Mansoura University Faculty of Engineering Dept. of Power Mech. Eng. Course Title: Power Plants Course Code: MPE4422		4th year Mech. Eng. June 2013 Exam Type: Final Time: 3 Hours Full Mark: 100

Answer all the following questions. Steam Tables and Charts are allowed

Question (1) (10 marks)

a. If the kinetic energy of flowing air stream is given by 0.5 m U^2, prove that, for air at 101.3 kPa and 273 K, the wind power through a given area A is given by: $P_w = 0.647\ AU^3$ W, where U is the wind speed in m/s. Evaluate the blade diameter if the windmill power is 1 MW and the efficiency is 60% of the maximum theoretical efficiency when the wind speed is 20 m/s at 101.3 kPa and 273 K. (5 marks)
b. Under which conditions, the Weibull distribution is called the Rayleigh distribution (1 mark)
c. Assume that a wind turbine rated at 100 kW at rated wind speed of 7.7 m/s, a cut-in speed of 4.3 m/s, and a furling speed of 17.9 m/s. determine the capacity factor and the yearly energy production in kWh for sites where c = 6.5 and k = 2.0. (4 marks)

Question (2) (20 marks)

a. In a Claude (open-cycle) OTEC power plant, the steam enters the turbine at 30°C and leaves at 10°C. The turbine has a polytropic efficiency of 0.80. Calculate the gross cycle efficiency (4 marks)
b. Give examples of working fluids used in a closed-cycle OTEC power plant. What is the advantage of using these working fluids in a closed-cycle OTEC power plant. (2 marks)
c. A 3 m wave has a 8 s period and occurs at the surface of water 100 m deep. Find the wave length, the wave velocity, the horizontal and vertical semiaxes for water motion at the surface, and the energy and power densities of the wave. Water density = 1025 kg/m^3. (12 marks)
d. The Bay of Fundy has an area of 13000 km^2 and an average range of 8 m. What is the actual power assuming an efficiency of 27.5%. Water density = 1025 kg/m^3. (2 marks)

Question (3) (10 marks)

a. If the temperature at a depth of 3 km is 150K above the surface temperature while the temperature at a depth of 6 km is 300K above the surface temperature. Calculate the geothermal temperature gradient and the useful heat content per square kilometer of the dry rock granite to a depth of 6 km. Take the density = 2700 kg/m^3 and the specific heat = 820 J/kg.K. (4 marks)
b. In a gas cooled reactor, an ideal Brayton cycle has a net work output of 150 kJ/kg and a backwork ratio (compressor work/turbine work) of 0.4. If both the turbine and the compressor had an isentropic efficiency of 85%, what is the net work output of the cycle. (4 marks)
c. In a gas cooled reactor, an ideal Brayton cycle using air an the working fluid (k = 1.4) is working between temperature limits of 300K and 1000K. What is the optimum pressure ratio. (2 marks)

Question (4) (24 marks)

1) Illustrate the tariff methods for electrical energy. **(4 marks)**
2) The two power plant A and B supply to a two system whose maximum load 200 MW and minimum load 20 MW during the year. The estimated costs of these stations are as follows CA= 120*kW+0.028kWh and CB= 110* kW+ 0.030 kWh

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If the load varies as straight line, find for minimum cost of generation:

1) Installed capacity of each power station and use factor of each machine 2) the annual load factor, capacity factor 3) The average cost of production per KWh for the entire system Assume reserve capacity of B as 20 % **(4 marks)**

3) What is main factor affecting for the selection of steam generator? **(4 marks)**

4) What is the different type of steam condenser? **(4 marks)**

5) the following observation are recorded during a test on a steam condenser:

Barometric reading	765 mm of HG	Condensate collected	2000kg/hr
Condenser vacuum	710 mm of HG	Rate of cooling water	60000kg/hr
Mean condenser temperature	35 °C	Inlet and outlet cooling water temperatures	10 and 20° C

Determine: 1) the vacuum efficiency 2) condenser efficiency

3) Mass of air per 1 m3 of condenser volume **(8 marks)**

Question (5) (18 marks)

1) Drive the economic load sharing in two power stations **(4 marks)**

2) An industrial plant needs 50 000 000 KWhr of electrical energy a year with maximum demand of 10 000 KW. These can be purchased from the local utility for $ 480 000 annually. As an alternate scheme the industry considers installing a 10 000 KW steam turbine plant. The three plants of the following tabulation have been proposed.

	Plant A	Plant B	Plant C
Steam rate (Kg/hr)/KW	5.4	4.8	3.9
Heat rate KJ/KWhr	16 000	13 500	12 000
Steam generator and auxiliaries $/(Kg/hr)	11	12.5	11.2
Steam turbine and auxiliaries $/KW	38	32	31
Electrical equipment $	200 000	200 000	200 000
Structures and miscellaneous $	200 000	200 000	200 000
Plant operators per shift	4	4	4

The station will run 24 hr a day with operators working 8 hr per day and 5 days a week The average annual salary for operators is $ 5 200. Repair costs are estimated to be $ 0.5 per ton of coal burned for all schemes. From past experience the designers have found that ultimate installed costs exceed original estimates by 20 %, so this allowance is made as contingency item. General operating supplies are estimated at $ 10 000 annually for all plants. Money earns 6 % in this business, which is expected to continue indefinitely, but the life of the plant is to be taken as 15 years. Taxes on real estate and property amount to 4 % and the various operating taxes add 1 % of annual operating costs. Annual insurance premiums equal 0.2 % of all equipment costs. Fuel will be coa

at $ 7.32 per ton having a high heat value of 32 000 KJ/Kg. Determine which scheme is the economic one. **(14 marks)**

Question (6) (18 marks)

1)What is importance of artificial draught system for power plant? Why forced draught is preferred over the induced draught? **(4 mark)**

2) drive the combined efficiency of steam and gas cycle as a function on the individual efficiency **(4 mark)**

3) Combined power plant consists of a gas turbine unit and a steam turbine unit. The exhaust gas from the gas turbine is supplied to the steam generator at which further supply of fuel is burnet in the gas . the following data are recorded:

For gas turbine unit		For steam turbine unit	
The pressure ratio	8	Flue gas temperature in furnace	800° C
The inlet condition to compressor	15° C	Steam supply condition	60 bar , 500° C
Heating value of fuel	40MJ/kg	Condenser pressure	0.08 bar
		Chimney gas temperature	200° C
The total power output of the plant 200 MW			

Calculate: 1) the combined efficiency 2) Boiler capacity
3) Power Generated in each unit 4) Equivalent evaporation
5) Mass flow rate of fuel **(10 mark)**

Question (7) (16 marks)

1) Compare between fire tube boiler and water tube boiler **(4 mark)**
2) Drive the condition for maximum efficiency **(4 mark)**
3) The annual costs of operating a 20 MW thermal plant are given below:
capital cost =1500LE/kW , Interest, insurance and depreciation = 10 % of plant cost, capital cost of primary and secondary distribution = 20,000,000 LE , Interest, insurance and depreciation on the capital cost of primary and secondary distribution = 8 % of plant cost, Plant maintenance cost= 100,000 LE/year, Plant maintenance cost primary and secondary distribution Internal cost=220,000 LE/year, salaries = 560,000 LE/year, consumption of coal= 40,000 ton/year, cost of coal=9LE/ton, divided to stockholders=1500,000LE/year, energy loss in transmission= 11 %, diversity factor=2.1, load factor= 0.80, maximum demand =19 MW 1)Devise two – part tariff, 2) find the average cost per kWh **(8 mark)**

Gook Luck
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