KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

Marks Scored:

Level : B.Sc.		Course	: ESEE 309
Year : III		Semester	: II
Exam Roll No. :	Time: 30 mins.	F. M.	: 20
Registration No.:		Date	: 07 JUL 2023

SECTION "A"
[10Q. × 0.5 = 10 marks]

Encircle the most appropriate alternative from each set of choices.

1. A run of river plant with pondage is proposed for a hydropower plant. The available flow of 50 m^3/sec and a head of 90 m. Hydro plant efficiency is 90% and transmission losses is 5%. Determine the capacity of the hydro plant.
   a. 40 MW b. 40 kW c. 400 kW d. 44 kW

2. What is Q of the equation $Q = V\,\rho\, C_p(t_r - t_s)$?
   a. total HVAC load b. heating load c. cooling load d. Infiltration load

3. The radiative portion of the heat gains from people is ________.
   a. 30% b. 70% c. 0% d. 100%

4. The outdoor temperature for 24 hours is given below. Calculate temperature below 18^0C reference temperature. The degree days is:

Outdoor Temperature (°C)																							
12	12	12	13	13	15	17	18	19	19	20	21	21	20	19	19	18	18	17	16	15	14	13	13

   a. 22 b. 0.2 c. 0.02 d. 2.2

5. The power developed by wind turbine is given by $\rho A\, \frac{\overline{U^3}}{2} = \rho A\, \frac{c^3}{2}\Gamma\,(1 + \frac{3}{k})$. Γ in the given equation refers to ______________.
   a. weibull shape factor b. gamma function
   c. average wind speed d. power generated

6. The thermal efficiency (HHV) is maximum for __________.
   a. No. 4 oil b. methane c. propane d. natural gas

7. 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◦ F to be heated to 140◦ F and returned to the boiler. The system operates in this mode for 8000 hours per year. If 47% of the fuel energy is transferred to the boiler water, what should the water flow rate be?
   a. 58 gpm b. 85 gpm c. 48 gpm d. 84 gpm

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. If utility electricity costs \$0.08/kWh, how much will the micro turbine save in avoided utility electricity?

a. \$ 67,200/yr b. \$ 67,000/yr c. \$ 37,300/yr d. \$ 59,520/yr

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

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

<u>SECTION "B"</u>

[10Q. × 1 = 10 marks]

Define in a sentence.

11. Renewable energy

12. Non – renewable energy

13. Combined heat and power

14. Cost chargeable to power

15. Infiltration

16. Total radiation

17. Integrated generation

18. Distributed generation

19. Wind power factor

20. Demand side management

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SECTION "C"

Attempt *ALL* questions.

1. Determine the collector overall loss coefficient for a single glass cover with the following specifications: Plate-to-cover spacing 25 mm Plate emittance 0.95 Ambient temperature 10°C Mean plate temperature 100°C Collector tilt 45° Wind heat transfer coefficient 10 W/m^2 °C. Assume Back-insulation thickness 25 mm Insulation conductivity 0.045 W/m °C. And edge loss of 1 W/m^2 °C. Assume missing data. [5]

$$U_t = \left(\frac{N}{\frac{C}{T_{pm}}\left[\frac{(T_{pm}-T_a)}{(N+f)}\right]^e} + \frac{1}{h_w} \right)^{-1} + \frac{\sigma (T_{pm}+T_a)(T_{pm}^2+T_a^2)}{\frac{1}{\varepsilon_p + 0.00591 N h_w} + \frac{2N+f-1+0.133\varepsilon_p}{\varepsilon_g} - N}$$

$f = (1 + 0.089h_w - 0.1166h_w\varepsilon_p)(1 + 0.07866N)$
$C = 520(1 - 0.000051\beta^2)$ for $0^\circ < \beta < 70^\circ$; for $70^\circ < \beta < 90^\circ$, use $\beta = 70^\circ$
$e = 0.430(1 - 100/T_{pm})$

2. Below shows a cash-flow analysis for a $40,000, 10%, 8-year loan used to pay for a conservation measure that, at the time of loan initiation, saves a homeowner $12,000/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? [8]

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

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

3. A fully mixed water tank storage containing 1400 liters of water has a loss coefficient–area product of 11.1 W/°C. At the beginning of a particular hour the tank temperature is 55.0°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 of problem 1 and the plate efficiency factor F' to be 0.841. The water flow rate through collector panel is 0.03 kg/s. [8]

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

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

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

Hour	Ls (MJ)	Ta (°C)	G_T (W/m²)
1	12	30	0
2	16	31	400
3	0	31.5	500
4	22	32	600
5	0	32.5	700
6	14	33	900
7	0	33.5	950
8	13	34	850

4. List key feeds used for biogas generation in Gandaki Urja. What is solar absorption air conditioning? [2+2]

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 = 6%.
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 the factors for Heating Ventilation and Air Conditioning (HVAC) Load. How can this HVAC load have minimized? [3+3]

6. What is power density of a wind turbines? How can the power from the wind be maximized? [6]

7. What are the direct uses of geo-thermal energy? Write down the advantages of geo-thermal energy. [3+3]

8. What is Distributed generation and Integrated generation? Explain its differences. [6]