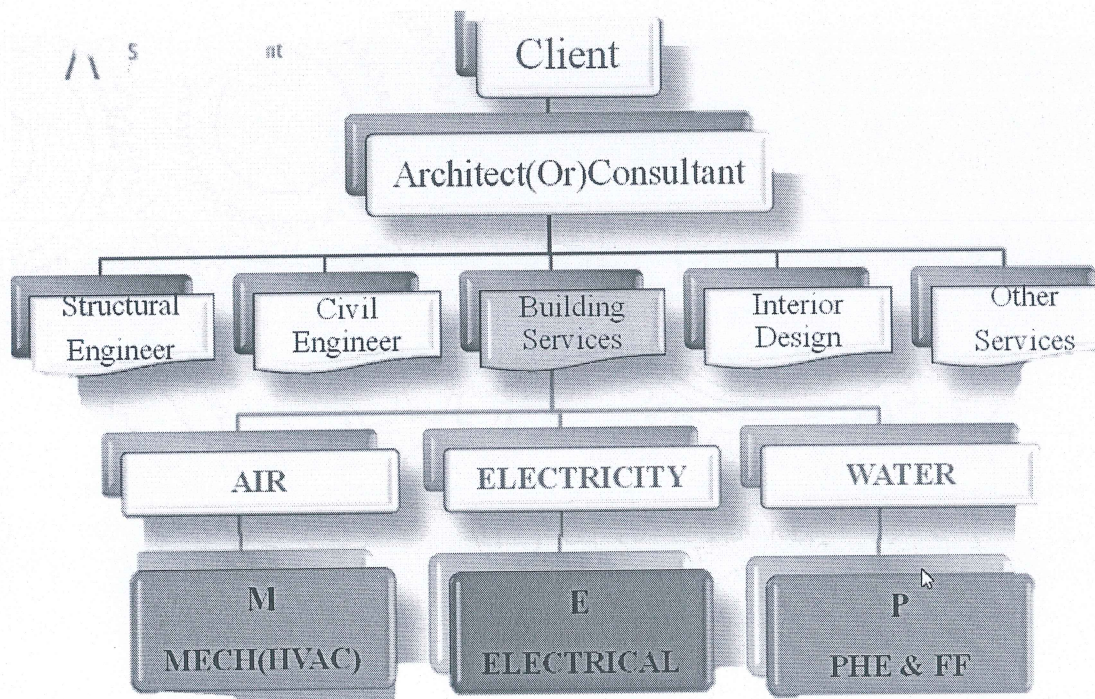
2) Horizontal Mechanical


3) Hydraulic



Q18. Draw the flow chart for building survey/Project?

18.



*hardik sharma*  






# BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

**School of Refrigeration & Air conditioning Skills**

**Session: 2020-21 (Winter Semester)**

**B. Voc. Program, 5th Semester,**

**End Sem. Examination**

**Set - A**

**Course Code: HVA1504**

**Course Name: AC system & Testing**

**Time: 2 Hour**

**Max. Marks: 50**

**Instruction:**

1. Read the question carefully.
2. Take given dimensions in Inches or convert them.

**Section – A**

**10X01 = 10 Marks**

Q1.) What is Nacph \_\_\_\_\_

- a) Number of air change per hour
- b) Number of volume change per hour
- c) Number of air distributed per hour
- d) None of the above

Q2) The condition of refrigerant after passing through the condenser in a vapor compression system is.

- a) Saturated liquid
- b) Saturated vapor
- c) Liquid + vapor
- d) All of the above

Q3) NBC Stands for

- a) National boiler codes
- b) National BIM Codes
- c) National bureau of standard
- d) National building codes

Q4) BIS-277 is for \_\_\_\_\_

- a) Sheet Metal Specification (GI).
- b) BIS-655 Sheet Metal Fabrication and Erection Installation (GI).
- c) Sheet Metal Work Safety Standards.
- d) Duct work

Q5. \_\_\_\_\_ Heat load calculation in excel is known as

- a) E-20 form
- b) B.O.Q
- c) R.F.I
- d) HLC HAP

Q6. \_\_\_\_\_ force is responsible for the body under rotation to be in circular motion

- a) Centrifugal
- b) Centripetal
- c) Rotational motion



d) Normal force

Q7. Chiller can be classified based on application as \_\_\_\_\_

- a) Process and Comfort Chiller
- b) Power Chiller
- c) Screw Chiller
- d) Absorption Chiller

Q8. compressor with screws are known as \_\_\_\_\_.

- a) Positive displacement
- b) Dynamic compressor
- c) Roto compressor
- d) Linear

Q9. GPM determines \_\_\_\_\_?

- a) Flow
- b) Flow rate
- c) Velocity
- d) Space

Q10. Fire dampers are certified by.

- a) Under writer's laboratory
- b) Din
- c) Space concern
- d) Volume

**Section – B**

04X04 = 16 Marks

Q11. How ducts are designed, Name the methods along with variable to control?

Q12. Name the types of fitting used in Central HVAC systems?

Q13. Using the continuity equation calculate the sizes of duct?  
whose area is.

- 1) 100 sq ft
- 2) 156 sq inches
- 3) 64 sq ft
- 4) 225 sq inches

Q14. What are the Types of compressors used in central plant (Chiller) with Neat and diagram?

**Section – C**

06X04 = 24 Marks

Q15. What are the Advantages of velocity design in a system and why it is typical?

Q16. Classify the duct based on

- a) Shapes
- b) Velocity with range

Q17. Calculate the required CFM and design the Duct for given building? Height to take 10.'

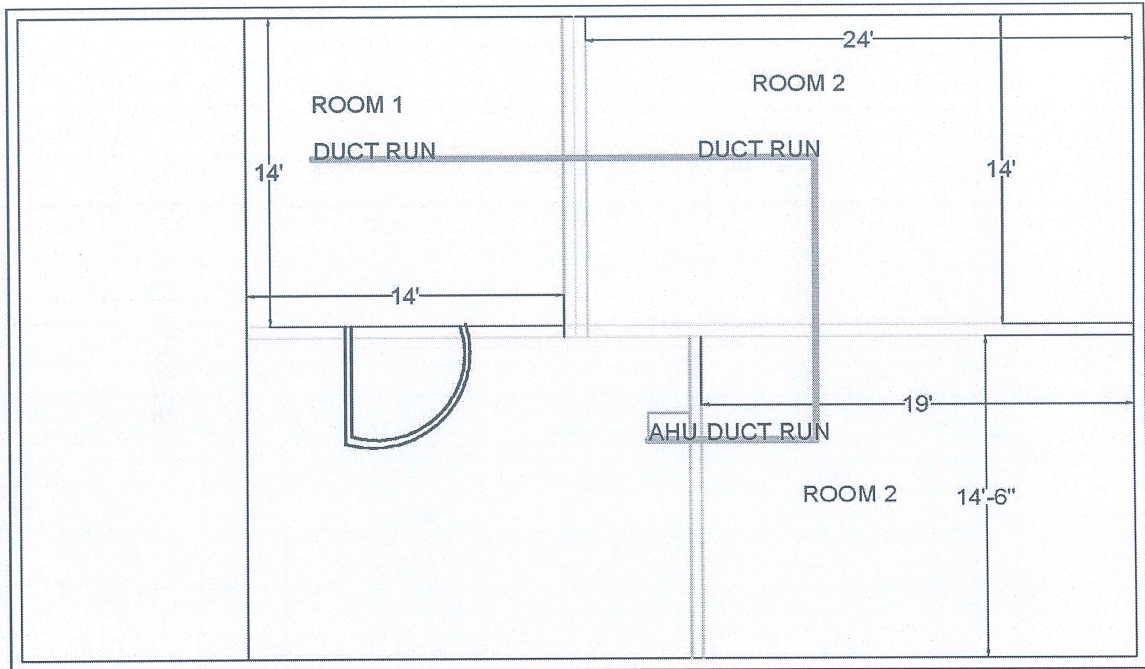
- 1) CFM of air required
- 2) Line diagram for duct design using EFM



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DUCT	CFM	VELOCITY	PRESSURE AT	Duct size D equivalent	Pipe sizes	GPM
Room 1		400	0.05"		3/4	
Room 2		450	0.05"		1/2	
Room 3		420	0.05"		1/2	

PRODUCED BY AN AUTODESK STUDENT VERSION



1. CALCULATE CFM FOR ROOM 1, 2 AND 3
2. WRITE DUCT DIMENSIONS
3. Make a table and fill in values for blanks

Q17. What are the types of Air Ventilation Explain with the help of A neat sketch?

Q18. Draw the flow chart for building survey/Project?

haroliksharna



Source : ASHRAE Handbook 2013

Figure 2.7 : Rigid Duct Design - Friction Chart  
Friction chart for Round Duct, Air Density = 0.075 lb/ft<sup>3</sup> and  $\epsilon = 0.0003$  ft.

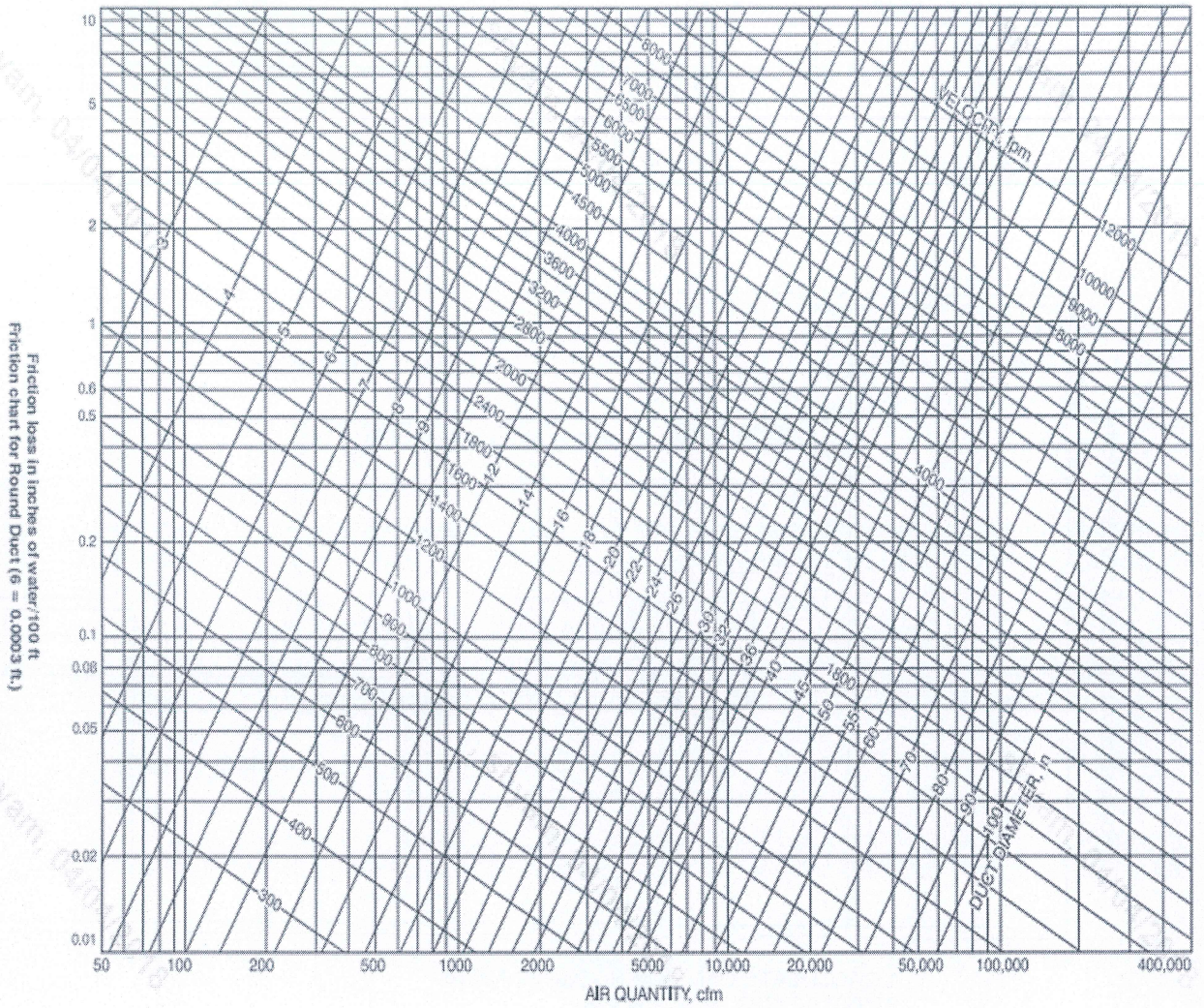
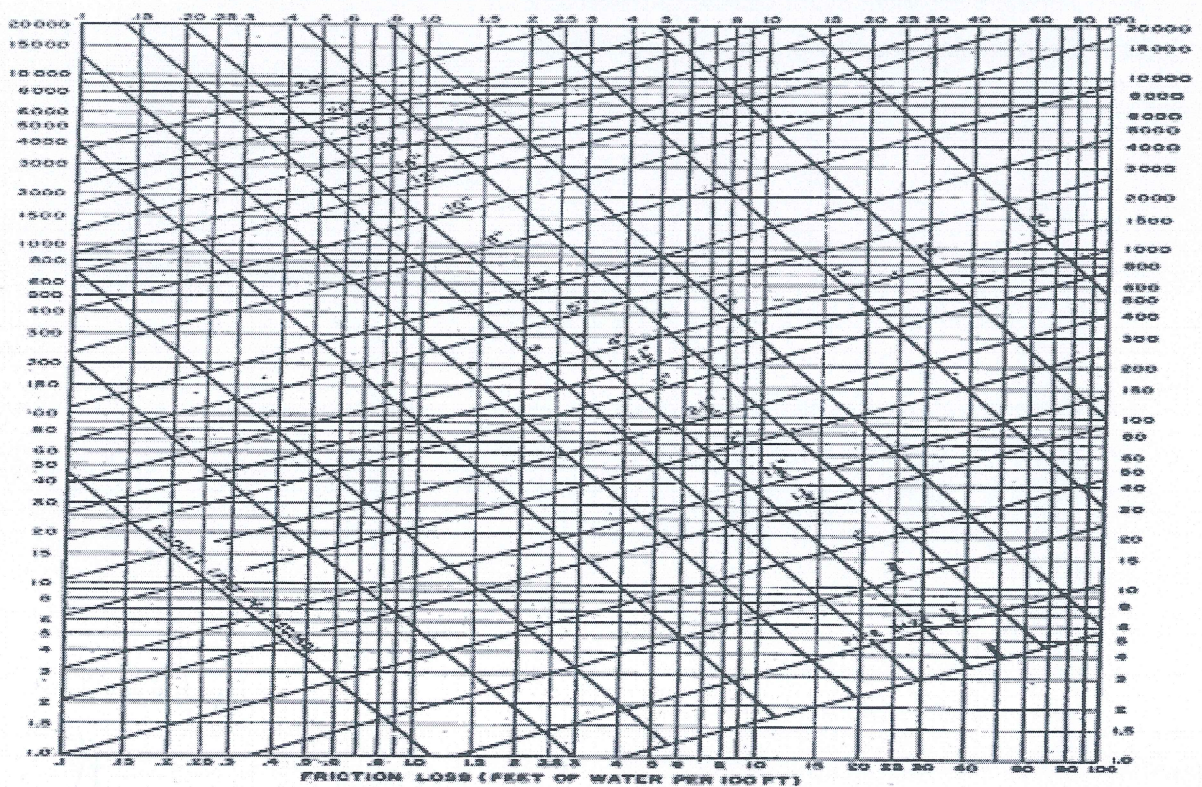


Chart 1 - Friction Loss for Closed Piping Systems (Water)  
Schedule 40 Pipe





# BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.....

School of Refrigeration & Air conditioning Skills

Session: 2020-21 (Winter Semester)

B. Voc. Program, V-Semester,

End Sem. Examination

SET - A

*Answer key*

Course Code:HVA1504

Course Name: AC system & Testing

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Time: 2 Hour

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- d)National building codes

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- a) Positive displacement

Q9. GPM determines \_\_\_\_\_?

- b)Flow rate

Q10. Fire dampers are certified by.

- a) Under writer's laboratory

Section – B

04X04 = 16 Marks

Q11. How ducts are designed, Name the methods along with variable to control?

A11. Duct shapes

1. Round-
2. Square-
3. Rectangle-
4. flat oval shape-

According to Duct velocity

1. Low – up to 1500 FPM
2. Medium -1500-2500 FPM
3. High 2500-4500 FPM

**Velocity reduction Method – Velocity**

**Equal friction method- Friction constant-**

**Static pressure regains- Static pressure of air to be constant**

Q12. Name the types of fitting used in Central HVAC systems?

A12.

1. Reducer
2. Enlarger
3. T-joint
4. Collar
5. Canvas
6. Flexible duct

Q13. Using the continuity equation calculate the sizes of duct?  
whose area is.

A13.

- 1) 100 sq.ft-10'\*10'
- 2) 156 sq. inches-(13'\*12') 14\*12
- 3) 64 sq. ft----(8\*8)
- 4) 225 sq. inches(15\*15)

Q14. What are the Types of compressors used in central plant (Chiller) with Neat and diagram?

#### A14. **Reciprocating Compressors**

Reciprocating compressors use a piston and cylinder to compress incoming refrigerant. As the piston moves downward, refrigerant is drawn into the cylinder. The piston then moves upwards compressing the refrigerant and discharging it downstream to the condenser.

Intake and exhaust valves ensure that the refrigerant does not flow backwards.

**Centrifugal Compressor** Rotary vane compressors typically are quieter than other options. They consist of vanes or blades that are attached to a core rotor. The rotor is positioned off-centre within its cylinder, creating multiple areas of varying sizes.

**Scroll** compressors work by compressing the refrigerant between two spiral plates, one stationary and one orbiting.



**Screw** Rotary screw compressors have two interlocking helical rotors mounted inside a casing. As the rotors turn, the gas is forced from the suction end of the casing to the discharge end. The available space between the rotors and the casing becomes increasingly smaller as the gas moves along the length of the screw, increasing the pressure.

## Section – C

06X04=24Marks

Q15. What are the Advantages of velocity design in a system and why it is typical?

A15. It helps us in following ways.

1. Reduce duct sizes.
2. Reduces fan operational cost.
3. Help us in optimizing the system.

Its is typical as to balance we need dampers and experienced skilled person for making a project to balance each duct is difficult .it requires manipulation of Standards and hit trial method for balancing

Q16. Classify the duct based on

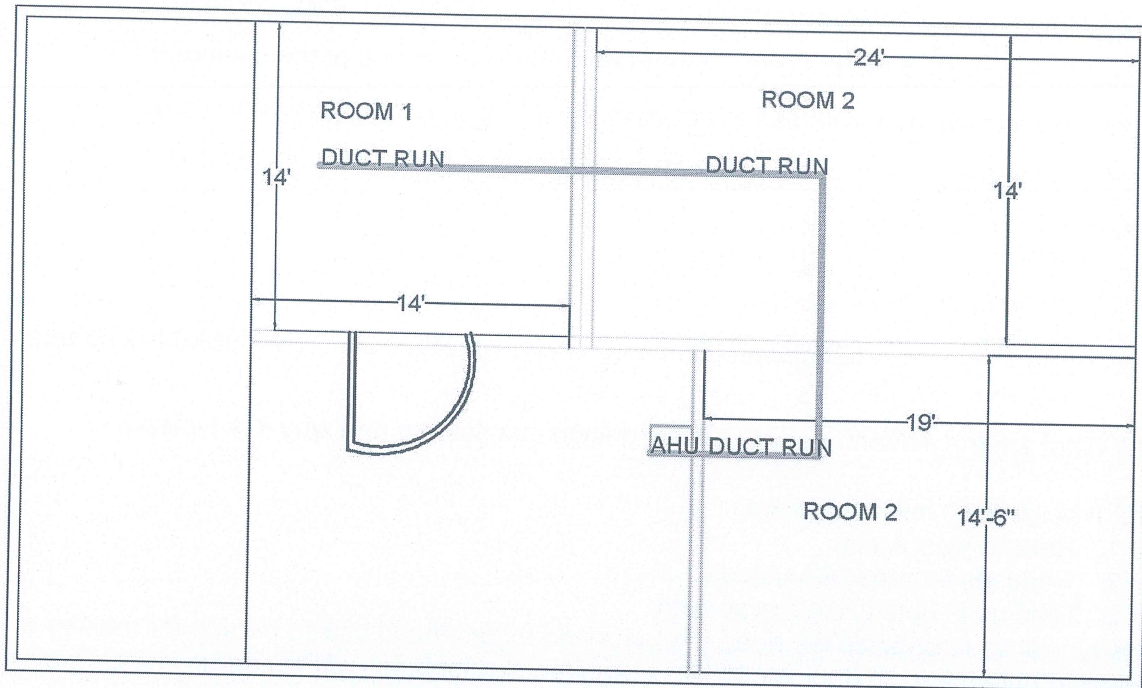
- a) Shapes
- b) Velocity with range

Q17. Calculate the required CFM and design the Duct for given building? Height to take 10.'

- 1) CFM of air required
- 2) Line diagram for duct design using EFM
- 3) Line diagram for duct design using EFM.

DUCT	CFM	VELOCITY	PRESSURE AT	Duct size D equivalent	DUCT	CFM
A	65.33	400	0.05"	6"	A	65.33
A1	112	450	0.05"	6.5"	A1	112
B	92.46/93	420	0.05"	6"	B	92.46/93

PRODUCED BY AN AUTODESK STUDENT VERSION

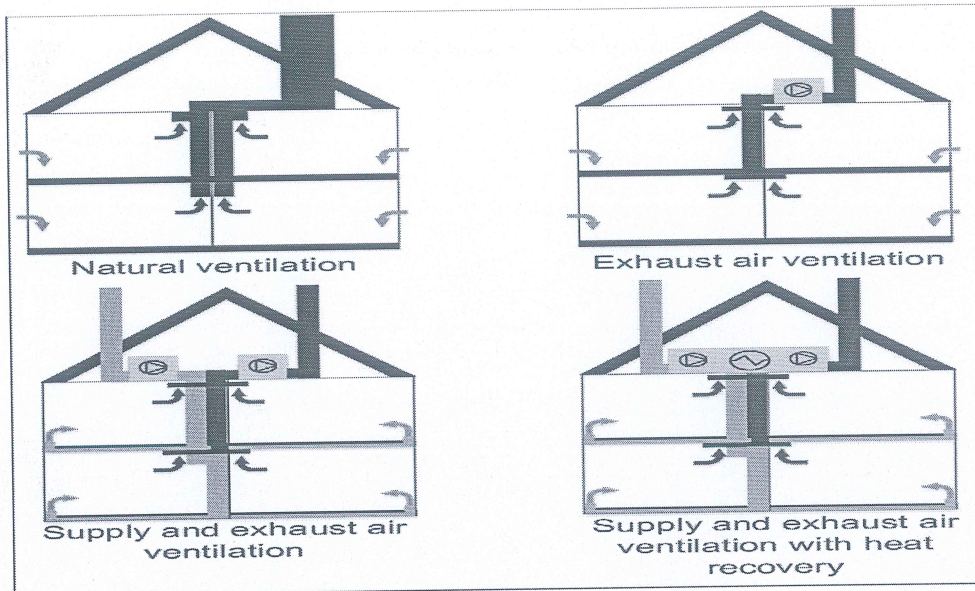


1. CALCULATE CFM FOR ROOM 1, 2 AND 3
2. WRITE DUCT DIMENSIONS
3. Make a table and fill in values for blanks

Q17. What are the types of Air Ventilation Explain with the help of A neat sketch?

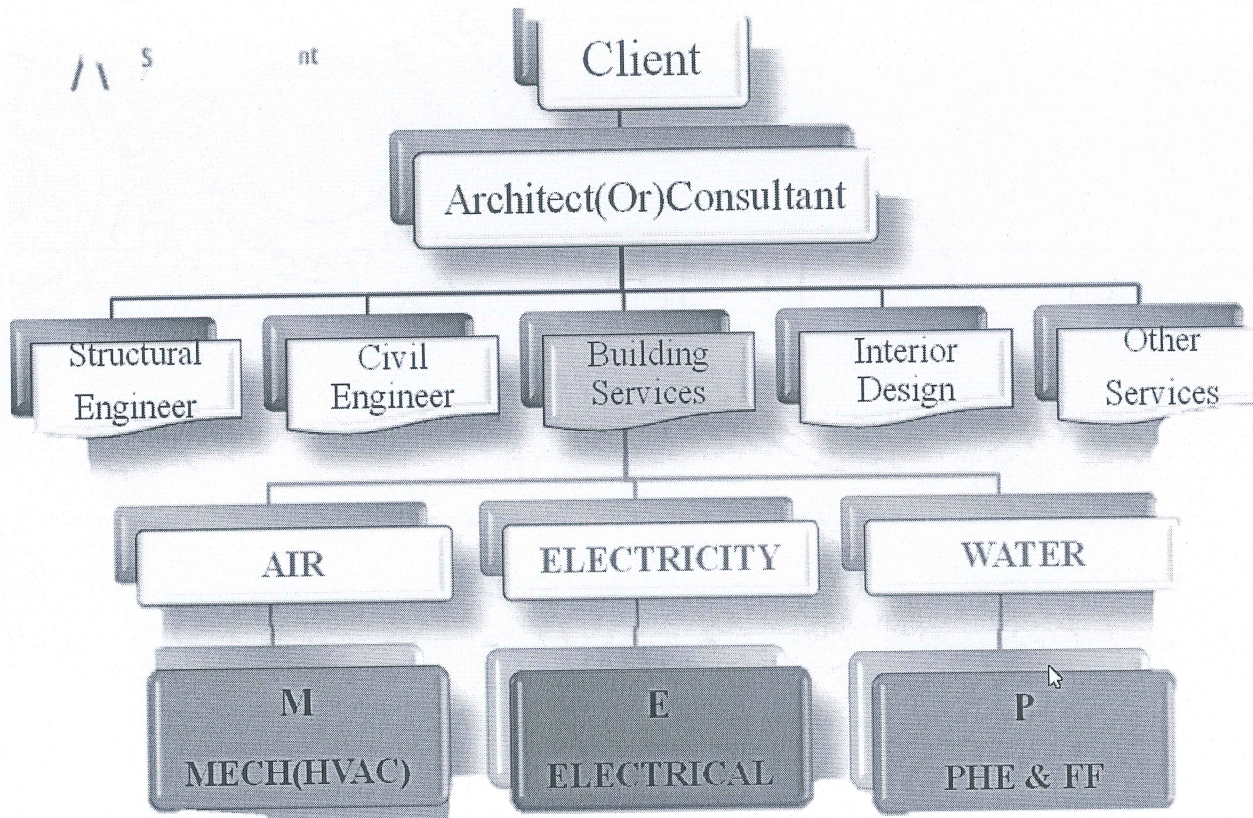
A.17 Natural Ventilation

- 1) single – side ventilation
  - 2) cross flow ventilation
  - 3) stack ventilation
  - 4) Top - down ventilation
- Forced ventilation.
- 1) positive pressure



Q18. Draw the flow chart for building survey/Project?

A18.



*Harsh Sharma*

