



9. The surface of a single point cutting tool on which the chip is formed in cutting operation side is called;  
 Flank                       Heel                       Face                       Shank
10. Sintering is performed \_\_\_\_\_  
 at room temperature                       below room temperature  
 below melting point                       at cryogenic temperature
11. Sintering increases  
 electrical conductivity, density and ductility  
 electrical conductivity, density and brittleness  
 porosity, electrical conductivity and brittleness  
 porosity, density and ductility
12. The ductile materials, during machining, produce  
 Continuous chips                       Continuous chips with built up edge  
 Serrated chips                       Built up edge
13. The process of infiltration in sintered product is to improve  
 Porosity                       Dimensional accuracy  
 Surface finish                       Coherent Property
14. In metal machining, the zone where the heat is generated due to friction between the moving chip and the tool face, is  
 Friction zone                       Shear zone  
 Work-tool contact zone                       Relief zone
15. The first five digits of Opitz classification system are  
 Norms code                       Secondary code  
 Supplementary code                       Form code
16. Which one of the following is not a function of servo-sub system in CNC Machine?  
 Profile generation                       Feedback Processing  
 Tool Change                       Position and velocity control
17. The depth that the tool is plunged into the surface is called as \_\_\_\_\_  
 Feed                       depth of cut                       depth of tool                       working depth
18. Function of CNC tool path is  
 Determines cutting speed                       Defines tools Movement  
 Measures tool temperature                       Modifies tool shape
19. Purpose of rapid transverse in CNC Machining  
 Slow movement for precision                       High speed positioning  
 Tool Change operation                       Cooling the spindle
20. Difference between absolute and incremental programming in CNC Machining.  
 Absolute refers to exact position, while incremental refers to relative movement.  
 Absolute is for milling and incremental is for turning operations.  
 Absolute uses G codes while incremental uses M codes.  
 Absolute is for SINUMERICK while increment is only for FANUC Control.

KATHMANDU UNIVERSITY  
End Semester Examination  
February, 2025

Level : B.E.  
Year : III  
Time : 2 hrs. 30mins.

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Course : MEEG 317  
Semester : II  
F. M. : 55

SECTION "B"  
[55 marks]

*Attempt ALL questions. Assume suitable data if necessary.*

1. What are the advantage of NC /CNC machine over conventional machine tool also write about the application characteristic of NC/CNC Machine tool? [4]
2. Consider the following machine component incidence matrix with 7 machines and 5 components to obtain the final machine - component cells using Rank order clustering Algorithm (ROCA). [6]

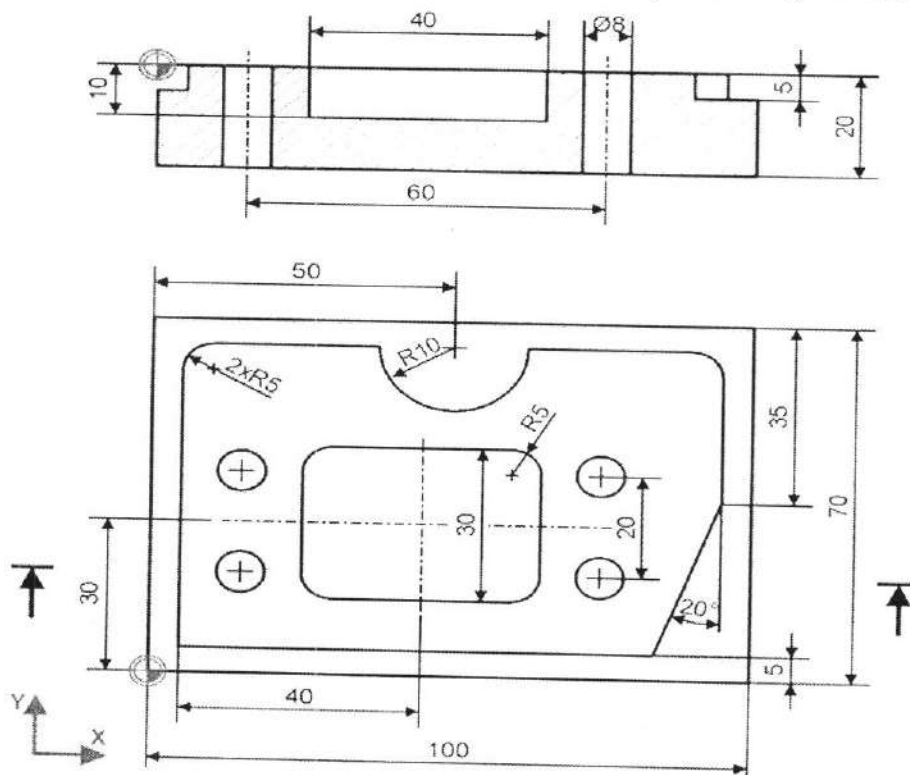
Machines	Components				
	1	2	3	4	5
M1	0	1	0	1	0
M2	1	0	0	0	1
M3	0	1	1	0	0
M4	1	0	0	0	1
M5	0	0	1	1	0
M6	0	0	0	0	1
M7	0	1	1	1	0

3. What is the term Green Compact in Powder metallurgy? What are the three steps in the sintering cycle in Powder metallurgy, described with a diagram with reference to time and temperature? [2+5]
4. Derive the relation and expression relating various cutting forces involved in material Removal on orthogonal cutting with the help of merchant circle diagram. [8]
5. Write short note on manufacturing continuous glass fibers with suitable diagram. What is the blown-film process for producing film stock in plastic processing? [4]
6. A screen with 10 mesh counts has wires with a diameter of 0.0213 inch. determine: (a) the maximum particle size that will pass through the wire mesh, and (b) the proportion of open space in the screen. (Refer  $PS = K/MC - t_w$ ). [5]

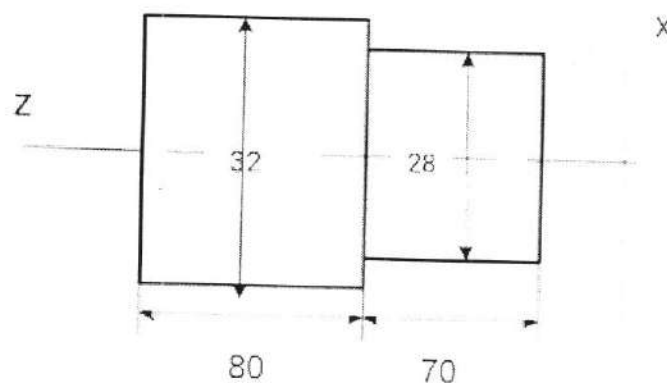
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7. A square hole is to be cut using ECM through a plate of low alloy steel that is 12 mm thick. The specific removal rate for this steel is  $3.7 \times 10^{-2} \text{ mm}^3/\text{A-s}$ . The hole is 35 mm on each side, but the electrode used to cut the hole is slightly less than 35 mm on its sides to allow for overcut, and its shape includes a hole in its center to permit the flow of electrolyte and to reduce the area of the cut. This tool design results in a frontal area of  $245 \text{ mm}^2$ . The applied current = 1200 amps. (a) Using an efficiency of 95%, how long will it take to cut the hole? (b) If the tool were designed with a frontal area equal to the hole size, how long will it take to cut the hole? (Refer:  $V=c \cdot I \cdot T = A \cdot T$ ) [6]

8. Write CNC program to machine the part shown in the figure below using Fanuc control CNC milling. Use sub programming commands (M98 and M99) for rectangular pocket and drilling procedure. Maximum depth of cut is 5mm. Assume suitable spindle speed and feed for individual process. All dimensions in the provided figure are in mm. [10]



9. Write CNC program to machine the part shown in the figure below from CNC Lathe. Maximum depth of cut is 5mm. Assume suitable spindle speed and feed for individual process. All dimensions in the provided figure are in mm. [5]



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Marks Scored:

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Semester : II

Exam Roll No. :

Time: 30 mins.

F. M. : 20

Registration No.:

Date :

Formula sheet is not required in this section.

SECTION "A"

[20 Q. × 1 = 20 marks]

**Choose and mark in [X] the most appropriate option from each set of choices**

- Impingement of free jets provides \_\_\_\_\_  
 the basic background on the application of linear momentum equation  
 concept of energy transfer, relative velocities  
 efficiency of energy transfer  
 all of the above
- The ratio of forces exerted by water jet when it is made to strike a stationary flat plate held normal to it and a flat plate moving in the direction of jet at one-third the velocity of jet would be  
 3:1                       9:4                       3:2                       2:1
- Cavitation damage is caused primarily by:  
 thermal effects of collapsing bubbles     chemical erosion from dissolved gases  
 pressure waves from collapsing bubbles     velocity changes in the fluid
- If a draft tube causes a head loss of 1.2 m and recovers 2.4 m of head, what is the efficiency of the draft tube?  
 33.3%                       50.0%                       66.7%                       75.0%
- What is the primary purpose of a draft tube in a hydraulic turbine?  
 to increase the velocity of water leaving the turbine  
 to convert kinetic energy into pressure energy  
 to reduce the back pressure on the turbine blades  
 to reduce turbulence in the flow
- In a centrifugal pump operating at part load, what happens to the efficiency and specific energy consumption?  
 efficiency decreases, and specific energy consumption increases  
 efficiency increases, and specific energy consumption decreases  
 both efficiency and specific energy consumption remain constant  
 efficiency decreases, and specific energy consumption decreases
- The specific speed of the turbine  $N_s$  has the dimensions of  
  $F^{1/2} L^{-3/4} T^{-3/2}$       $F^{-1/2} L^{1/4} T^{-3/2}$       $F^{1/2} L^{-5/4} T^{3/2}$       $F^{1/2} L^{3/4} T^{-1/2}$

8. A Pelton turbine has 2 jets, each delivering a flow rate of  $0.15 \text{ m}^3/\text{s}$  under a head of 200 m. Assuming an efficiency of 90%, the total power output is \_\_\_\_\_.  
 529.5 kW       541.0 kW       529.2 kW       515.8 kW
9. A Pelton turbine has a single jet of diameter 10 cm, and the water velocity from the nozzle is 60 m/s. The power of the jet is \_\_\_\_\_.  
 282.7 kW       285.0 kW       300.5 kW       275.0 kW
10. A fluid enters a turbine blade at an absolute velocity of 50 m/s at an angle of  $60^\circ$  to the tangential direction. If the blade speed ( $u$ ) is 20 m/s, the relative velocity ( $W$ ) of the fluid at the inlet is \_\_\_\_\_.  
 34.64 m/s       50.0 m/s       40.0 m/s       43.6 m/s
11. In a hydroelectric project, the available discharge is  $60 \text{ m}^3/\text{s}$  with a net head of 35 m. assuming a turbine efficiency of 92 % and rotational speed of 300 rpm, the least number of turbines of the same size and having a specific speed of 275 is \_\_\_\_\_.  
 1       2       3       4
12. In a Kaplan turbine, the absolute flow angle  $\alpha_1$   
 increases from the tip of the blade towards the hub  
 decreases from the tip of the blade towards the hub  
 remains constant all along the radius  
 is maximum at mid radius
13. Which of the following advantages is/are possessed by a Kaplan turbine over a Francis turbine?  
 i. low friction losses  
 ii. considerably high part load efficiency  
 iii. more compact and smaller in size  
 The correct answer is  
 Only 1       1 and 2 only       2 and 3 only       1, 2 and 3
14. A Francis turbine has a guide vane angle of  $15^\circ$  and its inlet flow is radial. The ratio of inlet to outlet diameter is 2. The flow velocity is 5 m/s and is constant. The blade angle at outlet when the exit discharge is radial is \_\_\_\_\_.  
  $28.18^\circ$         $18.18^\circ$         $32.18^\circ$         $26.18^\circ$
15. Generally buckets of Pelton turbines are casted as single solid piece, in order to  
 avoid local cavitation       avoid fatigue failure  
 increase efficiency       maximize impulsive force
16. It is required to pump  $1.3 \text{ m}^3/\text{s}$  of water to a total head of 45 m. How many pumps of specific speed 40 and running at 1450 rpm would be needed when connected in parallel, when the dynamic head in the system can be neglected?  
 2       3       4       6

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17. A centrifugal pump impeller has outer and inner diameters of 0.3 m and 0.15 m respectively. When running at 1450 rpm, with the discharge pipe completely shut off, the theoretical head produced is about  
 53 m                       26.5 m                       13.3 m                       106 m
18. A centrifugal pump operates at a flow rate of  $0.02 \text{ m}^3/\text{s}$ , a total head of 20 m, and an input power of 5 kW. The efficiency of the pump is \_\_\_\_\_  
 78.5%                       60.0%                       79.6%                       81.5%
19. If the rotational speed of a pump is doubled, what happens to the power requirement, assuming constant efficiency?  
 power doubles     power triples  
 power increases by 4 times     power increases by 8 times
20. A pump has a Net Positive Suction Head Required (NPSHR) of 6 m, while the Net Positive Suction Head Available (NPSHA) is 5 m. The most likely result is \_\_\_\_\_  
 cavitation will occur     increased efficiency  
 reduced cavitation risk     improved pump head

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SECTION "B"

[5 Q. × 11 = 55 marks]

Attempt *ALL* questions. Formula sheet is supplied in this exam along with the question. Assume suitable data if missing/necessary.

1.
  - a. Show that how is the fluid jet on a moving flat plate is not a practical engineering cases. [3]
  - b. What is meant by a single overhung and a double overhung Pelton turbine? What are the advantages of the later over the former? [3]
  - c. A Pelton wheel delivers a maximum power of 14.4 MW when working under a head of 855 m and running at 600 rpm. Find the least diameter of the jet and the mean diameter of the wheel. What would be the approximate diameter of orifice of the nozzle tip? Determine the value of the jet ratio and state if it is within the limits. Specify the number of buckets for the wheel. Take the overall efficiency of the turbine as 89.2 %. [5]
2.
  - a. What importance has the jet ratio in designing the Pelton turbine? [2]
  - b. Draw typical velocity triangles at inlet and at outlet for low, medium and high specific speed Francis turbines. Explain why it is not same. [3]
  - c. For given flow rate =  $2.35 \text{ m}^3/\text{s}$ , head = 201 m, speed = 1000 rpm,  $a = 1.10$ ,  $b = 0.10$ ,  $\beta_2 = 15^\circ$ ,  $u_2 = 38 \text{ m/s}$ ,  $\eta_h = 0.96$ ,  $u_1 = 0.72$ ,  $c_{u2} = 0$  and acceleration = 10 %, design the main dimensions of Francis turbine. How do you assure that your design is free from cavitation problem? [6]
3.
  - a. Why is it necessary to choose the number of Francis turbine runner blades as odd and the number of guide vanes as even? [2]
  - b. If you are asked to design a Kaplan turbine, how do you fix the main dimension of the Kaplan turbine? [3]
  - c. A Kaplan turbine develops 40 MW of power under a head of 35 m and a speed of 175 rpm. The tip diameter of the runner is 5 m and the hub diameter is 2.5 m. The overall efficiency and hydraulic efficiency of the turbine are 89 % and 92 % respectively. Determine the (a) speed ratio and flow ratio, and (b) the inlet guide vane angle, inlet and outlet blade angles at (i) hub, and (ii) tip. [6]

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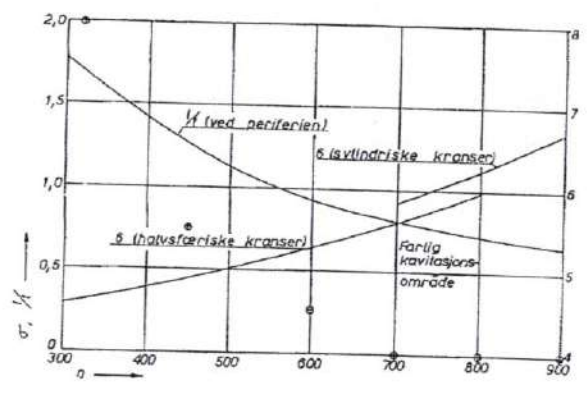
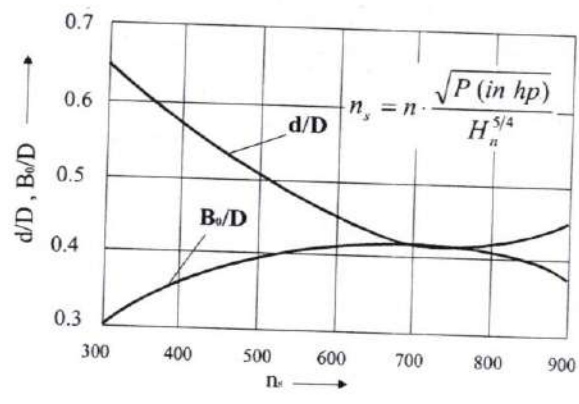
4.

- a. Distinguish between Euler head and manometric head of a centrifugal pump [3]
- b. Derive Thoma's factor of cavitation. Explain its significance for hydraulic machines. [4]
- c. A centrifugal pump has an impeller of 0.5 m outer diameter and when running at 600 rpm discharges 9000 liter per minute against a head of 11 m. The water enters the impeller radially without whirl or shock. The inner diameter is 0.15 m. The vanes are set back at an angle of  $28^\circ$  to the tangent at the periphery of the outlet. The area of the flow is constant from inlet to outlet of the impeller and is  $0.05 \text{ m}^2$ . Determine the (a) vane angle at inlet, (b) manometric efficiency of the pump, and (c) minimum speed at which the pump commences to work. [5]

5.

- a. What are the conditions of making the turbine model? Why is the turbine model manufactured? [3]
- b. What is the function of a governor in a water power plant? State the different types of water turbine governors. [3]
- c. A jet of water with velocity of 18 m/s impinges on moving curved vane at  $25^\circ$  to the direction of motion. The velocity of the vane is 8 m/s. The vane angle at the outlet is  $30^\circ$ . Find (a) the blade angle at inlet so that water enters without shock, (b) the rate of work done per unit weight of water entering the vane, and (c) the efficiency of the system. [5]

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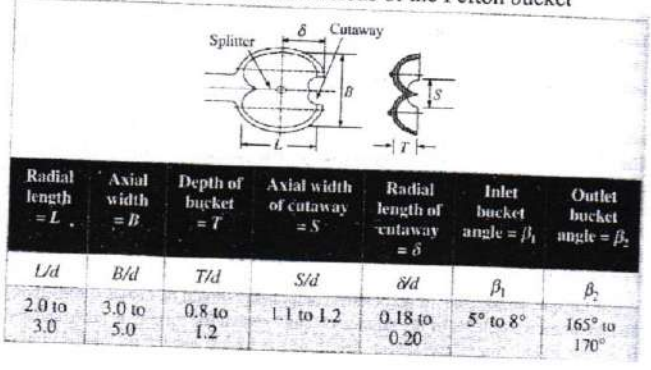
$$(\sigma_c)_{Francis} = 0.625 \cdot \left( \frac{n_s}{380.78} \right)^2 \approx 431 \cdot 10^{-8} \cdot n_s^2$$

$$(\sigma_c)_{Kaplan} = 0.28 + \left( \frac{1}{7.5} \left( \frac{n_s}{380.78} \right)^3 \right)$$

$$(\sigma_c)_{CP} = 1.03 \cdot 10^{-3} \cdot n_s^{\frac{4}{3}}$$

$\sigma \geq \sigma_c$  Or  $NPSH \geq \sigma_c H \Rightarrow$  no cavitation  
 $NPSH_{min} = \sigma_c H$

Basic geometrical dimensions of the Pelton bucket



$\eta = \frac{u_1 \cdot v_{u1} - u_2 \cdot v_{u2}}{g \cdot H_n}$	$13^\circ < \beta_2 < 22^\circ$ (lowest value for highest head) $35 < U_2 < 43$ m/s (highest value for highest head)	$H_m = h_s + h_d + h_{\beta} + h_{jd} + \frac{v_d^2}{2}$
$h_f = f \cdot \frac{L}{D} \cdot \frac{v^2}{2 \cdot g}$	$v_{m2} = 1.1 \cdot v_{m1}$ $H_m = \left[ \frac{P_a}{\rho \cdot g} + \frac{v_o^2}{2 \cdot g} + z_n \right] - \left[ \frac{P_l}{\rho \cdot g} + \frac{v_l^2}{2 \cdot g} + z_l \right]$	$n_q = n \cdot \frac{\sqrt{Q}}{H^{3/4}}$ $n_{s,turbine} = 2.97 \cdot n_{q,pump}$
$N_s = \frac{N \cdot \sqrt{P}}{H^{3/4}}$ (P in kW) Pelton, 1 jet: 12 - 30 Pelton, 2 jet: 17 - 50 Pelton, 4 jet: 24 - 70 High head Francis: 80 - 150 Medium head Francis: 150 - 250 Low head Francis: 250 - 400 Propeller/ Kaplan: 300 - 1000 Bulb or Tubular: 1000 - 2000	$H_s = 10 - NPSH_R$ $NPSH_R = a \cdot \frac{v_{m2}^2}{2 \cdot g} + b \cdot \frac{u_2^2}{2 \cdot g}$ <i>Turbines</i> <i>Pumps</i> $a$ 1.05 < $a$ < 1.15    1.6 < $a$ < 2.0 $b$ 0.05 < $b$ < 0.15    0.2 < $b$ < 0.25 $d_s = \sqrt{\frac{4 \cdot Q}{z \cdot \pi \cdot v_1}}$	Affinity Law 1: $\frac{Q_1}{Q_2} = \frac{n_1}{n_2}$ $\frac{H_1}{H_2} = \left( \frac{u_1}{u_2} \right)^2 = \left( \frac{n_1}{n_2} \right)^2$ $\frac{P_1}{P_2} = \left( \frac{n_1}{n_2} \right)^3$
$n_q = n \cdot \frac{\sqrt{Q}}{H^{0.75}}$	$\underline{Q}_n = \frac{\pi \cdot (D^2 - d^2)}{4} \cdot c_{1m}$ $D = \sqrt{\frac{\underline{Q}_n \cdot 4}{\pi \cdot c_{1m}}} \quad n = \frac{3000}{z_p}$ $\sigma = \frac{10 - H_s}{H}$	Affinity Law 2: $\frac{Q_1}{Q_2} = \left( \frac{D_1}{D_2} \right)^3$ $\frac{H_1}{H_2} = \left( \frac{D_1}{D_2} \right)^2$ $\frac{P_1}{P_2} = \left( \frac{D_1}{D_2} \right)^5$
$* \Omega = * \omega \cdot \sqrt{Q}$ $* \Omega \leq 0.22$ (Pelton) $0.2 < * \Omega < 1.25$ (Francis) $* \Omega > 1.0$ (Kaplan/Bulb)	$c_{1m} = 0.12 + 0.18 \cdot \Omega$	$P = \rho \cdot Q \cdot g \cdot H_t$ $H_t = \frac{u_2 \cdot v_{u2} - u_1 \cdot v_{u1}}{g}$ $H_t = \frac{u_2^2 - u_1^2}{2 \cdot g} + \frac{v_2^2 - v_1^2}{2 \cdot g} - \frac{w_2^2 - w_1^2}{2 \cdot g}$ $\eta_{man} = \frac{g \cdot H_m}{v_{u2} \cdot u_2}$
$H_e = \frac{u_2 \cdot v_{u2}}{g} = \frac{u_2}{g} [u_2 - v_{r2} \cdot \cot \beta_2]$	$v_1 = C_d \cdot \sqrt{2 \cdot g \cdot H_n}$ [ $C_d = 0.97$ to $0.98$ ]	$n_{min} = \frac{120 \cdot \eta_{man} \cdot v_{uz} \cdot D_2}{\pi (D_2^2 - D_1^2)}$ $D_{Housing} = D + K \cdot B$
$\phi = \frac{u}{v} = 0.45 - 0.48$ Pelton $\phi = \frac{u}{v} = 0.62 - 0.82$ Francis	$\frac{1 - \eta_M}{1 - \eta_P} = \left( \frac{D_P}{D_M} \right)^{1/5}$ $\frac{0.94 - \eta_M}{0.94 - \eta_P} = \left( \frac{Q_P}{Q_M} \right)^{0.32}$	$\eta_d = \frac{\frac{v_2^2 - v_3^2}{2g} - h_f}{\frac{v_2^2}{2g}}$
$3.1 > \frac{B}{d_s} \geq 3.4$ $D = 10 \cdot d_s$ , for $H_n \leq 500$ m $D = 15 \cdot d_s$ , for $H_n = 1300$ m	Pr. rise = $\frac{P_2 - P_1}{\rho g} = \frac{1}{2g} [v_1^2 - v_2^2 + 2v_{u2} u_2]$	head or lift co-efficient: $\frac{\sqrt{H}}{D \cdot n}$
$I = \frac{p}{\rho \cdot g} + \frac{w^2}{2 \cdot g} - \frac{(\omega \cdot r)^2}{2 \cdot g} = const$	flow co-efficient: $\frac{Q}{D^3 n}$	power co-efficient: $\frac{P}{D^5 \cdot n^3}$