1- A centrifugal pump having impeller diameter of 105 cm delivers 1320 lit/s at a total manometric head of 65 m when running at 750 rpm, the measured SHP being 1370. The impeller vanes are backward curved and make an angle of 20° to the tangent and the effective circumferential area at outlet is 0.35 m^2. Assuming leakage loss through clearance ring 3% of the discharge. External losses including disc friction , bearing and gland friction 50HP, determine

      a- The theoretical head which could be developed if net HP given to the water flowing though the impeller was converted to head

      b- The theoretical head assuming an infinite number of impeller vanes.

      c- The hydraulic efficiency and the overall efficiency.

2- A new pumping station is to be installed to supply water to a town with 13000inhabitants. The water consumption per head is 180 lit/day. Half of the total consumption is to be supplied in 8 hours, the total static head is 60 m and the head losses in suction and delivery sides are 34m. Select the number of pump stages, if the proposed specific speed for the pump stage is 32.2, N=1450 rpm, φ_2= 1.02, η_{mech}=0.75, assume D_1/D_2=0.2, V_F= 3 m/s, β_2= 30°. Determine the pump dimension and HP.

3- It is proposed to build a three stage centrifugal pump to handle 60 lit/s of water at a speed of 900 rpm and under a total manometric head of 70 m. The vanes are to be radial at inlet and are to be curved backward at exit at an angle f 45°.assuming a manometric efficiency of 84% and a mechanical efficiency of 75% and considering that vane thickness accounts for 8% of the circumferential area. Determine the probable external diameter and the width of each impeller and the HP input. The velocity of flow may be assumed constant at 3 m/s, the diameter ratio is 1/2.

4- A multi stage centrifugal pump is to be designed to deliver 750 lit/s of water against a manometric head of 60 m. there are to be four equal impeller keyed to the same shaft which has a speed of 350 rpm. The vanes are to be curved backward so that the direction of the relative velocity of the discharge makes an angle of 120° with the direction of corresponding peripheral velocity, and the impeller is surrounded by guides. Assuming that the water enters the vane passage in a radial direction and the velocity of the flow through the impeller is 0.27 of the peripheral velocity, and that the losses in pump amount to one-third of the velocity head at discharge from the impeller, find:

      a- Outer dimension of the impeller.

      b- The manometric efficiency.

      c- The angle of guides.

5- A multi- stage boiler feed pump is required to pump 110,000kg of water per hour against a pressure difference of 30 bars when running at a speed of 2900 rpm. The density of preheated feed water is 960 kg/m^3. If all the impeller are identical and the specific speed per stage is not to be less than 20 , find:

      a- The least number of stages and head per stage

      b- The diameters of the impellers assuming peripheral velocity $= 0.96\sqrt{2gH}$

      c- The shaft HP required to drive the pump, assuming η_o=0.78.

6- A multi – stage centrifugal boiler feed pump id required to pumps 25000 kg/hr of hot condensate water (40^oC) from the condenser up to the boiler drum. The pressure in the boiler drum is 21.5 bars and on the condenser is 721 mm Hg vacuum, the static head from the condenser water level to boiler water level is 5.25 m. estimate :

      a- The total manometric head of the pump and BHP if η_o=0.88.

      b- The minimum number of impeller for this pump when the speed of rotation is 2900 rpm.

      c- The outside diameter, outside width and outlet blade angle (η_{hyd}=0.75).
         You may use the following data

Ns	10	20	30
$\Phi2$	0.95	1	1.05
$\Psi2$	0.09	0.12	0.15
$\lambda2$	0.06	0.1	0.15