Name: **Enrolment No:**	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2019

Course: Small Hydropower **Semester: II**

Program: M.Tech. Renewable Energy Engineering, EPEC 7018

Time: 03 hrs. **Max. Marks: 100**

Instructions: ***"OPEN BOOK EXAM" – Textbooks and Notes are allowed during the Examination***

SECTION A

S. No.		**Marks**	**CO**
Q 1	a) Describe the main steps in the "Salt Gulp" method for measuring the flow of water in a mountain stream. b) Explain how the flow rate is calculated from the readings taken.	5	**CO1**
Q 2	A hydro turbine that rotates at 600 RPM delivers 900 kW of shaft power when it is operated at a net head of 40 metres. a) Calculate the specific speed of this turbine. b) Which type of turbine would you select for this application? c) For the same Head and RPM, if a 5 MW hydro turbine is installed, then which type of turbine would you select?	5	**CO2**
Q 3	a) Explain the functions of the Silt Basin and the Forebay Tank used in micro-hydro power projects. b) What are the similarities and differences between these two components?	5	**CO1**
Q 4	a) Explain why Expansion Joints must be installed in the penstock pipe. b) Discuss the criteria for locating Expansion Joints in the penstock. c) How much movement does one Expansion Joint have to accommodate if it is installed in the middle of a 100 m length of steel pipe? The coldest temperature in winter is 0^{o} C and the hottest temperature in summer is 40^{o} C.	5	**CO3**
SECTION-B			
Q 5	a) Discuss the function of the Governor in a hydropower scheme. b) Explain how the Electronic Load Controller can be used as a Governor. c) Compare the Electronic Load Controller with the conventional Oil Pressure governor.	10	**CO3**
Q 6	A 'Run-of the River' microhydro power project is being planned on a stream that has a flow of 200 liters per second for 4 months and 50 liters per second for the remaining 8 in the year. The scheme should be able to generate at least 80 kW of power throughout the year. a) What is the Gross Head required from the intake to the powerhouse If the	10	**CO1** **CO2**

	overall efficiency of the scheme is 50%? b) If a 160 kW turbine-generator is installed at this site, what is the Plant Load Factor (Capacity Utilisation Factor)? Assume that all of the power produced is utilised.		
Q 7	a) A proposed 20 kW hydropower scheme has a capital cost of Rs.14 lakhs. The Plant Load Factor is = 50% and the electricity is sold at 4.00 Rs/kWh. Annual Operation & Maintenance costs can be taken to be 5% of the Capital Costs. Calculate: (i) 'Simple Payback' period; and (ii) 'Discounted Payback' period. b) Discuss the difference in your answers between the 'Simple Payback' period and the 'Discounted Payback' period.	10	**CO4**
Q 8	a) Give one method to avoid Flow Separation in a Silt Basin. b) Why is it important to keep the penstock mouth fully submerged in the forebay tank? c) Why is it necessary to install an air vent at the point where the penstock is joined to the forebay tank? **d)** What is the maximum Bar Spacing in a Trashrack in case of (i) Pelton turbine, and (ii) Francis turbine ? **e)** What is the difference between 'Sealing' a channel and 'Lining' a channel? **OR** The turbine manufacturer specifies that particles larger than 0.3 mm should be avoided. Assume that: • Water carries Silt Load = 0.5 kg/m3; • Emptying Frequency = twice daily; • Density of sand = 2600 kg/m3; • Packing Density for sand = 50%; • Water Flow Rate at entry of basin = 200 l/s. Calculate all the dimensions of the Silt Basin and show them on one or two figures.	10	**CO1** **CO2**
SECTION-C			
Q 9	The villagers in an un-electrified village form a Co-operative Society for installing and operating a 20 kW Micro-hydro power plant. The Co-operative Society will operate the power plant at the 'Break-even point' (i.e. No-profit, No-loss basis'). Analyse and discuss the Financial viability of this project by calculating the following: a) What is minimum Tariff that the villagers should pay for the electricity? b) If 100% of the project cost is financed by taking a loan from the bank, what is the maximum interest rate that makes the project viable?	20	**CO4**

	(if villagers pay a Tariff = 5.00 Rs / kWh) Assume that: • The village has a maximum load = 20 kW. • Capacity of the Micro-hydro turbine-generator = 20 kW. • Annual Plant Load Factor = 50%. • Project Lifetime = 20 years. • Discount Rate = 12 % • Initial Capital Cost = 70,000 Rs. / kW installed • O & M costs = 2% of Capital Cost per year		
Q 10	A power canal made of coarse concrete carries 200 lps of water from the silt basin to the forebay tank. Assume that freeboard allowance = 1.3, water velocity = 1.0 m/s, channel length = 100 m. Calculate the following design parameters for the canal: a) Cross-sectional area b) Height of channel c) Bed width d) Top width e) Wetted perimeter f) Hydraulic mean radius g) Slope of channel h) Head Loss **OR** A micro-hydropower scheme is being designed for electrification of a village, using a direct penstock, 200 m long, from the desilting basin to the powerhouse. The Gross Head is 160 m and the design Flow Rate is 200 lps. The penstock has four 45^{O} bends (take 'r/d = 2'), one Gate Valve near the inlet and another Gate Valve in the power house just before the turbine. Assume that there are no other losses. Sufficient length of PVC pipe with a maximum working pressure = 10 bar is available. This pipe has Nominal diameter = 16 inches (400 mm), Minimum wall thickness = 23 mm, and Internal diameter = 352 mm. It is proposed to use a single penstock pipe from the Forebay to the Turbine. Use the data on PVC pipes given in Table 3.11.5 (page 130), Analyse and discuss the suitability of this 16" PVC pipe for the penstock by calculating the following: a) Wave velocity (m/s) b) Estimated total head (m) c) Effective wall thickness (mm) d) Calculated safety factor e) Assumed roughness (mm) f) Velocity of water (m/s) g) Total Head Loss (m)	20	**CO1** **CO2**

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SECTION A

S. No.		Marks	CO
Q 1	a) Explain briefly how topographical maps (contour maps) can be used for the Pre-feasibility study of a small hydropower scheme. b) Discuss the sources of error of the "Salt Gulp method" for flow measurement.	5	**CO1**
Q 2	a) Explain the operation of a 'Pumped Hydro' power scheme. (with the help of a schematic) b) What are the advantages of integrating a Wind farm or a Solar PV power plant with a Pumped Hydro scheme?	5	**CO2**
Q 3	Explain the function of the following in a hydropower scheme: a) Anchor Block b) Spillway c) Forebay tank d) Draft Tube e) Aquaduct	5	**CO1** **CO2**
Q 4	a) Explain one method to avoid Flow Separation in a Silt Basin. b) Explain why it is important to keep the penstock mouth fully submerged in the forebay tank. c) Why is it necessary to install an air vent at the point where the penstock is joined to the forebay tank. d) What is the maximum Bar Spacing in a Trashrack in case of (i) Pelton turbine; and (ii) Francis turbine. e) What is the difference between '**Sealing**' a channel and '**Lining**' a channel.	5	**CO1** **CO2**

SECTION-B

Q 5	a) Explain the operation of the Oil Pressure governor (with the help of a schematic). b) Discuss the advantages and disadvantages of the Oil Pressure governor in comparison with the Electronic Load Controller.	10	**CO3**
Q 6	It is proposed to install a 80 kW generator for a Run-of the River hydro power plant with a hydro turbine for a village electrification project. The flow of water in a nearby stream is 100 liters per second for 8 months and 50 liters per second for the remaining 4 months. A should be able to generate at least 40 kW of power	10	**CO2**

	throughout the year. If the overall efficiency of the scheme is 50%, determine: a) Gross Head required from Intake to Turbine; b) Plant Load Factor for the 80 kW turbine-generator installed at this site.		
Q 7	a) Explain the difference between the 'Simple Payback' period and the 'Discounted Payback' period. b) Calculate the 'Simple Payback' and the 'Discounted Payback' periods for a hydropower scheme with the following details: • Capacity of the hydropower scheme = 10 kW. • Initial capital cost = Rs.7 lakhs. • Plant Load Factor = 50%. • Selling Price of electricity = 4.00 Rs/kWh. • Annual Operation & Maintenance costs = 35,000 Rs / yr.	10	**CO4**
Q 8	The water Flow Rate at channel entry of a 'Settling / Desilting Basin' = 200 l/s. The turbine manufacturer specifies that particles larger than 0.3 mm should be avoided. a) Calculate ALL the dimensions of the Desilting Basin. b) Show these dimensions on a figure of the Desilting Basin. <u>Assume that</u>: • Silt Load = 0.5 kg/m3; • Emptying Frequency = twice daily; • Density of sand = 2600 kg/m3; • Packing Density for sand = 50%; • Flow Rate at entry of basin = 200 l/s. **OR** a) Explain the location and the function of a Draft Tube in a hydropower project. Explain why a Draft Tube can be used with a Francis turbine but it cannot be used with a Pelton runner. b) Discuss the use of Specific Speed of a hydro turbine in the Turbine Selection process.	10	**CO1** **CO2**
SECTION-C			
Q 9	Analyse and discuss the Financial Evaluation of a 10 kW Micro-hydropower project for village electrification by examining the key Financial parameters: a) Net Present Value; b) Internal Rate of Return; c) Levelised Cost of Energy; <u>Assume that</u>: • A village with a maximum load of 10 kW is being electrified.	20	**CO4**

	• Capacity of the Micro-hydro turbine-generator = 10 kW. • Annual Plant Load Factor = 50%. • Project Lifetime = 20 years. • Discount Rate = 12 % • Initial Capital Cost = 70,000 Rs. / kW installed • O & M costs = 2% of Capital Cost per year • Electricity is sold to the villagers at 5.00 Rs./kWh.		
Q 10 Q 10	A direct penstock is being designed to carry 200 lps of water from the desilting basin to the powerhouse. The penstock has one Gate Valve near the forebay tank, another Gate Valve in the power house just before the turbine, and two 20^{O} bends (take 'r/d = 2'). Assume that there are no other losses. The gross head is 160 m and the length of the penstock is 200 m. A single penstock pipe of 16 inches nominal diameter and minimum wall thickness = 23 mm (internal dia = 352 mm) is used. Calculate the following parameters using the data on PVC pipes given in Table 3.11.5 (page 130): a) Wave velocity (m/s) b) Estimated total head (m) c) Effective wall thickness (mm) d) Calculated safety factor e) Assumed roughness (mm) f) Velocity of water (m/s) g) Total Head Loss (m) **OR** A 250 metre long channel lined with coarse concrete is designed to carry a water flow of 150 l/s. Assume a Freeboard Allowance = 1.3. For a water velocity = 1.0 m/s calculate the following parameters: a) Cross-sectional area b) Height of channel c) Bed width d) Top width e) Wetted perimeter f) Hydraulic mean radius g) Slope of channel h) Head Loss.	20	**CO1** **CO2**