

KATHMANDU UNIVERSITY
End Semester Examination
June/July, 2023

Marks Scored:

Level : B.Tech.
Year : III

Course : ENVE 399
Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date

07 JUL 2023

SECTION "A"
[20Q. × 1 = 20 marks]

Encircle the most appropriate option.

- In a cooling system the work is done in order to generate the cooling effect.
a. evaporative
b. vapor Compression
c. absorption
d. turbine
- 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 F_R is defined as
a. Overall loss coefficient
b. Top loss coefficient
c. Heat removal factor
d. Efficiency
- The ratio of lower heating value (LLV) and higher heating value of is highest.
a. gasoline
b. natural gas
c. methane
d. propane
- 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
- A microturbine has a natural gas input of 13,700 Btu (LHV) per kWh of electricity generated. Find its HHV efficiency if $1\text{kWh}=3412\text{ Btu}$. $\text{LHV}/\text{HHV}=0.9010$.
a. 24.91 %
b. 27.65 %
c. 22.44 %
d. 21.44 %
- World electricity generation by fuel TWh is highest for
a. nuclear
b. fossil thermal
c. hydro
d. renewables
- We should use renewable energy sources because
a. non-renewable resources are limited
b. security of supply
c. sustainability
d. all of the mentioned
- The CO_2 emission by fuel type is highest for.....
a. renewable sources
b. coal/peat
c. oil
d. natural gas
- An equation for atmospheric transmittance due to aerosols is based on the equation $\tau_{a,\lambda} = \exp(-\beta\lambda^{-\alpha}m)$, where, β is known as
a. wavelength
b. angstrom turbidity
c. air mass
d. single lumped wave length exponent

10. 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
11. 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. \$1135 b. \$2400 c. \$1092 d. \$1395
12. Suppose the energy-efficiency retrofit of a large building reduces the annual electricity demand for heating and cooling from 2.3×10^6 kWh to 0.8×10^6 kWh and the peak demand for power from by 150 kW. Electricity costs \$0.06/kWh and demand charges are \$7/kW-mo, both of which are projected to rise at an annual rate of 5%. What is the total annual savings?
- a. \$ 90,000/yr b. \$ 12,600/yr c. \$ 100,000/yr d. \$102,600/yr
13. 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% 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
14. Pyranometer is an instrument measuring solar radiation for
- a. diffuse radiation b. beam radiation c. total radiation d. ground reflectance
15. For a particular day, the radiation on a tilted surface, using the Liu-Jordan can be written as $H_T = (H - H_d)\bar{R}_b + H_d \left(\frac{1+\cos\beta}{2}\right) + H \rho_g \left(\frac{1-\cos\beta}{2}\right)$ where β is
- a. tilt angle b. azimuth angle c. incident angle d. zenith angle
16. 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. Equiterrestrial energy
17. 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

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18. The hydraulic energy of impulse turbine are completely converted into before transformation in the turbine runner.
- a. Internal energy
 - b. Potential energy
 - c. Kinetic energy
 - d. Mechanical energy
19. The total power from a hydro electric power plant is given by
$$P = \rho gZ + 1/2 \rho v^2) \times Q \times \epsilon$$

The term inside the bracket is
- a. static head
 - b. dynamic heat
 - c. hydraulic head
 - d. net head
20. The following data relate to a proposed hydro-electric station:
Available head = 28 m,
catchment area = 420 sq. km,
rainfall = 140 cm/year,
percentage of total rainfall utilized = 68%,
penstock efficiency = 94%,
turbine efficiency = 80%,
generator efficiency = 84%, and
load factor of 44%
- The total power developed by the plant is.....
- a. 2186 kW
 - b. 325 kW
 - c. 2.6 kW
 - d. 4000 kW

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SECTION "B"

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/m² °C. Assume Back-insulation thickness 25 mm Insulation conductivity 0.045 W/m °C. And edge loss of 1 W/m² °C. Assume missing data. [5]

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

$$f = (1 + 0.089h_w - 0.1166h_w\varepsilon_p)(1 + 0.07866N)$$

$$C = 520(1 - 0.000051\beta^2) \text{ for } 0^\circ < \beta < 70^\circ; \text{ for } 70^\circ < \beta < 90^\circ, \text{ use } \beta = 70^\circ$$

$$e = 0.430(1 - 100/T_{pm})$$

2. Below shows a cash-flow analysis for a \$30,000, 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 Savings
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$$CRF(i, n) = \text{Capital recovery factor (yr}^{-1}\text{)} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

3. Annual electricity use of 1500 kW-h is consumed for a home located in Kathmandu. Explain different measures to reduce this demand to 1000 kW-h. [6]

4. A fully mixed water tank storage containing 1500 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 45.0°C. During the hour energy Q_u is added to the tank from a solar collector, and energy L_s is removed from the tank and delivered to a load as indicated in the table. A calculation of the solar gain Q_u using below equations shows that no energy is delivered during the first hour. A calculation of the load energy L_s 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]

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

$$T_s^+ = T_s + \frac{\Delta t}{(mC_p)_s} [Q_u - L_s - (UA)_s(T_s - T_a)]$$

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

Hour	L_s (MJ)	T_a (°C)	G_T (W/m ²)
1	12	30	0
2	14	31	400
3	0	31.5	500
4	30	32	600
5	0	32.5	700
6	40	33	900
7	0	33.5	950
8	32	34	850

5. Discuss the function of mechanical governor in hydroelectric plant. What are pumped storage plant and where they are used? [2+2]

The daily load curve data for a certain area is as follows:

12 MN-5AM: 100MW
 5AM-8AM: 120MW
 8AM-12 noon: 250 MW
 12 Noon-1PM: 100 MW
 1PM-5PM: 250MW
 5PM-9PM: 350MW
 9PM-12MN: 150MW

It is proposed to install a run-off river plant with a pondage for supplying the above load. The run off data indicates that a flow of 50 m³/s is available. The head is 90 m. Hydro plant efficiency is 90% and the transmission losses are 5%. Determine the capacity of hydroelectric power plant? [6]

6. Explain the factors for contributing heating ventilation and air-conditioning load. [6]
7. What is the role of temperature, density and tower height in defining the power output from a wind turbine? [6]
8. What are the direct uses of geo-thermal energy? What are the advantages of geo-thermal Energy? [3+3]