# Energy Systems Engineering

MTech Admission Test

May 9, 2004 Time-1 hour Max. Marks 36

1. Water flowing in pipe (of 30 mm outer diameter and 1.6 mm thickness) has mass flow of 100 kgls and density of 995.7 kg/$m^3$ at the pressure of 1 atm and temperature of 30°C. If the flow passes through a nozzle of 10 mm inner diameter then find the velocity of water at the nozzle. State the basic principles used. Make, state and justify suitable assumptions if required. [3]

2. Plot tan x, $0 \leq x \leq 2\pi$ [3]

3. Power dissipated in a resistive circuit is given both by the formulae: $I^2$ R and $V^2$ /R. To increase the power output, the formula $I^2R$ suggests that R should be increased. On the other hand, the formula $V^2/R$ suggests that R should be decreased to increase the power output. Isn't it contradictory? Based on this discussions sggest which one of the following will have more resistance: 60W lamp and 100W lamp. [3]

4. The consumption of a certain nuclear fuel is found to vary with time as follows:

$$F = F_0 [ 1 + e^{-t} \cos t]/2$$

Where, F = fuel consumption at time t in million tons
t = time in years

i. Will the consumption ever become maximum? If so when would it occur? [3]

ii. Find out the total consumption of the fuel over a period of 20 years. [4]

5. A city is supplied power by 5 power plants (each of 250 MW rating). Each plant has an availability of 90%(10% probability of outage). At a particular hour, the system load is 950MW. What is the probability that this load is not met? [3]

6. Prove that dimensionally "watt" is equivalent to the product of "volt" and "ampere". [3]

[1]

7. The total (global) radiation, Ig from the Sun on a horizontal surface at a place on the Earth is measured to be 898.4 WI m2. A thin metal sheet kept in the Sun in horizontal position is perfectly insulated on the bottom side and has reached temperature T at steady state in still air. Assume that the metal sheet acts as a perfect black body.

i. Write down the energy balance equation for this sheet.

ii. Calculate T, if the natural convective heat loss from the top of the sheet is 15 W/m2. The ambient temperature is 27°C. Stefan-Boltzman constant is $5.67 \times 10^{-8}$. $W/m^2/K^4$.

[2] 8. A steel plant has an exhaust gas stream at $700^0$ C. The heat content of this waste stream is 5MW (thermal). An equipment supplier claims that using a gas turbine based power plant using only the waste stream as an energy input, it is possible to recover 3.5 MW (electric). Is this process feasible from the laws of thermodynamics? [3]

9. A 200 V, 2000 rpm, 10 A separately excited dc motor has an armature resistance of 2 ohms. Rated dc voltage is applied to both the armature and field winding of the motor. If the armature draws 5A from the source, determine the torque developed by the motor. [3]

10. A single-phase alternator has a synchronous reactance of 3 ohms and negligible resistance. If it supplies 5 A to a purely capacitive load at 200 V , determine the generated e.m.f. [3]

11. Particulate emissions from an incinerator of solid wastes are rated at $0.18 g/m^3$ (dry basis) at NTP. A 50,000 kg/day incinerator exhausts 20 kg exhaust gases per kg of solid waste feed at I atm. and 453°C. Assume average gas molecular weight as 30 and exhaust composition of 12% carbon dioxide and 10% water. What is the daily emission of particulates? [3]