

Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Micro Hydro Power (Elective III) (EE 78501)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) With a neat and clean schematic layout of a micro hydro plant, explain the functions of its different components. Define plant factor and explain its significance in a micro hydro plant. [8]
 b) In an effort to predict annual average daily flow (ADF) by area rainfall method using three rain gauges, the following: Rainfall recorded in gauge A = 3000 mm/yr, Rainfall recorded in gauge B = 2500 mm/yr, Rainfall recorded in gauge C = 3500 mm/yr. In the graphical mapping, the number of squares referred to gauges A, B and C were found to be 70, 55, and 25 respectively. The scale of map is 1:50000 and a side of square in the graph is 3 mm. Assuming run off the catchment to be 50% of the rainfall, find the ADF. [8]
2. a) Define nomogram. Explain how it is used to select turbine type and determine the diameter of runner. [8]
 b) A micro hydro scheme of 10 kW capacity is to be designed. A turbine with 80% efficiency at full flow is to be used. The generator efficiency is 90% when used between half power and full power and 80% when used for quarter power. Assume a drive system with efficiency of 98%. [8]
 - (i) What is the power required for turbine during full flow condition?
 - (ii) What is the output power of generator at half flow?
 - (iii) What is the output power of generator at quarter flow?

The turbine efficiency at half flow and quarter flow is 70% and 40% respectively.
3. a) Explain the brushless excitation system in synchronous generators. What are the practical considerations for AVR when an off the shelf (diesel) generators are used in micro hydro? [4+4]
 b) A 3 phase 20 kW induction motor rated at 440 V (line to line), 50 Hz have been chosen to be used as induction generator. The manufacturer's data sheet shows full load current of 28 and full load power factor of 0.85. Calculate the size and voltage rating of the excitation capacitors to be connected in a) delta b) star [8]
4. a) Mention the causes of over and under voltage trip and over and under frequency trip in the protection system of a micro hydro plant. [8]
 b) Mention the coverage and significance of the operation manual, component manual and training manual with regard to smooth operation of micro hydro power plants. [8]
5. a) What are the factors to be considered while designing tariff in community owned micro hydro scheme? Explain the types of tariff employed in such scheme. [4+4]
 b) A feasibility study for a micro hydro scheme estimates annual revenue of \$20,000 and annual expenditure of \$8,000 for 15 years life period. If the startup cost is \$120,000 find out the net present value and discounted payback period for a discount rate of 12%. Also find the internal rate of return of the scheme. [8]

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1. a) A proposed micro hydro scheme with a gross head of 50 meters is proposed to meet the following demands as an alternative to a diesel powered mill and a generator which costs around \$0.05 per kWh of energy.

Category	Time	Demand	Duration in year
Lighting	6 am to 12 am	40 kW	Round the year
Milling	8 am to 4 pm	20 kW	Round the year
Irrigation	suitable slot	4000 m ³ /day	During dry months only
Storage Cookers	any time	3 kW	As per the power availability
Battery charging	any time	1.5 kW	As per the power availability

Provided that the minimum flow of 160 l/s is available during winter from Kartik to Chaitra while it does not fall less than 200 l/s from Baishakh to Ashwin, will there be enough water to satisfy the irrigation demand together with lighting and milling demand? If yes, decide whether the proposed hydro scheme is viable if the annual cost of capital repayment is \$ 6,000 and O and M cost is 10% of the annual repayment cost.

- b) Explain how you determine the annual Average Daily Flow (ADF)?
2. a) Explain, with suitable circuit diagram, how a discrete resistance type of ELC functions as governor in micro hydro. What is its advantage over AC voltage control type of ELC?
- b) A micro hydro scheme is supposed to supply a maximum single phase load of 12 kW at 230 V, 50 Hz. Water immersion kettle elements are to be used as ballast load for an AC voltage control type of ELC. Estimate the size and number of kettle elements and the water flow rate if the temperature to be maintained for entering water is 22°C and that for outgoing water is 4°C. The specific heat of water is 4,200 J/kg/°C for the temperature range concerned.
3. a) What are the basic elements of an Automatic Voltage Regulator (AVR)? What kinds of under speed protections can be incorporated if a diesel generator AVR is used in a micro hydro installation?
- b) A 10 kW, 50 Hz, 380 V (line to line) 3 phase induction motor draws a line current of 15 A when the machine supplied at its rated voltage and frequency with mechanical load. What size of excitation capacitors are needed for delta connection in order to make the machine generate at approximately its rated voltage when driven slightly above its rated speed? Find also the voltage for which the capacitors have to be designed. Also calculate the value of excitation capacitance and their voltage ratings when they are to be star connected.
4. a) Mention the causes of the followings in the protection system of a micro hydro plant:
- (i) Under voltage trips
 - (ii) Temperature trip
 - (iii) Over frequency trips

- b) Write short notes on the following switchgear device used in micro hydro applications: [8]
- (i) Module case circuit breaker
 - (ii) Earth leakage circuit breaker
5. a) Give the causes and remedial measures for the following faults in a micro hydro scheme: [10]
- (i) Turbine does not start
 - (ii) No voltage from the alternator
- b) A feasibility study for a micro hydro scheme estimates annual revenue of \$30,000 and annual expenditure of \$12,000 for 15 years life period. If the start up cost is \$ 180,000, find the net present value and discounted payback period for a discount rate of 12%. Also find the internal rate of return of the scheme. [6]

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1. a) Why prioritize Operation and Maintenance first, economics and plant factor second, and engineering design last in micro-hydro design? [4]
- b) Why Salt Dilution Method is used for MHP? As a surveyor of a MHP, you performed Salt Dilution Test and collected following data. [2+6]

Time(Sec)	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
Reading 1 (μS)	24	24	24	26	28	29	30	32	32	36	36	38	39	39	38	37	34	32	30	29	27	25	24	24
Reading 2 (μS)	25	25	27	28	29	30	31	32	33	34	34	35	35	35	34	34	33	32	31	30	29	28	27	26

The weight of salt for sample 1 and sample 2 was 200gm and 300gm. If salt constant is 1.8 μS/mg/liters, find the average discharge.

- c) Why is the analysis of load demand curves essential for aligning power supply with demand in micro-hydroelectric projects (MHP), and how does it contribute to determining the optimal generating installed capacity? [4]
2. a) Why do drive systems in Microhydro projects exhibit constant losses despite fluctuations in loading at the generator or turbine, and how does this consistency impact the overall efficiency of the system? [4]
- b) Design a Pelton turbine for a micro hydro site with 150 meters gross head and turbine flow 75 to 200 l/s during a year. The turbine is required to deliver mechanical power to the generator with a 1500 rpm speed. Assume, friction loss in penstock pipe equal to 10% of the gross head. [8]
Taking part flow efficiency into consideration, recommend the following;
 - (i) The number of jets,
 - (ii) Diameter of runner and
 - (iii) The bucket sizes
 - (iv) Number of buckets
- c) Explain the effect of ELC on generator sizing. [4]
3. a) For a proposed MHP at an altitude of 4000 m and maximum ambient temperature 45°C, an induction motor as a generator is proposed. Determine the size, rotational speed and capacitor bank size if the village load is 10kW and 0.8 power factor is to be maintained. Rated Efficiency of Induction Motor at Full Load is 0.89. [8]

Max. Ambient temperature in °C =>	20	25	30	35	40	45	50	55
Temperature Factor (A)	1.10	1.08	1.06	1.03	1.00	0.96	0.92	0.88

Altitudes	1000	1250	1500	1750	2000	2250	2500	2750	3000	3250	3500	3750	4000	4250	4500
Altitude Factor (B)	1.00	0.98	0.96	0.945	0.93	0.915	0.90	0.88	0.86	0.845	0.83	0.815	0.8	0.785	0.77

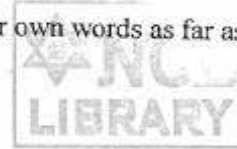
- b) Define AVR. Why AVR is must require in self excited Generators? [1+3]
- c) Define Brushless Generator. Why Brushless generator is gaining popularity in MHP? [2+2]
4. a) Draw Single line diagram of MHP with its protection system and measuring units. Explain the importance and layout/location of Earthing in MHP. [4+4]
- b) What is the Endurance test of Micro-hydro? Explain shutdown procedure of Micro-hydro for generating electricity. [1+3]
- c) Write short notes on: [2+2]
- (i) Training Manuals and (ii) Log Books
5. a) An community with 30 Household is considering whether they should install an MHP scheme. The installed capacity is 20kW and the total project cost is Rs 1,020,000. The expected subsidy from the government is Rs 11,500 per household and equivalent labour work donation of Rs. 20,000 and land donation of 1,00,000. They plan to draw the remaining investment as loan from the cooperative at an annual interest rate of 16 percent. [8]
- The entrepreneur's monthly income is estimated to be as follows.
- 60W bulbs x 100 @ Rs 70 per bulb/month
- 40W bulbs x 150 @ Rs 55 per bulb/month
- 25W bulbs x 120 @ Rs 40 per bulb/month
- 20W bulbs x 50 @ Rs 35 per bulb/month
- Income from agro-processing Rs 6000/month (average)
- The entrepreneur's monthly expenses on salaries are as follow.
- Salary to operators: Rs 2500/month
- Salary to the manager: Rs 3000/month
- Determine whether the scheme is financially viable.
- b) Grid connection of the installed micro/mini hydro project is the burning issue of the day" provide your logic to prove this statement. [4]
- c) Is it more appropriate to use "Cost per kW" or "Cost per kWh" as a decisive factor for project selection in Micro-Hydro Power (MHP)? Explain why you think one is more important than the other. [4]

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Chaitra

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Year / Part	IV / II	Time	3 hrs.

Subject: - Micro-hydro Power (Elective III) (EE 78501)

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1. a) The Hills of Nepal are both a blessing and a curse for Nepal's hilly region electrification. Why? [4]
- b) Three rain gauges are placed at three location x, y and z to estimate rainfall in catchment area and the recorded rainfall are as follows: [8]
 - Gauge at x rainfall x = 2000 mm/yr
 - Gauge at y rainfall y = 2500 mm/ yr
 - Gauge at z rainfall z = 3000 mm/yr

It is estimated that there are 30% evaporation losses and around 10% absorption losses. If the area of x, y and z count 45, 40 and 50 square where 1 square = 1 square mm and the scale of map is 3 KM to 10 mm. Calculate,

 - (i) The average rainfall in the catchment area in mm/yr
 - (ii) Total catchment area in mm^2
 - (iii) Run off from the catchment area.
 - (iv) The annual average daily flow in m^3/sec
- c) Describe the salt dilution method of discharge measurement with the explanation of good and bad curve shapes along with reason and solution. [4]
2. a) Define Nomograph. Explain how it is used to select turbine type and determine diameter of runner. [4]
- b) A cross flow turbine is to be run at 1000 rpm in a micro hydro project with net head of 45 meter and discharge of 450 liter/sec. [6]

Calculate;

 - (i) The thickness of the water jet
 - (ii) Diameter of the runner and
 - (iii) Length of the runner
- c) Explain the effect of harmonics produced by ELC and possible ways to mitigate it. [6]
3. a) A 8 KW, 750 rpm, 0.8 pf (lag), 50 Hz, 380 V (line to line) 3 phase induction motor draws a line current of 15 A when the machine supplied at its rated voltage and frequency with mechanical load. What size of excitation capacitors are needed for delta connection in order to make the machine generate at approximately its rated voltage when driven slightly above its rated speed? Find also the voltage for which the capacitors have to be designed. Also calculate the value of excitation capacitance and their voltage ratings when they are to be star connected. [8]
- b) Define AVR. Why AVR is must require in self excited Generators? [4]
- c) What do you mean by Brushless AC Generator and why it is gaining popularity in MHP? [4]

4. a) Write short notes on : (Any Two)

- (i) ELCB
- (ii) Temperature Trips
- (iii) Earthing System

[8]

b) What is the Endurance test of Micro-hydro? Explain the startup and shutdown procedure of Micro-hydro for generating electricity.

[8]

5. a) A feasibility study for micro-hydro scheme estimates annual revenue of NRs.2,500,000 and annual expenditure of NRs.960,000 for 15 years life period. If the startup cost is NRs. 14,500,000, find out the net present worth and discounted payback period for a discount rate of 12%. Find IRR of the scheme with your recommendation for the developer.

[8]

b) Explain how different economic and financial indices used for project selection in MHP.

[4]

c) Explain tariff structure in Micro-hydro.

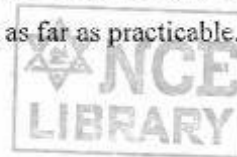
[4]

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2078 Chaitra

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Year / Part	IV / II	Time	3 hrs.

Subject: - Micro Hydro Power (Elective III) (EE78501)

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1. a) Nepal is one of the fastest electrifying countries in the World. What's the role of Micro-hydro in this achievement? Explain. [4]
- b) Discuss the impacts and challenges of grid connected micro hydro power in Nepal. [4]
- c) A Consultant carried out a hydrological survey and measured discharge from January 1 to January 15. The discharge rate (m^3/s) are 0.25, 0.4, 1.6, 1.0, 0.6, 4.5, 3.0, 2.4, 1.9, 1.3, 1.1, 0.3, 0.2, 5.0 and 3.3 respectively. Now from the given data prepare flow duration curve. [8]
2. a) The site under consideration for a Pelton turbine has the following characteristics:
 - Gross head: 90 meter
 - Turbine flow: from 75-200 l/s during a year
 - Alternator speed: 1500 rpm
 - The efficiency of Pelton Turbin: 80%
 - Friction loss in penstock to be 10% of the gross head

Taking part flow efficiency also into consideration recommend the no. of jets, runner diameter, number of buckets and the bucket size. [8]
- b) What types of drive system are commonly used in micro hydro projects? When can you use direct coupling drive system? [4]
- c) Explain the variation of voltage and frequency of Micro-hydro loads like Lamps, Motors, Heating Cooker and Transformers. [4]
3. a) Define intelligent AVR and when is use of such AVR made in micro-hydro? A 8 kW, 750 rpm, 50 Hz, 380 V (line to line) 3 phase induction motor draws a line current of 15 A when the machine supplied at its rated voltage and frequency with no mechanical load. What size of excitation capacitors are needed for delta connection in order to make the machine generate at approximately its rated voltage when driven slightly above its rated speed? Find also the voltage for which the capacitors have to be designed. Also calculate the value of excitation Capacitance and their voltage ratings when they are to be star connected. [2+6]
- b) A Micro-hydro is using Induction Generator with ELC. Do we require AVR for such micro-hydro or not? Support your judgement. [4]
- c) Explain why a C-2C Capacitor is used for supplying single-phase power from a three-phase induction generator. [4]

4. a) Why direct equipment earthing is not recommended for Micro-hydro? Explain types of system earthing. TT-arrangement for earthing is used for Micro-hydro, Why? [8]
- b) What do you mean by maintenance? Explain the different types of maintenance in MHP. Mention the significance of the following operation and maintenance document for the smooth run of micro-hydro [8]
- (i) Repair book
 - (ii) Log Book
 - (iii) Training manual
5. a) An entrepreneur is considering whether he should install an MHP scheme. The installed capacity is 15 kW and the total project cost is Rs. 1,020,000. The expected subsidy from the government is Rs. 306,000 and he plans to draw a loan of Rs. 500,000 from the bank at an annual interest rate of 16%.
- The entrepreneur's monthly income is estimated to be as follows.
- (i) 60Wbulbs $\times$ 100 @ Rs 70 per bulb/month
 - (ii) 40Wbulbs $\times$ 150 @ Rs 55 per bulb/month
 - (iii) 25Wbulbs $\times$ 120 @ Rs 40 per bulb/month
 - (iv) Income from agro-processing Rs 9000/month (average)
- The entrepreneur's monthly expenses on salaries are as follow.
- (i) Salary to operators: Rs 3500/month
 - (ii) Salary to the manager: Rs 2500/month
- Determine whether the scheme is financially viable. [8]
- b) Explain various financial indicators for micro hydro systems and their role in investment and decision making. [4]
- c) Explain tariff structure in Micro-hydro. [4]

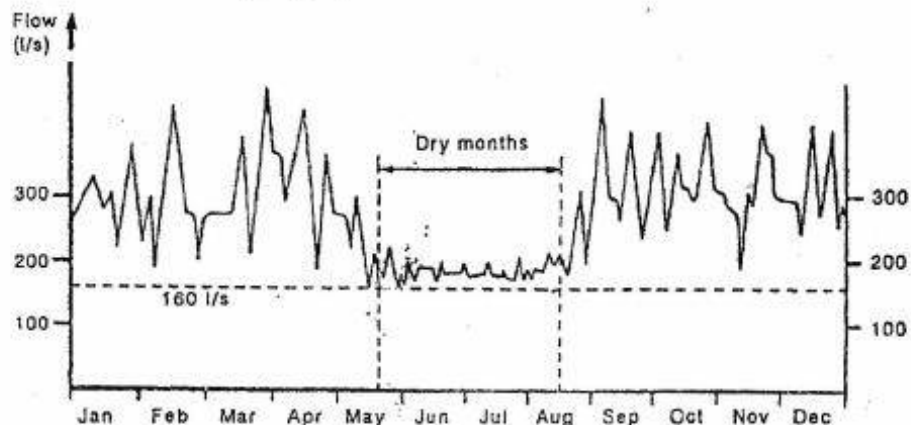
TRIBHUVAN UNIVERSITY
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1. a) What are the challenges of Micro-hydro Plants in Nepal? Discuss the issues for Micro-Hydro Plant in being connected to mini-grid and / or national grid. [8]
- b) Discuss the responsibility of designer, installer and users towards the operation and maintenance works (C and M). [8]
2. a) A 3 phase 20 kW induction motor rated at 440 V, 50 Hz has been used in a micro hydro plant for power production. It takes full load current of 28 amps and full load power factor of 0.85. Calculate the size and voltage rating of the capacitors in star and delta conditions. [8]
- b) Discuss about use of Under Voltage trip, Over Frequency trip and lightning protection in Micro Hydro system. [8]
- c) Discuss the factors that need to be considered during the feasibility study for new Micro-Hydro Power Project. [4]
3. a) Describe the methods of head measurement and water flow measurement during detailed feasibility study and Micro-Hydro Power. Also mention their limitations. [8]
- b) What is tariff system? Explain the energy tariff system in micro hydro scheme with suitable example. [4]
4. The proposed hydro scheme will supply for lighting, grain milling, battery charging and heat storage cooking in a village. The gross head of the scheme is 50 meters. The flow variation is shown in the hydrograph.



It is estimated that the lighting demand will grow within four years to 40 KW for the hours 6 pm to 12 pm all through the year. The mill in the village is to be operated between 8 am to 4 pm every day, which requires a power of 12 KW. The battery charging requires 2 KW of power. The survey has shown that 20 villagers want to use heat storage cookers requiring 200 watts of power.

During three dry months, farmers in the village intend to irrigate 40 hectares of land each hectare needing 5m^3 water per day. This irrigation demand is estimated to double within four years. Will there be enough water to satisfy this irrigation demand together with lighting and milling demand?

Suggest whether the hydro scheme so proposed seems to be viable proposition if the diesel power is available at cost of 0.1 \$/kWh. The year wise capital for MHP is \$4000 and 10% of capital is the O and M cost.

[10]

5. a) Explain various financial indicators for micro hydro systems. Describe their role in investment and decision-making. [6]
- b) Differentiate between Micro-hydro Power and large hydro power from the load-frequency control point of view. [4]
- c) What is unit energy cost and how it is calculated? Explain with example. [4]
6. A Pelton turbine with 85% efficiency is to be used in a proposed micro hydro plant with the head of 100 meter. Flow varies from 60 LPS to 120 LPS in a year. If an alternator is to be driven at speed of 1500 rpm. Recommend the no of jets, runner diameter and bucket size. Assume 10 percent loss is in penstock. [8]

16 A TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Bhadra

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1. a) What is micro hydro power? Show the major components of micro hydro project in a neat sketch. Define gross head. [8]
- b) Three rain gauges are placed at three locations A, B and C to estimate rainfall in a catchment which recorded following rainfalls data [8]
 - Record of Gauge A = 2000 mm/yr
 - Record of Gauge B = 2700 mm/yr
 - Record of Gauge C = 3000 mm/yr

If the area for A, B and C count 58, 69 and 15 squares where 1 square = 1 square mm and the scale of map is 1:100,000 (i.e 1mm = 100 meter), calculate

 - (i) Total catchment area
 - (ii) The average rainfall in the catchment are in mm/year
 - (iii) Run off from the catchment are (Assume run off as 50% of the rainfall.)
 - (iv) The annual average daily flow in m³/sec
2. a) Write different types of turbines. Explain about pelton turbine with neat sketch. Which turbines are commonly used in micro hydro projects in Nepal? [10]
- b) Mention different types of drive systems. Describe pulley and belt type drive system with neat sketch. [6]
3. a) What is an alternator? Describe different types of alternators use in micro hydro projects. [8]
- b) A 3 phase 20 kW induction motor rated at 440V (line to line), 50 Hz have been chosen to be used as induction generator. The manufacturer's data sheet shows full load current of 28 and full load power factor of 0.85. Calculate the size and voltage rating of the excitation capacitors to be connected in (i) delta (ii) star [8]
4. a) Describe the commonly used protection systems in micro hydro projects? [8]
- b) Write short notes on: (Any four) [8]
 - i) ELC
 - ii) IGC
 - iii) Lightning Protection
 - iv) Earthing System
 - v) Modular case circuit breakers (MCCB)
 - vi) Under / over voltage trips
 - vii) 3 phase star and delta connection

5. a) Which type of tariff systems are commonly used in micro hydro projects of Nepal?
What is the major differences between those tariff systems? [8]

b) Two households of a community are using the following appliances each; [8]

- i) 5 Watt bulb - 4 nos.
- ii) 20 Watt bulb - 3 nos
- iii) 45 Watt tube light - 1 no.
- iv) 75 Watt TV - 1 no.

One household is paying NRs. 1/Watt/month basis while the other household is paying NRs.5/unit basis. How much should each of them pay per month if they use each appliance for;

- i) 5 hours/day
- ii) 10 hours/day and
- iii) 15 hours /day

Compare the differences in payment (consider 30 days in one month)

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1. a. Define micro-hydro? What are the advantages of micro-hydro over wind power and solar power? [1+3]
- b. What do you mean by compensation flow? What happens if demand exceeds the supply capacity and vice-versa? [1+3]
- c. Three rain gauges are placed at three location x, y, and z to estimate rainfall in catchment area and the recorded rainfall are as follows: [8]

Gauge at x	rainfall x = 2800 mm/yr
Gauge at y	rainfall y = 3500 mm/yr
Gauge at z	rainfall z = 3800 mm/yr

If the area for x, y, and z count 60, 72 and 10 squares where 1 square = 1 square mm and the scale of map is 1KM to 10 mm. calculate,

 - i. The average rainfall in the catchment area in mm/yr.
 - ii. Total catchment area in mm².
 - iii. Runoff from the catchment area (assume 50% evaporation).
 - iv. The annual average daily flow in m³/sec.
2. a. Explain why impulse turbine are popularly used in micro-hydro installation. What are the advantages of ELC over conventional hydro mechanical governor? [4+4]
- b. A single phase maximum load of 18 kw at 0.5 pf lagging is to be supplied at 230 V, 50Hz from micro-hydro scheme. Estimate the rating of the synchronous generator and the size and number of the water immersion kettle elements to be used as a ballast load. Also, estimate the water flow rate if the temperature of entering water is 20 °C and only 30 °C temperature rise is allowed. The specific heat of water is 4200 J/kg/°C for the temperature range concerned. [8]
3. a. Explain why an induction generator be rated to supply a load of power factor not less than 0.8 lagging? How will u choose whether to supply single-phase or three-phase power supply? [4+4]
- b. A 3-φ 12 kw IM rated at 380V (1-1), 50Hz have been chosen to be used as induction generator. The manufacturer's data sheet shows the following data

Full load current:	23A
Full load pf	: 0.8

Calculate,
The size and voltage rating of excitation capacitor when they are connected in delta and star.

4. a. Draw single line diagram of switchgear used in micro hydro. What are the causes of under voltage and over frequency trip in micro-hydro? [4+4]
- b. Mention the coverage and significance of the following operation and maintenance documents with regard to smooth operation of micro hydro. [8]
- i) maintenance Schedules
 - ii) Repair manual
 - iii) Log Book
 - iv) Training Manual
5. a. Differentiate between flat tariff and energy tariff? What are the different issues associated with the development of micro hydro in Nepal? [4+4]
- b. A feasibility study for a micro-hydro scheme estimates annual revenue of \$20000 and annual expenditure of \$8000 for 15 years life period. If the startup cost is \$120000, find out net present worth and discounted payback period for a discount rate of 12%. CommNet on your result and also find IRR of the scheme. [8]

26A TRIBHUVAN UNIVERSITY
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1. a) What are the steps for matching the power supply with demands? How the per unit cost of micro hydro scheme be calculated? How the plant factor be improved for MHP schemes? [8]
- b) Describe the salt dilution method of flow measurement. What are the sources of error and how can they minimized? [8]
2. a) Mention different types of turbines used in hydropower projects. Which type of turbines are most commonly used in micro hydro projects in Nepal and why? [5]
- b) What types of drive system are commonly used in micro hydro projects? When can you use direct coupling type drive system? [3]
- c) You have to design a pelton turbine for a micro hydro site having;
 - The gross head of 90 meters,
 - Turbine flow of 75 to 200 l/s during a year
 - Friction loss in penstock pipe equal to 10% of the gross head

The turbine is required to deliver mechanical power to the generator such that the generator speed is 1500 rpm. Taking part flow efficiency also into consideration, recommend

 - (i) The number of jets,
 - (ii) Diameter of runner and
 - (iii) The bucket size
3. a) Discuss the effect of ballast load on Generator sizing. [8]
- b) Discuss why induction generator cannot supply load of power factor less than 0.8 lagging. [6]
- c) A 20 KW, 50Hz, 4 pole, 415 V, 3 phase induction motor draws a current of 4.5 A when supplied at its rated voltage and frequency and run as a motor with no mechanical load. Calculate the excitation capacitance which must be connected in delta to make the generator at approximately its rated voltage when driven at slightly above the rated speed. Also calculate the voltage ratings of the capacitor. [4]
4. a) Describe the protection systems used in a micro hydro projects. [6]

b) Write short notes on:

[8]

- (i) 3 phase star and delta connection
- (ii) ELC
- (iii) Switch gear
- (iv) Earthing System

5. a) Mention two different tariff systems used in micro hydro projects? Which tariff system will you be implemented in your micro hydro project if you are in decision making position? Why?

[8]

b) The feasibility study of a micro hydro project provides the following data.

- Initial Investment: NRs. 12,000,000
- Annual revenue: NRs.2,000,000
- Annual expenditure: NRs.800,000
- Life period: 15 years

If a discount rate is 12% find;

- (i) The net present value
- (ii) Payback period and
- (iii) The internal rate of return of the scheme

[8]

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Micro Hydro Power (Elective III) (EE78501)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. a) Explain with schematic layout the operation of a micro hydro power plant. Discuss the usefulness of such plant for rural electrification compared to other forms of generating sources. [5+3]
- b) Three rain gauges are placed at three locations A, B and C to estimate rainfall in a catchment which recorded following rainfalls data [8]

Record of Gauge A = 2000 mm/yr
Record of Gauge B = 2700 mm/yr
Record of Gauge C = 3000 mm/yr

If the area for A, B and C count 58, 69 and 15 squares where 1 square = 1 square mm and the scale of map is 1:100,000 (i.e 1 mm = 100 meter), calculate

 - (i) Total catchment area
 - (ii) The average rainfall in the catchment area in mm/year
 - (iii) Run off from the catchment area (Assume run off as 50% of the rainfall.)
 - (iv) The annual average daily flow in m³/sec
2. a) How the nomogram chart be used for selection of turbine type and runner diameter? [8]
- b) A pelton turbine for a micro hydro plant has the gross head of 90 meters, turbine flow of 75-200 l/s during a year and fraction loss in penstock pipe equal to 10% of the gross head. The turbine is required to deliver mechanical power to the generator such that generator speed is 1500 rpm. Taking the part flow efficiency also in consideration, recommend the number of jets, diameter of runner and notch width of the buckets. [8]
3. a) A 15 kW, 4 pole, 50 Hz 415/240 V induction motor is star connected for operation as a generator. The manufacturer's data sheet shows full load current of 27 Amp and power factor of 0.87. Calculate the size of excitation capacitor that should be connected in delta to make the machine generated at approximately its rated voltage, when driven at slightly above its rated speed. [8]
- b) Explain why voltage regulator is required. Also explain the essential elements of an automatic voltage regulator. [8]
4. a) What are the modifications to be considered in mechanical specifications when a diesel generator is to be used in micro hydro? [8]
- b) Explain how induction generator is specified for a particular KW demand. [8]
5. a) What are different financial indicators for investing? Why are they important? [5]
- b) Generally flat watt tariff is employed in micro hydro rather than KWh tariff. Why? [4]
- c) A villager's committee deposits Rs Five lakhs to the bank for repayment of the loan and its interest and spends 10% of the annual repayment as O&M cost each year. The scheme has 12 KW capacity but can supply only 10 KW for 9 hours per day. Calculate the unit energy cost of the scheme. [7]

Exam.	Regular		
	Level	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Micro Hydro Power (Elective III) (EE78501)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. (a) What is a hydrograph? How do you convert a hydrograph into a flow duration curve? Discuss the usefulness of flow duration curve. [6]
- (b) Three rain gauges are placed at three locations X, Y and Z to estimate rainfall in a catchment area and the recorded rainfalls are as follows:
 Gauge at X: rainfall $x=2800$ mm/yr
 Gauge at Y: rainfall $y=3500$ mm/yr
 Gauge at Z: rainfall $z=3800$ mm/yr
 If the area for X, Y and Z count 60, 72 and 10 squares where 1 square = 1 square mm and the scale of map is 1 KM to 10 mm, calculate
 i) the average rainfall in the catchment area in mm/yr
 ii) total catchment area in mm^2
 iii) run off from the catchment area (use run off rain fall chart)
 the annual average daily flow in m^3/sec [10]
2. (a) With a neat sketch, explain the operation of a Pelton turbine and mention its advantages. How is runner diameter, bucket width and number of jets of such turbines estimated? [10]
- (b) A Pelton turbine with 85% efficiency is to be used in a proposed micro hydro plant with head of 125 metre. The flow to the turbine varies from 65 l/s to 150 l/s in a year. If the alternator is to be driven at 1500 rpm, recommend the number of jets, runner diameter and the bucket size. Assume 10 % friction loss in the penstock. [6]
3. (a) Compare the 'off-the-shelf' vs 'custom built' generators in terms their merits and demerits. What are mechanical specifications to be considered when off the shelf generators are used in micro hydro sites? [8]
- (b) A 15 KW, 1500 rpm, 50 Hz, 380 V (line to line) 3 phase induction motor draws a line current of 25A when the machine is supplied at its rated voltage and frequency without any mechanical load applied to it. What size of excitation capacitors are needed for delta connection in order to make the machine generate at approximately its rated voltage when driven slightly above its rated speed? Find also the voltage for which the capacitors have to be designed. Also calculate the value of excitation capacitance and their voltage ratings when they are to be star connected. [8]

-
4. (a) What should be the role of designer for the effective operation and maintenance of micro hydro plant? [6]
- (b) Mention the coverage and significance of the following operation and maintenance documents with regard to smooth operation of micro hydro plants:
- i) Operational manual
 - ii) Component manuals
 - iii) Installers' manuals
 - iv) Maintenance schedule [10]
5. (a) Explain the various financial indicators used for investment decision making along with their significance. What are the advantages of flat (per watt) tariff compared to per kilowatt hour tariff in community owned micro hydro schemes? [5+3]
- (b) A feasibility study for a micro hydro scheme estimates annual revenue of \$20000 and annual expenditure of \$8000 for 15 years life period. If the start up cost is \$120000, find out the net present value and discounted payback period for a discount rate of 12%. Also find the internal rate of return of the scheme. [8]

Exam.	New Back (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Micro Hydro Power (Elective III) (EE78501)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

1. (a) With a neat and clean schematic layout of a micro hydro plant, explain the functions of its different components. [8]
- (b) Calculate the unit energy cost of a scheme which re-pays \$4000 per year to the Bank and spends \$400 as operation and maintenance cost per year. The scheme has 10 KW capacity but supplies only 6 KW for 8 hours a day. [4]
- (c) In a flow measurement process using salt gulp method, 100 gram of salt was mixed with water in a bucket and poured into the stream at a point which is 20 meter up from the location of the conductivity meter. The readings of conductivity meter when plotted v/s time gave a total of 130 squares each square being 5 second $\times$ 5 ohm⁻¹ $\times$ 10⁻⁶.
If the temperature of water is 22 °C, find the flow of the stream in liter/sec.
Reciprocal of the conversion factor K⁻¹ for 22 °C is 2.04 $\times$ 10⁻⁶ ohm⁻¹/mg l⁻¹. [4]
2. (a) With a neat sketch, explain the operation of a cross flow turbine. What are the advantages and limitations of such turbine? How is diameter and length of runner of such turbines estimated? [12]
- (b) A single phase maximum load of 20 KW at 0.5 p.f. lagging is to be supplied at 230 V, 50 Hz from a micro hydro scheme. Estimate the water flow rate to the ballast tank with water heaters if the water enters at 25 °C and exits at 50 °C. The specific heat of water is 4200 J/kg/°K for the temperature range concerned. [4]
3. (a) Mention the advantages and limitations of an induction generator in micro hydro installations. Discuss the voltage build up process in an Induction Generator. [6]
- (b) Define intelligent AVR and when is use of such AVR made in micro hydro? A 8 KW, 750 rpm, 50 Hz, 380 V (line to line) 3 phase induction motor draws a line current of 15 A when the machine supplied at its rated voltage and frequency with mechanical load. What size of excitation capacitors are needed for delta connection in order to make the machine generate at approximately its rated voltage when driven slightly above its rated speed? Find also the voltage for which the capacitors have to be designed. Also calculate the value of excitation capacitance and their voltage ratings when they are to be star connected. [2+8]

4(a) Mention the causes of **any two** of the followings in the protection system of a micro hydro plant: [6]

- i) Under voltage trips
- ii) Temperature trip
- iii) Over frequency trips

(b) Mention the coverage and significance of the following operation and maintenance documents with regard to smooth operation of micro hydro plants: [10]

- i) Maintenance schedules
- ii) Repair manuals
- iii) Log book
- iv) Training manual.

5(a). A 70 KW scheme with a start up cost of \$150000 earns an annual revenue of \$20000, re-pays \$15000 each year to the Bank and spends 2% of the start up cost as operation and maintenance cost per year. If the discount rate and life of the scheme is assumed to be 12% and 15 years respectively calculate the benefit cost ratio, discounted payback period and the internal rate of return. [8]

(b) Discuss the various issues of micro hydro power currently in place in context of Nepal. [8]

26C

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING

Examination Control Division
2071 Bhadra

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Micro Hydro Power (Elective III) (EE78501)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

- 1(a). Give the historical development of micro hydro power in Nepal with indication of key institutions involved. [6]
- (b) A proposed micro hydro scheme with a gross head of 50 meters is proposed to meet the following demands as an alternative to a diesel powered mill and a generator which costs around \$0.05 per kwh of energy.

Category	Time	Demand	Duration in year
Lighting	6 am to 12 am	40 KW	Round the year
Milling	8 am to 4 pm	20 KW	Round the year
Irrigation	suitable slot	4000m ³ /day	During dry months only
Storage Cookers	any time	3 KW	As per the power availability
Battery charging	any time	1.5 KW	As per the power availability

Provided that the minimum flow of 160 l/s is available during winter from Kartik to Chaitra while it does not fall less than 200 l/s from Baishakh to Ashwin, will there be enough water to satisfy the irrigation demand together with lighting and milling demand? If yes, decide whether the proposed hydro scheme is viable if the annual cost of capital repayment is \$ 6000 and O and M cost is 10% of the annual repayment cost. [10]

- 2(a). With the help of Nomogram and part flow efficiency curves, explain the process for selecting a turbine. [6]
- (b) Give the general features of a wedge belt drive system with extra bearings. [6]
- (c) A single phase maximum load of 20 KW at 0.5 p.f. lagging is to be supplied at 230 V, 50 Hz from a micro hydro scheme. Estimate the water flow rate to the ballast tank with water heaters if the water enters at 25 °C and exits at 50 °C. The specific heat of water is 4200 J/kg °K for the temperature range concerned. [4]
- 3(a). What are the considerations to be made if a diesel generator AVR is to be used in a Micro hydro installation? [6]
- (b) What is meant by intelligent AVR and when is use of such AVR made in micro hydro? [4]
- (c) A 8 KW, 750 rpm, 50 Hz, 380 V (line to line) 3 phase induction motor draws a line current of 15 A when the machine supplied at its rated voltage and frequency with mechanical load. What size of excitation capacitors are needed for delta

connection in order to make the machine generate at approximately its rated voltage when driven slightly above its rated speed? Find also the voltage for which the capacitors have to be designed. Also calculate the value of excitation capacitance and their voltage ratings when they are to be star connected. [6]

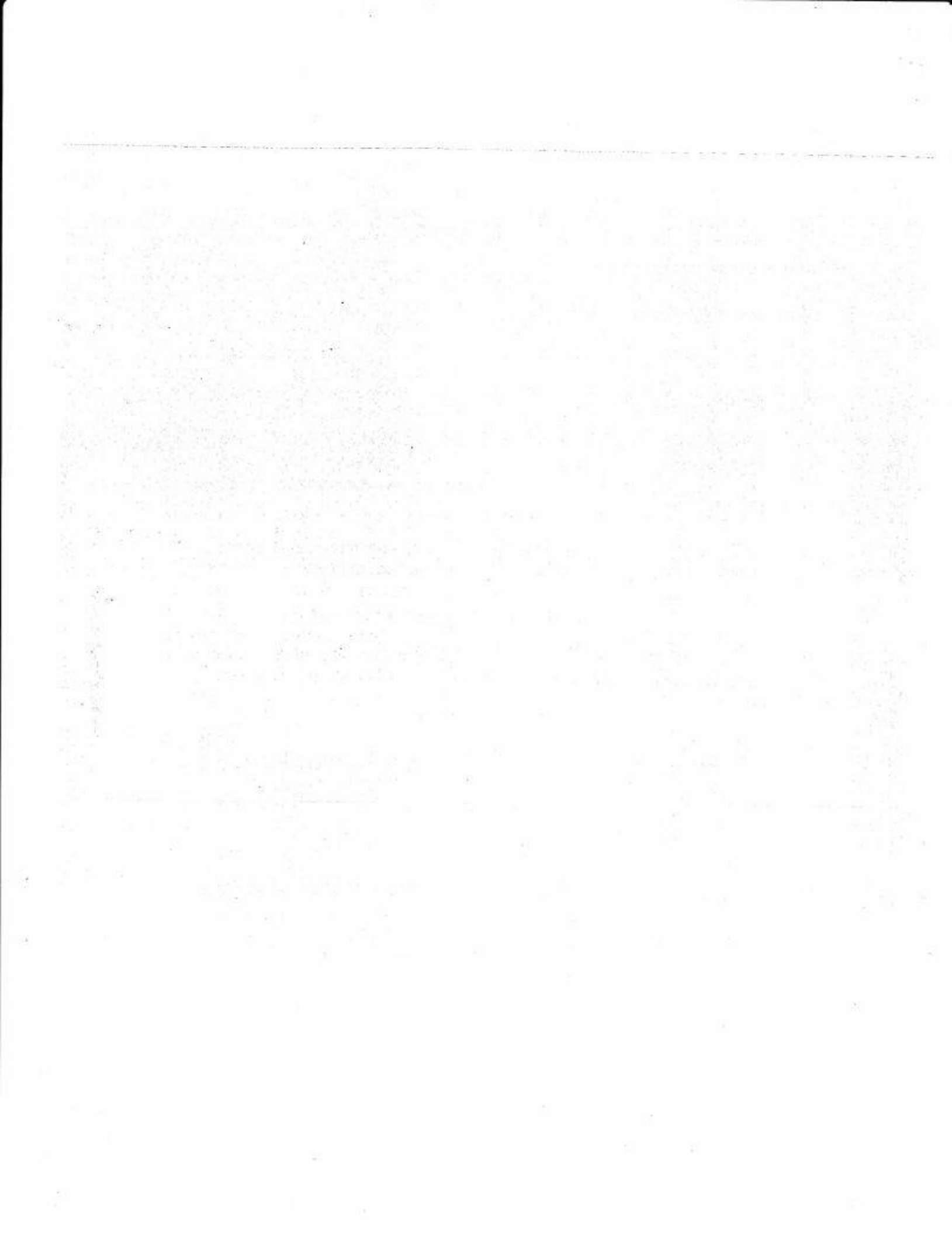
- 4(a) What should be the role of designer for the effective operation and maintenance of micro hydro plant? [6]
- (b) Mention the coverage and significance of the following operation and maintenance documents with regard to smooth operation of micro hydro plants:
- i) Operational manual
 - ii) Component manuals
 - iii) Installers' manuals
 - iv) Maintenance schedule [10]
- 5(a) Discuss the various issues of micro hydro power currently in place in context of Nepal. [8]
- (b) Why is flat watt tariff is normally employed in micro hydro? [2]
- (c) A micro hydro scheme deposits \$3000 per year in the lender's account as repayment of loan and its interest and spends 12% of the annual repayment as operation and maintenance cost each year. The scheme has 6 KW capacity but supplies only 4 KW for 8 hours a day. Calculate the unit energy cost of the scheme. [6]

Exam.	New Back (2066/3) (2071 Magh)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Micro Hydro Power (Elective III) (EE78501)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

- 1(a) Defining plant factor, explain its significance in the development of micro hydro plant. Also explain how it can be improved to the desired value. [3]
- (b) Three rain gauges are placed at three locations X, Y and Z to estimate rainfall in a catchment area. The recorded rainfalls at gauge X, Y and Z were 3200mm/yr, 3700mm/yr and 4200 mm/yr respectively. If the area for X, Y and Z count 80, 90 and 35 squares where 1 square = 1 square mm and the scale of map is 1 KM to 10 mm, calculate the annual average daily flow in m³/sec. Assume run off as 50% of the rainfall. [8]
- 2(a) With a neat sketch, explain the operation of a cross flow turbine and mention its advantages. How are the dimensions of this turbine determined? [8]
- (b) How can the effective head be increased while using a cross flow? [2]
- (c) A Pelton turbine with 85% efficiency is to be used in a proposed micro hydro plant with head of 125 metre. The flow to the turbine varies from 65 l/s to 150 l/s in a year. If the alternator is to be driven at 1500 rpm, recommend the number of jets, runner diameter and the bucket size. Assume 10 % friction loss in the penstock. [6]
- 3(a) Discuss why: [4]
- i) the rated electrical output power will be significantly less than the motor rating when the induction motor is used as induction generator.
 - ii) induction generators should be rated to supply a load of power factor not less than 0.8 lagging.
- (b) Explain the brushless excitation of synchronous generator. Why is such system popular? [6]
- (c) A 3 phase 20 KW induction motor rated at 440 V (line to line), 50 Hz have been chosen to be used as induction generator. The manufacturer's data sheet shows full load current of 28 and full load power factor of 0.85. Calculate the size and voltage rating of the excitation capacitors to be connected in a) delta b) star. [6]
- 4(a) Mention the causes of over voltage trip and under frequency trip in the protection system of a micro hydro plant: [6]
- (b) Highlight the role of i) installers ii) users for the efficient and continuous operation and maintenance of micro hydro power plant. [10]
- 5 (a) What are the guiding principles of tariff design in a micro hydro scheme? Why is flat tariff (cost per watt) often adopted in such scheme? [10]
- (b) A 70 KW micro hydro project is proposed which has a start up cost of \$ 120000. Annual operation and maintenance costs are expected to be 2% of start up cost. The discount rate is 12 %. The annual revenue is expected to be \$ 18000 per year. Decide whether it is worth investing on project whose life is considered to be 15 years. [6]



Exam.	BE	Regular	
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

45

Subject: - Micro Hydro Power (Elective III) (EE78501)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
- ✓ The figures in the margin indicate Full Marks.
- ✓ Assume suitable data if necessary.

- 1(a). What are the steps to follow for matching power supply and demands and finding the unit energy cost while planning a micro hydro scheme? [6]
- (b). Explain, in detail, the velocity area method of flow measurement. What precautions should be taken while conducting the method to ensure a good degree of accuracy? [10]
- 2(a). Enlist the general features of a quarter turn belt drive. [3]
- (b). Mention the essential requirements of installation of air cooled ballast. [3]
- (c). It is intended to design a pelton turbine for a micro hydro site having the gross head of 90 meters, turbine flow of 75-200 l/s during a year and friction loss in penstock pipe equal to 10 % of the gross head. The turbine is required to deliver mechanical power to the generator such that the generator speed is 1500 rpm. Taking part flow efficiency also into consideration, recommend the number of jets, diameter of runner and the notch width of the bucket. [10]
- 3(a). Discuss why: [4]
 - i) the rated electrical output power will be significantly less than the motor rating when the induction motor is used as induction generator.
 - ii) induction generators should be rated to supply a load of power factor not less than 0.8 lagging.
- (b). Why is an under speed protection required for AVR ? Mention any two common methods of protecting AVR from under speed. [6]
- (c). A 3 phase 20 KW induction motor rated at 440 V (line to line) , 50 Hz have been chosen to be used as induction generator. The manufacturer's data sheet shows full load current of 28 and full load power factor of 0.85. Calculate the size and voltage rating of the excitation capacitors to be connected in a) delta b) star. [6]
- 4(a). Mention the causes of any two of the followings in the protection system of a micro hydro plant: [6]
 - i) Under voltage trips
 - ii) Temperature trip
 - iii) Over frequency trips
- (b). Mention the coverage and significance of the following operation and maintenance documents with regard to smooth operation of micro hydro plants: [10]
 - i) Maintenance schedules
 - ii) Repair manuals
 - iii) Log book
 - iv) Training manual.
- 5(a). Explain the various financial indicators used for investment decision making, along with their significance. [5]
- (b). What are the advantages of flat (per watt) tariff compared to per kilowatt hour tariff in community owned micro hydro schemes? [3]
- (c). A feasibility study for a micro hydro scheme estimates annual revenue of \$20000 and annual expenditure of \$8000 for 15 years life period. If the start up cost is \$120000, find out the net present value and discounted payback period for a discount rate of 12%. Also find the internal rate of return of the scheme. [3]

Exam.	Regular / Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Micro-Hydro Power (EG785EE) (Elective II)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt **All** questions.
- ✓ **All** questions carry equal marks.
- ✓ Assume suitable data if necessary.

- 1(a). Give two reasons why capability and demand survey is carried out in the planning phase of micro hydro scheme. [2]
- (b) Explain how you estimate the annual average daily flow using Thiessen method. [6]
- (c) In an attempt to determine annual average daily flow, three rain gauges are placed at three locations X, Y and Z to estimate rainfall in a catchment area and the recorded rainfalls are as follows:
 Gauge at X: rainfall $x=1800$ mm/yr
 Gauge at Y: rainfall $y=2300$ mm/yr
 Gauge at Z: rainfall $z=2800$ mm/yr
 If the area for X, Y and Z count 70, 82 and 15 squares where 1 square = 1 square mm and the scale of map is 1 KM to 10 mm, calculate
 i) the average rainfall in the catchment area in mm/yr
 ii) total catchment area in mm^2
 iii) run off from the catchment area (use run off rain fall chart)
 iv) the annual average daily flow in m^3/sec [8]
- 2(a). Discuss the sizing of a pelton turbine for standard bucket already available in your stock. [8]
- (b) Explain the use of the following components of pelton turbine with appropriate diagram: [8]
 i) Shut off valves ii) Spear valve iii) Deflector plate
- 3(a). What are the basic elements of an Automatic Voltage Regulator (AVR)? what under speed protections need to be incorporated if a diesel generator AVR is used in a Micro hydro installation? [8]
- (b) How is the rating of an induction generator estimated? [4]
- (c) A 3 phase 15 KW induction motor rated at 400 V (line to line), 50 Hz have been chosen to be used as induction generator. The manufacturer's data sheet shows the following data:
 full load current: 25 A
 full load power factor: 0.9
 Calculate the size and voltage rating of the excitation capacitors when they are to be connected in a) delta b) star. [4]

4(a) Explain the operating principle of an Electronic Load Controller (ELC). What are its advantages over the conventional governors. [4]

(b) A particular micro hydro site for use of pelton turbine has the following characteristics:

Gross head: 95 meters, Turbine flow: 80-250 l/s

Alternator speed: 1500 rpm

Friction loss in penstock: 10 %

Efficiency of pelton turbine: 80%

Taking part flow efficiency also into consideration, recommend the number of jets, runner diameter and the bucket size (notch width). [8]

(c) What are the factors to be considered while designing tariff in a community owned micro hydro scheme? Why is tariff in per watt basis is oftenly used in such scheme how is such tariff calculated? [4]

5(a) Enlist the causes of any two of the followings in the protection system of a micro hydro plant:

i) Temperature trip

ii) Frequency trip (Over and under)

iii) Voltage trip (Over and under) [6]

(b) Give the causes and remedial measures for any two of the following faults in a micro hydro scheme:

a. Alternator voltage too high with no load

b. Turbine starts but does not come up to speed.

c. Ballast voltages unequal when load is not connected [10]
