TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Chaitra

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

Subject: - Hydropower Engineering *(CE 704)*

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

1. a) The monthly flows of a stream over the period of the driest year on record are as shown below: [7+3+2]

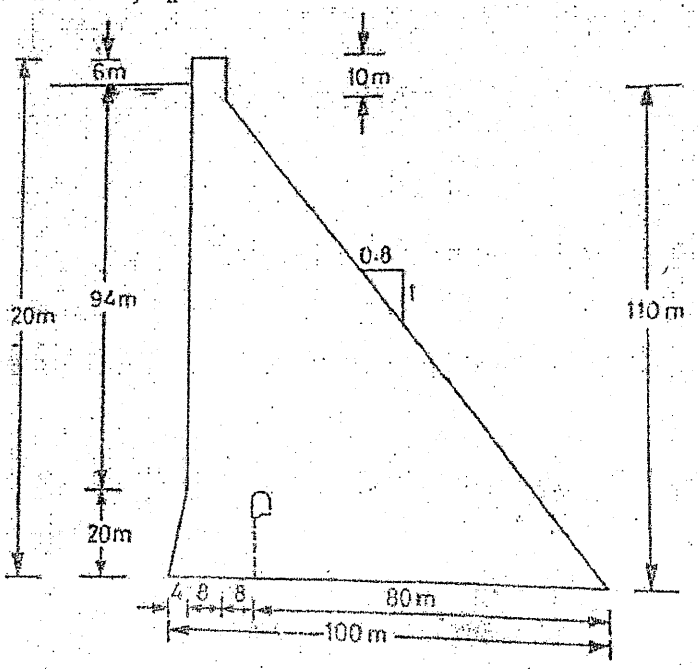
Month	J	F	M	A	M	J	J	A	S	O	N	D
Flow ($\times 10^6 m^3$)	4.0	2.25	5.0	1.25	0.5	0.75	0.5	0.75	1.25	1.25	5.0	6.25

(i) Estimate the maximum possible uniform draw-off from this stream and determine the reservoir capacity to achieve the uniform draw-off and the minimum initial storage to maintain the demand.

(ii) If the reservoir has only a total capacity of $8\times10^6 m^3$ with an initial storage of $4\times10^6 m^3$, determine (a) the maximum possible uniform draw-off and (b) the spillage.

b) Describe various types of hydroelectric scheme based on hydraulic characteristics. [4]

2. a) Determine the principal stresses at the toe and heel of the dam shown in figure for the reservoir full conditions. Consider the following forces: [10]
(i) Self weight (w_c=25kN/m^3)
(ii) Water pressure (w=10kN/m^3)
(iii)Uplift pressure
(iv)Silt pressure the depth of silt as 20m
(v) Earthquake forces, α_h=0.1



b) Determine the maximum and minimum vertical stresses to which the foundation of the dam will be subjected from the following data:
Total overturning moment about toe(ΣM_o)=1.2×10^6 kN-m
Total resisting moment about toe (ΣM_R) = 2.5×10^6 kN-m
Total vertical force above the base (ΣV) = 6×10^4 kN
Base width of dam = 55m.
Slope of d/s face = 0.8:1
Also calculate the maximum principal stress at the toe. Neglect tail water depth. [2+2+2]

3. a) What are the main parts of non-pressurized and pressurized ROR intake? Present the general arrangement of such intakes in a neat proportionate sketches. [2+6]

b) Find out the dimension of a setting basin with turbulence flow for a high hydropower plant, which utilizes a discharges of 60 m^3/sec. The sediment particles coarser than 0.2mm (fall velocity w=1.5 cm/sec) have to be trapped in the basin. Draw plan and section showing major components and flushing arrangement, neat and proportionately. [4+4]

4. In a pumped – storage hydropower project, water is delivered from the upper impounding reservoir through a low-pressure tunnel and four high-pressure penstocks to the four pump-turbine units. The elevation of the impounding reservoir water level is 500m, and the elevation of the downstream reservoir water level is 200m. The maximum reservoir storage which can be utilized continuously for a period of 48h is $15\times10^6 m^3$. [6+3+3+2+2]

The low pressure tunnel is constructed as follows: length = 4km; diameter=8m; friction factor, f=0.028.

The high pressure penstocks (4 nos) are constructed as follows:
length of each penstock = 500m;
diameter = 2m,
friction factor, f = 0.016;
turbine efficiency when generating = 90%;
generator efficiency (16 poles, 50Hz) = 90%;
turbine efficiency when pumping = 80%;
barometric pressure = 10.3m of water;
Thoma's cavitation coefficient, $\sigma = 0.043\ (N_s/100)^2$.

a) Determine the maximum power output from the installation
b) Estimate the specific speed and specify the type of turbine
c) Determine the safe turbine setting relative to the downstream reservoir water level.
d) If a simple surge chamber 6m in diameter is provided at the end of the low-pressure tunnel, estimate:
   (i) the maximum upsurge and downsurge in the surge chamber for sudden rejection of one unit and
   (ii) the maximum downsurge for a sudden demand of one unit.

5. a) Write down advantages and suitability of chute type spillway, shaft spillway, ogee type spillway and roller gate. [2+2+2+2]

b) Why is vertical shaft arrangement preferred while laying turbine and generator in a powerhouse? Explain briefly. [4]

c) State the objectives of the current Hydropower Development Policy of Nepal. Discuss the necessary amendment required to improve the existing scenario of the Hydropower Development Sector. [2+2]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2076 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Hydropower Engineering *(CE 704)*

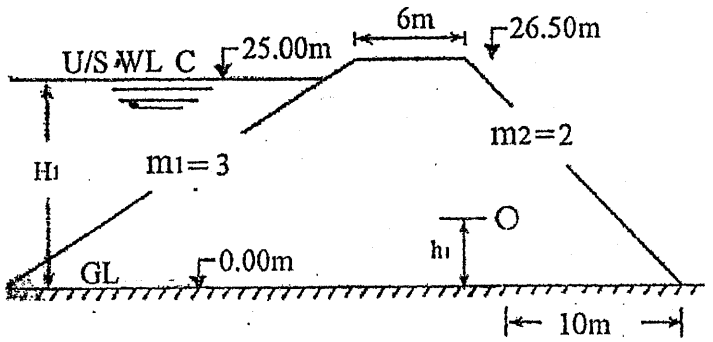
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt <u>All</u> questions.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *Assume suitable data if necessary.*

1. a) During a low water week a river has an average daily flow of 40 m^3/s with a fluctuation during the day required a pondage capacity of approximately 30% of the daily discharge. A hydroelectric plant is to be located on the river which will operate 6 days a week, 24 hours a day, but will supply power at a varying rate such that the daily load factor is 50%, corresponding to which the pondage required is equal to 0.2 times the mean flow to the turbine. On Saturday all the flow is ponded for use on the rest of the days. If the effective head on the turbines when the pond is full is to be 25 m and the maximum allowable of fluctuation in pond level is 1m, find

   (i) the surface area of the pond to satisfy all the operating conditions
   (ii) the weekly output at the switch board in kwh. Assume turbine efficiency 80% and generator efficiency 90% [5+5]

   b) Explain the working principle of RoR, PRoR and ST plants with the help of figures. Also comment on the suitability of those plants in the context of Nepal. [6]

2. a) An earthen dam of homogeneous materials with a drain pipe is shown in figure. Determine the co-ordinate of phreatic line and specific discharge passing through the body of dam. coefficient of permeability = 15×10^{-4} m/s. [6]



   b) Explain the necessity of grouting and drainage galleries in concrete gravity dam. Draw an elevation view of a concrete gravity dam showing the alignment of drainage galleries and series of grout holes.
   Drawing a section of concrete gravity dam show arrangement of vertical formed drain, trap drain and drainage hole. [2+4+4]

3. a) Design a settling basin for a high head project in a river which utilizes 60 m^3/s discharge and gross head of 300 m. The sediment particles larger than 0.15 mm (fall

velocity = 1.5 cm/s) need to be trap in the basin. Consider effect of turbulence as well. Also draw plan and section of the basin showing major components. [8+4]

b) Explain various remedial measures that help to control the deposition of sediments in RoR project. [4]

4. a) A penstock carries 8 m^3/s of water at head of 25m. The cost of pipe line in place is given by US\$250hd^2 per meter length, where h = head and d = diameter of the pipe. Annual fixed charges are 8% of the pipe line cost. The estimated head loss in friction is $\frac{0.025Q^2}{12.1d^5}$ per m length of the pipe. Efficiency of the turbine is 80% and selling price of the power is US\$500 per kW per annum. Calculate the most economic diameter of the penstock. [8]

b) It is proposed to form a hydraulic jump in a stilling basin to dissipate the energy below spillway. Depth of flow changes from 1.5m to 4m. Calculate the discharge over the spillway if the length of the crest is 120m. [3]

c) Mention the four different types of spillway and describe each of them in short. Also write down the functions of the spillway. [4+1]

5. a) What are the opportunities and challenges for Hydropower development in Nepal? Write your comments on the Hydropower Development Policy – 2001 of Nepal. [4+2]

b) A Francis turbine works under a head of 25m and produces 11760 kW while running at 120 rpm. The turbine has been installed at a station where atmospheric pressure is 10 m of water and vapour pressure is 0.20 m of water. Calculate the maximum height of the straight draft tube for the turbine. [6]

c) Draw a section of vertical axis Francis turbine in a powerhouse showing different parts of powerhouse. [4]

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02 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Chaitra

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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. What are the major provisions in hydropower development policy in 2001? List out the major institutions involved in hydropower development sector. [3+3]
2. What is a daily peaking power plant? With a neat sketch show the general arrangement of such plant daily peaking power plant. [3+3]
3. Find the specific discharge through homogeneous earthen embankment dam with 2 m thick central impervious core, [7]

   Height of the dam = 50m

   Upstream water level = 48.00m

   Downstream water level = 3.0m

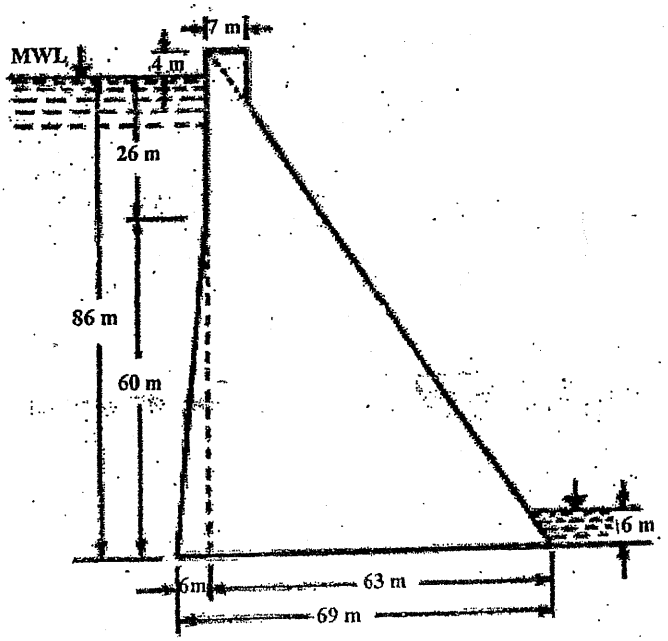
   Width of the dam at the top = 10.00m

   Upstream and downstream slope of the dam = 1:3 (V:H)

   Coefficient of permeability of the soil =3 cm/hr

   Coefficient of permeability of impervious core = 1.0×10^{-8} m/s

4. a) Examine the stability of the gravity dam shown in figure below considering seismic effects. Also indicate the values of various kinds of stresses that are developed at heel and toe. Uplift may taken same as hydrostatic pressure at base of corresponding faces and is considered to act over 60% of the base area. Seismic coefficients (α) are 0.1 and 0.05 for horizontal and vertical directions respectively. Take, $\gamma_c = 24$ KN/m^3 and $\gamma_w = 10$ KN/m^3. [10]



   b) Derive an equation for determining the length of discharge face for an earthen dam without filter. The downstream slope lies between 30° and 60°. [6]

5. a) Describe design principle of a settling basin of a hydropower plant based on particle size and concentration approach. [7]

   b) Design a hydraulic jump stilling basin for the flood discharge 25 $m^3/s/m$ flowing from an overfall spillway with the spillway crest 60 m above the downstream gravel river bed with a slope 0.001 and manning's roughness coefficient 0.028. Assume, $C_d = 0.75$, $\sigma = 1.2$, $k = 4.5$ and sp.gr = 2.65. [10]

6. How does a siphon spillway function ?What are the ways in which a siphon spillway can be primed? What are the limitations of siphon spillway? [2+2+2]

7. a) Describe geometrical shapes of tunnel with neat sketches and write down the suitability of those shapes for various rock conditions. [4]

   b) Differentiate between forebay and surge tank. Design a forebay which accumulated water for 3 minutes for operation of a hydropower plant having data as given below. Also check the length of fore bay and limiting velocity. [2+6]

   Design discharge = 20 m^3/s
   Number of penstock = 1
   Diameter of penstock = 2.2 m
   Limiting velocity = 0.2 m/s

8. A hydropower plant having net head of 150 m and design discharge of 25 m^3/s is going to use Franci's turbine. Take efficiency = 81%. Find the specific speed, turbine diameter and elevation of turbine with respect to the water surface in tailrace. [6]

9. Sketch a typical type of layout of powerhouse project and briefly explain of each. [4]

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02 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2075 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Hydropower Engineering *(CE704)*

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

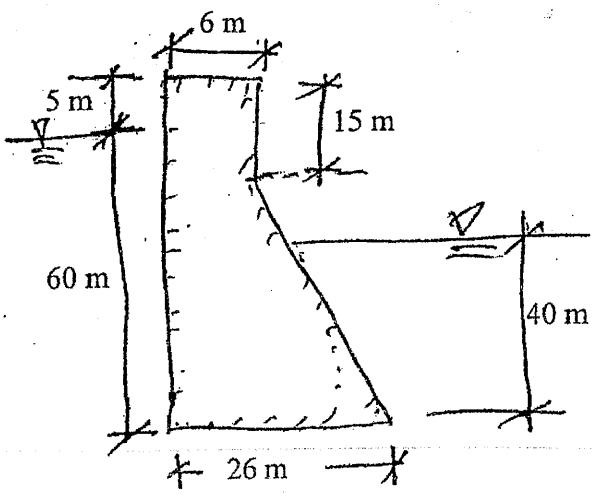
1. What are the opportunities and challenges for Hydropower development in Nepal? Write your comments on the Hydropower Development Policy-2001 of Nepal. [4+2]
2. Sketch and explain layouts of the run of river plant. Also explain the importance of storage hydropower plants over run of river plant. [3+3]
3. a) A RoR plant has a minimum flow of 30 m^3/s and net head of 70 m. The overall efficiency of plant is 85%. Calculate the installed capacity of the plant (i) Without pondage (designed for pure RoR plant) and (ii) If the plant is designed for a peaking plant with 6 hours peaking. The plant has two set of unit such that one unit full capacity if operating during off peak hour. Total evaporation and other losses is 5% of the stored water. [6]

   b) Monthly flow volumes feeding a reservoir are given in the table. Determine the storage capacity required to supply the mean annual flow. [4]

Month	1	2	3	4	5	6	7	8	9	10	11	12
Volume ($10^6 m^3$)	296	386	504	714	810	1154	746	1158	348	150	223	182

4. a) Write about the "Middle third rule" in the design of concrete gravity dam? Describe with necessary derivation. [6]

   b) A concrete gravity dam of given profile is purposed by a designer for implementation. The unit shear resistance and angle of resistance is 500 KN/m^2 and 35° respectively. $\gamma_{con} = 24\,KN/m^3$, check the stability of dam against flotation, overturning and sliding. [8]



5. a) Design a settling basin for a high head project in a river which utilizes 60 m^3/s discharge and gross head of 300 m. The sediment particle larger than 0.15 mm (fall velocity = 1.5 cm/s) need to be trap in the basin. Consider effect of turbulence as well. [7]

   b) Design a hydraulic jump stilling basin for the flood discharge 28 $m^3/s/m$ flowing from an ogee spillway with the spillway crest 55 m above the downstream gravel river bed with a slope 1:1000 and Manning's roughness coefficient 0.028. Assume coefficients of discharge, depth and length are 0.75, 1.2 and 4.5 respectively. Also assume sp.gr of sediment as 2.65. [10]

6. Describe with governing equations the procedure to obtain the specific discharge through the body of earthen dam with horizontal drain. [6]

7. a) Find out the dimension of a forebay which accommodates a storage for 3 minutes of operation for a hydropower plant having following data: [3]

   Design discharge = 20 m^3/s

   Length of penstock = 300 m

   Diameter of penstock = 2.20 m

   b) Discuss the various factors which govern the determination of economic diameter of a penstock. Find the wall thickness of penstock pipe if the internal diameter is 3.0 m which supplies water from a head of 220 m with a possibility of increase in pressure upto 40% due to transit condition. Take $\sigma_{st} = 1400\ kg/cm^2$ and efficiency of joint = 0.95. [2+3]

8. Determine the diameter of Francis turbine for a site where the net head is 110 m and discharge 140 m^3/sec having efficiency of 90%. Determine also the elevation of turbine with reference to the water surface in tailrace. Assume the turbine will have to drive a 50 cycle generator. [8]

9. Explain the different types of power house use in hydropower project. [5]

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03 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Chaitra

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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. What are the objectives of the Hydropower Development Policy, 2058? List out various hydropower development institutions in Nepal. [4+2]
2. a) Draw a general layout (plan and section) of the diversion type hydropower project. Comment on the suitability of the Run of River (RoR), Peaking Run off River (PRoR) and Storage projects in Nepal. [3+3]
   b) Briefly describe the hydropower development cycle. [2]
3. The hydrograph of a typical river of Nepal follows the equation as:

   $Q_t = 5.589t^2 - 51.275t + 139.94$; where Q_t is mean monthly discharge in m^3/s and 't' is time in months counted as October as the 1st month and so on. A hydropower plant has to develop in this river with net head of 150m and overall efficiency as 85% and the environmental flow is not considered. [3+3+4]

   a) Calculate the installed capacity and firm energy for RoR Project that will be developed for design discharge as Q_{40}.

   b) If the project has to design as a Peaking Run of the river (PRoR) Project for 6 hrs daily peaking (3hrs in morning and 3hrs in evening) and with design discharge as Q_{40}. What is the installed capacity of the PRoR Project? Assume that the project is designed such a way that 50% of available flow is used during the off peak hours and remaining 50% of available flow is stored for peak hour generation. Neglect all the losses.

4. a) A concrete gravity dam (trapezoidal in section) has height 20 m, top width 1.2 m and bottom width 10 m is proposed to block the water of height 18 m. The u/s face of the dam is vertical and the d/s face has slope 1:2 (H:V). Considering the forces: self weight, hydrostatic force and uplift pressure, check the stability of the dam. (Assume unit weight of concrete = 24 KN/m^3, permissible shear stress of joint as 1400 KN/m^2, coefficient of friction as 0.75, and uplift factor k as 0.8). Neglect the tail water effect to the dam. [8]
   b) Discuss the construction procedure of phreatic line in embankment dam. [4]
   c) Write about the cavitations in spillways and its preventive measures. [4]
   d) Explain the different types of gates use in hydropower head works. [4]
5. a) Design a settling basin to remove the sediments of size greater than 0.3mm having a design discharge of 25 cumecs. The sediment has specific gravity of 2.65 and fall velocity of 50 mm/sec. [7]
   b) What are the general requirements of a functional RoR headworks? [5]

6. a) What is tunnel support? What are the parameters for evaluation of tunnel support? [1+3]

   b) A power station is fed by a 2030m long concrete lined tunnel of 4.22m diameter and 380m long pressure shaft of 3.41m diameter operating under a gross head of 250m. It has a surge tank of 15.85m diameter at end of tunnel. If the design discharge of the plant is $60m^3/s$ and friction factors in tunnel and pressure shaft are 0.014 and 0.012 respectively. Compute the maximum, minimum and normal water level at surge tank if the water level at reservoir is 457.00m. Draw neat sketches showing the calculated values. [8]

7. In a hydropower project, it is planned to use a Francis turbine. The project has a head of 185m and discharge of 100 cumecs. Determine the size and the elevation of the turbine if the overall efficiency is taken as 85%. [8]

8. Draw plan and sections of a powerhouse showing various components. Assume a Francis Turbine is used in this powerhouse to generate the electricity of 10 MW. [4]

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03 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2074 Ashwin

Exam.	Back		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / I	Time	3 hrs.

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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.*

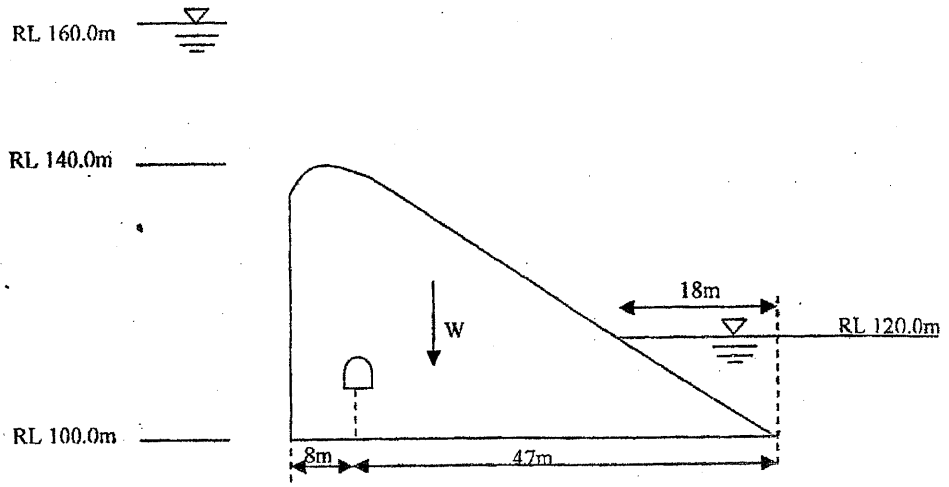
1. Discuss about the Hydropower Development Policy 2058 of Nepal. [6]
2. What are the various stages of hydropower planning? If you have been appointed as a water resources engineer in Water Resources Ministry and you are assigned to undertake various investigations related to water resources field. Discuss field investigations you carry out at various stages of the Hydropower project. [2+6]
3. The hydrograph of a typical river of Nepal follows the equation as:

   $Q_t = 5.589t^2 - 51.275t + 139.94$; where Q_t is mean monthly discharge in m^3/s and 't' is time in months counted as October as the 1st month and so on. A hydropower plant has to develop in this river with net head of 150m and overall efficiency as 85% and the environmental flow is not considered. [3+3+4]

   a) Calculate the installed capacity and firm energy for RoR Project that will be developed for design discharge as Q_{40}.

   b) If the project has to design as a Peaking Run of the river (PRoR) Project for 6 hrs daily peaking (3hrs in morning and 3hrs in evening) and with design discharge as Q_{40}. What is the installed capacity of the PRoR Project? Assume that the project is designed such a way that 50% of available flow is used during the off peak hours and remaining 50% of available flow is stored for peak hour generation. Neglect all the losses.

4. a) Check the stability of the overflow section of the gravity dam shown in figure. Assume the weight of concrete, gates, piers and weight of water over crest, W_{total} = 3.0×10^4kN. Moment of weight of concrete, gates, piers and water above crest etc. about toe $M_{toe} = 10^6$ kN-m. Neglect all forces other than weight, uplift pressure and water pressure. Also check for tension. Take $\mu = 0.75$ and $q = 1400$ kN/m^2. [10]



b) Design a hydraulic jump stilling basin for the maximum discharge of $25m^3s^{-1}m^{-1}$ flowing from an overall spillway, with the spillway crest 50m above the downstream gravel river bed with a slope $S_0 = 0.001$ and $n = 0.028$. [6]

c) What are the purposes of spillway? What are the advantages of ogee shape spillway? Explain. [2+2]

5. a) With considering turbulent effect, design a settling basin to remove the sediment size greater than 0.3 mm diameter. Assume design discharge of the basin is $8m^3/s$ and trap efficiency as 90%. [8]

b) Differentiate between pressurized and non-pressurized intakes. [4]

6. a) A hydropower plant has planned to use a steel penstock pipe of length 600m having a diameter of 0.8m to carry a discharge of $5m^3/s$. The static head available is 80m. The wave velocity, design stress and joint efficiency for the penstock pipe are 1200m/s, $1326kg/cm^2$ and 85% respectively. What thickness of the penstock pipe would you recommend for the power plant if the gate closure time is 30 seconds? [8]

b) Discuss various shape of tunnel with their advantages. [4]

7. a) A hydropower plant has design discharge of 60 m^3/s and net head of 90m. Design Francis turbine for this power plant (number of turbine, specific speed, diameter and setting of turbine). Take turbine efficiency 94%. [6]

b) What are the functions of draft tube? [2]

8. Write about the structure and dimensioning of the power house? [2+2]

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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2073 Shrawan

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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. Describe briefly the provision for licencing of Hydropower according to Hydropower Development Policy Nepal, 2058. [6]
2. Lists out the minimum Checklist for Reconnaissance, prefeasibility and feasibility studies for hydropower development. [7]
3. The power supplied by the state electricity authority throughout the year by steam power plant are as shown in table below. [5+5]

Month	Power Supplied (MW)
jestha	550
asar	500
shrawan	450
bhadra	380
asoj	330
kartik	280
mangsir	250
poush	220
Magh	200
falgun	150
chaitra	145
baisakh	100

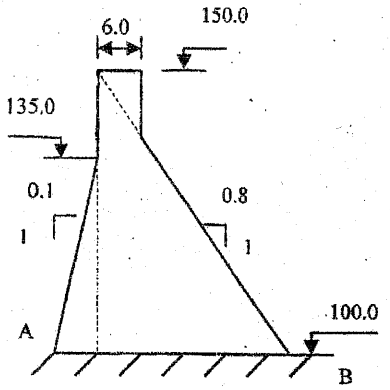
But the current demand forced them to have loadshedding. To minimize the loadshedding by providing at least power equivalent to Magh month throughout the year, Authority has decided to import power from neighbouring country for only 3 months i.e. Falgun, Chaitra and Baisakh as 50 MW, 55 MW and 100 MW respectively.

a) Despite importing power, authority felt that they can not provide uniform power of Magh throughout. So they decide to have a diesel plant for deficit. Estimate the minimum capacity of diesel plant. (Use load duration curve for analysis)

b) If instead of above system (Steam plant +import+diesel plant), Authority has planned to provide the power in near future by constructing ROR hydropower plant by its own to substitute the current model. Derive the Flow duration curve for such new hydro project to supply the power demand given in table. Assume power demand is constant in future.

4. a) Check the stability of dam against overturning, sliding and material failure (stresses) with respect to worst location assuming that in addition to self weight, 25% of mass of dam will act as horizontal component (from upstream side), whereas 15% as upward vertical component as seismic load and will act at the CG of the section.

Assume unit weight of the concrete as 24 kN/m^3, Assume unit weight of the concrete as 24 kN/m^3, allowable compressive stress in foundation and concrete as 2,500 kN/m^2 and 3,000 kN m^2, angle of friction between concrete and foundation as 36° and unit shear resistance between foundation and dam as 700 kN/m^2. [4+4+2]



b) Write with neat sketch, expressions for computing seepage and phreatic surface in Earthen dams for two cases; homogeneous and without drain and dam with toe drain. [2+3]

c) Draw a neat sketch of side intake with all components. How do you calculate hydraulic loss at trash rack? [3+2]

5. a) What do you mean by sediment flushing in settling basin? Briefly explain the different type of flushing system used in hydropower in Nepal. [2+4]

b) With considering turbulent effect, design a settling basin to remove the sediment size greater than 0.3 mm diameter. Assume design discharge of the basin is 8 m^3/s and trap efficiency as 90%. [6]

6. a) Derive an expression for minimum upsurge without damping effect in the surge chamber using continuity and momentum equations. [3+7]

In a storage hydropower plant, water is delivered from upper impounding reservoir through low pressure headrace tunnel and three high pressure penstocks to three francis turbine units.The elevation of reservoir and tailwater level are 320 m and 200 m above datum respectively. It is decided to design a simple surge tank between headrace tunnel and penstocks for sudden rejection or demand of two units. If the maximum and minimum water level elevation in the surge tank is limited to 330 m and 310 m above datum respectively due to topography and construction difficulty, determine the minimum area of surge tank and permissible length of low pressure headrace tunnel to fulfill the design objective.
Given data:
Discharge in tunnel: 100 m^3/s
Head race tunnel: diameter-7 m and head loss in tunnel= 10 % of gross head of system.
Penstocks: each length 500 m, diameter 2.5 m, f = 0.016

b) Write procedure to compute the dimensions of the forebay and write the equations used for such purpose. [3]

7. Drawing efficiency curves, discuss the performance characteristics of Pelton and Francis Turbines. What is the advantage of pelton turbine over Francis? Write down the principle behind setting of Francis turbine relative to the tail water level. [2+2+2+2]

8. Draw plan and sections of a powerhouse showing various components. Assume a Francis Trubine is used in this powerhouse to generate the electricity of 10 MW. [4]

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03 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Chaitra

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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.*

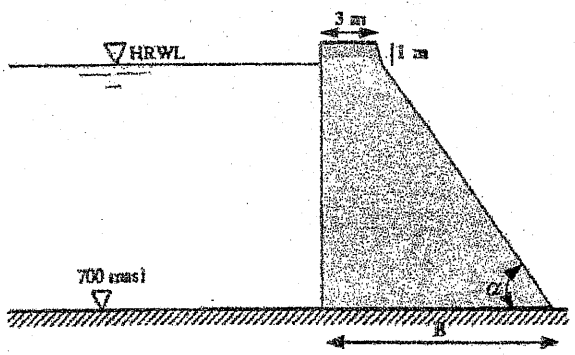
1. Discuss about the objectives and strategies of *the Hydropower Development Policy-2001* (2058 BS) of Nepal. [6]
2. Highlight the major studies and investigations carried out during reconnaissance, prefeasibility and feasibility studies. [8]
3. A hydropower plant is to be planned in a Nepalese river, where the mean monthly flows for a typical year are as follows:

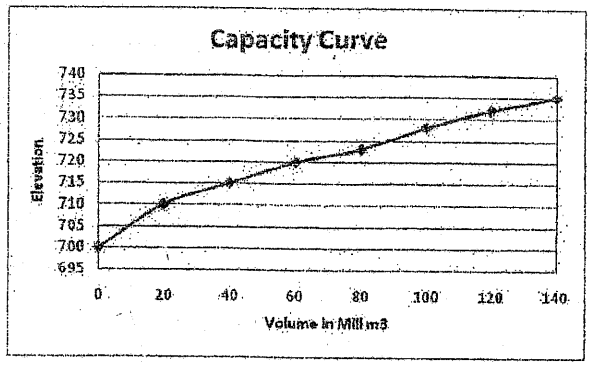
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q(m^3/s)	4.4	3.9	3.4	4.2	5.6	16.5	78.1	108.9	52.8	22.0	9.9	6.4

Other data pertaining to the plant are as follows:
- Design Discharge = 18 m^3/s
- Full Supply Level = 2250 masl
- Turbine Center line = 1650 masl
- Dia of 4.0 km long tunnel = 3.0 m, f=0.014
- Dia of 1.0 km long penstock = 2.2 m, f=0.012
- Hydraulic Efficiency, 95%; turbine efficiency, 93%; Generator Efficiency; Transformer efficiency, 99%

Considering only Frictional loss,
a) Compute installed capacity, primary and secondary energy to be produced from the power plant assuming that 10% minimum flow to be released downstream. What is plant factor ? [5+2]
b) The developer is interested to develop a daily peaking reservoir for 4 hours. What will be the capacity of the reservoir to satisfy daily peaking requirement? [3]

4. a) A concrete gravity dam shown in figure below was constructed for development of hydropower project. The dam has a vertical upstream and inclined downstream face. The highest regulated water level (HRWL) of the dam is fixed at 1 m below the top crest level. At HRWL, the storage capacity of reservoir created by the dam is 60 mill m^3. The reservoir capacity curve of the dam is shown in figure below. In a flood situation the 80 m long dam creat can serve as a spillway to discharge the flood. Assume density of concrete γ_C = 24 KN/m^3 and the friction angle between the dam and foundation $\phi = 43°$. [3+5+3+5]





a) Find all main forces acting on the dam when the water level in the reservoir is at HRWL. Give your answer in terms of base width "B".

b) Find the bottom width "B" and downstream inclined angle α, if dam is at state of moment equilibrium with respect to downstream dam toe. Use a factor of safety against overturning as 1.4.

c) Is the dam free from tensile stress? Find the required unit shear resistance (cohesion) if the shear safety factor of the dam is F_{SF}=2.5.

d) In a flood event the dam shown on figure overtopped but didn't fail. The outflow discharge over the dam crest was estimated to 320 m3/s. During this time, the reservoir water level was raised to 722.5 masl(m above sea level). Find the discharge coefficient and give your comments of the value.

b) Drawing a neat sketch of Hydropower Intake, show major components. How do you minimize headloss in intake? [3+1]

5. Draw a neat sketch of ROR plant Headworks showing each component clearly in plan and section. Describe briefly the general requirements of such headworks for optimum functions for sediment loaded rivers. [6+6]

6. a) Discuss various tunnelling methods used in Hydropower projects. Why do you provide tunnel supports? How are they realized? [4+2+2]

b) Explain with mathematical expression the optimization of penstock. [4]

7) A Francis turbine works under a head of 40 m and discharge Q = 10 m^3/s. The speed of the runner is 300 rpm. At the inlet tip of the runner vane, the speed ratio is K_u=0.85 and flow ratio K_f=0.3. If the overall efficiency and hydraulic efficiency of turbine are 80% and 90% respectively. Assume discharge at the outlet is radial and velocity of flow is constant. [2+2+1+2+1+4]

Determine:

a) power developed in KW.
b) Diameter and width of runner at inlet.
c) guide vane angle at inlet.
d) specific speed of turbine.
e) diameter of runner at outlet.

Dimension suitably the powerhouse (length, breadth and height) with sketch, if three such turbines were used in a power plant. Assume suitably any requirements for calculations.

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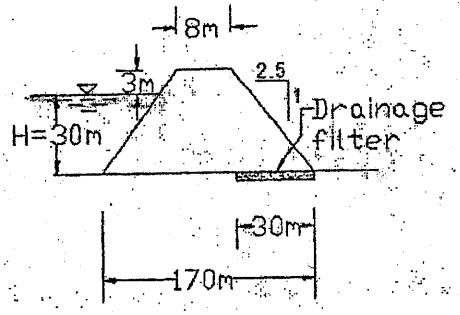
03 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2072 Kartik

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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. Discuss about the advantages and disadvantages of hydropower projects comparing to other sources of energies. [6]
2. What are the different stages of hydropower development? Explain the working principle of peaking run off river plant and show general arrangements of components with neat sketches. [2+3+3]
3. a) What do you mean by sediment yield and life of a reservoir? Explain various remedial measures that help to reduce the reservoir sedimentation. [1+3]
   b) A hydropower plant receives design discharge of 25 m^3/s from 150 m height. The annual output of the plant is 220 GWh. If he peak load demand is 30 MW, determine (i) annual load factor (ii) Capacity factor and (iii) Utilization factor. Assume overall efficiency of the plant equals to 85% and neglect head loss in the penstock. [2+2+2]
4. a) Following Figure shows the cross-section of an earthen dam having coefficient of permeability 1×10^{-6} m/s. Calculate the seepage discharge through the body of the dam with the help of phreatic line. [8]



   b) Write the purpose of use of filter material in earthen dam. Explain its design principle. [4]
   c) What are the factors to be considered in the dam site evaluation? Describe the different failure modes of a gravity dam? [4+4]
5. a) Find the dimensions of a settling basin for a high head project of Himalayan River which utilizes a discharge of 60 m^3/s and a gross head of 100m. The sediment size to be removed is up to 0.15 mm. Consider the turbulence effect also. Draw the plan and section. [5+2]
   b) What are the requirements of good intake? Explain different types of intake used in hydropower projects in Nepal with neat sketches. [2+3]

6. a) Describe advantages and disadvantages of different tunnel shapes based on geometry with neat sketches. [4]

   b) In a hydropower project, the headrace tunnel of 4.5 m diameter and 2,500 m length carries 25 m^3/s discharges to the surge tank of 10 m diameter. The penstock from surge tank to power house has 3.5 m diameter and 1000 m length. Considering the case of instantaneous closure, find the maximum height of surge tank required and time period of oscillation of wave. Assume friction factor = 0.02. [8]

7. a) Determine the size and setting height of the Francis turbine for a site having net head of 150 m, discharge is 160 m^3/s and efficiency of 85%. [4]

   b) Water is being supplied to a pelton wheel under a head of 300 m through a 100 mm diameter pipes. If the quantity of water supplied to the wheel is 1.50 m^3/s, find the number of jets in the wheel. Assume coefficient of velocity is 0.96. [4]

8. What are the different types of power houses used in hydropower? Explain their relative suitability considering the field conditions. [4]

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03 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Chaitra

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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. Discuss the advantages and disadvantages of hydropower over other sources of energy. [3+3]
2. Differentiate between pre-feasibility and feasibility studies of a hydropower project with explaining the site specific hydrological and topographical investigations. [8]
3. a) A hydropower project is planned to develop in a Nepalese River having net head of 150 m, turbine efficiency of 90% and generator efficiency of 95% with the monthly hydrograph as shown below: [3+2+3]

Months	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Q (m^3/sec)	100	80	60	50	40	30	40	50	70	110	150	120

As an environmental flow, a minimum flow of 10% of each month is mandatory.

If the storage project is designed with full regulation of annual hydrograph find out: the capacity of the reservoir; installed capacity of the power plant, and annual energy generation.

4. a) Design an elementary profile of a gravity dam made of stone masonry using following data: [8]
   R.L of base of dam = 198 m
   HFL = 228 m
   Sp. gravity of masonry = 2.4
   Safe compressive stress in masonry = 1200 KN/m^2
   $\tan \phi = 0.70$
   Seepage coefficient = 1

   b) Show with neat sketch, various seepage control measures in embankment dam. [6]

   c) Discuss with sketch the arrangement and suitability of 3 different types of spillways used in a headworks. [2×3]

5. a) Differentiate between pressurized and non-pressurized intakes in RoR system. [3]

   b) Design the settling basin from the particle size and concentration approach and calculate the trap efficiency from the following data. (Refer figure 3 &4) [8]

   Design discharge = 80 m^3/s
   Installed capacity of the plant = 110 MW
   Particle size to be removed = 0.2 mm
   Flushing discharge = 1 m^3/s
   Number of basin = 2
   Water temperature = 12°C
   Manning's constant (n) = 0.01
   (If flushing system is continuous)

   Assume other necessary data if needed. If the flushing system is changed to intermittent with single basin what are the changes, describe with suitable reason.

   c) What are minimum performance standards of the sound headworks. [3]

6. a) Design a forebay using following data sets: [4]
   $Q = 15\ m^3/s$
   Storage requirements = 4 minutes
   Length of penstock = 500 m
   Diameter of penstock = 2 m

   b) Discuss various tunneling methods used in Hydropower projects. What is the purpose of shotcreting? Discuss the procedure. [4+2+2]

7. Design a pelton wheel turbine for a hydropower plant having net head of 310 m and discharge of $5m^3/s$. Take the efficiency of the turbine as 90%. What will be the specific speed of such turbine? [7+1]

8. Describe with sketch different types of power house and their general arrangement. [4]

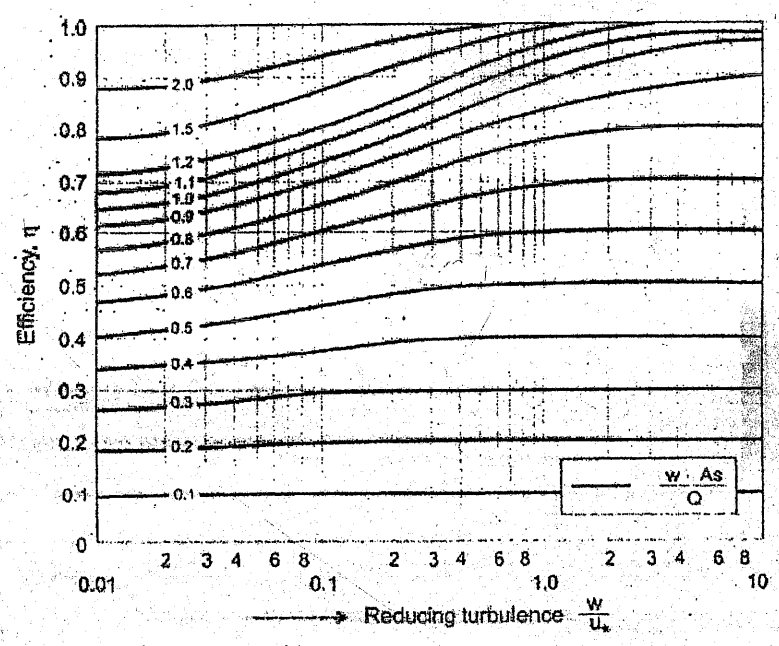

Figure 3: Camps Diagram

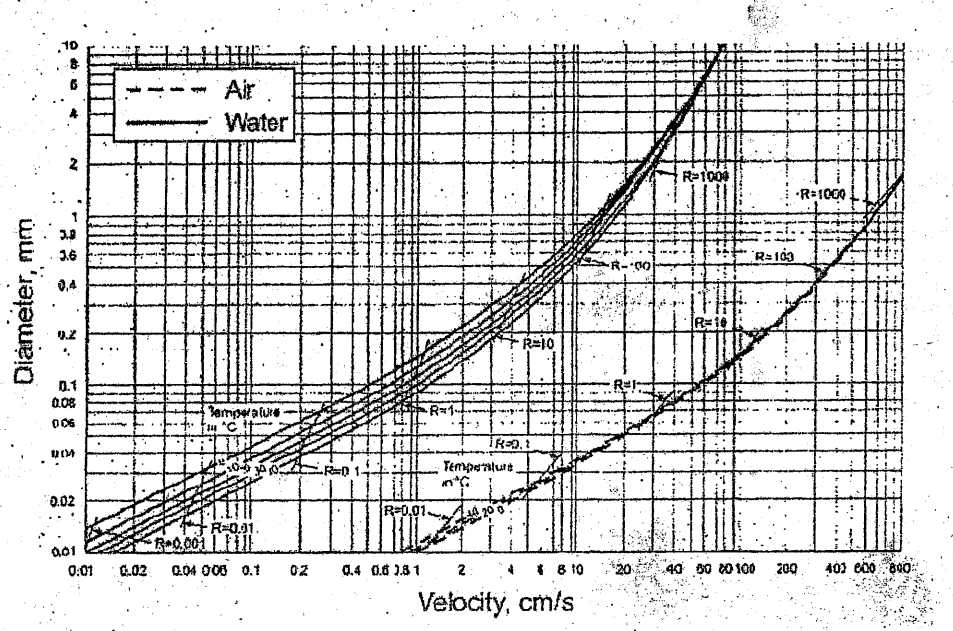

Figure 4: Fall velocity of quartz spheres in water and air after Rouse

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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2071 Shawan

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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**.*
- ✓ ***Necessary figures are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. a) Briefly discuss the historical development of Hydropower in Nepal. [3]
   b) Do you think daily peaking RoR projects are advantageous over RoR projects in Nepal? Justify your answer with daily load curve. [2]
   c) If you are developing 10 MW RoR hydropower project in Nepal, write different studies carried out during the feasibility level study. [5]
2. a) The average monthly flow of river in a typical dry year are as follows: [5+2+2]

month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Q m^3/s	65	53	51	115	187	270	580	974	1179	355	176	123

And other relevant data are follows i) prevailing interest rate =12% ii) Energy selling price for primary energy=Rs 5000/ Mwh and 3000/Mwh for secondary energy iii) installation (Electro-mech) cost = RS 80000/kW iv) project life time = 40 yrs v) overall efficiency of the plant = 87% vi) Effective head = 100m vii) O&M cost = 2% of electro mechanical cost viii) fixed cost = Rs $30*10^9$

a) Determine the installed capacity of such plant

b) Calculate the firm power of the plant, considering 95% probability of exceedance of flow

c) If the deficit in the firm power in the power system is 200 MW what is the storage capacity of reservoir to satisfy the demand.

b) In a minigrid the average load variation is recorded as: [3]

Time	10 PM to 6 AM	6 AM to 9 AM	9 AM to 6 PM	6 PM to 10 PM
Load (KW)	400	540	450	820

Power is supplied by the plant capacity of 950 KW Micro-hydro. Find out load factor, plant capacity factor and utilization factor.

3. a) Discuss the selection criteria of different types of dam in hydropower projects. What type of dam do you select in different foundation condition? [3+2]
   b) Design and draw section of a side intake with coarse trash racks for a project in which river bed level is 3315.0 m amsl. Weir crest level is fixed to 3317.5 m amsl. The highest flood level in 100 years return period is 3320.83 m amsl and flood level in 20 years return period is 3319.55 m amsl. The canal water level is fixed at 3317.5 m amsl. The design discharge is 1.45 m^3/se. Assume other suitable data. [6]

c) Determine the specific discharge of the flow through earthen embankment dam having 2.5 m thick centre impervious core. The upstream and downstream slopes of an earthen embankment dam are 1:1 and 2:1 respectively. The water depth at upstream is 25 m. The dam has a crest width of 4 m and free board of 2 m. The coefficient of permeability of dam body material and center impervious core are 2.5 cm/hr and 0.15 cm/hr respectively. Also draw the phreatic lines. [6+4]

d) Why drainage gallery is provided in concrete dam? Mention the suitable location of a gallery in dam section with its effect in uplift pressure. [1+2]

4. a) What do you mean by mass curve? Write step wise procedure of calculation of reservoir capacity using the mass curve. [1+3]

b) What are the design considerations of headworks in high sediment laden rivers of Nepal to minimize the entry of sediments from the intake? Explain the favorable conditions to construct the bottom rack (drop) intake. [3+2]

c) Classify settling basin based on flushing system. Also explain its operation mechanism during flushing. [1+2]

5. a) In a hydropower project the following data are given: [1.5×4]

Design discharge (Q) = 60 m^3/s
No.of penstock = 3
Dia. of penstock = 2.0 m
Length of tunnel = 6.5 km
Dia. of tunnel = 9.0 m
Velocity of wave in penstock = 1750 m/s
Frictional factor for tunnel = 0.016

If the simple cylindrical surge tank of 25 m dia has been provided at the end of the tunnel, find (i) Max. up surge in the tank (ii) Max down surge in the tank (iii) water hammer pressure and (iv) Time of oscillation.

b) A penstock of discharge capacity 5m^3/s is functioning for a hydropower with dynamic head of 50 m over the turbine. Determine its economic diameter. [2]

c) Discuss methods of tunneling practiced in hydropower project. [4]

6. a) A pelton wheel has to be designed for the following data; [6]

Power to be developed = 6 M

Net rated head =300m

Ratio of the jet diameter to the wheel diameter =0.1

Overall efficiency =90%

Assume coefficient of velocity (Cv) = 0.98 and ratio of peripheral velocity of wheel to jet velocity = 0.46

b) Draw a plan and section of powerhouse having two unit of vertical axis Francis turbine showing from penstock to tailrace outlet. [4]

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04 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Chaitra

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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**.*
- ✓ ***Necessary figures are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. a) "Most of the political parties of Nepal are determined to avoid Load Sheding during 5 years in their menufesto" Do you agree with their commitment during this period? What approach need to be taken for hydropower development in Nepal to meet the demand rate up to 2020. [2+3]

   b) Explain site specific hydrological, geological and topographical investigations to be carried out during the pre feasibility study level of a hydropower project. [5]

2. Hydropower project is planned to develop in a river having net head of 100 m and overall efficiency of 85% with the monthly hydropgraph as shown below.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Discharge	100	120	140	300	320	1800	2000	2500	2100	900	500	300

   i) Calculate installed capacity, annual spill energy and firm energy if RoR project is designed based on the 40% probability of exceedence flow. [2+2+2]

   ii) If the storage project is developed with full regulation of annual hydrograph (design discharge is equal to average monthly flow), Calculate the storage requirements. [2]

   iii) Calculate the installed capacity and annual energy generation from the storage project as mentioned in above case. [2+2]

3. a) Show that the resultant force in a concrete gravity dam should pass within the middle third of the base width in order to avoid tension in the heel. [6]

   b) Design a hydraulic jump stilling basin at the toe of the spillway with the following data; [9]

   Discharge = 80 m^3/s
   Width of the spillway = 8m
   Spillway crest level = 96.00m
   River bed level = 65.00m
   Tril water level = 71.00 m
   Coefficient of discharge = 0.7
   Downstream bed slope (i) = 1:500 and Manning's roughness coefficient = 0.016 and ratio of length of stilling basin and sequent depth = 5.1

   c) Explain very briefly three types of gates and its working mechanism with sketches widely practiced in hydropower projects in Nepal. [1+3]

   d) Determine the seepage discharge for the earthen dam having 33 m total height with 3m width impervious central core. Take top width of the dam is 7m and freeboard 3m. The coefficient of permeability of dam material is 4×10^{-6} m/sec and that of impervious core is 4×10^{-8} m/sec. The upstream and downstream slope of the dam is 3:1 and 2.5:1 respectively. [5]

4. a) Find out the dimension of a continuous flushing settling basin for a high head project in Himalayan River which utilizes a discharge of 60 m^3/s and head of 300 m the sediment particles larger than 0.15 mm have to be trapped efficiency 95% in the basin. Consider the effect of the turbulence and check the length of basin using Valikanov's relation of the density of the silty water of 1.105 ton/m^3. Draw plan and section of the basin showing major components. [6+3]

   b) Explain the general requirements of a functional ROR headworks. [3]

5. a) What do you mean by hydraulic design of tunnel? Explain the selection criteria of tunnel alignment. [2+2]

   b) What are the design considerations of Forebay? Design a Forebay with turbine discharge $12m^3/sec$, water is conveyed from Forebay to powerhouse by two number of penstock of 2 m diameter each. Take retention time 3 minute and limiting velocity 0.2 m/sec. [2+4]

   c) Why restricted origice type is more efficient than simple cylindrical type. [2]

6. a) Design specific speed, turbine diameter and setting of the Francis turbine in a hydropower project having net head of 150 m and design discharge of 25 m^3/sec. Take turbine efficiency 81%. [2+2+2]

   b) What are the conditions Francis turbines are preferable than Pelton turbine? [4]

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01 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2070 Ashad

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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. List out the major features of Hydropower Development policy 2001. Is the policy able to attract private sector? Write your comments. [6]

2. a) Drawing neat sketch (plan and section with all components), discuss the principal characteristics of diversion type storage hydropower plant. [4]

   b) Highlight the major studies and investigations carried out during reconnaissance, prefeasibility and feasibility studies. [4]

3. The mean monthly flow of a typical Nepalese river is as follows: [2+4+2]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q (m^3/s)	80	74	83	100	130	222	600	800	590	240	120	100

   i) Calculate the installed capacity of a plant based on minimum flow of the river without pondage (if the plant is designed for pure run of river plant) with net head of 200 m and overall efficiency of a plant is 85%.

   ii) The plant has three sets of units (turbine and generator) such that one unit with full capacity is operated during off peak hour. If the plant is designed for a peaking plant with 4 hour peaking (morning 2 hour and evening 2 hour), what will be the installed capacity of a plant?

   iii) What will be the increase in benefit from peaking if peak hour energy rate is Rs 12/kWh and off peak energy rate is Rs 6/kWh during minimum flow month?

4. a) A concrete gravity dam on the rocky foundation is acted by the upstream horizontal hydrostatic force of 4.50 million KN and by the downstream the same of 0.50 million KN. Determine the volume of concrete works (r_{con} = 24 KN/m^3), neglecting bond stress and up lift force and taking a factor of safety on the horizontal thrust of 2.5 and a friction coefficient between the concrete and rock of 0.65. [8]

   b) Write with necessary sketch and their hydraulics, any three types of spillways used in a head works of a hydropower plant. [6]

   c) Explain causes of failure of earthen dam. What criteria do you adopt for safe design of earthen dam? [2+4]

5. a) Discuss the requirements of a functional RoR headworks. Drawing a typical plan of such headworks, discuss how these requirements are fulfilled. [2+3]

   b) Find out the dimension of a settling basin with turbulent flow for a high-head hydropower plant, which utilizes a discharge of 40 m^3/s. The sediment particles coarser than 0.15 mm (ω = 1.5 cm/s) have to be trapped in the basin. Draw plan and sections (cross and longitudinal) showing major components and flushing arrangement. [3+3]

   c) If you have allocated about 10% volume for sediment storage and overall trapping efficiency of settling basin is 40%, find out the frequency of flushing of settling basin, when the sediment concentration is 2000 ppm. [3]

6. a) The design discharge through the tunnel of a hydropower project is 60 m^3/s is conveyed by three number of penstock to the turbine of 2 m diameter each. Take the length of tunnel is 7 km, diameter of tunnel is 10 m, friction factor of tunnel is 0.016, friction factor of penstock = 0.04 and velocity of wave in penstock = 1800 m/sec. If the surge tank of 30 m diameter has been provided at the end of the tunnel, find the following: (i) maximum up-surge and down-surge in the tank (ii) water hammers pressure (iii) Time of oscillation of wave. [4+2+2]

   b) Discuss with sketch, types of tunnel supports and their necessity? [3+1]

7. What do you mean by setting of turbine? The pipe line 1200 meter supplies water to 3 single jet pelton wheels. The need above the nozzle is 360 m. The velocity coefficient for the nozzle is 0.98 and the coefficient of the friction for the pipe line is 0.02. The turbine efficiency is 0.85. The specific speed of turbine is 15.3 rpm and loss head is 18 meter in pipeline due to friction. If the operating speed of each turbine is 560 rpm, determine (i) Total power developed (ii) Discharge (iii) Diameter of each jet and diameter of pipe line. [2+6]

8. Drawing a section of vertical axis Francis turbine in a powerhouse, show the different parts of powerhouse structure. [4]

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01 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Chaitra

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

Subject: - Hydropower Engineering *(CE704)*

- ✓ 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. What are the objectives of Hydropower Development Policy 2001? Explain five main features provisioned in Hydropower Development Policy 2001 for the development of hydropower in Nepal. [3+3]

2. a) Prepare a three alternative layouts plan and sectional drawings of the ROR Hydropower plants. [6]
   b) What are the stages of hydropower development cycle? [2]

3. The stream flow record for a hydropower development site is given below. Draw a flow duration curve and determine firm and secondary energy if the available head is 60 m design discharge capacity is 45m^3/s and overall efficiency is 82%. [8]

Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Q(m^3/s)	30	38	28	22	16	32	56	72	54	46	38	36

4. a) Draw uplift pressure diagram (i) for dam holding 50 m water depth at upstream vertical face with top and bottom width 10 m and 30 m respectively. Uplift may be considered to be acting an 60% of the area of section. Tail water depth is 5 m. (ii) for the same dam there is a drainage gallery at 6 m from face. [3+2]
   b) The u/s and d/s slope of a homogeneous earthen dam with 12m toe drain are 2:1 and 3:1 (H:V) respectively. The water depth at u/s of dam is 50m. The dam has a crest width of 20m and free board is of 5m. The coefficient of permeability of dam material is 2.5 cm/hr calculate (i) Specific discharge through the body of dam (ii) co-ordinate of phreatic line. [10]
   c) With appropriate drawings illustrate the general arrangement of intake for storage plants. [5]

5. a) How are the control of bed load and floating debris in ROR intake done? Explain with appropriate plan and sectional drawings of the system. [6]
   b) Compute the dimension of periodic type settling basin considering and without considering the turbulence effect for a hydropower plant through settling theory. [8]
   Take,
   Settling velocity = 6 cm/sec
   Discharge = 5m^3/sec
   Particle size to be removed = 0.2 mm
   Depth of basin = 2.4 m

6. a) A power station is fed by a 4000m long concrete lined tunnel of 5.0 m dia and 600 m long pressure shaft of 4.0 m dia operating under a gross head of 250 m. If the design discharge of the plant is 60 m^3/sec and the friction factors in tunnel and pressure shaft are 0.014 and 0.012 respectively,
      i) Compute the sectional area required for mass oscillation in a surge tank [3]
      ii) Maximum upsurge and downsurge levels [3]
      iii) If the headwater level is 1048 m, find out the invert level of the headrace tunnel at surge tank [3]
   b) Explain the importance of tunnel lining. [3]

7. Discuss the various types of reaction and impulse turbines used in a hydropower plant. Discuss their suitability and major performance characteristics. [8]

8. Discuss the arrangement in a typical surface powerhouse. How do you compute the basic dimensions of such building? [2+2]

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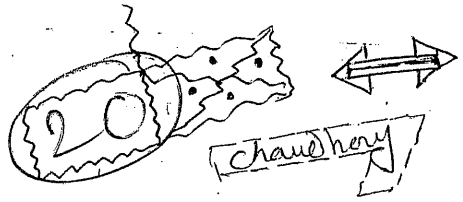

01 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Bhadra

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

Subject: - Hydropower Engineering *(EG764CE)*

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

1. a) Briefly discussing the major sources of electric power generation, highlight the major merits of hydropower over other sources in Nepalese context. [3+3]
   b) Drawing neat sketch (plan and section with all components), discuss the principal characteristics of a peaking run-of-river hydropower plant. [3+3]
   c) Highlight the major studies and investigations carried out during reconnaissance, prefeasibility and feasibility studies. [4]
2. The mean monthly flow of a typical Nepalese river is as follows

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q (m^3/s)	88	76	86	102	140	250	705	1000	610	260	130	100

   a) Draw mass curve showing the time of maximum spillage and deficit time of the year. If the firm flow is to be ensured, what is the capacity of the reservoir required? [4+2]
   b) Compute the installed capacity, firm and secondary energy and plant factor of the power plant based on the following data: [8]
      - Probability of exceedance of flow as 0.30
      - Minimum environmental release as 10%
      - Gross head of plant as 210m
      - Hydraulic, turbine, generator and transformer efficiency as 96%, 93%, 98% and 99% respectively.
      - The outage (forced shutdown) of the plants as 3%
   c) Draw power duration curve showing firm and secondary energy.
3. a) Give a suitable design for a 20m high dam for a site where both clay silt and sand gravel are available in abundance and where foundation is pervious to a depth of 10m, Assume suitable data, Give reasons favoring the suggested design. [2]
   b) A homogenous earthen dam is 21.5m high and has a free board of 1.5m. A flow net was constructed and the following results were noted: [10]

      Number of potential drops = 12
      Number of flow channels = 3

      The dam has a horizontal filter of 15m length at its drawdown end. Calculate the discharge per meter length of the dam if the coefficient of permeability of the dam material is 2.7×10^{-3} cm/s [6]

4. a) How do you determine the wall thickness and size of an embedded penstock? Why optimization of penstock is needed? Explain with mathematical expressions. [6+2]

b) Determine the size of a fore bay for a hydropower project having following data: [8]

Design discharge = 14 m^3/s
Diameter of penstock = 1.9m
Velocity in penstock = 5.4m/s
Limiting velocity = 0.2m/s - 0.8m/s
Retention time = 3 mins
Transitional slope = 1 in 5

5. a) A Francis turbine developing 10 MW under a head of 20m has a draft tube with inlet diameter 2.6 m and is placed 1.5m above tail water. If the vacuum gauge connected to the draft tube indicated reading of 5m of water, determine the efficiency of turbine if efficiency of draft tube is 75%. [8]

b) Describe the different methods of energy dissipation below the spillway structure, with sketches. [8]

6. a) Determine (i) minimum number of Francis turbines required for a hydroplant on a stream having 250 cumecs flow and 25m head. The generator is directly coupled to the turbine which has specified speed of 250, efficiency of 85%. The frequency of generation is 50 cycles/s and number of poles used is 20. (ii) What will be the minimum number of Kaplan turbines with a specific speed of 700? [6+2]

b) Design a hydraulic jump stilling basin for a maximum discharge of 40 m^3/s flowing from an overflow spillway, with the spillway crest 40m above the downstream gravel river bed with a slope 0.00515 and n = 0.025 [8]

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01 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2069 Poush

Exam.	Old Back (2065 & Earlier Batch)		
Level	BE	Full Marks	80
Programme	BCE	Pass Marks	32
Year / Part	IV / II	Time	3 hrs.

Subject: - Hydropower Engineering *(EG764CE)*

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

1. a) Justify with facts and figures the statement regarding hydropower development in Nepal "Highest potential and lowest consumption". Why storage (Reservoir) types of hydropower projects are preferred than Run of River projects in Nepal? [4+2]

b) The average monthly flow of river in a typical dry year are as follows: [10]

Month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Qm^3/s	65	53	51	115	187	270	580	974	1179	355	176	123

And other relevent data are follows: (i) Prevailing interest rate = 12% (ii) Energy selling price = $30/Mwh (iii) Installation (Electro-mech) cost = $600/Kw (iv) Project life time = 40 yrs (v) Overall efficiency of the plant = 87% (vi) Effective head = 100m

i) Determine the installed capacity of such plant
ii) Calculate the firm power of the plant, considering 95% probability of exceedance of flow
iii) If the deficit in the firm power in the power system is 200Mw what is the storage capacity of reservoir to satisfy the demand.

2. a) What are planning parameters and data required for a hydropower project? Discuss the hydropower development cycle with flow chart. [2+6]

b) Explain with neat sketch all types of the Run-of-river hydro plant? What do you understand by peaking hydro plant? [5+3]

3. Drawing a neat sketch of a gravity dam

a) Show major regulation levels and write their significance. [4]
b) Show forces acting on dam and categorize them [3+3]
c) Calculate the seepage discharge passing through an embankment dam with a typical cross section consisting of the following data: [6]
Top width of the dam = 8m
Upstream/downstream slope = 1:3(V:H)
Downstream water depth = 0 m
Base width of the dam = 700m
Coefficient of permeability of dam body = 1×10^{-6}m/s

4. a) Drawing a neat sketch (Plan and sections) of a bottom intake, discuss the suitability and advantages of such intake. [3+3]

   b) Find out the dimension of a setting basin with turbulent flow for a high-head hydropower plant, which utilizes a discharge of $30m^3/s$. The sediment particles coarser than 0.15mm (ω = 1.5cm/s) have to be trapped in the basin. Draw plan and sections (cross and longitudinal) showing major components and flushing arrangement. [5+3]

5. a) Find out the dimension of a forebay, which accommodates a storage for 3 min of operation for a hydropower plant having the following data: [4+4]

   Design discharge = $30m^3/s$
   Length of penstock = 250m
   Diameter of penstock = 3.0m
   Draw plan and section of such a fore bay showing main components and dimensions you composed.

   b) Drawing appropriate sketches, describe with their suitability four types of spillway gates. [8]

6. a) Write with necessary sketch, two types of energy dissipaters in a head works of a hydropower plant. [6]

   b) Discuss the various types of reaction and impulse turbines used in a hydropower plant. Discuss their suitability and major performance characteristics. [6]

   c) With definition sketch, explain mathematically the main function of a draft tube. [4]

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CIVIL IV/II

01 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2068 Bhadra

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

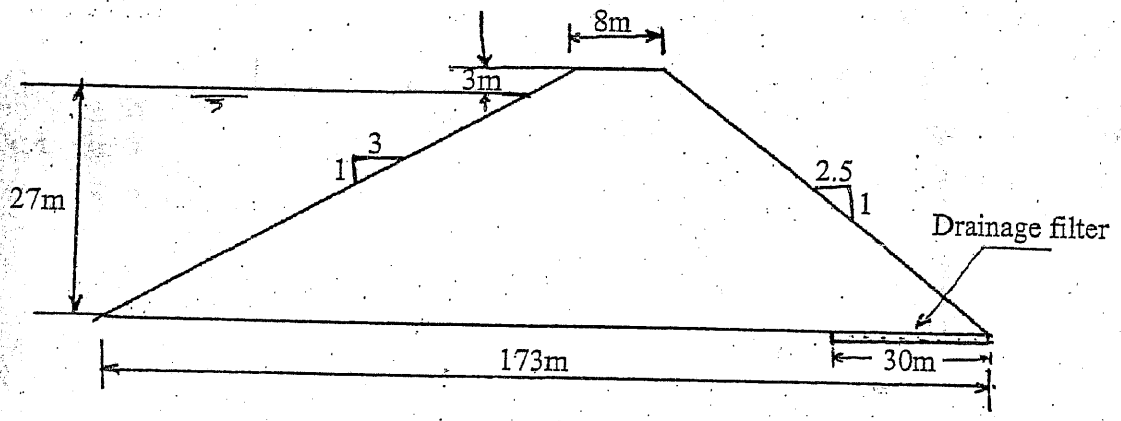
Subject: - Hydropower Engineering

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

1. a) Make a neat sketch of a hydropower plant and show clearly the various elements. [7]

   b) Discuss different types of energy dissipating methods used below the spillways. Where would you prefer shaft spillway over other types of spillways? [5+4]

2. a) Figure below shows the cross-section of an earth dam. Construct the base parabola (phreatic line) and calculate the seepage through the body of the dam. Take $K = 1\times10^{-6}$ m/s. [9]



   b) What is grouting? What are different types of grouting used in a gravity dam? [2+5]

3. a) In a hydropower project, penstock of diameter 2.5m carries a flow of 5.5 m^3/s to the turbine located in the power house. A simple surge tank of diameter 5m is located at a distance of 1500m from the power house. The total length of the penstock is 3.5 Km. Considering the friction factor (f) = 0.02 and the instantaneous total closure, find (i) maximum height of surge tank required and (ii) time period of the oscillation wave. [7]

   b) Hydropower plant developed in the river has net head of 110m with overall efficiency of 85% and 10% of water is required to be left for environment and downstream user in the river. If the plant is used as a peak load plant operating only for 6 hours a day, determine the firm capacity of the plant. [4+5]

Mean monthly flow for a Nepalese river is given below

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

i) Without pondage
ii) With pondage but allowing 10% of water to be lost in evaporation.

4. a) Compute the dimension of periodic type settling basin for a hydropower plant using the simple settling theory with the data given below, [4+3]

Design discharge = 5 m3/s
Particle diameter to be removed = 0.2mm
Depth of basin = 3.5m
Take settling velocity of the particle = 2.5 cm/sec.

If the turbulence is considered, what will be the dimension of basin?

b) How would you reduce the rate of sedimentation of reservoir? What is trap efficiency? How would you estimate the useful life of a reservoir? [4+5]

5. a) A Pelton turbine develops 3000 KW under a head of 300m. The overall efficiency of the turbine is 83%. If the speed ratio (speed of bucket / speed of jet) = 0.46, $C_V = 0.98$ and specific speed is 16.5, then find: [5+4]

i) Diameter of turbine
ii) Diameter of jet

b) Name 7 large hydropower plants of Nepal with their installed capacities. [7]

6. a) Explain the underlying principles in design of tunnel lining. [4]

b) Explain the general arrangements for a power house. How would you fix the approximate dimension of a power house? [4+3]

c) What do you understand by power system grids? Enumerate the advantages of such system. [2+3]

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01 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2067 Mangsir

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

Subject: - Hydropower Engineering

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

1. a) What is a daily peaking power plant? With neat sketch (plan and section) show the general arrangement of such a plant. [1+5]

   b) Long term average monthly flow of a large tropical river is given below: [5+5]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Discharge (m^3/sec)	280	250	210	84	84	210	868	1064	2380	2492	2156	659

   A hydropower plant is proposed on the river to meet the peak demand of 18 MW in the month of May of an isolated town, where average annual load is 7 MW. Topography permits a natural net head of 28m and plant efficiency is 0.78.

   i) If installed capacity is to be fixed to meet the peak demand, determine the percentage utilization of run off.
   ii) If peak load increases to 37 MW and average load to 23 MW in the month of May; the installed capacity is increased accordingly; and the power plant is to be operated for only five days, calculate the pondage requirement to regulate the flow over that period.

2. a) Starting from the first principle, describe with the help of equations the procedures to obtain the specific discharge through the body of an earthen dam with core. [10]

   b) Show that the resultant force in a concrete dam should pass within the middle third of the base width in order to avoid tension in the heel. [6]

3. a) What do you understand by economical diameter of penstock, and why is it necessary to work out one? [3+5]

   b) Determine required reservoir capacity from the data given below: [8]

Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Mean monthly flow (m^3/s)	30	33	35	30	29	20	15	13	10	8	7	15
Rainfall (cm)	28	30	34	8	0	0	0	0	4	6	10	16
E_o (cm)	10	7	6	9	5	4	4	5	10	10	12	13
Demand (ha-m)	1500	2000	2700	4000	4800	4800	4600	4500	4500	2700	2500	1500

   Assume that surface area of reservoir is 6,000 ha throughout.

4. a) How is specific speed of a turbine different from its speed and how does it help us select a particular type of turbine? [4]

   b) In a hydropower station, the available discharge is 300 m^3/s under the net head of 5m. If the speed of the turbine is to be maintained at 50 rpm and overall efficiency is 82%, determine the number of Kaplan turbines, provided their specific speed should not exceed 500 rpm. Also calculate the power produced by each turbine. [6]

   c) Write short notes on: [3+3]

   i) Power house planning ii) Governing of a turbine

5. a) Draw neat sketches of three types of spillways and three types of spillway crest gates. Also discuss their suitability and advantages. [6+4]

   b) Describe in detail what level of topographic and geological information is required during reconnaissance, prefeasibility and detail feasibility studies for a hydropower project. [6]

6. a) Draw a typical cross-section of a surface power house with Francis turbine. Also label the components you will be showing in the sketch. [5]

   b) Discuss with sketch the arrangement and suitability of four different types of intake used in hydropower plants. [2×4]

   c) Explain why a restricted orifice surge tank is more efficient than its simple cylindrical counterpart. [3]

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01 TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2066 Magh

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

Subject: Hydropower Engineering

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

1. a) Where do you provide pumped-storage plants? Explain the working and general arrangements of pumped storage plant with neat sketches. [2+6]

   b) What are the different investigations and their levels during reconnaissance, prefeasibility and feasibility studies? [8]

2. The monthly flow of a river supplying water to a power plant is as follows:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q(m^3/s)	11.0	7.8	6.9	7.4	12.3	47.8	140	177.0	94.1	34.7	19.4	13.8

   a) Draw a mass curve, showing spillage and deficit region. Find out the spilling discharge and compute the storage required to assure a regulated flow from the mass curve? [4+2]

   b) Compute installed capacity, firm and secondary energy from the power plant assuming the following data: [6]

   - Probability of exceedance of flow as 0.25
   - 10% of the minimum monthly flow as environmental flow to be released downstream
   - Gross head of the power plant = 230m
   - Hydraulic, turbine, generator and transformer efficiency as 96%, 93%, 98% and 99% respectively.

   c) If it is intended to develop the power of 1.5 times installed capacity by providing a storage, determine the minimum capacity of reservoir. [4]

3. a) The cross-section of an earthen embankment dam consists of following data: [4+6]

   Top width of dam = 8m
   Upstream slope = 1:3 (V:H)
   Upstream water depth = 27m
   Height of the dam = 30m
   D/S water depth = 10m
   D/S slope = 1:2.5 (V:H)
   Base width of dam = 173m
   Coefficient of permeability of body of dam = 1×10^{-6} m/s

   Consider impervious foundation.

   Based on above data:

   i) Derive the equation for the seepage discharge from this dam.
   ii) Calculate the seepage discharge and plot the phreatic line for this dam.

b) Drawing a clear sketch, show/discuss primary, secondary and exceptional loads in a concrete gravity dam. [6]

4. a) Drawing definition sketch (plan and section), write methods of computing the size of the settling basin by particle approach and concentration approaches. [6]

b) Find out the dimension of a forebay, which accommodates a storage for 3 minutes of operation for a hydropower plant having following data: [3+3]

Design discharge = 20 m^3/sec
Length of penstock = 300m
Diameter of penstock = 2.2m

Draw plan and section of such a forebay showing main components.

c) Show that the resultant force in a dam should pass within middle third of the base width in order to avoid tension in the heel. [4]

5. a) The following data refers to a proposed hydro-electric power plant: [4+6]

Installed capacity = 60 MW
Net head = 200m
No. of units = 3
Normal operating speed (synchronous to generator) = 750 rpm
Draft tube efficiency = 90%
Maximum K.E. of water at exit of draft tube = 10% of K.E. of water from runner

i) Determine type of turbines to be selected, specific speed and size of the turbines.

ii) Starting from first principle, determine location of centreline of turbine with respect to tail water level. Check with thoma criteria, if critical cavitation coefficient is calculated from $\sigma = 0.0432\left(\frac{N_S}{100}\right)^2$, where N_S = specific speed, Barometric pressure head = 10m of water, vapour pressure ≤ 3m of water.

b) Check whether further excavation for a stilling basin is required below a dam discharging 200 m^3/s flow through a spillway crest located 50m above the downstream river bed having a width as 50m, bed slope as 0.001 and Manning's rugosity coefficient as 0.025. [6]

6. a) Describe with neat sketches, the various types of intakes and gates used for hydropower development. [8]

b) With neat sketch, describe the purpose and working principle of governor. [8]

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