KATHMANDU UNIVERSITY
End Semester Examination
May/June, 2022

Marks scored:

Level : B.Tech.
Year : III

Course : ENVE 339
Semester : II

Exam Roll No. :   Time: 30 mins.   F. M. 20

Registration No.:   Date :

SECTION "A"
[15Q. × 1 = 15 marks]

Encircle the most appropriate answer.

1. In a ………… cooling system the mechanical compressor of a convention system that do the same function is driven by thermo-chemical system.
   a. Evaporative   b. Vapor Compression
   c. Absorption   d. Compressor

2. The useful gain from a solar thermal collector is given by $Q_u = A_C[F_R(\tau\alpha)G_T - F_R U_L(T_i - T_a)]$. The term U_L is defined as
   a. Overall loss coefficient   b. Top loss coefficient
   c. Edge loss coefficient   d. Side loss coefficient

3. The ratio of lower heating value (LLV) and higher heating value of ……… is 0.9378.
   a. gasoline   b. natural gas   c. methane   d. propane

4. More recently, a new generation of very small gas turbines has entered the marketplace. Often referred to as ……. turbines, these units generate anywhere from about 500 watts to several hundred kilowatts.
   a. pico   b. micro   c. nano   d. macro

5. The Elliott TA 100A at its full 105-kW output burns 1.24 × 106 Btu/hr of natural gas. Its waste heat is used to supplement a boiler used for water and space heating in an apartment house. The design calls for water from the boiler at 120^0F to be heated to 140^0F and returned to the boiler. The system operates in this mode for 8000 hours per year. It takes 1 Btu to raise 1 lb of water by 1^0F, and one gallon of water weighs 8.34 lb. If 47% of the fuel energy is transferred to the boiler water, what should the water flow rate be?
   a. 123.4 gpm   b. 38 gpm   c. 80.85 gpm   d. 58 gpm

6. If the boiler in above question is 75% efficient, and it is fueled with natural gas costing $6 per million Btu, how much money will the microturbine save in displaced boiler fuel?
   a. $37,300/yr   b. $79,362/yr   c. $67,200/yr   d. $59,520/yr

7. The chemical reaction in the anaerobic digestion of organic matter is given by below equation

$$C_nH_aO_bN_cS_d + H_2O + \text{bacteria} \rightarrow CH_4 + CO_2 + NH_3 + H_2S + \text{new cells}$$

   The desired end product is methane (CH_4) and the relative amount of methane in the digester gas is typically between ……………...
   a. 55% and 75%   b. 75% and 85%   c. 45% and 65%   d. 85% and 95%

8. Suppose that a customer subject to the rate structure in Table below uses 1200 kWh/mo during the summer. What would be the total cost of electricity ($/mo, ignoring the monthly service charge)?

Tier Level	Winter: November–April		Summer: May–October	
Tier I	First 620kWh	7.378¢/kWh	First 700kWh	8.058¢/kWh
Tier II	621–825	12.995¢/kWh	701–1000	13.965¢/kWh
Tier III	Over 825	14.231¢/kWh	Over 1000	15.688¢/kWh

a. 56.41 b. 84.336 c. 129.68 d. 98.301

9. Two 100-hp electric motors are being considered—call them "good" and "premium." The good motor draws 79 kW and costs $2400; the premium motor draws 77.5 kW and costs $2900. The motors run 1600 hours per year with electricity costing $0.08/kWh. Over a 20-year life, find the net present value of the cheaper alternative when a discount rate of 10% is assumed. Present value factor is given by following equation.

$$\text{PVF}(d, n) = \frac{(1+d)^n - 1}{d(1+d)^n}$$

a. $1135 b. $2400 c. $1092 d. $1395

10. An industrial facility that needs a continuous supply of process heat is considering a 30 kW microturbine to help fill that demand. Waste heat recovery will offset fuel needed by its existing 75-percent efficient boiler. The microturbine has a 29% electrical efficiency and it recovers 47% of the fuel energy as usable heat. Find the Energy Chargeable-to-Power (ECP) in Btu/kWh

a. 3395 b. 4314 c. 3033 d. 4393

11. Pyrheliometer is an instrument measuring solar radiation for

a. Diffuse radiation b. Beam radiation
c. Total radiation d. Ground reflectance

12. The atmospheric transmittance for the beam radiation is given as $\tau_b = a_0 + a_1 \exp(-\frac{k}{Cos\theta})$ where θ represents

a. Zenith angle b. Incident angle
c. Solar azimuth angle d. declination

13. .... is the energy received by earth surface per unit time per unit area outside the atmosphere of earth.

a. Solar energy b. Solar value c. Solar constant d. Equiterrestial energy

14. The loss coefficient computation of a solar thermal collector assumes.

a. Heat flow through a cover is one dimensional.
b. There is a negligible temperature drop through a cover.
c. The covers are opaque to infrared radiation.
d. All of the above

15. The hydraulic energy of impulse turbine is completely converted into .... before trans formation in the turbine runner.
a. Internal energy b. Potential energy c. Kinetic energy d. Mechanical energy

SECTION "B"

[5 Q × 1 marks =5 marks]

Define in a sentence.

16. Smart grid system

17. Distributed generation

18. Wind power factor

19. Demand side management

20. Sustainability

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SECTION "C"

Attempt *ALL* questions.

1. A fully mixed water tank storage containing 1500 kg of water has a loss coefficient–area product of 11.1 W/^{0}C and is located in a room at 20^0 C. At the beginning of a particular hour the tank temperature is 45.0^{0}C. During the hour energy Qu is added to the tank from a solar collector, and energy Ls is removed from the tank and delivered to a load as indicated in the table. A calculation of the solar gain Qu using below equations shows that no energy is delivered during the first hour. A calculation of the load energy Ls shows 12 MJ is extracted from the tank during the first hour. Using Euler integration, calculate the temperature of the tank at the end of each of 8 h and show the instantaneous efficiency. Also calculate the area of the collector required to meet the load. For the collector assume the overall loss coefficient U_L to be 8.0 W/m^2 ^{0}C and the plate efficiency factor F' to be 0.841. The water flow rate through collector panel is 0.03 kg/s. [10]

$$F_R = \frac{\dot{m}C_p}{A_c U_L}\left[1 - \exp\left(-\frac{A_c U_L F'}{\dot{m}C_p}\right)\right]$$

$$T_s^+ = T_s + \frac{\Delta t}{(mC_p)_s}\left[Q_u - L_s - (UA)_s(T_s - T_a')\right]$$

$$Q_u = A_c[F_R(\tau\alpha)_{av}\, G_T - F_R U_L(T_i - T_a)]$$

Hour	Ls (MJ)	Ta (^{0}C)	G_T (W/m^2)
1	12	30	0
2	14	31	400
3	18	31.5	500
4	21	32	600
5	20	32.5	700
6	20	33	800
7	18	33.5	900
8	16	34	800

2. Repeat calculation when flow rate is doubled. Also show change in efficiency. [5]

3. Below shows a cash-flow analysis for a $10,000, 6%, 8-year loan used to pay for a conservation measure that, at the time of loan initiation, saves a homeowner $15,000/yr in electricity. This savings in the electric bill is expected to increase 5% per year. The homeowner has a personal discount factor of 10%. Since this is a home loan, any interest paid on the loan will qualify as a tax deduction and the homeowner's federal (and perhaps state) income taxes will go down accordingly. Let's work our way through the spreadsheet. When is the loan paid off? What is the pay-back period? [10]

Loan principal ($)=	Energy savings (kWh/yr)=
Interest=	Price at t=0 ($/kWh)=0.1
Loan term (yrs)=	Savings at t=0,=
CRF(i,n) per year=	Escalating at (%/yr)=
Payments ($/year)=	Personal discount rate =
Tax bracket = 0.305	

End of Year	Loan Payment	Interest	Delta Principal	Loan Balance	Tax Savings	Loan Cost	Electric Savings	Net Savings	PV Savings	Cum PV Savs
0	0.00	0.00	0.00	1000.00	0.00	0.00	0.00	0.00	0.00	0.00

$$\text{CRF}(i, n) = \text{Capital recovery factor}(\text{yr}^{-1}) = \frac{i(1+i)^n}{(1+i)^n - 1}$$

4. The following data is available for a hydro-power plant:
Available heat=140 m; catchment area =2000 sq. km; annual average rainfall =145 cm; turbine efficiency = 85%; generator efficiency = 90%;
percolation and evaporative losses = 16%.
Determine the power developed and suggest type of turbine to be used if runner speed is to be kept below 240 r.p.m [6]

5. Explain different type of heat gain and losses through air conditioned room. [6]

6. How does wind power varies with tower height? [6]

7. Explain the uses of geo-thermal energy appropriate below 90^0C. [6]

8. Write short notes on electric-demand side management strategies. [6]