TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Baishakh

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) A hydropower plant is planned to be designed in Nepalese river, where mean monthly flows for a typical year are as follows.

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
m³/s	4.4	3.9	3.4	4.2	4.2	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 m³/s
Full supply level = 2250 masl
Turbine centerline = 1650 masl
Dia of 4 km long tunnel = 3 m, f = 0.014
Dia of 1 km long penstock = 2.2 m, f = 0.012
Hydraulic efficiency = 95%, Turbine efficiency = 93%, Generator efficiency = 99%, Transformer efficiency = 99%

Considering only the frictional loss,
(i) Compute installed capacity, primary and secondary energy to be produced from the power plant assuming that 10% of minimum monthly flow to be released downstream. What is the plant factor? [2+2+2+2]
(ii) 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? [4]

   b) Discuss about the objective and the strategies of the hydropower development policy-2001. List out the various hydropower development institutions in Nepal. [3+1]

2. a) A homogeneous earthen dam has the following data: Dam crest level = 300.00 masl; Deepest river bed level = 278.00 masl; HFL in the reservoir = 297.50 masl; Dam crest width = 4.50 m; Dam u/s slope = 3:1; Dam d/s slope = 2:1 and coefficient of permeability of the dam material = 5×10^{-4} cm/s. Determine the phreatic line of the dam section and the discharge passing through the dam. [4+4]

   b) What measures are applied for treatment of foundation before construction of a gravity dam? Discuss briefly. [4]

   c) Find the minimum safe width for an elementary profile of a gravity dam of 18 m height. The specific gravity of the dam material is 2.25. Consider both no and full uplift condition. [4]

3. a) Design a fore bay structure with turbine discharge of 14.5 m³/s with two penstocks 1.8 m diameter each. Take retention time 3 minutes and limiting velocity 0.22 m/s. Draw neat sketch of plan and section. [6]

b) Determine the discharge through a chute spillway of 250.00 m long ogee crest, if the height of the spillway crest above the u/s approach channel s 10.50 m, the width of the approach channel is 2500 m, and the head over the crest is 4.50 m. Take $C_d = 0.85$. [4]

c) What are the most commonly used intakes in Run-of-River projects in Nepal? What factors do you consider while selecting the site for intake location? [3+3]

4. a) If you have to develop a small hydropower project of capacity 10 MW in a cost effective manner in a remote area of Nepal. What are the stages of study that have to be undertaken before the construction start? [8]

b) A Pelton wheel develops 70 kW under a head of 100 m of water, it rotates at 400 rev/min. The diameter of penstock is 200 mm. The ratio of bucket speed to jet velocity is 0.46 and overall efficiency of the installation is 85%. Calculate

    (i) Volumetric flow rate
    (ii) Wheel diameter [2+2]

c) Specify with neat sketch the location of a spiral casing and draft tube used in hydroelectric power generation. Mention their importance. [2+2]

5. a) Find out the dimension of a settling basin with turbulence flow for a high head hydropower plant, which utilizes a discharge of 25 m³/sec. The sediment particles coarser than 0.2 mm (w = 1.5 cm/sec) have to be trapped in the basin. Draw plan and section showing major component and flushing arrangement. [6+2]

b) The design discharge through the tunnel of a hydropower project is 25 m³/sec is conveyed by two number of penstock to the turbine. The length and diameter of tunnel is 4 km and 8m respectively, friction factor of tunnel is 0.016 and length of each penstock is 500 m, diameter and friction factor of penstock is 2m and 0.04 respectively and velocity of wave in penstock = 1600 m/sec. If the surge tank of 15 m diameter has been provided at the end of the tunnel, find the following for full load rejection. [8]

    (i) Maximum up-surge
    (ii) Maximum down-surge
    (iii) Water hammer pressure
    (iv) Time of oscillation of wave

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2078 Bhadra

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 _All_ questions.
✓ The figures in the margin indicate _Full Marks_.
✓ Assume suitable data if necessary.

1. a) Answer the followings:

    (i) What are the top three hydropower producing country in the world till 2020?
    (ii) What are the three existing largest power plant in Nepal (with capacity)?
    (iii) What are the first three hydropower plant (capacity and year) from the history of Nepal? [4]

   b) A peaking ROR project in western Nepal with net head of 250m has following river flow data: [12]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
River flow (m^3/s)	100	80	80	105	200	500	1100	1200	800	350	200	120

   The storage capacity avaliable for this project is 1100 million m^3. This storage capacity is utilized for dry months (Nov-May) during which the plant is used as peak load plant operating 4 hours a day. Considering design flow as Q_{25}, calculate maximum power generation (in MW) and ratio of wet season energy to dry season energy.

2. a) The discharge of water over a spillway 12m wide is 300m^3/s into stilling basin of the same width. The lake level behind the spillway has an elevation of 50m and river water surface elevation downstream of stilling basin is 25m. Assume a 10% energy loss in flow down the spillway, find invert level elevation of the flow of the stilling basin so that hydraulic jump forms in the basin. Select an appropriate USBR stilling basin and list all the dimensions. [10]

   b) What is economic diameter of penstock? A steel penstock with an internal diameter of 1.25m, supplies water at a head equivalent to 18kg/cm^2. There is a possibility of a 20% increase in pressure due to transient conditions. The design stress and efficiency of the joint may be assumed to be 1025kg/cm^2 and 85% respectively. Compute the thickness of the penstock required. [2+4]

3. a) Design and draw section of a side intake for a project in which river bed level is 3315.0 masl. Weir crest level is fixed to 3317.5 masl. The highest flood level in 100 years returned period is 3319.55 masl. The canal water level is fixed as 3317.3 masl. The turbine discharge of a period is 1.45m^3/s. Assume other suitable data. Take cylindrical trashrack bar with 10mm thick and 100mm spacing. [6]

   b) Determine the basewidth of a 20m high trapezoidal concrete dam having a vertical upstream face and top width of 5m. Design water depth is 18m. There is no tail water Ignore earthquake, silt and ice loads. Take $e=B/6$, $\sigma_{concrete}=30MPa$, $\sigma_{foundation} = 80MPa$, $\tau_s = 6MPa$. Specific weights of water and concrete are 10kN/m^3 and 24kN/m^3 respectively. Assume suitable data, if necessary. [6]

c) For embankment dam on pervious foundation, soil seepage underneath the dam poses a serious problem. Briefly discuss the consequences of this problem and how it is reduced? [4]

4. a) Draw a layout (plan and section) of ROR hydro project for following cases: [6]
    (i) Alignment with pressure tunnel
    (ii) with free surface flow

    Name salient features also (draw with representative contours).

    b) Design a settling basin (i) with intermittant flushing (ii) continuous flushing for a hydroelectric plant by using the simple settling theory. The design discharge of the plant is $5m^3/s$ and depth of the basin is 3.20. Take $w=2.5cm/s$ and $\lambda=1.5$. Compare and justify the result. Assume 15% flushing discharge and efficiency $=90\%$. [10]

5. a) Consider the design of a multi-jet pelton wheel with parameters and operating conditions as given below: [8]
    Head $=200m$
    Flow rate $=4m^3/s$
    Nozzle velocity coefficient $=0.98$
    Wheel dia. $=1.47m$
    Mechanical efficiency $=86\%$
    Blade speed to jet speed ratio $=0.47$
    Jet dia. to wheel dia. ratio $=0.113$

    (i) Calculate the wheel rotational speed (rev/min).
    (ii) Calculate the power output (MW).
    (iii) Determine no. of nozzle required.
    (iv) Calculate specific speed of machine.

    b) Explain the general arrangement for a power house. How would you fix the appropriate dimensions of a power house? [2+2]

    c) Discuss different types of intakes used in storage hydel plants. [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 **All** questions.
✓ The figures in the margin indicate **Full Marks**.
✓ Assume suitable data if necessary.

1. a) During a low water week a river has an average daily flow of 40 m³/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]
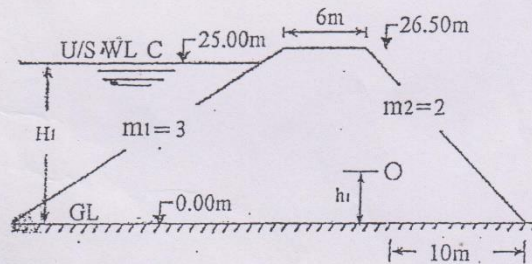
   b) Explain the necessity of grouting and drainage galleries in concrete gravity dam.
   Draw an elevation view of a concrete gravity dam showing the alignment of drainage galleries and series of grout holes.
   Drawing a section of concrete gravity dam show arrangement of vertical formed drain, trap drain and drainage hole.   [2+4+4]

3. a) Design a settling basin for a high head project in a river which utilizes 60 m³/s discharge and gross head of 300 m. The sediment particles larger than 0.15 mm (fall

3

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 m³/s of water at head of 25m. The cost of pipe line in place is given by US$250hd² 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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4

| Exam.		Regular / 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 *All* questions.
✓ The figures in the margin indicate *Full Marks*.
✓ Assume suitable data if necessary.

1. a) A run-of-river hydroelectric power station is proposed across a river at a site where a net head of 30m is available on the turbine. The river carries a sustained minimum flow of 25 m^3/s in dry weather and behind the power station sufficient pondage is provided to supply daily peak load of demand with a load factor of 65%. Assuming the plant efficiency of 60%, determine the maximum generating capacity of the generator to be installed at the power house. If the daily load pattern indicates 20 hours average load and 4 hrs of peak load, determine the volume of pondage to be provided to supply the daily demand. [4+4]

   b) You are developing 300 MW reservoir type project in a river basin of Nepal. Briefly mention what steps you would follow from planning to commissioning of the project. [5]

   c) What do you mean by pumped storage power plant? How it can benefit the Nepal's power sector? [3]

2. a) Derive the equations for principal stress and shear stress at toe and heel of a gravity dam with tail water present and also considering hydrodynamic pressure produced by an earthquake. [8]

   b) Drawing section of concrete gravity dam show arrangements of vertical formed drain, trap drain and drainage hole. What are the general criteria for size, depth and pattern of grout holes for certain grouting in gravity dam foundation. [2+2]

   c) Find the seepage discharge through the homogenous earthen embankment dam with 3m width of central impervious core as shown in figure. Given:

   (i) Height of the dam = 45m with free board as 3m,
   (ii) Upstream water level = 42m, top width of the dam = 8m,
   (iii) U/S and D/S side slope of the dam = 1V:3H
   (iv) Coefficient or permeability of the dam material = 4×10^{-6} m/s and that of impervious core = 5×10^{-8} m/s. [4]

Fig: Earthen Dam with impervious Core
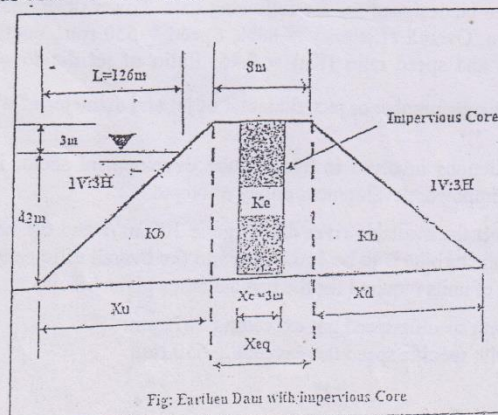
3. a) Find the dimensions of the settling basin for a high head project of Himalayan river which carry a discharge of 30 m^3/s and a gross head of 100m. The sediment size to be removed is up to 0.20mm and fall velocity $\omega = 2$ cm/sec.
If the turbulence is considered, what will be the dimension of the basin? Check the length of settling basin using Velikanov's method given correction factor $\lambda = 1.5$. [8]

b) What do you mean by intake? Write down its functions. [1+2]

c) Determine the necessary length of a rack of a bottom intake with the intercepted flow of 8 m^3/s and width of the rack is 10m. Inclination of the rack is 30°. Thickness, spacing and contraction factor of the bars are 10 mm, 15 mm and 0.82; respectively. [5]

4. a) What are the functions of a Surge tank? Write down the formulas to calculate the maximum upsurge and down surge, time of oscillation and minimum area of Surge tank with usual notations. [6]

b) Estimate the minimum length of the concrete apron (So = 0.001) for stilling basin downstream from an overflow spillway. The spillway crest is 15m long and consider a discharge of 115 m3/s. Manning's roughness factor n = 0.025. Assume the stilling basin is the same width as the spillway crest. Assume any other suitable data if necessary. Refer figure below. [10]
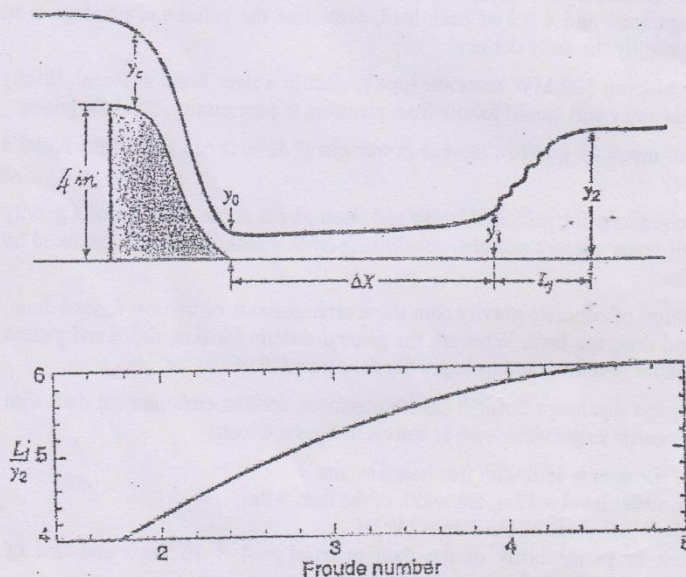
5. a) A Pelton turbine has to be designed for the following data. Power developed = 6867 KW, net head = 350m, Overall efficiency = 80%, Speed = 550 rpm, coefficient of velocity (Kv) = 0.98 and speed ratio (Ku) = 0.46. Ratio of jet dia to wheel dia $\left(\dfrac{d}{D}\right)$=1:12. Find discharge, number of jets, diameter of jet and diameter of wheel. [6]

b) Name the major institutions involved in hydropower development sector in Nepal. Briefly outline the hydropower development policy of Nepal. [4]

c) In a hydropower project the available river discharge is 300 m^3/s and the net head is 30 m. If the speed of the turbine is to be 166.7 rpm and the overall efficiency is 88%, determine the number of units required for the turbine cases given below. [3+3]

(i) Francis turbines with specific speed not exceeding 267 rpm.
(ii) Kaplan turbines with specific speed not exceeding 650 rpm.

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2

| 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. 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 m³/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 (10⁶m³)	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/m² and 35° respectively. $\gamma_{con} = 24\,KN/m^3$, check the stability of dam against flotation, overturning and sliding.   [8]
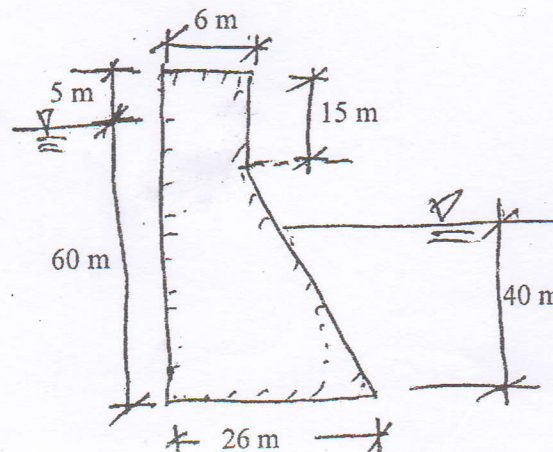
5. a) Design a settling basin for a high head project in a river which utilizes 60 m³/s discharge and gross head of 300 m. The sediment particle larger than 0.15 mm (fall velocity = 1.5 cm/s) need to be trap in the basin. Consider effect of turbulence as well.   [7]

   b) Design a hydraulic jump stilling basin for the flood discharge **28 m³/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 m³/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 m³/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
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.
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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, $W_{total} = 3.0 \times 10^4 kN$. 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/m². [10]
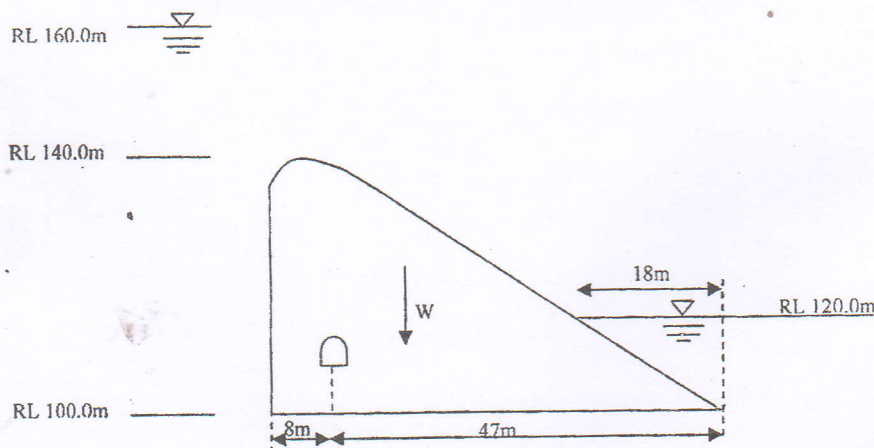
b) Design a hydraulic jump stilling basin for the maximum discharge of $25m^3s^{-1}m^{-1}$ flowing from an overall spillway, with the spillway crest 50m above the downstream gravel river bed with a slope $S_0 = 0.001$ and n = 0.028. [6]

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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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.
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✓ 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/m³, Assume unit weight of the concrete as 24 kN/m³, allowable compressive stress in foundation and concrete as 2,500 kN/m² and 3,000 kN m², angle of friction between concrete and foundation as 36° and unit shear resistance between foundation and dam as 700 kN/m².   [4+4+2]
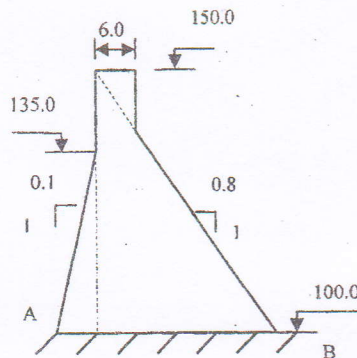
b) Write with neat sketch, expressions for computing seepage and phreatic surface in Earthen dams for two cases; homogeneous and without drain and dam with toe drain.   [2+3]

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 m³/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 m³/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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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(m³/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 m³/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 m³. 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/m³ and the friction angle between the dam and foundation ϕ = 43°. [3+5+3+5]
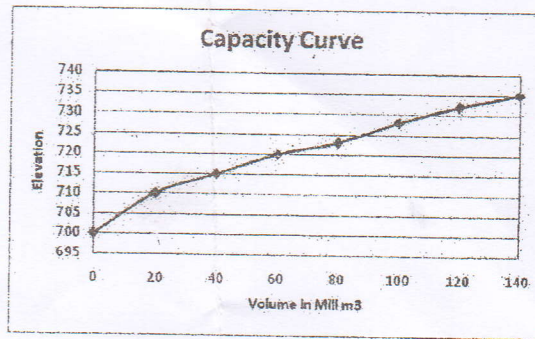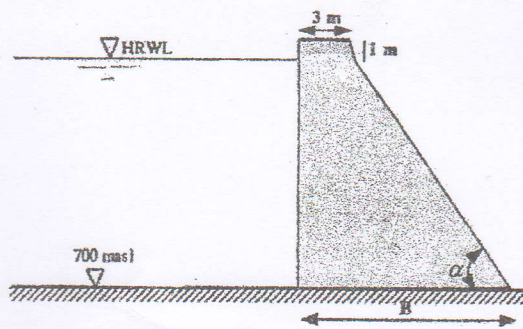
a) Find all main forces acting on the dam when the water level in the reservoir is at HRWL. Give your answer in terms of base width "B".

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 m³/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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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]
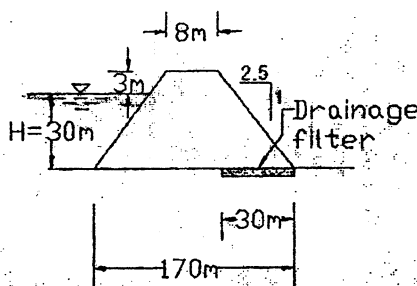
   b) Write the purpose of use of filter material in earthen dam. Explain its design principle. [4]

   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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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 (m³/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/m²
   tan ϕ = 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 m³/s   Number of basin = 2
   Installed capacity of the plant = 110 MW   Water temperature = 12°C
   Particle size to be removed = 0.2 mm   Manning's constant (n) = 0.01
   Flushing discharge = 1 m³/s   (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 m³/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 5m³/s. Take the efficiency of the turbine as 90%. What will be the specific
   speed of such turbine? [7+1]

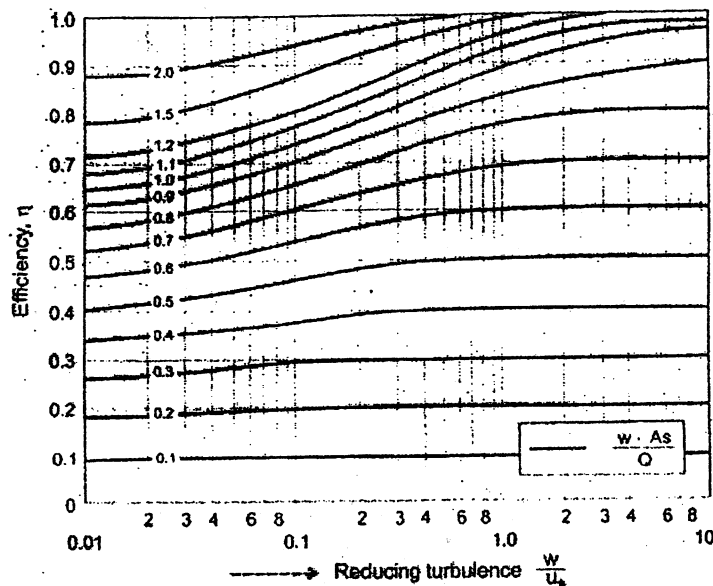8. Describe with sketch different types of power house and their general arrangement. [4]
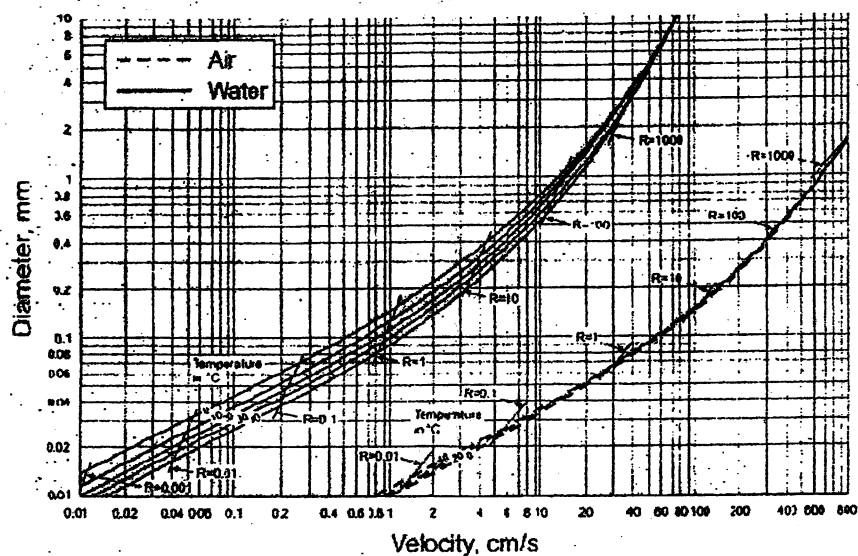

Figure 3: Camps Diagram

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

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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 m³/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 m³/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/m³. 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 12m³/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 m³/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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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 (m³/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/m³), 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 m³/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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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 45m³/s and overall efficiency is 82%. [8]

Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Q(m³/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. Take, [8]
   Settling velocity = 6 cm/sec
   Discharge = 5m³/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 m³/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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