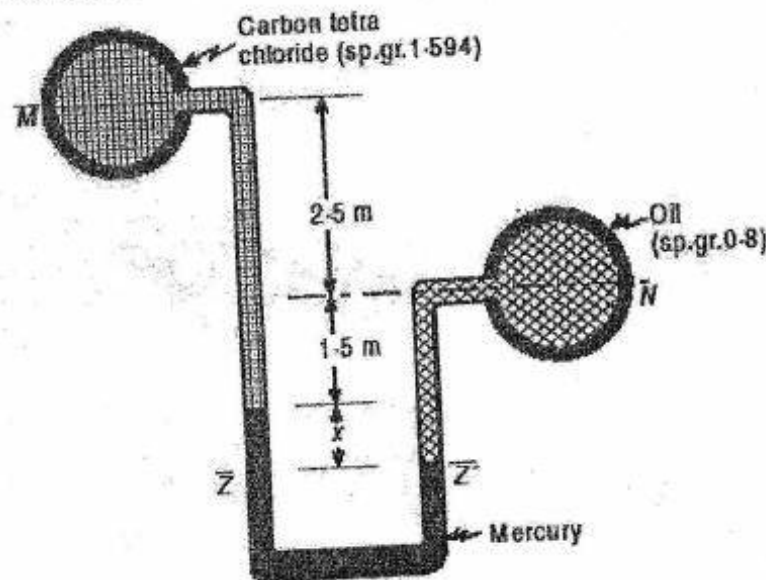


Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Hydro Power (CE 660)

- ✓ 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. Define compressible and incompressible flow, laminar and turbulent flow, and steady and unsteady flow. [6]
2. As shown in the figure below, pipe M contains carbon tetrachloride of specific gravity 1.594 under a pressure of 105 kN/m^2 and pipe N contains oil of specific gravity 0.8. If the pressure in the pipe N is 175 kN/m^2 and the manometric fluid is mercury, find the difference x between the levels of mercury. [6]



3. A circular plate of diameter 2.2 m is immersed in a liquid of specific gravity 1.2. The highest and lowest points of the plate are at depths of 2.5 m and 4.5 m below the free surface, respectively. Calculate the total pressure force on one face of the plate and the location of its center of pressure. [6]
4. Using Euler's equation of motion along a streamline, derive the Bernoulli's equation of flow. [4]
5. Find the depth of flow in a triangular channel having a longitudinal slope of 1 in 2000 and side slopes of 1.5H:1V. The channel carries a discharge of $2.5 \text{ m}^3/\text{s}$. Take Manning's roughness coefficient $n = 0.025$. [6]
6. With a neat sketch, explain the hydrological cycle. Describe the Thiessen polygon method for determining mean precipitation over a basin. [3+3]

7. The monthly power output (in kW) for a proposed hydropower plant is given below. The interest rate is 10%, energy price is US\$ 40/MWh, variable cost is US\$ 800/kW, annual operation and maintenance cost is 2.5% of variable cost, and the economic life of the project is 40 years. Determine the best-installed capacity, firm energy, secondary energy, total energy, and plant factor. [10]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Power (kW)	80	65	95	200	320	400	510	650	560	270	140	110

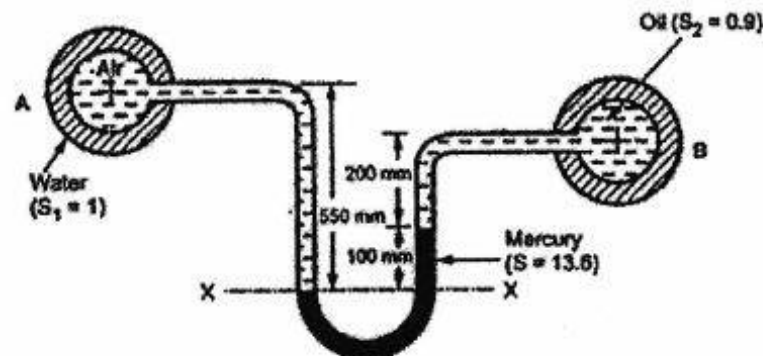
8. What do you mean by elementary profile of gravity dam? A concrete gravity dam with a triangular section has a height of 40 m and a base width of 28 m. The water on the upstream side is up to the crest. Considering only self-weight, hydrostatic pressure, and uplift pressure (with an uplift intensity factor of 0.6), calculate the eccentricity of the resultant force from the toe, the factor of safety against sliding (take coefficient of friction = 0.7), the maximum vertical stress at the toe, and the factor of safety against overturning. Take unit weight of concrete = 24 kN/m³ and unit weight of water = 10 kN/m³. [2+8]
9. Explain why desander is necessary in most of the hydropower projects in Nepal. [3]
10. A steel penstock pipe has an internal diameter of 1.5 m. It is designed to carry water under a pressure head of 250 m. Considering a 30% allowance for pressure rise due to water hammer, determine the required thickness of the pipe plate. Use a design stress of 120 N/mm² and a joint efficiency of 85%. [5]
11. What is a spillway? Classify spillways based on their prominent features. With a neat sketch, describe an Ogee spillway. [1+2+4]
12. What is a draft tube? Write down its functions. Show that the pressure at inlet of draft tube is less than atmospheric pressure. [1+2+3]
13. In a hydropower project, the available discharge is 380 m³/s under a net head of 30 m. If the speed of the turbine is to be 150 rpm and the overall efficiency is 90%, determine the number of units required if a Kaplan turbine with a specific speed of 620 (in SI units) is selected. Also, find the output of each unit. [5]

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

Subject: - Hydro Power (CE 660)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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1. A differential manometer is connected to points A and B, as shown in the figure below. Given that the air pressure at A is 60 kN/m^2 , determine the pressure at point B. [5]



2. Define the terms total pressure and center of pressure. Derive an expression for the total pressure acting on a vertically immersed plane surface. [2+4]
3. Briefly explain the different types of heads in a moving liquid. Define Bernoulli's equation and list the assumptions made in its derivation. [3+1+2]
4. Water flows through a 250 m long penstock pipe at a velocity of 2.5 m/s. If the pipe is suddenly closed, determine the pressure rise due to water hammer and the period of oscillation of the pressure wave, assuming a wave speed of 1,450 m/s. [2+2]
5. A trapezoidal channel carries a discharge of $5 \text{ m}^3/\text{s}$. Design the channel section given a slope of 1 in 1200 and side slopes of 1:1, using Chezy's formula with $C = 56$. [6]
6. Calculate the average precipitation using the arithmetic mean method and the Thiessen polygon method based on the following data. [1+3]

Station No.	Precipitation (mm)	Area (km^2)	Station No.	Precipitation (mm)	Area (km^2)
1	30.8	45	3	32.0	30
2	34.6	40	4	24.6	38

7. Determine the best-installed capacity of a hydropower plant based on the given power duration data. [10]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Power (KW)	700	590	535	300	255	180	150	105	80	70	60	50

Interest rate = 12%, Energy price = US\$ 36/MWh, Variable cost = US\$ 750/KW, Economic life of the project = 50 years.

8. Explain the failure modes and the structural stability criteria of gravity dams. [8]
9. What is an intake? Write its functions. [1+3]
10. Explain the design criteria of settling basin. [5]

11. Calculate the thickness of a penstock pipe with an internal diameter of 1.3 m that conveys water under a pressure head of 20 kg/cm², considering a 20% potential increase in pressure due to water hammer. Use a design stress of 1050 kg/cm² and a joint efficiency of 90%. [4]
12. List the various types of spillway gates and describe the radial gate with a neat sketch. [1+3]
13. What is a draft tube? Write down its function. Show that the pressure at the inlet of the draft tube is below atmospheric. [1+2+3]
14. Design a Francis turbine for a hydroelectric station with a design discharge of 55 m³/s, a net head of 25 m, and an efficiency of 85%. The turbine will be installed at a location where the atmospheric pressure is equivalent to 10 m of water, and the vapor pressure is 0.2 m of water. [8]

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INSTITUTE OF ENGINEERING
Examination Control Division
2081 Chaitra

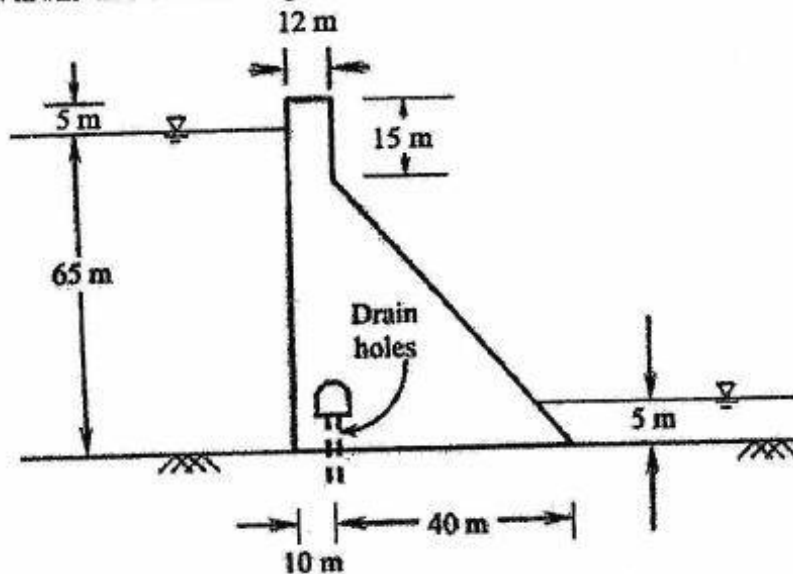
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Hydro Power (CE 660)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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1. Define the following terms: specific mass, specific weight, specific gravity and surface tension. [4]
 2. The space between two parallel plates, 5 mm apart, is filled with crude oil. A force of 2 N is required to drag the upper plate at a constant velocity of 0.8 m/s, while the lower plate remains stationary. The area of the upper plate is 0.09 m². Determine the dynamic viscosity and kinematic viscosity of the oil, given that the specific gravity of the oil is 0.9. [5]
 3. How can the hydrostatic force on a curved surface be analyzed? Explain. [4]
 4. Water flows through a 1 km long horizontal pipe of 150 mm diameter with a velocity of 2 m/s. Calculate the discharge and head loss in the pipe if the friction factor is 0.02. [1+2]
 5. In a pipe of 500 mm diameter and 2500 m length, provided with a valve at its end, water is flowing with a velocity of 1.5 m/s. Assuming velocity of pressure wave = 1460 m/s, Find (i) the rise in pressure if the valve is closed in 25 seconds and (ii) the rise in pressure if the valve is closed in 2 seconds. Assume the pipe to be rigid one and take bulk modulus of water as 2.132 GN/m². [3+3]
 6. What do you mean by most-economical section of an open channel? Show that the hydraulic mean depth of a most-economical rectangular channel section is half of the channel flow depth. [1+5]
 7. a) Explain the Thiessen polygon method for estimating the average rainfall over a catchment area. [3]
b) The following data were obtained from a rainfall event.
- | | | | | |
|-------------------------|-----|-----|----|-----|
| Rainfall Station | A | B | C | D |
| Area (km ²) | 100 | 150 | 80 | 120 |
| Rainfall (mm) | 80 | 70 | 90 | 65 |
- Determine the average rainfall over the catchment using the Thiessen polygon method. [3]
8. Enumerate the advantages and limitations of hydro-electric power. [6]
 9. Design a settling basin for a run-of-river hydropower station, considering turbulence effects using settling theory. The basin should remove particles larger than 0.2 mm in diameter from sand-laden water. Given a design discharge of 12 m³/s and a basin depth of 3.5 m, use $w = 6$ cm/s and $\lambda = 1.50$ for the design. [6]
 10. What are the advantages of tunneling in a hydropower project? Draw a typical cross-section of a pressure tunnel, indicating the key components. [2+2]
 11. An overflow spillway is 60 m long, with a crest elevation of 133 m and a reservoir water surface elevation of 135 m. Calculate the discharge over the spillway, assuming a discharge coefficient of 0.74. [4]

12. For the concrete gravity dam shown in the figure below, calculate the maximum vertical stresses at the heel and toe, the major principal stresses at the toe, and the shear stress intensity on a horizontal plane near the toe. Assume the unit weight of concrete is 24 kN/m^3 and the unit weight of water is 10 kN/m^3 . [12]



13. Differentiate between impulse and reaction turbines with suitable examples. [4]
14. Explain why governing of hydraulic turbines is necessary. [3]
15. Design a Pelton wheel turbine for a hydroelectric station with a design discharge of $3.75 \text{ m}^3/\text{s}$, a net head of 380 m, and an efficiency of 86%. Assume a jet coefficient of 0.97 and a speed ratio of 0.46. [7]

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2081 Ashwin

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

Subject: - Hydro Power (CE 660)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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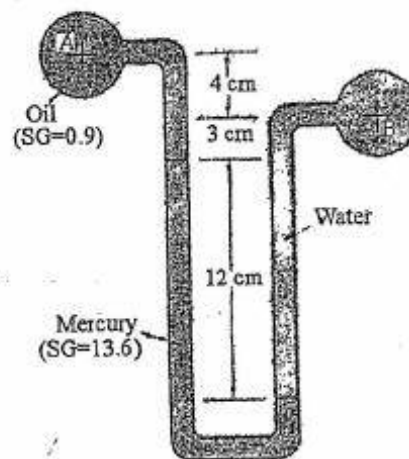
1. Define compressible and incompressible flow, laminar and turbulent flow, and steady and unsteady flow. [6]
2. Calculate the total pressure and center of pressure on a vertically submerged rectangular plate 2 m high and 3 m wide, with the top edge 1 m below the free surface. [5]
3. Derive Bernoulli's equation. Explain its limitations and provide an example of its application in hydropower engineering. [5+2+1]
4. Water is flowing in a 200 mm diameter pipe with a velocity of 2 m/s. If the pipe is abruptly closed, calculate the pressure rise due to water hammer and the period of oscillation of the pressure wave. Assume the wave speed in the pipe is 1400 m/s. [2+2]
5. Design the best hydraulic rectangular cross-section for a canal conveying 15 m³/s discharge with Manning's $n = 0.02$ and a bed slope of 0.001. [5]
6. Describe various techniques used to determine the average depth of rainfall over a river catchment area. [6]
7. Outline the stages of hydropower development, highlighting the key factors considered during the study of each stage. [8]
8. Describe flow duration and power duration curves with their significance in estimating power potential of a hydropower project. [6]
9. Explain the failure modes and criteria of structural stability of gravity dams. [8]
10. Design a settling basin for a ROR hydropower plant considering the turbulent effect by using the settling theory. The basin should serve to remove particles greater than 0.15 mm diameter from the water conveying mainly sand. The design discharge is 10 m³/s and the depth of the basin is 4.0 m. Take $w = 6$ cm/s and $\lambda = 1.50$. [6]
11. Explain the purpose of spillways and list the different types of spillways based on various classification criteria. [1+3]
12. Discuss the selection criteria of hydraulic turbines for a hydroelectric powerplant. [6]
13. Design a Francis turbine which is to be installed at a hydroelectric station where atmospheric pressure is 10.3 m of water and vapour pressure is 0.2 m of water. The turbine should have a design discharge of 45 m³/s, a net head of 150 meters and an efficiency of 85%. [8]

Exam.	Back		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
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Subject: - Hydro Power (CE 660)

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1. A U-tube manometer contains oil, mercury, and water as shown in figure below. For the column heights indicated, what is the pressure differential between pipe A and B? [6]



2. A horizontal pipe 150 mm in diameter is joined by sudden enlargement to a 225 mm diameter pipe. Water is flowing through it at the rate of $0.05 \text{ m}^3/\text{s}$. Find (i) loss of head due to sudden expansion, (ii) pressure difference in the two pipes, and (iii) change in pressure if the change of section is gradual without any loss. [6]
3. State and prove Pascal's law. [5]
4. What is the condition for the most economical Rectangular section? A trapezoidal channel having bottom width 6m and side slope 2:1, carries a discharge of $15 \text{ m}^3/\text{s}$. Find the value of the bed slope of the channel if the depth of the flow is 1.2 m and Manning's 'n' = 0.013. [2+6]
5. The data pertaining to a stream-gauging operation at a gauging site are given below. The rating equation of the current meter is $V = 0.51 N + 0.03 \text{ m/s}$ where, N = revolutions per second. Calculate the discharge in the stream. [8]

Distance from left water edge (m)	Depth (m)	Revolutions at 0.6 depth	Duration of observations (s)
0	0	0	0
1	1.1	39	100
3	2.0	58	100
5	2.5	112	150
7	2.0	90	150
9	1.7	45	100
11	1.0	30	100
12	0	0	0

6. The mean monthly flow of a river in Nepal is given in the below table. Calculate the primary and secondary energy that can be generated from the river if the plant capacity is fixed at power corresponding to the flow available for 45% of the time. Consider the plant's overall efficiency as 85% and the Net head as 170m.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow (m^3/s)	30	28	24	29	18	37	65	90	74	56	42	39

7. Check the stability of a trapezoidal concrete gravity dam having maximum reservoir level of 250.0 m, base level of 200.0 m, tail water elevation of 210.0 m, base width of 40 m, top width of 6 m, location of drainage gallery 10 m from u/s face. Take sp. wt and permissible compressive strength of the dam material are 24 kN/m^3 and 300 kN/m^2 , respectively. [10]
8. Why are forebay and Surge Tanks provided in a hydropower plant? Mention the difference between these two. [3+3]
9. Calculate the thickness of a penstock of internal diameter 1.20 m which conveys water at a pressure head of 17.5 kg/cm^2 . There is a possibility of a 20% increase in pressure due to the water hammer. Take design stress = 1050 kg/cm^2 and joint efficiency = 87%. [4]
10. What is the purpose of providing spillway? List out different types of spillways with neat sketches. [1+5]
11. Design a pelton wheel turbine with design discharge of $2 \text{ m}^3/\text{s}$, overall efficiency of 85% and a net head of 500m. [8]
12. Differentiate between impulse and reaction turbine. [5]

Exam.	Regular		
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Subject: - Hydro Power (CE 660)

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1. A circular plate of 2.5 m diameter is immersed in liquid of specific gravity 0.9, its greatest and least depth below the free surface being 3 m and 1 m respectively. Find the total pressure on one face of the plate and position of center of pressure. [6]
2. Two reservoirs are connected by a pipeline which is 15cm diameter for the first 6m and 25cm diameter in remaining 15m length. The entrance and exit are sharp and change of section is sudden. If water surface in upper reservoir is 6 m above that of lower reservoir, calculate rate of flow. Take friction factor 0.04 for all pipes. [8]
3. In which basis the continuity equation is derived? Discuss Bernoulli's equation with mathematical expression and neat sketch. [1+5]
4. A trapezoidal channel has side slopes of 1:2 (H:V) and slope of the bed is 1 in 1500. The sectional area is 50 m². Find the dimensions of the section if it is considered the most economical. Also determine the discharge if Chezy's C = 50. [8]
5. Given the following data for a stream gauging operation in a river, compute discharge. [8]

Distance from right bank (m)	0	1.5	3	4.5	6	7.5	9
Depth (m)	-	1.3	2.5	1.7	1.0	0.4	-
Velocity at 0.2d (m/s)	-	0.6	0.9	0.7	0.6	0.4	-
Velocity at 0.8d (m/s)	-	0.4	0.6	0.5	0.4	0.3	-

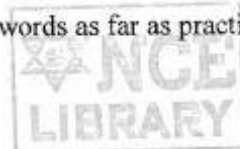
6. Water stand on the u/s side of a gravity dam of triangular section up to the full height of 35 m. The base width of dam is 26 m. If the uplift pressure coefficient is 0.5, calculate
 - a) Eccentricity of the resultant from the toe.
 - b) Factor of safety against sliding.
 - c) The crushing strength developed in the dam.
 - d) Factor of safety against overturning.

Take coefficient of friction between base and foundation is 0.75 and the unit weight of dam material is 2400 kg (f)/ m³ [8]
7. In what stages study of a hydropower project are completed? What parameters do you investigate in each stage? Discuss with hydropower development cycle. [8]
8. What are Spillways and gates? What are the various types of spillways used in Hydropower projects? [2+4]
9. How do you calculate thickness and economic diameter of penstock? Discuss with mathematical equations and derivations as required. [4]
10. Design of a Pelton turbine for a hydropower plant having net head of 312.5m and discharge 5 cumecs. Take efficiency of turbine 85%, frequency 50Hz and velocity coefficient 0.98. [8]
11. How do you determine the height and area of simple circular surge shaft? Discuss with neat sketch and mathematical equation. [6]
12. What parameters do you consider while fixing the dimensions of a power house in a hydel plant? Discuss with plan diagram. [4]

Exam.	Regular		
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Programme	BEL	Pass Marks	32
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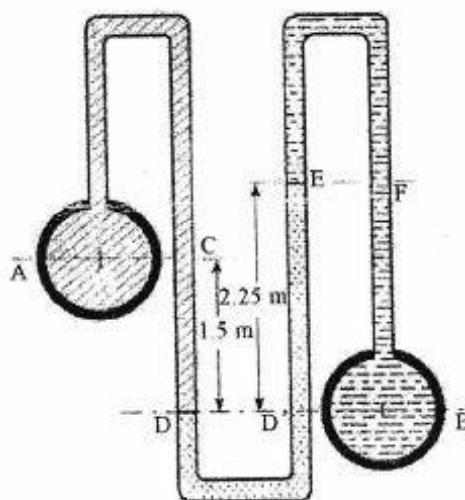
Subject: - Hydro Power (CE 660)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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- Two pipes as shown in figure convey oil of specific gravity of 0.875 and water respectively. Both the liquids in the pipes are under pressure. The pipes are connected to a U-tube manometer and the hoses connecting the pipes to the tubes are filled with the corresponding liquids. Find the difference of pressure in two pipes if the level of manometric liquid having a specific gravity of 1.25 is 2.25 m higher in the right limb than the lower level of oil in the left limb of the manometer.

[6]



- Define laminar and turbulent flows. Water flows through a 700 mm diameter pipe with flow rate 1200 lps. Calculate the value of friction factor if the head loss in 50 m of pipe length is 0.6 m. [2+4]
- A circular plate 2.6 m in diameter is immersed in water, its greatest and least depth below the free surface being 3 m and 1 m and respectively. Find the total pressure on one face of the plate and the position of the center of pressure. [5]
- What is the condition required for the most efficient rectangular section? Determine the normal depth for a triangular channel with side slope 2H: 1V and longitudinal slope 0.0005 to carry discharge of $0.5 \text{ m}^3/\text{s}$ if Manning's coefficient n is 0.04. [2+6]
- During a flood flow the depth of water in a 10 m wide rectangular channel was found to be 3 m and 2.9 m at two sections 200 m apart. The drop in the water surface elevation was found to be 0.12 m. Estimate the flood discharge through the channel. Assume Manning's n to be 0.025. [8]
- Following table shows the mean monthly flow of a typical river in Nepal. Calculate annual firm and secondary energy if design discharge selected is $900 \text{ m}^3/\text{s}$. Take overall efficiency = 90% and head 100 m. [8]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Discharge m^3/s	120	100	90	150	350	1800	2000	2500	2000	900	650	500

7. Check the stability of a gravity dam having trapezoidal section with following data: [10]
- Crest level of dam = 1530 m
Maximum water level at upstream = 1525 m
Top width = 6 m
Base width = 60 m
Tail water depth = 6 m
Bed level = 1470 m
- Drainage gallery provided at 10 m from the heel. Consider full uplift condition and permissible compressive strength of concrete 3000 kN/m^2 . Take specific weight of concrete 24 kN/m^3 .
8. What is desander? Discuss its design criteria. [1+5]
9. What do you estimate economical diameter of penstock in hydropower plant? Discuss with mathematical expressions. [4]
10. Explain different types of gates to be provided for controlling the excess flow of water through the spillway. [6]
11. Design a Francis turbine for a site where the net head is 120 m and discharge is $140 \text{ m}^3/\text{s}$. Take efficiency of the turbine is 94%. [8]
12. Differentiate between Centrifugal and Reciprocating pumps. [5]

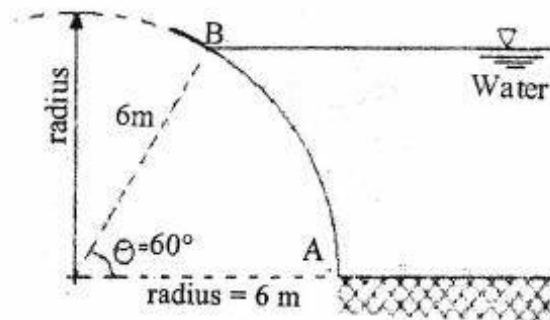
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Hydropower (CE660)

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- Define the terms specific weight, specific gravity, specific mass, specific volume, viscosity, surface tension, Capillarity and compressibility. [4]
- The sector gate shown in figure below consists of a cylindrical surface of which AB is the trace, supported by a structural frame hinged at O. The length of the gate is 10m. Determine the magnitude and location of the horizontal and vertical component of the total hydrostatic force on the gate. [10]



- What is the condition required for the most efficient trapezoidal section? Determine the normal depth for a triangular channel with side slope 2H: 1V and longitudinal slope 0.0005 to carry discharge of $0.5 \text{ m}^3/\text{s}$ if manning's coefficient n is 0.04. [2+6]
- Discuss hydrological cycle and describe about the different methods of finding the mean precipitation over an area. [4+6]
- Following are the mean monthly flow of the river [7]

Month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Flow(m^3/s)	100	120	140	300	320	1800	2000	2510	2000	900	100	300

Where head (H) = 100m, overall efficiency = 90% and design discharge selected is $900 \text{ m}^3/\text{s}$. Calculate the annual firm and secondary energy.

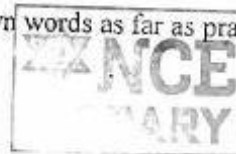
- What do you mean by dam? Enlist types of dam based on various criteria. Write the possible forces acting on gravity dam with a neat sketch. [1+4+4]
- A penstock is to convey $6 \text{ m}^3/\text{s}$ discharge with a design head of 60m. Determine the economic diameter of the penstock based on i) USBR formula, ii) Sarkaria formula, and iii) formula based on graphical solution. Take $n = 85\%$. [8]
- a) What is the function of surge tank in hydropower plant? [2]
- b) What is spillway? Classify it as per the pertinent features. Discuss ogee spillway with a neat sketch. [1+1+4]
- Write down the function of a draft tube. Describe the selection criteria of hydraulic turbines for hydroelectric power plants. [2+6]
- Design a pelton wheel turbine for a hydro-electric plant having a net head of 310m, design discharge of $5 \text{ m}^3/\text{s}$ and 86% efficiency of the turbine. [8]

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2077 Chaitra

Exam.	Regular		
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Year / Part	III / II	Time	3 hrs.

Subject: - Hydropower (CE 660)

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1. Calculate the dynamic viscosity of oil which is used for the lubrication between square plate of size $0.8\text{m} \times 0.8\text{m}$ and an inclined plane with an angle of inclination 30° . The weight of the square plate is 300N and it slides down the inclined plane with a uniform velocity of 0.3m/s . The thickness of oil film is 1.5mm . [7]
2. Derive the geometrical conditions for the most economical section of a rectangular channel. [6]
3. A rectangular plate $3\text{m} \times 5\text{m}$ is immersed vertically in water such that the 3m side is parallel to the water surface. Determine the hydrostatic force and the centre of pressure if the top edge of the surface is (i) flush with the water surface, and (ii) 2m below the water surface. [6]
4. How do you numerically classify laminar, transitional and turbulent flow in pipes? Differentiate laminar and turbulent velocity profiles in pipe flow with neat sketch and labels. [2+6]
5. Compute the river discharge by mid-section with the help of following data: [8]

Distance from the left bank (m)	Depth (m)	Velocity (m/s)			Where y is the depth of flow
		0.6y	0.2y	0.8y	
0	0	-	-	-	
1.2	0.7	0.4	-	-	
2.4	1.7	-	0.7	0.5	
3.6	2.5	-	0.9	0.6	
4.8	1.3	-	0.6	0.4	
6.0	0.5	0.35	-	-	
7.2	0	-	-	-	

6. Discuss working principle of centrifugal and reciprocating pumps. [5]
7. Explain Power market, Hydrology and Geology as a planning parameter for hydropower development. [6]

8. Explain elementary profile of dam and prove that $B = \frac{H}{\sqrt{G - K}}$ where B is base width, H is height of water at the upstream side of the dam, G is specific gravity of dam material and K is uplift pressure intensity coefficient. [7]
9. Explain about surge tank, its functions and design criteria with necessary sketch. [6]
10. Define firm power and secondary power. The load on a hydropower plant varies from a minimum of 12,000 kW to a maximum of 35,000 kW. Two turbo-generators of capacities 22,000 kW each have been installed. Calculate:
- (i) total installed capacity of the plant,
 - (ii) plant factor,
 - (iii) maximum demand,
 - (iv) load factor, and
 - (v) utilization factor. [1+7]
11. What is economic diameter of penstock? How do you determine the economic diameter of a penstock. [8]
12. What factors do you keep in mind while selecting an intake site in a RoR hydropower plant? [5]

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

Subject: - Hydropower (CE660)

- ✓ 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. State the Newton's law of viscosity and explain the importance of viscosity in fluid motion. [1+4]
2. Define the terms total pressure and centre of pressure. Derive expressions for total pressure and centre of pressure for a vertically immersed surface. [2+3+3]
3. Explain the total energy line and the hydraulic gradient line for fluid flow through a piping system with neat sketch. [4]
4. Find the rate of flow for a rectangular channel 7.5 m wide for uniform flow at a depth of 2.25 m. The channel is having bed slope as 1 in 1000. Take Chezy's constant $C = 55$. [8]
5. Compute the discharge of a stream with the following data. [10]

Distance from left bank (m)	0	2	4	6	8	10	12
Depth (m)	-	0.9	2.4	2.2	1.0	0.6	-
Velocity at 0.2d	-	0.6	0.9	0.7	0.6	0.4	-
Velocity at 0.8d	-	0.4	0.6	0.5	0.4	0.3	-

6. Determine the primary and secondary energy if the hydrograph as shown below is given net head = 200 m and efficiency = 80%. What is the volume of the pondage required if the firm capacity is increased by 150%. [10]

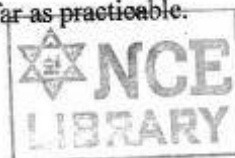
Month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Discharge (m^3/s)	100	120	140	300	320	1800	2000	2510	2000	900	500	300

7. a) What is meant by elementary profile of a gravity dam? Explain for fixing the width of the elementary profile of concrete gravity dam by considering no tension and no sliding criteria. [3+5]
 - b) Why settling basin is essential in hydropower electric project in Nepal? Draw a layout plan and section of typical settling basin along with its design criteria. [3+3]
8. What is meant by economic diameter of tunnel? How do you work out it? [1+5]
9. a) What are the functions of forebay? Describe briefly about the layout of forebay on hydropower project with neat sketch. [2+3]
 - b) Describe the criterions to be considered while designing a settling basin. [5]
10. What are the objectives of the provision of surge tank for the hydropower project? Discuss the various factors which govern the determination of economical diameter of penstock. [1+4]

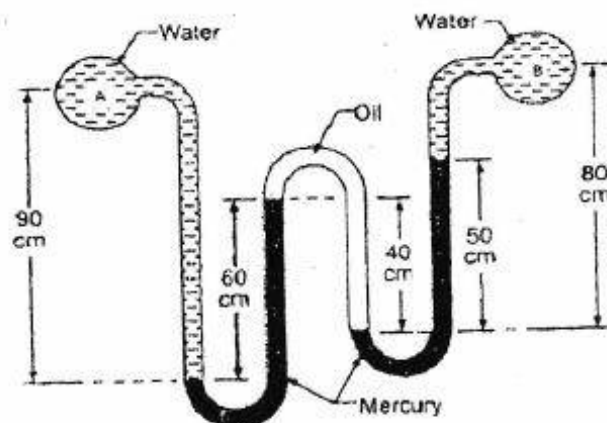
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Hydropower (CE660)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ Attempt All questions.
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1. Calculate the pressure difference between the points A and B. Specific gravity of oil is 0.8. [5]



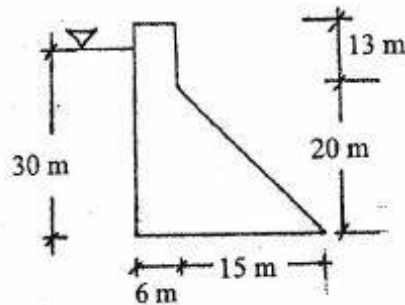
2. Define total pressure and center of pressure in static fluid prove that the center of pressure for a vertically immersed plane surface is always below its centroid. [2+6]
3. Derive Bernoulli's equation with the help of Euler's equation of fluid motion for a real flow. Sketch HGL and EGL for the horizontal circular pipe of gradually expanding cross-section towards the direction of flow. [2+2]
4. Verify that for the most economical trapezoidal channel, the length of one channel side must be equal to half the length of the top-width of the section. [6]
5. The following are the data obtained in a stream-gauging operation. A current meter with a calibration equation $V = (0.55N + 0.04)$ m/s, where N = revolutions per second was used to measure the velocity at 0.6 depth. Calculate the discharge in the stream. [7]
6. What is water hammer? Write down the problems with water hammer. Water is flowing through a cast-iron pipe of diameter 150 mm and thickness 10 mm which is provided with a valve at its end. Water is suddenly stopped with closing the valve. Find the maximum velocity of water, when rise of pressure due to sudden closure of valve is 1.962 MN/m^2 . Take $K = 1.962 \text{ GN/m}^2$ and $E = 117.7 \text{ GN/m}^2$. [1+2+5]
7. What do you mean by economical diameter of penstock pipe? How it can be achieved? [1+4]
8. Explain hydraulic tunnels and its design features. [1+5]
9. What is cavitation? What are its effects and how can it be avoided in reaction turbines? [1+2+2]

10. Explain the differences between Pre-feasibility and Feasibility studies in hydropower projects. [4]

11. Determine the firm and secondary energy for the following set of data of average monthly flows of river over a year. [8]

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q (m ³ /s)	150	250	300	425	500	100	1250	1100	1000	1300	1600	500

12. Check the stability of concrete gravity dam against overturning and sliding. Consider $\mu = 0.7$, $\gamma_{\text{concrete}} = 24 \text{ kN/m}^3$, average shear strength of material at the horizontal section $(q) = 1400 \text{ kN/m}$. [8]



13. What is the function of a spillway? Describe with sketches the vertical and radius gate use in spillway. [2+4]

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

Subject: - Hydropower (CE660)

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- ✓ Attempt All questions.
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1. a) Define mass density, specific weight, specific volume and specific gravity. [2]
b) A liquid compressed in a cylinder has a volume of 3600 cm^3 at pressure 4 MN/m^2 and a volume of 3200 cm^3 at pressure 8 MN/m^2 . What is bulk modulus of elasticity? [4]
2. A vertical rectangular gate $4\text{m} \times 2\text{m}$ (4 m side being vertical) is hinged at a point 10 cm below the centre of gravity of the gate. The depth of water is 6 m above the bottom of the gate. What is horizontal force must be applied at the bottom of the gate to keep it in vertical position? [8]
3. Define the following and give one practical example for each i) steady and unsteady flow ii) laminar and turbulent flow [4]
4. Find the normal depth of flow in a triangular channel having longitudinal slope of 0.0004 and side slopes of 1:1 when it carries $1 \text{ m}^3/\text{sec}$, manning roughness coefficient $(n) = 0.014$. [8]
5. Compute the stream flow for the measurement data given below. [10]

Distance (m)	0	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8	5.4	6.0	6.6
Depth (m)	0	0.3	1.29	2.16	2.55	2.22	1.68	1.41	1.05	0.63	0.42	0
Velocity (m/s) at 0.2d	0	0.42	0.57	0.78	0.87	0.81	0.75	0.69	0.63	0.54	0.45	0
Velocity (m/s) at 0.8d	0	0.21	0.36	0.54	0.60	0.30	0.51	0.45	0.39	0.33	0.30	0

6. Mean monthly flow for a Nepalese river is given below, the net head of river 150m, overall efficiency of 85%. Assume 10% of water of minimum flow is required to be left for environment and downstream user in the river. Determine the primary and secondary energy produced by the plant, if design discharge is set to $950 \text{ m}^3/\text{s}$. [10]

Month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Qm^3/s	100	120	140	300	350	1800	2000	2520	2000	900	650	500

Assume any other data suitably if required.

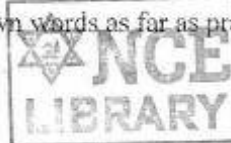
7. a) What do you mean by a spillway? Briefly describe on ogee spillway. [4]
b) A concrete gravity dam has maximum reservoir level 250 m, base level of dam 200 m, tail water elevation 210 m, base width of dam 40 m, location of drainage gallery 10 m from upstream face which may be assumed as vertical. Compute hydrostatic thrust and uplift force per unit length of dam at its base level. Assume 50% reduction in net seepage head at the location of the drainage gallery. [5+5]

8. A conical draft tube having inlet and outlet diameters 1.5 m and 2.1 m discharges water at outlet with a velocity of 3 m/s. The total length of the draft tube is 7.5 m and 1.5 m of length of draft tube is immersed in water. If loss of head due to friction in draft tube is $0.2 \times$ velocity head at the tube outlet, determine pressure head at inlet of the draft tube. Also find the efficiency of the draft tube. [6]
9. Why settling basin is essential in hydropower electric project in Nepal? Draw a layout plan and section of typical settling basin along with its design criteria. [3+3]
10. Describe the selection criteria of hydraulic turbines for hydroelectric power plants. [4]
11. Describe various types of spillways used in hydropower plants with neat sketches. [4]

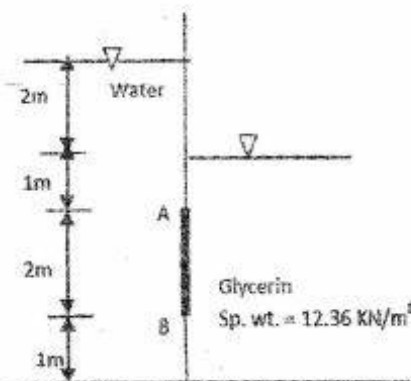
Exam.	Regular		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Hydropower (CE660)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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1. a) Classify the fluid flows with examples: (i) Laminar versus Turbulent (ii) Steady versus Unsteady. [2+2]
- b) Discuss surface tension and Capillarity. [4]
2. Find the net hydrostatic force per unit width on rectangular panel AB in the figure given below and determine its line of action. [10]



3. A pipe 5 cm diameter is 5 m long and carries a discharge of $0.005 \text{ m}^3/\text{s}$. Find the loss of head due to friction. The central 2 m length of the pipe is replaced by a pipe 7.5 cm diameter, the changes of section being sudden. Determine the loss of head due to these alternatives considering all losses. Take $f = 0.01$ for all pipes and contraction loss coefficient = 0.5. [4+6]
4. At known distances from an initial point on the stream bank, the measured depth and velocity of a river are shown in table. Calculate the corresponding discharge at this location. [8]

Distance from initial point (m)	0	10	20	30	40	50	60	70	80	90	99
Depth (m)	0	1.0	1.5	2.0	2.5	3.0	3.5	3.0	2.0	1.5	0
Mean velocity (m/s)	0	0.6	0.8	1.0	1.2	1.4	1.6	1.3	1.0	0.5	0

5. Following table shows the mean monthly flow of a typical river of Nepal. Estimate the primary and secondary energies available in the river throughout the year. Assume 10% of minimum flow of the series has to be released for environmental flow to the downstream from the dam. Take overall efficiency of the plant is 80% and effective head is 155 m. [10]

Month	1	2	3	4	5	6	7	8	9	10	11	12
Discharge, m^3/s	1150	1140	1450	1830	1700	1550	1150	1000	850	400	480	960

Note: The months are as per Nepalese calendar i.e 1 as Baishakh and so on.

6. A concrete dam of trapezoidal section is of height 50 m with upstream vertical face. Top width, base width and freeboard are 4.5 m, 42 m and 5 m respectively. Check the stability of the dam against (i) Overturning (ii) sliding (iii) Tension and (iv) Crushing. The unit weight of water is 10 KN/m^3 , the unit weight of concrete is 25 KN/m^3 and Crushing strength of the material 10 kg/cm^2 . Take angle of internal friction ($\phi=37^\circ$), uplift coefficient 0.8. Consider self-weight, hydraulic pressure and uplift pressure only. Mention your recommendation. [8]
7. With considering turbulent effect, design a settling basin to remove the sediment size greater than 0.25 mm diameter. Assume design discharge of the basin is $10 \text{ m}^3/\text{s}$ and trap efficiency as 95%. [8]
8. What is the main propose of spillway? List out the different type of spillway used in hydropower projects. [1+5]
9. a) Differentiate between impulse and reaction turbines with the help of their performance characteristics. [4]
b) What is the purpose of governor in a turbine? How does a centrifugal pump works? [4+4]
- ***

6

Subject: - Hydropower (CE660)

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- ✓ Attempt All questions.
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1. Classify the fluid flows with examples: (i) Compressible versus Incompressible (ii) Laminar versus Turbulent and (iii) Steady versus Unsteady. [2+2+2]
2. Define the following terms: [3×3]
 - i) Froude number
 - ii) Specific energy
 - iii) Best hydraulic section
3. A rectangular channel, 8 m wide and 1.5 m deep, has a slope of 0.001 in 1 and is lined with smooth concrete plaster. It is desired to enhance the discharge to a maximum by changing the dimensions of the channel but keeping the same amount of lining. Find the new dimensions and percentage increase in discharge. For smooth concrete plaster, take Manning's constant = 0.015. [10]
4. The data pertaining to a stream-gauging operation at a gauging site are given below. The rating equation of the current meter is $v = (0.55 N + 0.04) \text{ m/s}$. Calculate the discharge in the stream. [8]

Dist from left edge (m)	0	1.0	4.0	7.0	10.0	11.0
Depth (m)	0	1.5	2.5	3.5	2.4	0
Revolution of current meter at 0.6d	0	40	60	120	125	0
Duration of observations (s)	0	100	100	150	150	0
5. Sketch the layout of hydropower scheme showing different components parts. [3]
6. What are the major sources of electric power generation? Discuss the relative merits and demerits of hydropower as compared to thermal power. [2+3]
7. Describe the forces that possibly acted to the gravity dam. Show them in neat and clean sketch. Describe the stability requirements of gravity dam. [9]
8. Differentiate between a Surge Tank and a Forebay. [4]
9. Explain the design principle and criteria of settling basin with neat sketches of basin and discuss the different component of the basin. [7]
10. Differentiate between Pelton turbine and Francis turbine with the help of their performance characteristics. [6]
11. What is meant by economical diameter of penstock pipe? Why is it necessary to work out in hydropower plant? [3+3]
12. In hydropower project the available river discharge is $340 \text{ m}^3/\text{s}$ under the net head of 27.5 m. If the speed of the turbine is to be 166.7 rpm and overall efficiency is 88%. Determine the number of unit required if Kaplan turbine of specific speed 560 rpm in SI-unit is selected. [7]

5/25

23 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	III / II	Time	3 hrs.

Subject: - Hydropower (CE660)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
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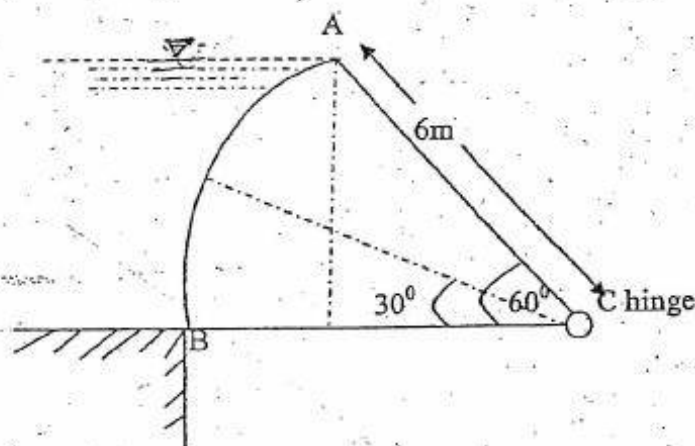
1. What factors should be considered in selecting a site for a stream gauging station? Describe briefly the procedure of using a current meter for measuring velocity of stream. [3+3]
2. State Bernoulli's equation. Mention the assumptions made. How is it modified while applying in real practice? [1+1+2]
3. A pipeline supplies $0.09 \text{ m}^3/\text{s}$ water from a reservoir to a building. The pipe is 2 km long and 0.15 m diameter with friction factor 0.025. It is desired to increase the discharge by 25% by installing another pipeline having same friction factor in parallel with this over half the length. Recommend a suitable diameter of the pipe to be installed. [8]
4. What is meant by economical channel section? Prove that a triangular channel section will be most economical when each of its slopes is 1:1 and sloping sides makes an angle of 45° with vertical. [2+5]
5. A rectangular plate 0.6 m wide and 1.2 m deep lies within a water body such that its plane is inclined at 40° to the horizontal and the top edge is 0.70 m below the water surface. Determine the total pressure force on the plate and the location of the center of pressure. [8]
6. What are the functions of forebay? Describe briefly about layout of forebay on hydropower project with neat sketch. [2+3]
7. What is the flow duration curve? Describe in brief the parameters influencing planning of hydropower projects. [2+6]
8. a) Why draft tube is used in Francis turbine? How does a centrifugal pump works? Discuss. [3+3]
- b) What is the significance of a governor in a turbine? [3]
9. What criterias do you consider while designing and laying out a hydraulic tunnel? Explain. [6]
10. Draw a typical layout of powerhouse with Francis turbine. How would you fix the appropriate dimension of the powerhouse? [2+3]
11. List out any five types of spillway used in hydropower projects in the dam reservoir system. Explain briefly the most suitably type of spillway in the contest of Nepalese river site. [2+4]
12. What is an elementary profile of a gravity dam? What condition should be satisfied for such profile? Explain with mathematical expression. [8]

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

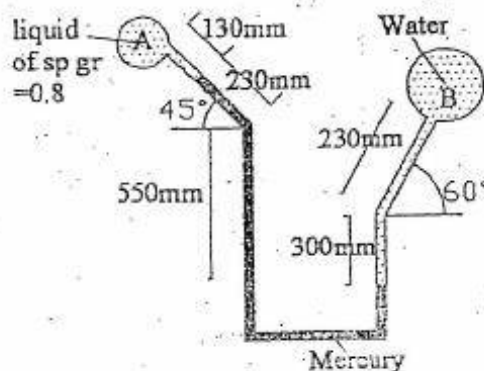
Subject: - Hydropower (CE660)

- ✓ 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.
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1. The sector shown in figure below consists of a cylindrical surface of which AB is the trace, supported by a structural frame hinged at C the length of the gate is 4 m determine the magnitude and location of the horizontal and vertical component of the total hydrostatic pressure on the gate. [7]

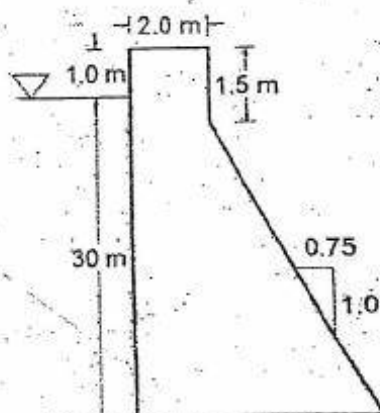


2. What is water hammer and what are its effects? How the water hammer pressure is calculated for the gradual closure of the valve in the pipe? [3+4]
3. Find the pressure difference between the container A and B as shown in figure. [7]



4. How the discharge of a stream or river can be computed by slope area method. [6]
5. State Bernoulli's equation of motion along one dimensional streamline flow of an incompressible fluid. Also explain the significant of various energy terms with assumptions. [2+3]

6. Explain the level of studies involved in reconnaissance, prefeasibility and feasibility studies of the hydro power project. [8]
7. Explain the hydraulic design criteria of a settling basin. [5]
8. Design a Pelton turbine with the following data: [9]
 - Design discharge = $2 \text{ m}^3/\text{s}$
 - Net head = 605 m
 - Overall efficiency = 87%
 - Specific speed = 100
 Assume the ratios and coefficients from their standard range.
9. Check safety against sliding and overturning for the gravity dam shown in figure. Assume, unit weight of water = 9.81 kN/m^3 , unit weight of concrete = 24 kN/m^3 , angle of internal friction $\phi = 37^\circ$, uplift coefficient = 80%. Consider self-weight, hydrostatic pressure and uplift pressure only. Mention your recommendations. [9]



10. Explain with neat sketch, different types of intakes and its suitability in hydropower projects. [5]
11. Define cavitation. Write about cavitation phenomenon over the spillway. [2+4]
12. What is the purpose of governor? Write about the governing of Francis Turbine. [2+4]

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

Subject: - Hydropower (CE660)

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1. Define the terms specific gravity, and specific weight. Differentiate between Newtonian and Non Newtonian fluid showing diagram of variations of shear stress with velocity gradient. [2+4]
2. What do you mean by a channel of hydraulically best section? Shows that the hydraulic mean depth for a trapezoidal channel is half the depth of flow. [2+6]
3. Two reservoirs are connected by a pipe line which is 20 cm in diameter for the first 5 m and 30 cm in diameter for the remaining 20 m. The entrance and exit are sharp and change of section is sudden. If the water surface in the upper reservoir is 6 m, above that in the lower reservoir, calculate head losses and rate of flow. Take $f = 0.01$ for all cases. [8]
4. What is the use of manometer? Show the working principle of inverted manometer with neat sketch. [2+4]
5. Define with application of stage discharge curve in hydropower project. [6]
6. What is the function of forebay? Describe the types of surge tank. [2+3]
7. Estimate primary and secondary energy from the data given below. [10]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Flow (m^3/s)	30	28	24	29	18	37	65	90	74	56	42	39

Net head available = 102 m

Discharge capacity = $55 m^3/s$

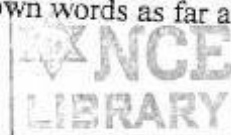
Overall efficiency = 76%

8. How does a centrifugal pump work? Mention the parameter that govern dimensioning of power house. [3+3]
9. Mention with neat sketches different types of spillway gates. [6]
10. A hydropower plant was designed for $150 m^3/s$ under the head of 46 m. If the speed of the turbine is to be 165 rpm and overall efficiency is 86.5%, determine the number of units required and output of each unit, if the propeller turbine of specific speed 234 is selected. [8]
11. Determine the uplift pressure force on a gravity dam of 40m height, 10 m top width with u/s face vertical and the base width = 30 m. The tail water depth is 5 m and the free board is 3 m. What will be the uplift pressure force when there is a drainage gallery at a distance of 6 m from u/s face? [3+3]
12. Explain different types of intake used in hydropower projects with neat sketch. [5]

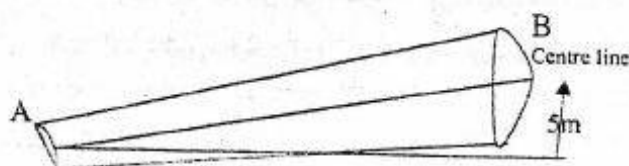
Exam.	New Batch (2066 & Later Batch)		
Level	BE	Full Marks	80
Programme	BEL	Pass Marks	32
Year / Part	III / II	Time	3 hrs.

Subject: - Hydropower (CE660)

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- ✓ Attempt All questions.
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1. How do you measure difference of pressure between any two points in a pipe? Explain with neat sketch and mathematical expression. [6]
2. Calculate dimensions of a most efficient trapezoidal channel section having side slopes 3H:4V with $n = 0.012$ consider bed slope 1 in 2000 which carries water at a velocity of 0.50 m/s. [6]
3. An isosceles triangle plate of base 4 m and altitude 6 m is immersed vertically in water. Its axis of symmetry is parallel to the free surface and at a depth of 6 m from the free water surface. Calculate the magnitude and location of the total pressure force. [7]
4. A pipe line (AB) conveying oil (specific gravity = 0.90) has diameter 500 mm and length 2000 m. The difference in elevation between A and B is 10 m. Find the loss of head and the direction of flow. [8]



5. Define cavitations erosion in spillway? Explain with neat sketch of different types of energy dissipator used on hydropower plant. [2+4]
6. What are the objectives of the provision of draft tube for the reaction turbine? Write notes on the working principal of governors. [2+4]
7. How peak flow is estimated by using unit hydrograph and S-curve method? [2+4]
8. Discuss with neat sketch the force acting on a gravity dam. [6]
9. What criterias do you consider while designing and laying out a hydraulic tunnel. Explain. [3+3]
10. Design a pelton turbine with following data: [8]
 - Overall efficiency = 87%
 - Discharge (Q_d) = $1.8 \text{ m}^3/\text{s}$
 - Net head (H) = 605 m
11. From the following data of flow at a given site for an average year compute and draw a power duration curve. Assume an average net available head of 100 m and a combined turbine generator efficiency of 89%. Determine the primary and secondary energy available during a year if the plant capacity is fixed at power corresponding to the flow available for 45% of time. [10]

Flow	900	600	500	450	400	360	340	300	280	200	140	100
time	1	10	20	30	40	50	60	70	80	90	93	100

12. What do you understand by economical diameter of penstock pipe? Why it is necessary to remove the sediment of flow in hydropower project? [3+3]