# Class Test-2 (13-4-2018)

## Air conditioning & Ventilation (ME60096)

Department of Mechanical Engineering, IIT Kharagpur

Duration: **1 hour** Full Marks: **20**

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1. Find the month and date on which the sun is directly overhead at Kharagpur (22.3° N, 87.3° E). Also find the time of sunrise and sunset and the total number of sunshine hours on this day? Use the following equations: **(6)**

$$Solar\ altitude\ angle, \beta = sin^{-1}\{\cos(l).\cos(h).\cos(\delta) + \sin(l).\sin(\delta)\}$$

$$declination, \delta = 23.47 \sin\left(\frac{360(284+N)}{365}\right)$$

where $l$, $h$ and $\delta$ are the latitude, hour angle and declination, respectively and $N$ is the day of the year counted from 1st of January.

2. A glass window of **2 m²** area is subjected to a total solar radiation flux of **900 W/m²** at a particular instance of time. The average transmittance and absorptance of glass for solar radiation are **0.8 and 0.12,** respectively. At steady state, the glass rejects **60%** of the absorbed radiation to the outside. The window has a U-value of **5.9 W/m².K**, a shading coefficient of **0.8** and a CLF value of **0.83**. Find the **total cooling load** on the building due to this window (in W), when the inside and outside dry bulb temperatures are **25°C and 42°C**, respectively. **(6)**

3. A circular duct system made of GI sheet is connected to a centrifugal fan. The system is designed to provide an air flow rate of **3.0 m³/s** with the fan delivering a total pressure of **120 Pa.** The speed of fan at the design condition is **1800 RPM**. The efficiency of the fan is **72 %** and is assumed to remain constant over its operating range. The duct is **30 m** long and the **total minor losses** are equivalent to frictional losses over a straight length of **50 m**. From the given data,

a) find the required duct diameter and fan power consumption (in W) at design condition. **(5)**

b) What will be the power consumption of fan at off-design condition if the flow rate required at this condition is 80 % of the design air flow rate? Assume that the reduction in flow rate is obtained by varying the fan speed only. **(3)**

The following equation relates frictional pressure drop through a circular duct ($\Delta p_f/L$ in Pa/m) to air flow rate ($Q$ in m³/s) and duct diameter ($D$ in m).

$$\left(\frac{\Delta p_f}{L}\right) = \frac{0.022243\, Q^{1.852}}{D^{4.973}}$$