KATHMANDU UNIVERSITY
End Semester Examination [C]
July, 2017

Marks Scored:

Level : B. E.
Year : IV

Course : CIEG 406
Semester: I

Exam Roll No. :

Time: 30 mins.

F. M. : 10

Registration No.:

Date JUL 13 2017

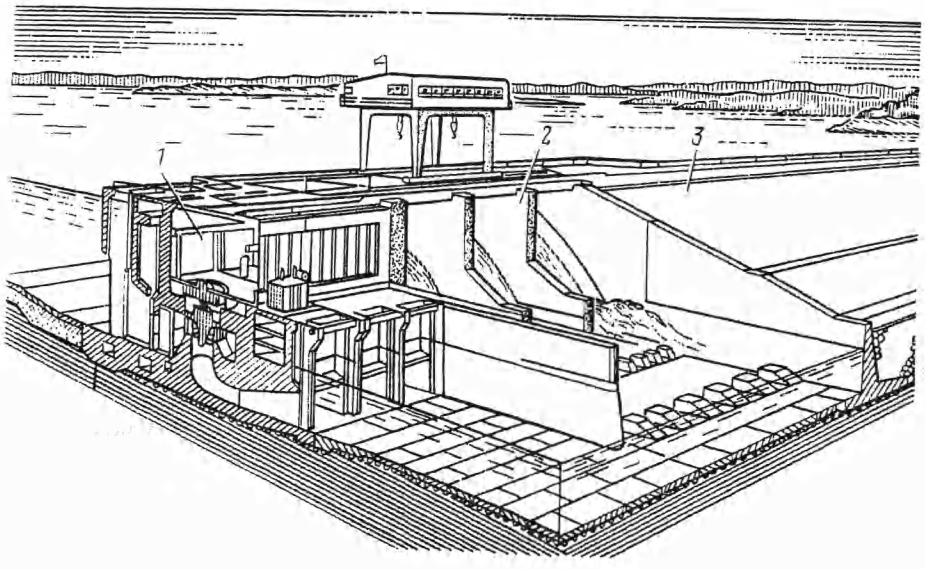
SECTION "A"
[20Q. × 0.5=10 marks]

Tick only the best answer.

1. The flow-mass curve is graphical representation of
   [ ] Cumulative discharge and time
   [ ] Discharge and percentage probability of flow being equaled or exceeded
   [ ] Cumulative discharge, volume and time in chronological order
   [ ] Discharge and time in chronological order

2. In the development of hydropower it is expedient to have water supply and irrigation in the first priority. Which Act addresses this issue?
   [ ]Water Resources Act 1992
   [ ]Foreign investment and technology transfer Act
   [ ]Electricity Act
   [ ]Environmental Protection Act

3. What type of power plant is this (name in blank box)? Name all the components of it in the blanks.
   [ ] [1] [2] [3]



4. If we need to achieve the well-being of a society from a development works then
   [ ]Only tangible aspects must be considered
   [ ]Tangible and intangible aspects must be given due consideration
   [ ]Only intangible aspects must be considered
   [ ]Only dollar evaluation may be adequate

5. Looking at the sequence of longitudinal profile of a river, the river may be zoned as upper course, middle course, lower course and estuary. Show qualitatively, where will be the equilibrium state of sediment transport occur?
[ ]In between middle course and lower course
[ ]In between lower course and estuary
[ ]In between upper course and middle course
[ ]In middle course

6. What is the meaning of PADRE:
[ ]Plan, Approve, Do, Review and Evaluate
[ ]Plan, Appraise, Discard, Revise and Evaluate
[ ] Prepare, Approve, Do, Revise and Eliminate
[ ]Plan, Activities, Do, Review and Estimate

7. Which of the following are not the elements necessary to be implemented during Reactivation, Upgrading and Modernization of a hydropower plant?
[ ] Chang old parts of the plant
[ ] Increase discharge or head or both
[ ] Betterment of landscape
[ ] Use of existing energy reserve
[ ] Use of state of art control mechanisms
[ ] Reduction of persons through automatization
[ ]Consideration on conservation, preservation of monuments
[ ]Optimization of hydraulic behavior of the component

8. Discharge over a weir is $Q = C_w L_{Weir} h^{1.5}$ where C_w is weir coefficient given by
[ ] $\frac{2}{3}\mu\sqrt{2g}$ [ ] $\frac{3}{2}a\sqrt{2g}$ [ ] $\frac{2}{3}a\mu\sqrt{2g}$ [ ] $a\mu\sqrt{g}$

9. The net frequency is 50 Hz and the designed speed of a turbine is 20 rpm. The available generator's synchronous speed is 400 rpm. How many pair poles (P) are there and what should be the gear ratio (G.R.) to fit the turbine the generator?
[ ] P= 6 and G.R = 20 [ ] P= 4 and G.R = 30
[ ] P= 8 and G.R = 25 [ ] P= 6 and G.R = 25

10. Which of the following is not true regarding the design of a surge tank?
[ ]The surge tank protects penstock from water hammer
[ ]The headrace tunnel does not play role in the design of Surge tank
[ ]It supply water to the turbine when the load in turbine varies suddenly
[ ]The upper water level in surge tank should be below the NWL at dam

11. A channel of bed slope 0.0005 carries a discharge of 15 m3/s when the depth of the flow is 1.2m.The discharge carrying capacity by the same channel at the same depth of flow would be 20.12 m3/s if the slope is increased to?
[ ] 0.00085 [ ] 0.00090 [ ] 0.00080 [ ] 0.00095

12. What is the main objective of a particular resources development project?
[ ] Well-being of our society [ ] Producing more electricity
[ ] Providing better transportation facility [ ] Securing a more dependable water supply

13. Where an anchor block is not needed?
[ ] Horizontal bends [ ] Vertical bends
[ ] Immediate upstream of power house [ ] Immediate downstream of expansion joints

14. Head loss in a trashrack is given by $h_f = k\left(\frac{t}{a}\right)^{4/3}\frac{v^2}{2g}\sin\alpha$ where t and a are:

[ ] Angle of bar inclination to horizontal Bar shape factor
[ ] Thickness and distance between bars
[ ] Angle of bar inclination to horizontal and Bar shape factor
[ ] Bar shape factor and angle of bar inclination to horizontal

15. The efficiency of particle settled in settling basin is given by Vetter equation, which is

[ ] $\eta = 1 - \left(1 + m\left(\frac{W}{V_o}\right)^{\frac{-1}{m}}\right)$ [ ] $\eta = 1 - e^{-\left(\frac{Q}{WA_x}\right)}$

[ ] $n = \frac{1}{v}\frac{A^{0.67}}{P^{0.67}}S_o^{0.5}$ [ ] $\eta = 1 - e^{-\left(\frac{WA_x}{Q}\right)}$

16. When an underground power house is not preferred?
[ ] When Good quality of rock is available
[ ] If there is space restrictions
[ ] If there is physical surface hazards like rock slide, snow avalanches etc. at powerhouse location
[ ] When ground surface area is enough and flat

17. What is the discharge that should be pumped from lower reservoir to upper reservoir located at the height 60 m above the tailrace water level through a pumped-storage power plant that consumes 147.15 MW of electrical power with the pump efficiency of 80%?
[ ] 200 m^3/s [ ] 212 m^3/s [ ] 250 m^3/s [ ]195 m^3/s

18. Two power plants, one is for peak and another is for base operation, are working in annual combined mode for the following cost equations. Find the optimum operation duration of peak power plant.
C_x= Rs (115x kW+0.028xkWh)
C_y= Rs (125xkW+0.032xkWh)
[ ] 1000 hrs [ ] 960 hrs [ ] 2500 hrs [ ] 1150 hrs

19. In a reservoir type of a project of installed capacity of 250 MW with the dam height =180 m. and overall efficiency is 87%, and reservoir volume of 3500 million cubic meter for its regulation period. Find the time taken for its regulation period if the regulated flow discharge is used for power generation.
[ ] T= 248.93 days [ ]T= 280.34 days [ ] T= 148.93 days [ ] T= 116.08 days

20. The total capacity on the passport Nameplate of a power plant installed is called?
[ ] Average capacity
[ ] Consumers maximum demand
[ ]Installed capacity
[ ]Maximum capacity

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SECTION "B"
(Short answer questions)

Attempt *ONLY TWO* questions. Q. No. 1 is compulsory. **[14]**

1. Provide your analytical review on the Ministry of Energy's statement on "Nepal ko Pani-Janta ko Lagani (literally: Nepal's Water-People's Investment)" that moves a power supply security to overcome the present and future energy crisis in Nepal. Describing your candid opinion on Nepal's Hydro-Vision 2026 "10 GW in 10 years", recommend necessary short-term, medium-term and long-term measures to follow. [4+4=8]

2. Answer the following questions:
   a. Describe the concept of Power Purchase Agreement between private power producer and Nepal Electricity Authority with a brief review of procedure to be followed for a project up to 25 MW. [3]
   b. With an appropriate numerical example and a neat sketch, describe the process of optimum utilization of Nepal Integrated Power Supply System in relation to power mixing from ROR, Storage, pump-storage and fossil fuel based power plants? [3]

3. What are the advantages and disadvantages of Rehabilitating, Upgrading and Modernizing (RUM) of existing hydropower plants? In the prospect of minimizing the load shedding in Nepal, describe with a case study of stations you studied in your mini-project, the role of public, private, community as well as KU's partnership? [3+3]

4. Briefly account the international law on water resources and give your opinion on how best an agreement could be reached to safeguard the national interest on the use of such resources. Describe briefly the Issues and Principles guided to formulate the Water Resources Strategy of Nepal. What is the national goal and enumerate the ten outputs of Water Resources Strategy. With reference to special aspects of these outputs describe briefly how they will contribute to this goal through the achievement of short- medium- and long-term purposes. [2+2+2= 6]

SECTION "C"
(Long answer questions)

Attempt *ONLY THREE* questions. Q. No. 6 is compulsory. Assume necessary data appropriately. **[26]**

5. Determine the electricity need of a village in Nepal for 200 households (HH) by providing 1000 W/HH that has to be fulfilled by a mini-hydropower plant sited at nearby rivulet-fountain situated at a level 750 m amsl and about 7.5 km away from that village. If a nearby rivulet has a mean monthly average discharge of 200 liter/s then find out the gross vertical distance from intake to powerhouse (Gross-Head) needed to satisfy the total power (Installed capacity) and energy demand calculated above of the village. Assume turbine efficiency of 90%, generator efficiency of 97%, transformer efficiency of 99%, transmission and distribution efficiency of 95% and hydraulic efficiency of water ways of 97%. Select an appropriate type of turbine if the system frequency has to be maintained at 50 Hz and a synchronous generator with 4 pair-poles has to be synchronized. Find the capacity of generator if the altitude factor and power factor are 0.95 and 0.80 respectively. [4+2+2=8]

6. Water is delivered from the upper impounding reservoir through a low-pressure tunnel and a high-pressure penstocks to the three turbine-generator units using a trifurcation in a high-head hydropower plant. The tunnel and penstock is separated by a simple surge chamber of 8 m diameter to cope with the transient in waterways. Due to ecological reason, only 50 % of maximum reservoir storage of $25*10^6$ m^3 can be utilized continuously for 6 hours during the peak-demand time period. The volume of lower reservoir, which is an artificial lake, is only $10*10^6$ m^3 to store incoming discharge from its rivers. The following data for the so-called peaking run-of-the-river hydropower plant are available: [10]

Given	**Symbol**	**Value**	**Unit**	
Elevation of the Impounding Reservoir water level	HWL	1200	m amsl	
Elevation of the downstream reservoir water level		900	m amsl	
Total volume of Impounding Reservoir (IR)	V_{IR}	$25*10^6$	m^3	
Period of daily peaking	T_{TM}	4	hrs	
Length of low-pressure tunnel	L_T	4.5	km	
Diameter of low-pressure tunnel	D_T	3.5	m	
Friction factor of low-pressure tunnel	f_T	0.025	-	
Number of High pressure Penstock	n	I	Nos.	
Length of Penstock	L_P	700	m	
Diameter of steel Penstock	D_P	2.0	m	
Friction factor of Penstock material	F_P	0.016	-	
Turbine efficiency	η_{TM}	95	%	
Efficiency of Generator (Generator with 16 poles, 50 Hz)	η_{GTM}	98	%	
Barometric pressure	BP	10.3	m of WC	
Thoma's Cavitation coefficient	σ_{TH}	$0.043*(n_s/100)^2$	-	
Determine:				**Marks**
(a) Draw a neat profile of the project components and show all necessary descriptions with dimensions complete				4
(b) Determine the maximum power output from the installation for 6 hrs	P		MW	0.5
(c) Estimate the specific speeds and specify the type of turbine. Give the fundamental difference between these two specific speeds.	n_s n_q		rpm	0.5
(d) Determine the safe turbine setting level relative to the downstream reservoir water level.	H_s		m amsl	0.5
(e) Determine the position of centerline of runner for vertical turbine setting.	H_T		m amsl	0.5
(f) Estimate:				
• The maximum upsurge and down surge in the surge chamber for a sudden rejection of one unit; and	$Z_{max.\ US}$ $Z_{max.\ DS}$		m amsl	0.5 + 0.5
• The maximum down surge for sudden acceptance of demand on one unit. And the time of oscillation	$Z_{max.\ DS}$ T		m amsl s	0.5+ 0.5
(g) Determine the power and energy from the powerhouse throughout a year of operation with 70% of Load Factor.	P E		MW MWh	0.5+ 0.5
(h) If the same project is planned to be modified to pump-storage type, then determine the extra volume of the lower reservoir that is needed to store the water during turbine mode. Give your final remarks on what needs to be done if the reservoir volume is not enough.	V_{ELR}		m^3	1.0

7. A multipurpose reservoir has to be created for water supply, irrigation, water navigation, recreation and power production by a hydropower developer. To maintain the ecological regime of the river downstream, an environmental flow shall also be released continually, which equals 15% of mean annual river flow. Twenty percent of produced electricity will be used for pumping water for irrigation and 10 % - for water-supply through canal. The canal is located at a level of 970 m amsl from the reservoir water level at 950 m amsl. The rest of electricity will feed the grid.

- What should be the installed capacity power plant, irrigation pump, water-supply pump and the power to grid in kW? Take total efficiency of hydropower = 90%, efficiency of pump = 80%. Mean annual flow of river = 80 m^3/s. The power plant is located at the tow of 40 m high dam at 910 m amsl. All other losses shall be ignored. Provide a neat sketch of the components of the multipurpose scheme. [3]

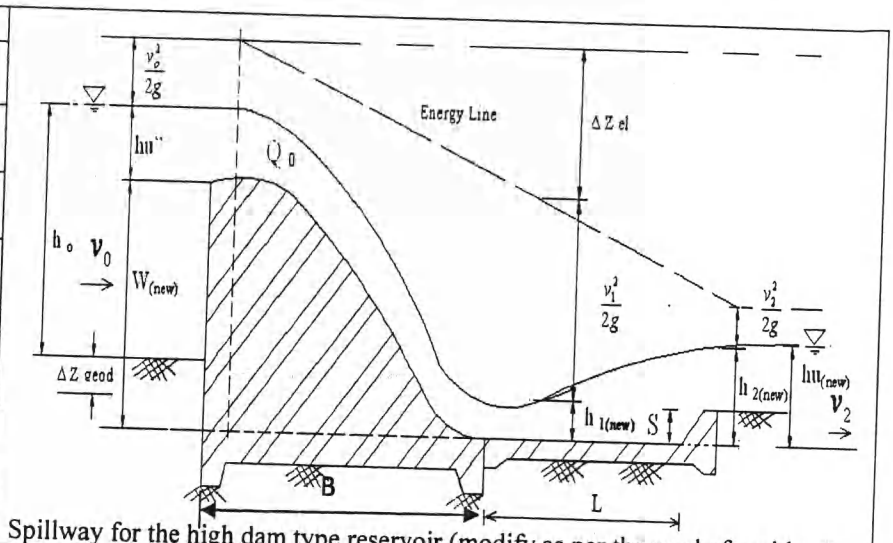
- How much of discharge for power plant, irrigation, water-supply and fish-ladder shall be released out of total river discharge? [3]

- If all the remaining power could be delivered to NEA grid each month throughout the year at the average rate of 7 Nrs/kWh with 75% Plant Factor, how much of money could be earned by the hydropower developer. [2]

8. A 120 m high dam across Indrawati River is planned to be constructed with RCC spillway with an ogee shaped chute reaching to stilling basin race-floor downstream. Considering 80% of maximum probable flood of 8000 m^3/s to pass over the spillway having a crest length of 150 m, design a spillway race-floor downstream with the following dimensions as shown in Fig.with the following parameters: [8]

• h_u"	8 m
• Q_{flood}	8000 m^3/s
• Discharge coefficient	2.1
• Upstream Height of Dam (W)	120 m
• Width of the base of dam (B)	2/3 of dam height
• Delta Z_{geod}	5 m
• D/S water h_u	2 m

Determine:
a. First conjugate depth (2)
b. Second conjugate depth (2)



Spillway for the high dam type reservoir (modify as per the need of problem)

c. Check for the need of a sill and a stilling basin and find the length of race floor (2)
d. Indicate all the dimension on the sketch (2)

$Z_{max, DS} = Z_{max}(1+2F_o)[m]$

T=2pi* Sqrt($L_T A_{ST}/(g A_T)$)[s]

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$Q = Av$

$v = \frac{1}{n} R^{2/3} S^{1/2}$

$A = By + zy^2$

$P = B + 2y\sqrt{1+z^2}$

$R = \frac{A}{P}$

$s = \frac{1}{k_1} \frac{t + a}{a} \frac{Q_i}{v_o} \frac{1}{\sin\alpha}$

K_1-coefficient related to the partial clogging of the screen

- For no automatic raker = 0.20 to 0.30
- For automatic raker with hourly operation = 0.4 to 0.6
- For automatic raker with differential pressure sensor = 0.8 to 0.85

$h_f = k\left(\frac{t}{a}\right)^{\frac{4}{3}} \frac{v^2}{2g} \sin\alpha$

Where: hf- loss of head through racks, m
t- thicknes of rack bars, mm
a-clear distance (spacing) between bars, mm
v- velocity of flow through the trashrack, m/s
α-angle of bar inclination to the horizontal
k-factor depending on bar shape

k=2.42 k=1.83

$h_e = \xi \frac{v_n^2}{2g}$

v_n-normal velocity through orifice

$\xi = \xi_s + \xi_\alpha$

Shape	ξ_s	Cone angle	ξ_α
Bell mouth	0.03 to 0.05	30°	0.002
Slightly rounded	0.12 to 0.25	45°	0.04
Sharp cornered	0.5	60°	0.07

$Q_A = \frac{2}{3} c \mu b L \sqrt{2gh}$

c-correction factor for submerged over-fall

$c = 0.6 \frac{a}{d} \cos^{1.5}\beta$

Where a-internal width between bars
d-centre to centre distance between bars

$h = \frac{2}{3} \chi h_s$

β	χ	β	χ
0°	1.00	14°	0.899
2°	0.980	16°	0.865
4°	0.961	18°	0.851
6°	0.944	20°	0.837
8°	0.927	22°	0.825
10°	0.910	24°	0.812
12°	0.894	26°	0.800

$v_{fall} = \sqrt{0.33(s-1)gd}$

$v_{permissible} = a\sqrt{d}$

$a = 36; d > 1mm$

$a = 44; 0.1 \le d \le 1mm$

$a = 51; d < 0.1mm$

submergence head $S = 1.5\frac{v^2}{2g}$

vortex free criteria

$\frac{S}{v\sqrt{d}} > 0.5$

$h = \frac{b_p - b_b}{c_b - c_p}$ [hour]

Where h- duration of peak plant operation
b_p-cost of power for peak plant
b_b-cost of power for base plant
c_p-cost of energy for peak plant
c_b-cost of energy for base plant

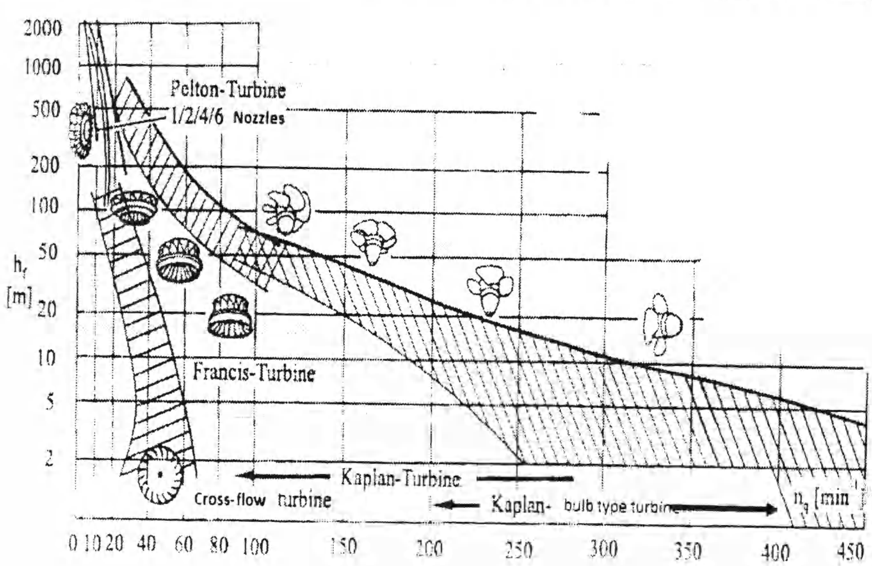
Stored Energy in a reservoir
$E_{St} = 1/(3.6*10^6)*g*\rho_w*V*h_s$ [kWh]
Where, h_s is head over tailrace up to the centre of gravity of the reservoir

submergence head $S = 1.5\frac{v^2}{2g}$

vortex free criteria

$\frac{S}{v\sqrt{d}} > 0.5$

$Q_{spillway} = \frac{2}{3} C_d \sqrt{2g}.b.H^{3/2}$



Formulae List:

$$S = \frac{1}{k_1}\left(\frac{t+a}{a}\right)\frac{Q}{v_0}\frac{1}{\sin\alpha}$$

$$h_r = k_s\left(\frac{t}{a}\right)^{\frac{4}{3}}\frac{v^2}{2g}\sin\alpha$$

$$h_i = k\frac{v^2}{2g}$$

$$Q = AC\sqrt{2g(NWL - TWL)}$$

$$Q = \frac{2}{3}c\mu bL\sqrt{2gh}$$

$$C = 0.6\frac{a}{d}\cos^{\frac{3}{2}}\beta$$

$$h = \frac{2}{3}h_{E}\chi$$

$$P_{max/min} = \frac{\sum V}{B}\left[1 \pm \frac{6e}{B}\right]$$

$$\bar{x} = \frac{\sum M}{\sum V}, e = \bar{x} - \frac{B}{2}$$

$$F_{sliding} = \frac{cB + \sum V.\tan\phi}{\sum H}$$

$Q = Av$

$$v = \frac{1}{n}R^{2/3}S^{1/2}$$

$f_s = 1.76d^{1/2}$

$A = By + zy^2$

$P = B + 2y\sqrt{1+z^2}$

$$R = \frac{A}{P}$$

$P = 4.75Q^{1/2}$,

$$v_{fall} = \sqrt{0.33(s-1)gd}$$

$$v_{permissible} = a\sqrt{d}$$

$a = 36; d > 1mm$

$a = 44; 0.1 \le d \le 1mm$

$a = 51; d < 0.1mm$

$$L = f\left(H\frac{v}{w - u_*}\right)$$

f = safety factor = 1.2 to 1.5

$$u_* = \sqrt{gRS_e}$$

$$S_e = \left(\frac{Q}{nAR^{2/3}}\right)^{1/2}$$

$$\sigma_c = 0.625\left(\frac{n_s}{380.78}\right)^2 \text{ for Francis Turbine}$$

Setting of turbine $H_s = (H_a - H_v) - \sigma_s H_n$

$$n_q = n_{syn}\frac{\sqrt{Q}}{h_e^{0.75}}\ [min^{-1}]$$

$$n_{syn} = \frac{60 * f}{p}\ [min^{-1}]$$

$$n_s = \frac{2400}{\sqrt{H}}\ rpm \text{ for Francis Turbine}$$

$$D = \frac{84.6\phi H}{n_{syn}}\ \text{m}$$

$$\boxed{\phi = 0.0197\ n_s^{2/3} + 0.025}$$

$$n_s = \frac{n_{syn}\sqrt{P\ [kW]}}{H_n^{5/4}}$$

submergence head $S = 1.5\frac{v^2}{2g}$

vortex free criteria

$$\frac{S}{v\sqrt{d}} > 0.5$$

$$\lambda = 0.005[1 + ((2000ks)/D + 10^6/Re)^{1/3}]$$

$$\frac{1}{\sqrt{\lambda}} = -2\log\left(\frac{k_s}{3.7D} + \frac{5.1286}{R_e^{0.89}}\right)$$

$$h_{dyn} = (a*v)T_R/(g*T_s)$$

$$T_s = \frac{\frac{QL}{A}}{gH}$$

$$A_{surge\ shaft} = \frac{v_0^2 A_t L_t}{2gP_0H_0}$$

$$h_f = \frac{flv^2}{2gD}$$

$$t = \frac{pR}{\sigma_{st}\eta_j - 0.6p} + 0.15(cm)$$

$$v_{opt} = 0.125\sqrt{2gH}$$

$$D = 0.52H^{-0.17}(P/H)^{0.43}$$

$$\sigma_{st} = 1200\ kg/cm^2$$

$$Generator\ rating = 1.3 * \frac{Turbine\ rating(kW)}{A * B * C * D}$$ [k 1]

$$C_P = \sqrt{\frac{\frac{K}{\rho}}{1 + \frac{D \cdot K}{t \cdot E}}}\ \text{m/s}$$

$$t = \frac{P_d D}{2\sigma}\text{mm}$$

$$h_f = \frac{f L v^2}{2gD}\ \text{m}$$

$T_c = 2\times(L/Vc)$

$$D_e = 0.62 \times \frac{P^{0.35}}{H^{0.65}}[m]$$

$V_{eco} = 0.125\sqrt{2gH}$[m/s]

$Z_{max} = v_o Sqrt(L_T A_T/(gA_{ST}))$[m]

$P_o = h_f/Z_{max}$ [-]

$hp = C_p * v_P/g$[-]

$Z_{max,\ US} = Z_{max}(1 - 2/3P_o + 1/9 * P_o^2)$[m]