1st Class Test (16-2-2018)

Air conditioning & Ventilation (ME60096)

Department of Mechanical Engineering, IIT Kharagpur

Duration: 1 hour

Full Marks: 20

Saturation pressure of water: $\ln(p_{sat}) = 16.54 - \left(\frac{3985}{T - 39.00}\right)$, p_{sat} in kPa and T in K

Apjohn Equation: $p_v = p'_v - \frac{1.8\, p_t (DBT - WBT)}{2700}$, DBT & WBT in °C

p_v is the vapour pressure, p'_v is the saturated vapour pressure at WBT and p_t is the barometric pressure (pressure units should be consistent)

Latent heat of water(kJ/kgw), $h_{fg} = 2501 - 2.36*t$, where t is temperature of water in °C.

c_p values (kJ/kg.K): Dry air = **1.005**; moist air=**1.02**; Liquid water = **4.18**, Water vapour = **1.88**;

Universal gas constant, R (kJ/kg.mol) = **8.314**, Barometric pressure = **101** kPa

Molecular weights (kg/kmol): Water = **18**, air = **29**, Stefan-Boltzmann const., σ = **5.678 X 10^{-8}** W/m².K⁴

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1. The dry bulb and wet bulb thermometers of a psychrometer indicate **27°C** and **15°C**, respectively. The convective heat transfer coefficient between the thermometer bulbs and surrounding air is **8.3 W/m².K**. If the mean radiant temperature of the surroundings is **29°C** and the emissivity of the bulbs is **0.9**, find a) the true dry bulb temperature of air, and b) humidity ratio of air, when the sensing bulb of the **wet bulb thermometer is provided with a perfect radiation shield**, but the dry bulb thermometer does not have a radiation shield. Assume a value of 1.0 for Lewis number. **(2+4 = 6)**

2. In one element of a counterflow type cooling tower, the temperature of **12 kg/s** of water decreases from **35°C** to **34°C** as it exchanges energy with **16 kg/s of air**. The condition of air at the inlet to the element is **42°C** (DBT) and **28°C** (WBT). If the convective heat transfer coefficient between water and air is **800 W/m².K**, find the required interfacial area for heat and mass transfer of the element. For the temperature range of interest, use the following equation for estimating enthalpy of saturated air. **(6)**

$$h_{sat} = 6.4t - 94$$, where h_{sat} is in **kJ/kga** and temperature t is in **°C**.

3. An air conditioning system that uses **100% outdoor air** is designed for outdoor conditions of **42°C** (DBT) and **28°C** (WBT). The required indoor conditions are **27°C** (DBT) and a humidity ratio of **0.0113 kgw/kga**. The building has a sensible cooling load of **50 kW** and a latent cooling load of **30 kW**. The required conditions are achieved by first cooling and dehumidifying the air, and then heating the air sensibly before supplying it to the conditioned space. The cooling and dehumidifying coil has a coil ADP of **7°C** (W_{adp} = **6.314 x 10^{-3} kgw/kga**) and a bypass factor of **0.05**. a) Draw the process on a psychrometric chart, and find b) Required capacity of the cooling and dehumidifying coil, and c) Required capacity of the heating coil. **(3+3+2 = 8)**

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