Assignment 01: Fundamentals of HVAC

Advanced psychrometry:

1. Select a computer software for psychrometric chart and draw a summer air conditioning cycle on a psychrometric chart using the following conditions. Show the important components of the cooling coil load on the chart. Calculate the cooling coil load and outdoor ventilation load of the system. Assume air density ρ = 1.2 kg.m^{-3}.

   - Outdoor air at dry-bulb temperature 34 ºC and wet-bulb temperature 29 ºC
   - Room air at dry-bulb temperature 25 ºC and relative humidity 55%
   - Supply air at dry-bulb temperature 15 ºC and relative humidity 95%
   - Supply fan and duct heat gain assumed to be 2 ºC
   - Return plenum and duct heat gain assumed to be 1.5 ºC
   - Outdoor air flow rate = 30 litre.s^{-1} and return air flow rate = 170 litre.s^{-1}

2. An operating theatre is maintained at an inside temperature of 26°C dry-bulb when the outside air is at 45°C dry-bulb, 32°C wet-bulb (sling) and the sensible and latent heat gains are 9 kW and 3 kW, respectively. Determine the cooling load if 100 per cent fresh air is handled, the air temperature leaving the cooler coil being 14°C and the apparatus dew point 12°C. Assume a rise of 1.5°C across the supply fan (which is located after the cooler coil) and a further rise of 2°C because of heat gains to the supply duct. Also, determine the percentage saturation maintained in the theatre under these conditions.

   By using a computer software for psychrometric chart, plot the air conditioning cycle and indicate clearly the state points.

Thermal comfort:

3. Explain the two important conditions for ensuring thermal comfort in a space and the four situations where local thermal discomfort may happen.

4. Write down an equation expressing the thermal balance between the human body and its environment. Under what conditions is the temperature of the deep tissues of the human body going to change? Discuss the physiological mechanisms which the body employs to adjust such an imbalance.

5. By using the CBE Thermal Comfort Tool (https://comfort.cbe.berkeley.edu/), investigate the thermal comfort conditions of your home or office and discuss the major factors affecting the perception of thermal comfort in the space. You may do some measurements of the space or make assumptions for the inputs of the thermal comfort assessment.

Load estimation:

6. A room measures 20 m x 10 m x 3 m high and is to be maintained at a state of 20°C dry-bulb and 50 per cent saturation. The sensible and latent heat gains to the room are 7.3 kW and 1.4 kW, respectively. Calculate from first principles, the mass and volume of dry air that must be supplied at 16°C to the room each second. Also calculate its moisture content. Take the specific heats of dry air and superheated steam as 1.012 and 1.890 kJ kg^{-1} K^{-1}, respectively, the density of air as 1.208 kg m^{-3} at 16°C and the latent heat of evaporation as 2454 kJ kg^{-1} of water.

7. When selecting the indoor design conditions for HVAC systems in buildings, it is usually divided into two sets of requirements (summer and winter). Briefly explain the reasoning and major considerations of the design parameters.

8. Explain the meaning of sol-air temperature and describe its equation.

Energy calculations:

9. Draw a diagram to show the basic principles and conversion process of heat gain into cooling load. Indicate clearly the components of transfer function method (TFM).

10. Using the MIT Design Advisor (http://designadvisor.mit.edu/), set up a sample building to perform a computer modelling of energy performance and indoor comfort for early-stage design. You may make assumptions for the inputs and develop up to four scenario cases in the analysis. You should present the input data and calculation results clearly with interpretation of the major findings.