BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

School of Refrigeration & Air Conditioning Skills

Session: 2019-20 (Summer Semester)

B. Voc. Program, III Semester,

End-Sem. Examination

Course Code: HVA1301 **Time: 2 Hours**

Course Name: Refrigerant & psychrometry **Max. Marks: 50**

Instruction:

All questions are compulsory.

Section A is objective type.

Section B is short answer type.

Section C is long answer type.

Use psychrometric chart and steam table as per requirement.

Section – A

10X01 = 10 Marks

1. What is the measuring unit of specific enthalpy?
   a) KJ/Kg b) m^3/Kg
   c) Kg/m^3 d) None
2. What is the measuring unit of specific enthalpy?
   a) g/Kg of dry air b) g/m^3 of dry air
   c) J/Kg d) None
3. Which type of process is involved in mixing of two air streams in an air conditioning system?
   a) Adiabatic process b) Polytropic process
   c) Isobaric process d) None
4. What is the suitable air velocity for human comfort in summer season?
   a) 15-20 m/s b) 20-40 m/s
   c) 40-50 m/s d) All of the above
5. Which type of heat is added in through infiltration?
   a) Sensible heat b) Latent heat
   c) Both d) None
6. Which type of heat is added in through ventilation?
   a) Sensible heat b) Latent heat
   c) Both d) None
7. Which type of heat is added in through internal electrical lights?
   a) Sensible heat b) Latent heat
   c) Both d) None

8. During the sensible heating process only, which of the psychrometric property remain constant?

a) Specific humidity b) Relative humidity

c) DBT d) None

9. During the latent heat addition process only, which of the psychrometric property remain constant?

a) Specific humidity b) DBT

c) Specific enthalpy d) None

10. On increasing the temperature of atmospheric air, the relative humidity will be-.

a) Increasing b) Reducing

c) Unchanged d) None

Section – B

04X04 = 16 Marks

1. Discuss the factors on which solar heat through glass depends.
2. What is effective temperature? How does it account for human comfort?
3. What is the importance of outside design conditions?
4. Write short notes on the selection of a refrigerant for a refrigeration system.

Section – C

04X06 = 24 Marks

1. 500 m^3/min of fresh air at 30° C DBT and 50% RH is adiabatically mixed with 1000 m^3/min of recirculated air at 22° C DBT and 10 ° C DPT. Calculate the enthalpy, Specific Volume, Humidity ratio and final DBT of mixture.
2. explain the concept of RSHF, GSHF and ERSHF.
3. The following data refers to summer air conditioning of a building:

Outside design condition = 43° C DBT, 27° C WBT

Inside design condition = 25° C DBT, 50% RH

RSH = 84 MJ/h, RLH = 21MJ/h, By pass factor = 0.2

The room air from the room is mixed with fresh air before entering the coil in the rate of 4:1 by mass. Determine:

a) Coil ADP.

b) Condition of air entering and leaving the coil.

c) Fresh air cmm.

d) Capacity of the coil in TR.

Sketch the process on psychrometric chart.

4. In a cooling application, moist air enters a refrigeration coil at the rate of 100 kg of air 35° C DBT and 50% RH. The ADP of the coil is 5° C and the bypass factor is 0.15. Determine the outlet state of moist air and cooling capacity of coil in TR.

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

School of Refrigeration & Air Conditioning Skills

Session: 2019-20 (Summer Semester)

B. Voc. Program, III Semester,

End-Sem. Examination

ANSWER KEY

Course Code: HVA1301 **Time: 2 Hours**

Course Name: Refrigerant & psychrometry **Max. Marks: 50**

Instruction:

All questions are compulsory.

Section A is objective type.

Section B is short answer type.

Section C is long answer type.

Use psychrometric chart and steam table as per requirement.

Section – A

10X01 = 10 Marks

1. What is the measuring unit of specific enthalpy?
   a) KJ/Kg
2. What is the measuring unit of specific humidity?
   a) g/Kg of dry air
3. Which type of process is involved in mixing of two air streams in an air conditioning system?
   a) Adiabatic process
4. What is the suitable air velocity for human comfort in summer season?
   a) 15-20 m/s
3. Which type of heat is added in through infiltration?
   c) Both
6. Which type of heat is added in through ventilation?
   c) Both
7. Which type of heat is added in through internal electrical lights?
   a) Sensible heat
8. During the sensible heating process only, which of the psychrometric property remain constant?
   a) Specific humidity
9. During the latent heat addition process only, which of the psychrometric property remain constant?
   b) DBT
10. On increasing the temperature of atmospheric air, the relative humidity will be-.
    a) Increasing

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Section – B

04X04 = 16 Marks

1. Discuss the factors on which solar heat through glass depends.

Ans:

The heat gain components through glass consists of solar radiation and conduction. Solar radiation is considered in two parts - direct and diffuse (or scatter). Diffuse radiation is the solar radiation that is absorbed, stored and scattered in the atmosphere. The glass can be in the sun (direct and diffuse radiation) or in the shade (diffuse or scatter radiation).

Conduction heat gain occurs due to the difference in temperature on either side of the glass. Conduction heat gain is positive if the outdoor air temperature is greater than indoor air temperature and it is negative (heat loss from the space) if the indoor air temperature is greater. Solar radiation is always positive.

Factors for Glass are based on:

A. Floor Level and Room Location

   a. Single Story Building (Table 8.8-A)
   b. Top Floor (Table 8.8-B)
   c. First / Ground Floor (Table 8.8-C)
   d. Middle Floor (Table 8.8-D)
   e. Interior Rooms (Table 8.8-E)

B. Number of Walls in the Space (1 & 2 or 3 & 4 or greater)
C. Floor Type (Concrete or Wood)
D. Ceiling Type (With or Without Suspended Ceiling)
E. Floor Covering (Carpet or Vinyl)
F. Partition Type (Gypsum or Concrete Block)
G. Inside Shades (Full, Half or None)

2. What is effective temperature? How does it account for human comfort?

Ans:

Effective temperature cannot be measured by a thermometer. It is an experimentally determined index of the various combinations of dry-bulb temperature, humidity, radiant conditions (MRT), and air movement that induce the same thermal sensation. The new effective temperature (ET*) of a given space is defined as the dry-bulb temperature of a thermo-equivalent environment at 50% RH and a specific uniform radiation condition. The combinations that induce the same feeling of warmth or cold are called thermo-equivalent conditions.

3. What is the importance of outside design conditions?

Ans:

Outdoor design conditions are important for heating, ventilating and air-conditioning (HVAC) system design and energy estimation for buildings. A research study on the determination of

outdoor design conditions for HVAC applications in Hong Kong is presented here. Methods for determining outdoor design conditions are examined and the existing data for Hong Kong are studied. New design data developed from the latest weather database compiled for Hong Kong are provided. The characteristics of the Hong Kong climate are studied from the 33-year long-term statistical distributions of its hourly dry-bulb and wet-bulb temperatures. Significance, properties and proper selection of outdoor design conditions for HVAC design are then discussed. It is hoped that designers can assess critically the outdoor design conditions they have taken for granted for their building design and evaluate suitable data for design weather based on their applications and risk levels.

4. Write short notes on the selection of a refrigerant for a refrigeration system.

Ans:

Selection criteria (sometimes referred to as award criteria or evaluation criteria) are lists of items against which a prospective supplier can be assessed before a selection is made and a contract awarded. They might also be used to help identify suitable individuals when seeking new employees. Defining specific selection criteria can help an employer agree among themselves the characteristics that they value. This helps ensure they identify the best value submission, rather than simply the lowest price submission. When the employer is evaluating submissions, referring to the selection criteria, or perhaps even giving marks against each criteria can help focus the assessment and prevent it being dominated by personal preferences or by forceful individuals. Informing applicants what the selection criteria are can create a fairer process, enabling applicants to consider in advance whether they are suitable, and helping them tailor their submissions. It also makes the application process more transparent and so less open to challenge. Assessment criteria will vary significantly depending on the nature of the role; whether it is for a consultant, contractor, other supplier or employee, however, some typical criteria might include:

- Price.
- Relevant experience.
- Understanding of the requirements.
- Past performance.
- Technical skills.
- Availability.
- Management skills.
- Proposed methodology.
- Compliance with the requirements of the submission process.
- Financial standing.

Section – C

04X06 = 24 Marks

1. 500 m^3/min of fresh air at 30° C DBT and 50% RH is adiabatically mixed with 1000 m^3/min of recirculated air at 22° C DBT and 10 ° C DPT. Calculate the enthalpy, Specific Volume, Humidity ratio and final DBT of mixture.

Ans:

Enthalpy of mixture = 48.82 KJ/kg of dry air

Specific volume = 0.856 m^3/Kg

Humidity ratio = 0.00948 Kg/Kg of dry air

2. explain the concept of RSHF, GSHF and ERSHF.

RSHF

It is defined as the ratio of room sensible heat to room total heat. The supply air having conditions given by any point on this line will satisfy requirements of the room with quantity of air supplied different for different points

RSHF= RSH /RSH+RLH

GSHF

It is defined as ratio of total sensible heat to the grand total heat which the cooling coil is required to handle after the outside fresh air and recirculated air mixing has taken place. GSHF= (Room sensible heat + Outside air sensible heat) ((RSH +ouside air sensible heat)+ (RLH+ outside air latent heat))/(Room sensible heat + Outside air sensible heat)((RSH +ousid e air sensible heat)+(RLH+ outside air latent heat)) The BPF fraction of outside air adds SH load and LH load to the room. However BPF fraction of return air has no effect as it is already at room condition. Thus,

Effective room sensible heat load (ERSH) =RSH+BPF x outside air SH

Effective room latent heat load (ERLH) =RLH+BPF x outside air LH

Hence, ERSHF=ERSH/(ERSH+ERLH)

3. The following data refers to summer air conditioning of a building:

Outside design condition = 43° C DBT, 27° C WBT

Inside design condition = 25° C DBT, 50% RH

RSH = 84 MJ/h, RLH = 21MJ/h, By pass factor = 0.2

The room air from the room is mixed with fresh air before entering the coil in the rate of 4:1 by mass. Determine:

a) Coil ADP.

b) Condition of air entering and leaving the coil.

c) Fresh air cmm.

d) Capacity of the coil in TR.

Sketch the process on psychrometric chart.

Ans:

RSH = 23.23 KW.

RLH = 5.83 KW

RSHF = 0.80

T_3 = 28.6° C

Condition of air entering the coil = 28.6° C DBT and 19.8° C

BPF = 0.2

a. Coil ADP = 10.6° C, T_4 = 14.2° C

b. Air leaving coil = 14.2° C DBT, 12.7° C WBT.

Total air flow = 129.6 Kg/min.

c. Fresh air quantity = 23.83 cmm.

d. Capacity of coil = 12.9 TR.

4. In a cooling application, moist air enters a refrigeration coil at the rate of 100 kg of air 35° C DBT and 50% RH. The ADP of the coil is 5° C and the bypass factor is 0.15. Determine the outlet state of moist air and cooling capacity of coil in TR.

Ans:

Mass flow rate = 100 kg of dry air/min

ADP = 10° C, BPF = 0.15

T_2 = 9.5° C

a. 9.5° C DBT , 9.2 ° CWBT.

b. Cooling capacity of the coil = $m(h1 - h_2)$

100*(81-27.5)/60

= 89.1 KW = 25.33 TR.

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

School of Refrigeration and Air-conditioning

Session: 2019-20 (Summer)

B. Voc. Program, 3rd Semester,

End-Sem. Examination

Course Code: HVA-1302 **Time: 2 Hours**

Course Name: Compressor, Condenser and Evaporator **Max. Marks: 50**

Section – A

10X01 = 10 Marks

1. The evaporator changes the low pressure liquid refrigerant from the expansion valve into:
   a) High pressure liquid refrigerant
   b) Low pressure liquid and vapour refrigerant
   c) Low pressure vapour refrigerant
   d) None of the above
2. The evaporator generally used in wine cooling and in petroleum industry for chilling oil is:
   a) Plate evaporator
   b) Finned evaporator
   c) Tube in tube evaporator
   d) Shell and coil evaporator
3. The fluid side heat transfer coefficient (h_f) when liquid flows through the evaporator shell is given by:
   a) $C\sqrt{m}$
   b) C.m
   c) $C.m^2$
   d) $C.m^4$
4. Ball and socket joint used in which type compressor:
   a) Rotary
   b) Reciprocating
   c) Scroll
   d) Screw
5. Which type of cooling tower used without spray nozzles:
   a) Natural draft
   b) Induced draft
   c) Forced draft
   d) Splash deck

6. What should be done to increase the compressor speed of a belt-driven compressor?
   a) Decrease drive pulley size
   b) Increase drive pulley size
   c) Increase driven pulley size
   d) Both A and C
7. What lubricates the refrigeration compressor?
   a) Refrigerants
   b) Moisture
   c) Oil
   d) Desiccants
8. The condition of refrigerant after passing through the condenser in a vapour compression system:
   a) Saturated Liquid
   b) Wet vapour
   c) Dry saturated vapour
   d) Superheated vapour
9. During a refrigeration cycle, heat is rejected by the refrigerant in a:
   a) Condenser
   b) Compressor
   c) Evaporator
   d) Expansion valve
10. The condensing medium used in evaporative condensers is:
   a) Air
   b) Water
   c) Both air and water
   d) None of these

Section – B

04X04 = 16 Marks

1. Differentiate between rotary and swing type compressor with sketch.
2. Explain evaporative cooling with neat sketch.
3. Explain with neat sketch construction and working of frosting evaporator
4. Explain with neat sketch construction and working of dry expansion evaporator

Section – C

04X06 = 24 Marks

1. Write down various performance parameters of forced draft cooling tower.
2. Explain with neat sketch construction and working of screw compressor.
3. Differentiate between air cooled and water cooled condensers.
4. What is the function of 4-way valve in heat pump? Explain working of 4-way valve with neat sketch

Registration No.: .....

School of Refrigeration and Air-conditioning

Session: 2019-20 (Summer)

B. Voc. Program, 3rd Semester,

End-Sem. Examination

Course Code: HVA-1302 **Time: 2 Hours**

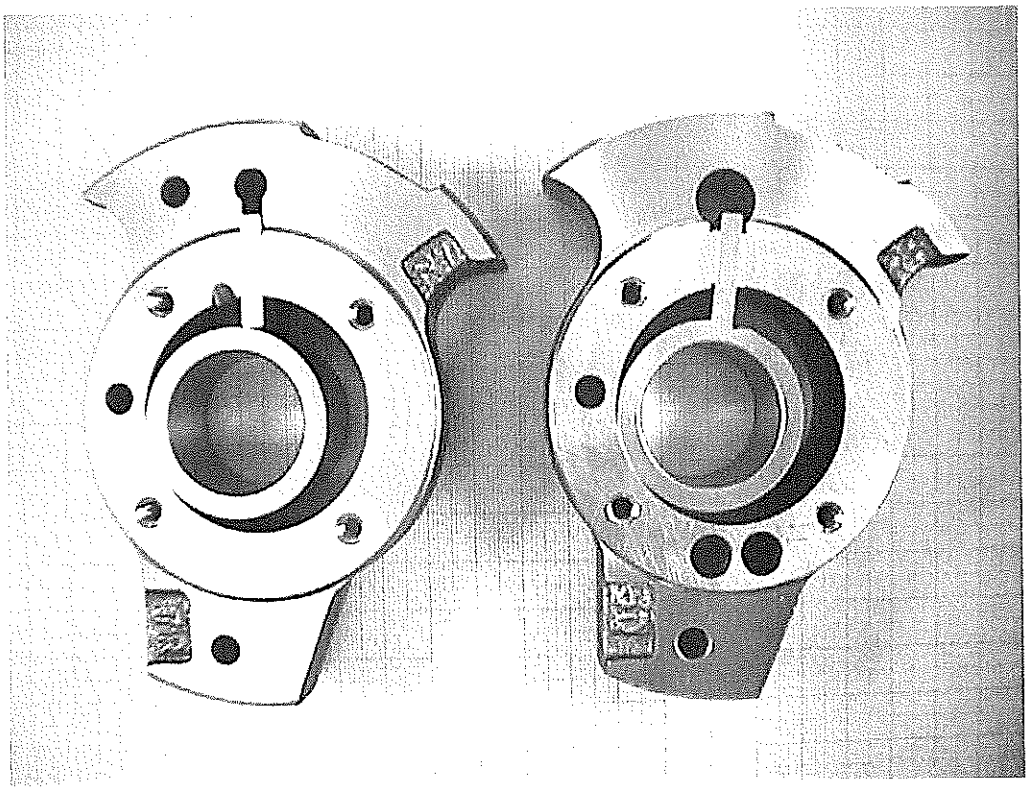
Course Name: Compressor, Condenser and Evaporator **Max. Marks: 50**

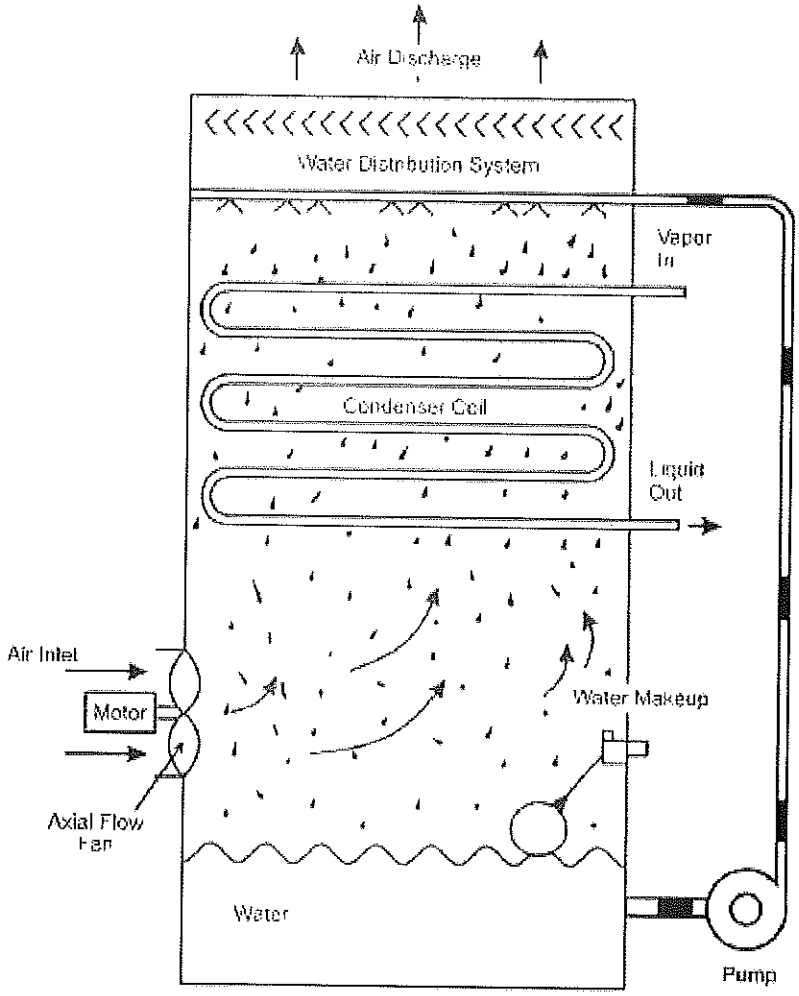
Section – A

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

Section b

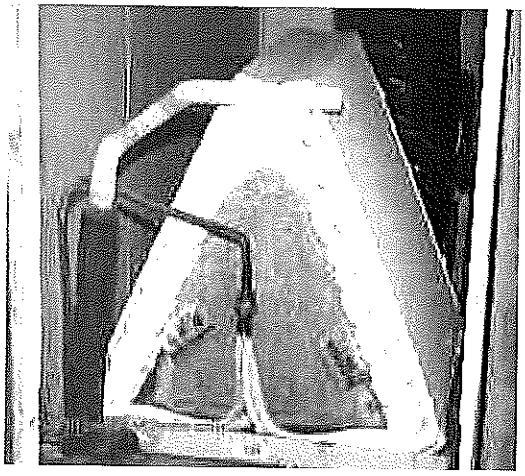
1. **Rotary and swing type**



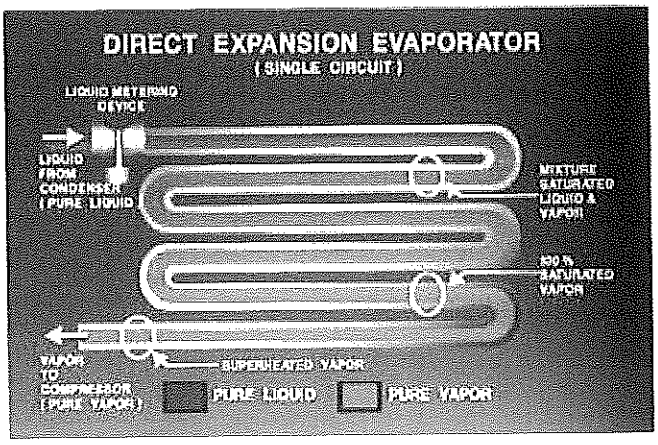


2.

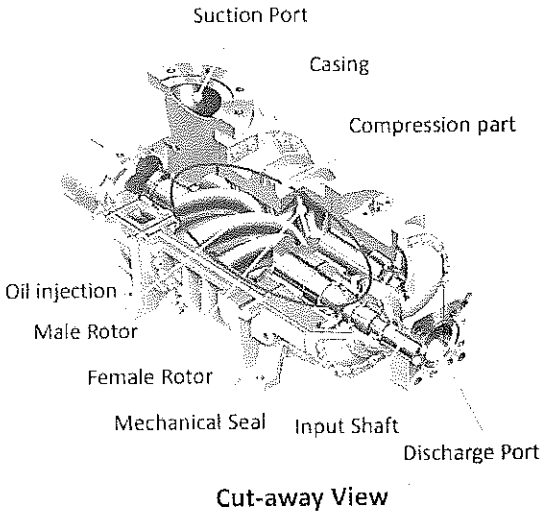
3. Frosting evaporator



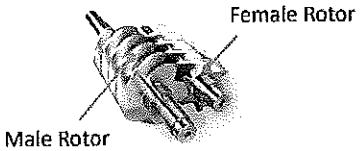
4. Dry expansion evaporator



Range, Approach, effectiveness evaporation loss



Cut-away View



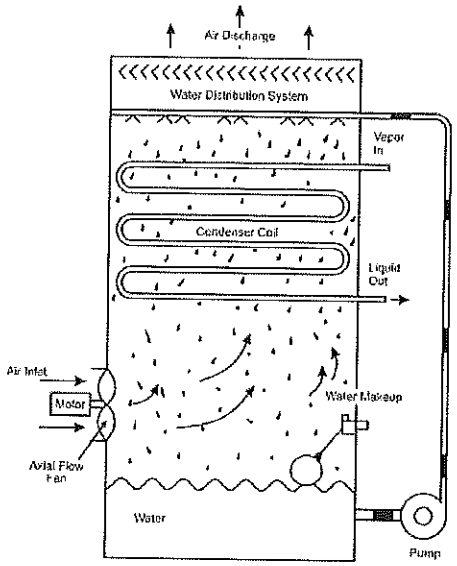
Compression Part

Compression process

Theory of Operation

5.

Section C forced draft



2.

3

4.

1. discharge connection

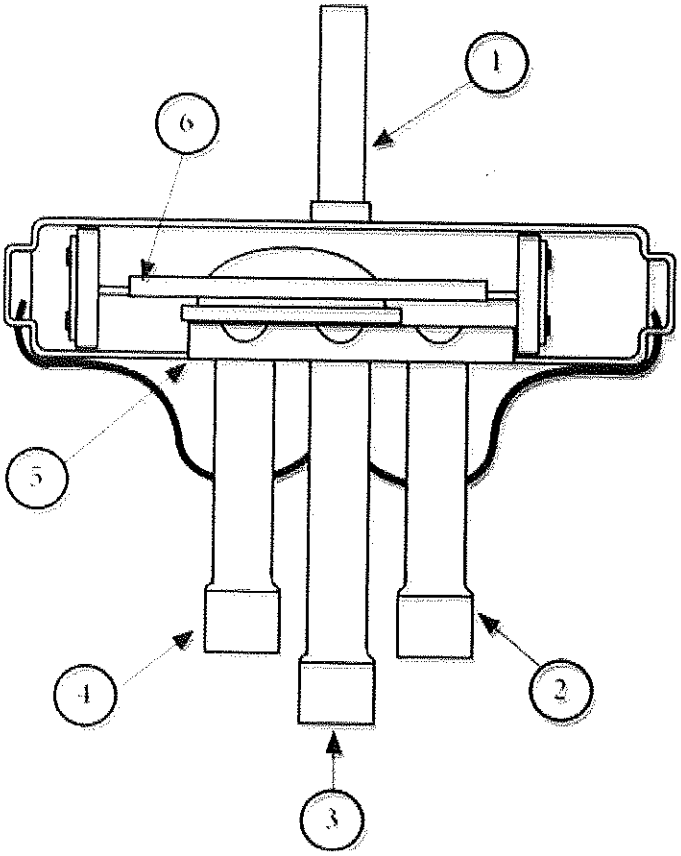
2. connection to evaporator/ condenser

3. suction connection

4. connection to condenser/ evaporator

5. valve body

6. slider



Four-way reversing valves are used to completely reverse the cycle of one-to-one heat pump systems. Such valves may be used to facilitate using the system for both heating and cooling, or to provide an effective and energetically optimized defrosting method.

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

School of RAC Skills

Session: 2019-20 (Summer / Winter Semester)

B. Voc. 3rd Semester,

End-Sem. Examination

Course Code: HVA-1303 **Time: 2 Hours**

Course Name: Air distribution **Max. Marks: 50**

Instruction: Attempt all questions

Section – A

10X01 = 10 Marks

1. Aspect ratio of a rectangular ductwork is kept as:
   a) 1:4
   b) 4:1
   c) 2:2
   d) 4:4
2. Cold air cools a room better if distributed
   a) low in the room.
   b) high in the room.
   c) behind the furniture.
   d) under the curtains.
3. Air system design must consider: -
   a) Noise
   b) Duct leakage
   c) Fire and smoke control
   d) All of the above
4. Each pound of air at standard atm pressure and 70°F can hold :
   a) 110 grains of moisture
   b) 0.01378 pounds of moisture
   c) Both a and b
   d) None of the above
5. If the RH is high then the space needs to be_____ to provide thermal comfort.
   a)Warmer
   b)Hotter
   c)Cooler
   d)Can't be determined.
6. The _____ procedure for determining the required ventilation rate is based on knowledge of the contaminants being generated within the space and the capability of the ventilation air supply to limit them to acceptable levels.
   a) indoor air quality b) ventilation rate c) contaminant mitigation d) all of the above
7. Filters collect particles by _____.
   a) straining b) inertial deposition c) electrostatic effects d) all of the above
8. The perception of comfort relates to which of the following?
   a) individual physical condition
   b) body heat exchange with the surroundings
   c) physiological characteristics
   d) all of the above
9. Air flow above _____ fpm is considered not good for human comfort.
   a) 30 b) 40) c) 60 d) 100
10. The minimum total supply of airflow for residential applications should be :
    a)0.05 cfm/ft2 b) 0.06 cfm/ft2 c)0.6 cfm/ft2 d)10 cfm

Section – B

04X04 = 16 Marks

1. Why should all ductwork design should start with accurate heat load study?
2. What are the different types of ducts that can be used in an air distribution system?
3. Name two types of blower drives.
4. Why are dampers recommended in all branch-line ducts?

Section – C

04X06 = 24 Marks

1. What is zoning? Explain.
2. What is a comfort chart? Explain with diagram.
3. What are the factors that affect heat exchange?
4. How the process of duct sizing is carried out?

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

School of RAC Skills

Session: 2019-20 (Summer / Winter Semester)

B. Voc. 3rd Semester,

End-Sem. Examination

Course Code: HVA-1303 **Time: 2 Hours**

Course Name: Air distribution **Max. Marks: 50**

Answer key

Section – A

10X01 = 10 Marks

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

Section – B

04X04 = 16 Marks

1. Right-sizing of a heating, ventilation, and air-conditioning (HVAC) system is the selection of equipment and the design of the air distribution system to meet the accurate predicted heating and cooling loads of the house. The estimated heating and cooling loads are those required to meet the inside design conditions on the design load day. The design load day is not the most extreme weather conditions or the conditions that represent the majority of hours in a year. Temperature swings are expected in the conditioned space during extreme weather, and the system must be able to deliver comfort during the many hours of partial load conditions.

2. **Rectangular Ducts:**
Rectangular metal ducts must be designed to avoid vibration and structural failure. Vibration can occur when a flat sheet acts as a drum, with the center of
the sheet vibrating back and forth. This behavior becomes more pronounced in both the scale of the vibration and the noise generated as the size of the flat metal area increases.

Round Metal Ducts
Round ducts are inherently strong and rigid, and are generally the most efficient and economical ducts for air systems.

3. Direct drive, where the fan is mounted directly on the motor shaft or an extension of the motor shaft, offers a more compact assembly and ensures constant fan speed. Fan speeds used to be limited to available motor speeds, an economical solution when practical. Today, at additional cost, the motor speed can be adjusted over

a wide range by supplying the motor through a variable frequency controller. Capacity is set during construction by variations in fan impeller geometry and motor speed.
Belt drive offers flexibility in that the fan speed can be changed by altering the drive ratio. This allows initial adjustments to match the fan output with the system actually installed. In some applications, this flexibility allows for changes in system capacity or pressure requirements due to changes in process, hood design, equipment location or air cleaning equipment.

4. They are used because they help in balancing the system and to supply proper amount of air in the room.

Section – C

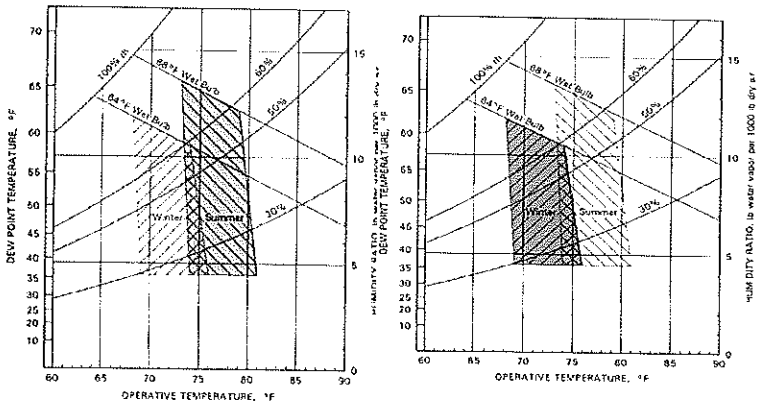
04X06 = 24 Marks

1. With the outlet devices selected and before duct layout and duct sizing can begin, the designer must determine how many zones of temperature control will be required for both perimeter zones and interior zones. In general, the exterior zone will be divided into zones that will be determined by building exposure (north, east, south or west exposure).

These perimeter zones may be further subdivided into smaller control zones, depending on variations in internal load or a requirement for individual occupant control. Typical situations would include private executive offices, where the owner may want individual control, or areas of high heat gain or loss such as computer rooms, conference rooms or corner rooms with two exposed walls.

Similarly, the interior zones may also be divided into control zones to satisfy individual room requirements or variations created by internal loads, such as lights, people or equipment.

2. The generalized comfort chart is used to compare one situation with another. The chart below represents the comfort chart for the summer months. In the center of this chart there is a bold rectangular square that encompasses the temperature and humidity combinations at which most people will be comfortable. The air temperatures are located along the bottom of the chart, and the (relative) humidity percentages are shown by the curved lines.



From the comfort chart for the summer months, it can be determined that the average individual will be comfortable if the surrounding air is 75°F with a relative humidity of 50%. This is because the 75°F line and the 50% relative-humidity line cross at a point that is located within the "comfort" square. It can also be determined that the average person will not be comfortable if the surrounding air is 85°F and the relative humidity is 50%. This is because these two lines intersect at a point that is outside the comfort region. The same concept applies to the comfort chart for the winter months as shown in the figure below:

3. **Dry bulb/Wet Bulb temperature:** The air dry-bulb temperature is the temperature measured on an ordinary thermometer. Instruments used to measure wet-bulb temperatures are called psychrometers.

Relative Humidity: Relative humidity compares the amount of water in the air to the amount of water the air can hold at a given temperature.

Thermal Radiation: All objects, including human bodies, emit electromagnetic radiation. The wavelength of radiation emitted depends on the temperature of the objects. Such radiation is called thermal radiation.

Air Movement: Air movement may provide desirable cooling in warm conditions, but it may also increase the risk of unacceptably cool drafts.

4. Having completed the preliminary HVAC system duct layout, the designer will then proceed to use one of the methods for sizing the duct system. Generally, these methods will give the equivalent round duct sizes and the

pressure losses for the various elements of the duct system. The designer will then incorporate this information into the preliminary duct layout.

If round ductwork is to be used throughout, the duct sizing efforts are completed, providing the ductwork will physically fit into the building. If rectangular or flat oval ductwork is chosen, the proper conversions must be made from the equivalent round duct sizes to rectangular or flat oval sizes. Applying the appropriate duct friction loss correction factors and using the duct fitting loss coefficients, the duct system total pressure loss can be calculated

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

School of RAC Skills

Session: 2019-20 (Summer Semester)

B. Voc. 3rd Semester,

End-Sem. Examination

Course Code: 1304 **Time: 2 Hours**

Course Name: Thermal insulation **Max. Marks: 50**

Instruction:

Section – A

10X01 = 10 Marks

1. Formula of critical thickness of insulation through cylindrical wall.

a) k/h b) 2k/h

c) h/2k d) h/k

2. Unit of conductive heat transfer is?

a) W/m^2K b) $Wm^{2/}K$

c) W/m K d) W m / K

3. what is unit of perm

a) 1 Grain/ hr ft in-Hg b) 1 Grain hr /ft^2 in

c) 1 Grain/ hr ft^2 in-Hg d) 1 Grain ft^2/ hr in-Hg

4. Which insulation has lowest working temperature?

a) Rock Wool b) plastic foams

c) Glass wool d) fiber Glass

5. Slag Wool is an example of

a) Mineral Wool b) Cellulosic Insulation

c) Loose insulation d) ceramic fiber

6.Which material has zero Coefficient of thermal expansion

a) Plastic Foams b) Natural fibers

c) Calcium Silicate) Loose insulation

7. Working range of PUF Insulation in degree centigrade is

a) 200 to 110 b) 300 – 800

c) 50 – 450 d) 100- 850

8. Which Formula represent heat capacity

a) $Q = m C_p \Delta T$ b) $Q = k A \Delta T / L$

c) $Q = h A \Delta T$ d) $Q = k A \Delta T / \Delta L$

9. Which Formula represent thermal resistance R?

a) $k A / X$ b) $X / K A$

c) $1 / C A$ d) $k / A x$

10. Which of following insulation material is non-combustible

a) XPS b) Mineral wool
c) Cellulosic fiber d) ESP

Section – B

04X04 = 16 Marks

1. Write a short note on insulation thickness required to prevent condensation
2. Write a short note on heat transfer by conduction and convection
3. Derive the Equation for heat transfer through cylindrical wall by conduction
4. What are R-value and U-value how they are related with C and R values?

Section – C

04X06 = 24 Marks

1. A 3 cm diameter pipe at 100 deg C losing heat at the rate of 100W per meter length of pipe to the surrounding air at 20 deg C. This is reduce to a minimum value by providing insulation. Insulation A has quantity of $3.15 \times 10^{-3} m^3$ and k is 5 w/ m-deg, insulation B has quantity of $4 \times 10^{-3} m^3$ and k is 1 w/ m-deg

Insulation A is placed inside insulation B

2. An oven is maintained at 850°C, wall thickness of walls are 500mm with k 0.4W/m-deg, Find out resistance (R) and heat flow per squire feet for outer temperature of 200°C. Also find temperature at 200mm from interior side

3. . Calculate the rate of heat loss through the vertical walls of a furnace of size 4x4x3 m. The walls are constructed from an inner fire brick wall 25 cm thick of thermal conductivity 0.4 W/m.K, a layer of ceramic blanket insulation of thermal conductivity 0.2 W/mK and 8 cm thick, and a steel protective layer of thermal conductivity 55 W/mK and 2 mm thick. The inside temperature of the fire brick layer was measured at 500°C and the temperature of the outside of the insulation 60 °C. Also find the interface temperature of layers.

4. A steam pipe of 10 cm ID and 10 cm OD is covered with an insulating substance k = 1 W/m K. The steam temperature is 300 °C and ambient temperature is 20 ° C. If the convective heat transfer coefficient between insulating surface and air is 8 W/m^2K, find the critical radius of insulation for this

value of r_c. Calculate the heat loss per meter of pipe and the outer surface temperature. Neglect the resistance of the pipe material.

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Registration No.: .....

School of RAC Skills

Session: 2019-20 (Summer Semester)

B. Voc. 3 Semester,

End-Sem. Examination

Course Code: HVA1304 **Time: 2 Hours**

Course Name: Thermal Insulation **Max. Marks: 50**

Instruction:

Answer key 2
Section – A

10X01 = 10 Marks

1. Formula of critical thickness of insulation through spherical wall.

   a) k/h

2. Unit of convective heat transfer is?

   a) $w/m^2 K$

3. What is emissivity?

   a) effectiveness of material in emitting energy as thermal conduction.

4. what is unit of perm

c) 1 Grain/ hr ft^2 in-Hg

05X01 = 05 Marks

5. Which insulation has lowest working temperature?

b) Plastic foams

6. Slag Wool is an example of ?

a) Mineral Wool

7. Working temperature Range of Cellular Glass Insulation is?

a) 800 °F

8. Working range of Elastomeric Insulation is

a) 200 to 250

9. Cellulose insulation is made of

   d) Recycled paper and tree fibers

10. Elastomeric Foam insulation is also known as

d) Expanded rubber foam

Section – B

04X04 = 16 Marks

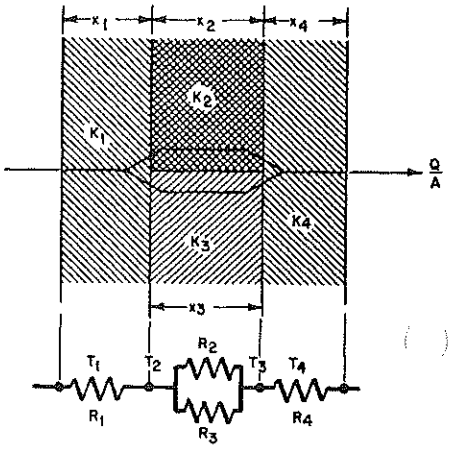
1. **Derive the Equation for heat transfer through plane wall (composite) by conduction.**

Answer

Heat Transfer through composite wall

Thermal resistances are added in the same way as electrical resistance.

So total resistance heat transfer through a plane composite wall we as follows.



$$\frac{1}{R_{net}} = \frac{1}{R_1} + \frac{1}{R_2}$$

As we know

Q = (T1 – T2)/ (R1 + R2)

then, total heat transfer will be

$$Q = \frac{T_1 - T_4}{R_1 + \frac{1}{1/R_2 + 1/R_3} + R_4}$$

2. **Derive the Equation for heat transfer through plane wall by combined heat transfer**

Answer

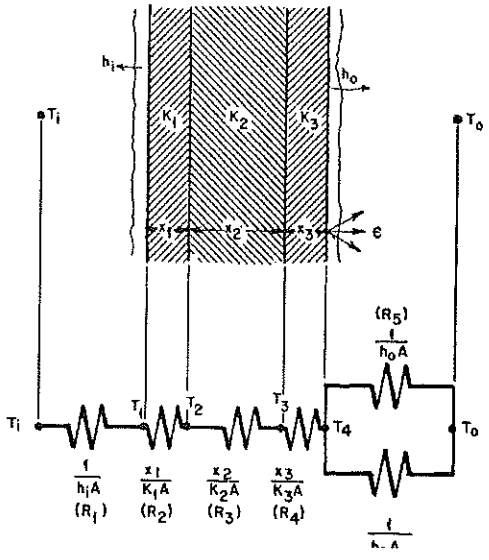
Combined heat transfer through a composite wall

$Q = T_i - T_o / R_{total}$

$$Q = \frac{T_i - T_o}{R_1 + R_2 + R_3 + R_4 + \left(\frac{1}{1/R_5 + 1/R_6}\right)}$$

$$Q = \frac{T_i - T_o}{\frac{1}{h_i A} + \frac{x_1}{k_1 A} + \frac{x_2}{k_2 A} + \frac{x_3}{k_3 A} + \frac{1}{(h_o + h_r) A}}$$

here we need to find $(h_0 + h_r)$



let assume h_o is equal to h_r to simplified equation

$$\frac{Q}{A} = \frac{T_4 - T_o}{\left(\frac{1}{h_o + h_r}\right)}$$

$$T_4 = T_o + \frac{Q}{A}\left(\frac{1}{h_o + h_r}\right)$$

This value for T_4 can be used to calculate a new value for h_r. If the old h_r is not the same as the new h_r, return to the original equation and use the new h_r to find a new value for Q/A. Keep finding updated values for T4 , hr, and Q/A until the change is not significant. Usually, three or four iterations will be sufficient.

$Q = T_i - T_o / R_{total}$

$Q = U A \Delta T$

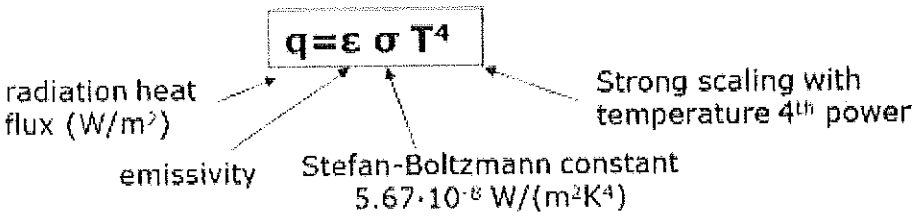
where $U = 1/ R_{total} A$

3. **Write a short note on heat transfer by radiation?**

Answer

Radiation is the transfer of energy through waves (electromagnetic radiation) or fast travelling particles (particulate radiation).

- Radiation can be in the form of heat, sound and light.
- Radiation can be felt or seen like light or detected through special instruments like X-ray.
- Radiation from a hot object is shorter and more intense than radiation from a cooler object.
- The Sun, Earth, soil, microwave, television, cell phones all expose us to radiation.



Emissivity:

The emissivity of the surface of a material is its effectiveness in emitting energy as thermal radiation. Thermal radiation is electromagnetic radiation and it may include both visible radiation (light) and infrared radiation.

The rate of energy exchange between two black bodies

$$Q = \sigma A_1 f_{12} (T_1^4 - T_1^4)$$

Here, A1 , is the surface area of the first body that is able to "see" the second body, and F_{12} may be interpreted as the fraction of all the radiation leaving A_1 in all directions that is intercepted by A_2. F_{12} is called the shape factor, or configuration factor, and can be determined from the geometry of any particular problem. Shape factors have been worked out for many cases; the reader is referred to heat transfer textbooks for examples. It can be shown that A1F12 = A2 F2.

$$(T_1^4 - T_2^4) = (T_1^2 + T_2^2)(T_1 - T_2)(T_1 + T_2)$$

$$Q = \sigma A_1 f_{12} (T_1^2 + T_2^2)(T_1 - T_2)(T_1 + T_2)$$

$$Q = (T_1 - T_2) / R$$

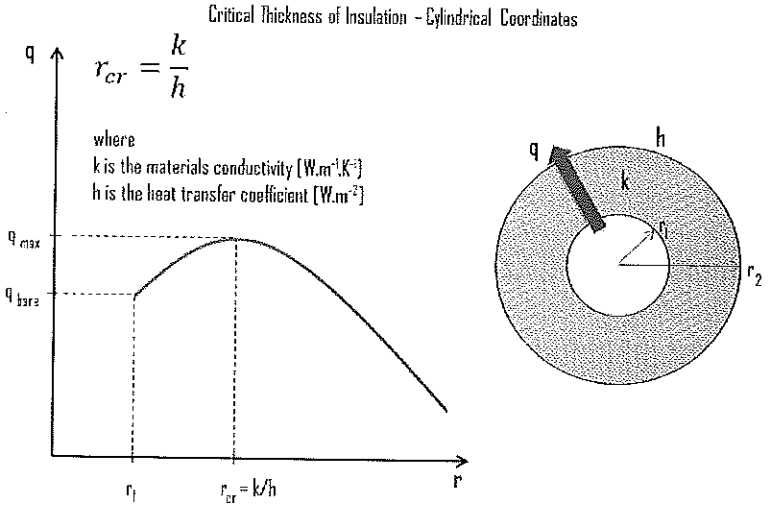
$$\text{where } R = 1 / \sigma A_1 f_{12} (T_1^2 + T_2^2)(T_1 + T_2)$$

4. **What is critical thickness of insulation?**

Answer

Critical thickness

The thickness up to which heat flow increases and after which heat flow decreases is termed as critical thickness. In the case of cylinders and spheres it is called critical radius. It can be derived the critical radius of insulation depends on the thermal conductivity of the insulation k and the external convection heat transfer coefficient h.



For Spherical coordinates

$$r_{cr} = \frac{2k}{h}$$

Section – C

04X06 = 24 Marks

1. Calculate insulation thickness (minimum value) required to insulate a hot water tank (plane wall) for inside temperature at 100C. The wall thickness is 1" and the maximum allowable temperature of outer wall of insulation is 25C. Thermal conductivity of the insulation material (glass wool) for the temperature range of the wall can be taken as 0.04 W/m·K. The heat loss from steam per meter of pipe length should not to be more than 80 W/m.

Answer

T1 = 100C
T2 = 25C
r1 = 1" = 1 × 0.0254 m = 0.0254 m
k = 0.04 W/m K
L = length of the cylinder

Q/L = Heat loss per unit length of pipe
Q/L = 80 W/m

$80 = 2\pi \times 0.04 \times (100-25)/ \ln(r_2/0.0254)$

$\ln(r_2/0.0254) = 2\pi \times 0.04 \times (100-25) / 80 = 0.2356$

Hence, $r_2/= r_1 \times e^{0.2356}$

$r_2/= 0.0254 \times 1.26 = 0.032$ m

thickness = 0.032- 0.0254 = .006m

2. An oven is maintained at 850°C, wall thickness of walls are 500mm with k 0.3W/m-deg, Find out resistance (R) and heat flow per squire feet for outer temperature of 250°C. Also find temperature at 200mm from interior side

Answer

R = L / k A0
= 0.5 / 0.3x 1
=1.667deg/W

Q = T1- T2 / R
=850- 250 /1.667
=359.92 W

temperature at distance from interior side

t = T1+ {(T2 – T1)/L} X
= 850 +({ 250 – 850) / 0.5} x 0.2
= 610 deg C

3. . Calculate the rate of heat loss through the vertical walls of a furnace of size 4 m by 3 m by 3 m high. The walls are constructed from an inner fire brick wall 25 cm thick of thermal conductivity 0.4 W/mK, a layer of ceramic blanket insulation of thermal conductivity 0.2 W/mK and 8 cm thick, and a

steel protective layer of thermal conductivity 55 W/mK and 2 mm thick. The inside temperature of the fire brick layer

was measured at 600 °C and the temperature of the outside of the insulation 60 ^{0}C. Also find the interface temperature of layers

Answer

Given:

Composite Wall l= 4m b= 3m h= 3m

Area of rectangular wall lb = 4x3 = 12m2 L1 = 25 cm

Fire brick k_1 = 0.4 W/mK L2 =0.002m

Steel k2 = 54 W/mK L3 = 0.08 m

insulation k_1 = 0.2 W/mK

T1 = 6000 C T2 = 600 C

Find (i) Q (ii) (T3 –T4)

We know that

$Q = \Delta T / R_{th}$

(ΔT) overall = T1 – T4

And ΣR th = Rth1 + Rth2 + Rth3

Rth1 = L1/ k1 A =0.0521K/W

Rth2 L2/ k2 A2 =0.0333K/W

Rth3 = L3/ k3 A =0.0000031K/W 3 ,

$Q = Q = \Delta T / R_{th}$

=600- 60 / 0.0521 + 0.0000031 + 0.0333

= 6320.96 W

(i) To find temperature drop across the steel layer (T3 - T4) , =,

Q = T3- T4/ Rth2

T3- T4 = 6320.96 x 0.0000031

T3- T4 = 0.0196 K

4. A steam pipe of 10 cm ID and 11 cm OD is covered with an insulating substance k = 1 W/m K. The steam temperature is 200 ^{0}C and ambient temperature is 20 ^{0}C. If the convective heat transfer coefficient between insulating surface and air is 8 W/m2K, find the critical radius of insulation for this value of rc. Calculate the heat loss per m of pipe and the outer surface temperature. Neglect the resistance of the pipe material.

Answer

R_i = 0.05m

R_o = 0.55m

k =1 W/mK

Ti = 200 °C To =20 °C

h_0 =8 W/m^2K

To find critical radius of insulation

$r_c = k/ h_o = 1/8 = 0.125m$

if critical radius is outer radius

$$\frac{Q}{L} = \frac{2\pi(T_0 - T_\infty)}{\frac{\ln\left(\frac{r_c}{r_0}\right)}{k} + \frac{1}{h_o r_o}}$$

Q/L = { 2π (200 – 20)} / {ln(0.125/ 0.050) / 1} + (1 / 8 x0.125)

= 621 W/ m

Registration No.: .....

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

School of HVAC & R Skills
Session: 2019-20 (Summer Semester)
B. Voc. Program, 3rd Semester,
End – Semester Examination

Course Code: HVA 1305 **Time: 2 Hours**
Course Name: Electrical and Electronics Safety Testing **Max. Marks: 50**

Instruction: Answer all questions from section A, each question carries one mark. Answer all questions from section B, each question carries four marks. Answer all questions from section C, each question carries six marks. Scientific calculator is allowed.

Section – A

10x01 = 10 Marks

1. Which one of the following shows the benefits in the PCB design process?
   (a) Bug identification (b) Time increases
   (c) Cost increases (d) None of these
2. Which one of the following is true for LEDs?
   (a) light generating diode.
   (b) Lights up when current flows through it
   (c) It will only allow current to flow in both directions.
   (d) None of these
3. A 10 µF, 20 µF, 22 µF, and 100 µF capacitor are in parallel. Which one of the following shows total capacitance?
   (a) 2.43 µF (b) 4.86 µF (c) 100 µF d. 152 µF
4. Which one of the following is true for fuse?
   (a) Open the circuit
   (b) Protect the appliance.
   (c) Protect the line
   (d) Prevent excess current from flowing into the line.
5. Remove the patient from the live source of accident by:
   (a) Wooden stick (b) Iron road (c) Holding him directly (d) none of these
6. CO2 fire extinguishers are used to extinguish the fire of:
   (a) Class A (b) Class B (c) Class C (d) Class D
7. The earthing resistance of electronic system should be less than:
   (a) One ohm (b) Two ohms (c) Three ohms (d) Five ohms
8. Switch board of light to be fixed at a height of:
   (a) 1.5 metres (b) 2 metres (c) 4 metres (d) 3 metres
9. Arc flash tested panels will blow the fault:
   (a) Upwards (b) Sideways (c) both A and B (d) None of these

B

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

10. The full form of PM in reference to air pollution is:
    (a) Program manager (b) Particulate Matter
    (c) Past meridiem (d) Per-trophic matrix

Section – B

04x04 = 16 Marks

1. What is the purpose of permit to work system?
2. What is the benefits of lockout and tagging in the process of electrical shutdown?
3. Which kind of safeties are required to work with electronic circuitry?
4. How do you use test a relay? Explain.

Section – C

04x06 = 24 Marks

1. Explain in detail the philosophy of 5S. How it is useful for improving efficiency or quality in work place?
2. What are the two basic reasons of an electrical accident? Please explain the same with appropriate example.
3. What is MOSFET? Explain the working of MOSFET using suitable diagram.
4. What is PCB testing? Explain the common causes of PCB failures.

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

School of HVAC & R Skills
Session: 2019-20 (Summer Semester)
B. Voc. Program, 3rd Semester,
End – Semester Examination

Course Code: HVA 1305 **Time: 2 Hours**
Course Name: Electrical and Electronics Safety Testing **Max. Marks: 50**

Section – A

10x01 = 10 Marks

1. Which one of the following shows the benefits in the PCB design process?
   Ans. (a) Bug identification
2. Which one of the following is true for LEDs?
   Ans. (b) Lights up when current flows through it
3. A 10 μF, 20 μF, 22 μF, and 100 μF capacitor are in parallel. Which one of the following shows total capacitance?
   Ans. (d) 152 μF
4. Which one of the following is true for fuse?
   Ans. (d) Prevent excess current from flowing into the line.
5. Remove the patient from the live source of accident by:
   Ans. (a) Wooden stick
6. CO2 fire extinguishers are used to extinguish the fire of:
   Ans. (c) Class C
7. The earthing resistance of electronic system should be less than:
   Ans. (a) One ohm
8. Switch board of light to be fixed at a height of:
   Ans. (a) 1.5 metres
9. Arc flash tested panels will blow the fault:
   Ans. (a) Upwards
10. The full form of PM in reference to air pollution is:
    Ans. (b) Particulate Matter

Section – B

04x04 = 16 Marks

1. What is the purpose of permit to work system?

Ans. Permit to work system inbuilt safety to workmen engaged in electrical work. The Permit to work is the process which will promote a culture of safe working among its personnel while carrying out any work in electrical system. This in turn will ensure safety of personnel, safety of equipment and safety of society of large.

2. What is the benefits of lockout and tagging in the process of electrical shutdown?

Ans. Lockout is the physical way to ensure that the energy source is de-energized. Tagging is an important part of lockout. Tags are means of communication. They are used to inform others that the device is locked out, who has locked out it and why? Tag devices and systems must not b re-energized without the authority of those named on the tag.

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

3. Which kind of safeties are required to work with electronic circuitry?

Ans. **General Safety**

Before working on any electronics, consider following these basic safety precautions to help reduce any hazards.

- Remove any electronic equipment you're testing or working on from the power source.
- Never assume the power circuit is off. Test and test again with a voltmeter to confirm.
- Remove fuses and replace them only after the power to the circuit is disconnected.
- Don't connect power to a circuit until you're done working on it and rechecked the work.
- Always ensure that all electronics equipment is properly grounded
- If it's damaged, replace it. For instance, replace cables instead of repairing with insulating tape.
- Always use the right electronics repair and maintenance tools.
- Always return covers after removing them to reduce the risk of electric shock.
- Make sure your circuit is not overloaded.
- Always have safety equipment like a fire extinguisher, a basic first aid kit and a mobile phone nearby.

Personal Safety

It's important to ensure that you're safe when working on electronic circuits. Here are some personal safety precautions to keep in mind:

- Always keep your work area dry.
- Always work in a well-ventilated area.
- Don't wear flapping or loose clothing when working.
- Don't work with metallic jewelry on your hands like watches, rings and bracelets.
- Don't use bare hands to remove hot parts.
- Always wear non-conductive shoes.
- Always wear insulator gloves in your hands when carrying out repairs.
- When removing high-voltage charges on capacitors, always use a shorting stick.
- Don't hold the test prods when measuring voltage over 300V.
- Always remove power to a circuit before connecting alligator clips.
- Always wear safety goggles.
- Be careful when handling large capacitors as they can still hold high voltage even after you've disconnected the circuit from power.

4. How do you use test a relay? Explain.

Ans. A relay will usually have a coil, pole terminal and a set of contacts. The set of contacts that are open when the relay is not energized are called normally open (N/O) contacts and the set of contacts that are closed when the relay is not energized are called normally closed (N/C) contacts.

- Keep the multimeter in the continuity check mode.
- Check for continuity between N/C contacts and pole.
- Check for discontinuity between N/O contacts and pole.
- Now energize the relay using the rated voltage.
- For example use a 9V battery for energizing a 9V relay. The relay will engage with clicking sound.
- Now check for continuity between N/O contacts & pole
- Also check for discontinuity between N/O contacts & pole
- As a final test, measure the resistance of the relay coil using a multimeter & check it is matching to the value stated by the manufacturer.

Section – C 04x06 = 24 Marks

1. Explain in detail the philosophy of 5S. How it is useful for improving efficiency or quality in work place?

Ans. Principle of 5 S

BHARTIYA SKILL DEVELOPMENT UNIVERSITY

The concept of "5S" originated in Japan. It is an integral tool of TQM which lays a very strong foundation for quality movement within the organization. The 5S are pre-requisites (basics) for any improvement programme. 5S Philosophy focuses on effective work place organization, simplifying work environment, reducing waste while improving quality and safety. There is no other way for improving efficiency or quality in work place.

The five S stands for the five first letters of these English words:

Japanese Term English Equivalent

Sort

Set In Order

Shine

Standardize

Sustain

Meanings:- Calling these principles as "5S" is a good way to remember their meaning and content. They stand for:-

Safety and the 5S

Efficiency and the 5S

Breakdown and the 5S

Quality and the 5S

2. What are the two basic reasons of an electrical accident? Please explain the same with appropriate example.

Ans. The two basic reasons are as follows:

1. Unsafe act:

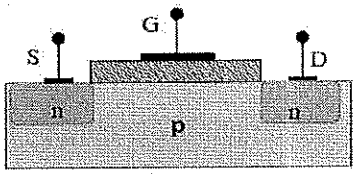
   Example: If a person is working on the electrical system without taking proper shutdown then it is the unsafe act of and electrician.

2. Unsafe condition:

   Example: If a person is working on the HT pole without using full body harness. It creates unsafe condition for an electrician.

3. What is MOSFET? Explain the working of MOSFET using suitable diagram.

A metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a field-effect transistor (FET with an insulated gate) where the voltage determines the conductivity of the device. It is used for switching or amplifying signals. The ability to change conductivity with the amount of applied voltage can be used for amplifying or switching electronic signals. MOSFETs are now even more common than BJTs (bipolar junction transistors) in digital and analog circuits.



MOSFET Structure

MOSFET Operation

The working of a MOSFET depends upon the MOS capacitor. The MOS capacitor is the main part of MOSFET. The semiconductor surface at the below oxide layer which is located between source and drain terminals. It can be inverted from p-type to n-type by applying positive or negative gate voltages.

When we apply positive gate voltage the holes present under the oxide layer with a repulsive force and holes are pushed downward with the substrate. The depletion region populated by the bound negative charges which are associated with the acceptor atoms. The electrons reach channel is formed. The positive voltage also attracts electrons from the n+ source and drain regions into the channel.

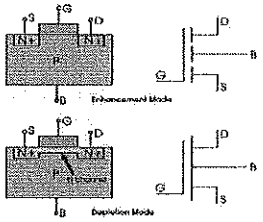
BHARTIYA SKILL DEVELOPMENT UNIVERSITY

Now, if a voltage is applied between the drain and source, the current flows freely between the source and drain and the gate voltage controls the electrons in the channel. If we apply negative voltage, a hole channel will be formed under the oxide layer.

P-Channel MOSFETP-Channel MOSFET

The drain and source are heavily doped p+ region and the substrate is in n-type. The current flows due to the flow of positively charged holes also known as p-channel MOSFET. When we apply negative gate voltage, the electrons present beneath the oxide layer experience repulsive force and they are pushed downward in to the substrate, the depletion region is populated by the bound positive charges which are associated with the donor atoms. The negative gate voltage also attracts holes from p+ source and drain region into the channel region.

N-Channel MOSFET



N-Channel MOSFET

The drain and source are heavily doped n+ region and the substrate is p-type. The current flows due to the flow of negatively charged electrons, also known as n-channel MOSFET. When we apply the positive gate voltage the holes present beneath the oxide layer experience repulsive force and the holes are pushed downwards in to the bound negative charges which are associated with the acceptor atoms. The positive gate voltage also attracts electrons from n+ source and drain region in to the channel thus an electron reach channel is formed.

4. What is PCB testing? Explain the common causes of PCB failures.

Ans. Bug identification: The primary benefit of **PCB testing** is that it helps identify problems in PCBs. Whether the issue lies in functionality, manufacturability or elsewhere, **PCB testing** identifies issues in a **PCB** design so that designers can adjust accordingly.

Testing is a crucial part of the development cycle for PCBs. Conducted throughout the production cycle, PCB testing can help save money and prevent issues when it comes to the final production run.

Some design analysis techniques can be used during the early stages to help minimize major issues during the manufacturing process, but there's also a wide range of PCB testing methods that can be used on physical boards. These tests, run on prototypes or small-scale assemblies, look most closely at potential shorts, solder joint issues and functionality, ensuring that each tested PCB will function as intended.

This type of testing offers several **benefits in the PCB design process**, including the following:

- **Bug identification:** The primary benefit of PCB testing is that it helps identify problems in PCBs. Whether the issue lies in functionality, manufacturability or elsewhere, PCB testing identifies issues in a PCB design so that designers can adjust accordingly.
- **Time savings:** PCB testing in the early stages can help save time in the long run, allowing designers to identify major issues during the prototyping stage. Thorough testing enables designers to determine the root cause of each problem posed quickly and easily, making adjustments so that they can move on with production at a faster rate and reduce product lead-time.
- **Cost reduction:** PCB testing prevents wasteful production of faulty products by using prototypes and small-scale assemblies to test the products. By completing thorough testing early in the design process, designers can prevent wasteful full-scale assemblies of faulty

PCBs, ensuring that the design is as flawless as possible before it goes into production. This step helps to significantly reduce production costs.

While thorough testing isn't necessary for all types of PCBs, especially matured products well into their product lifecycle, the majority of new PCB designs need robust and frequent testing of the design process.

1. Burnt Components
Burnt Printed Circuit Board: It is common for PCB's components to burn due to the high temperatures they undergo, especially if there is insufficient space around the component. Each component only has a certain amount of heat that it can absorb which is dependent on size and structure.

2. Poorly Manufactured Components
There is always a possibility of acquiring a poorly manufactured PCB.

Some signs and symptoms include:

- loose components
- connection issues
- even a bad solder or left over flux. One example of a bad solder job is a cold solder. This symptom occurs when the soldering technician fails to properly heat the solder at a through hole or surface mount connection joint. This causes a bad connection and has the potential to lead to burnt components and power issues. Left over flux, a substance used to aid in the soldering process, can also do harm to your component as it can cause corrosion on a PCB.

PCB Component Failure

3. Environmental Factors
Temperature change could be the cause of a PCB's malfunction.

With temperature change, expansion and contraction of the PCB is possible, potentially risking a warped board and damaged soldering joints.

Environmental Damaged to a PCB: Moisture is also a PCB's enemy as it can cause rusting, oxidation, and corrosion. A third environmental issue that can cause problems with a PCB is the buildup of debris such as dust, dirt, and even insects. These pesky items can get into equipment, causing it to clog and/ or overheat; this is common in most electronics.

4. Age
Finally, with age comes component failure. A failing capacitor will generate intermittent power issues. The same goes with other PCB parts. Old parts can be changed out for new ones.

Old PCB Components : Of course with damage comes the fear of high pricing on a completely new circuit board. Fortunately, most PCB issues can be fixed for a fraction of the price of a newly manufactured PCB. Some of the previously mentioned issues, such as a burnt component, can be diagnosed through visual inspection; however, deep rooted issues need to be diagnosed by a trained technician.