1- A pump has the following characteristics when running at 1450 rpm:

$Q(m^3/s)$	0	0.225	0.335	0.425	0.545	0.65	0.75	0.8
H(m)	20	17	15	13	10	7	3	0

A system is designed where the static lift is 5 m and the operating point is H=11.1 m and $Q=0.5m^3/s$, when using the pump as above. The system is redesigned, the static lift being 5 m but the frictional and other losses increased by 40%. Find the new pump operating head and power. **(H= 12 m & $Q=0.46\ m^3/s$ & power 73HP)**

2- The characteristics of two rotodynamic pump at constant speed are as follow:

	$Q(m^3/s)$	0	0.006	0.012	0.018	0.024	0.03	0.036
Pump (A)	H(m)	22.6	21.9	20.3	17.7	14.2	9.7	3.9
	η(%)	0	32	74	86	85	66	28
Pump (B)	H(m)	16.2	13.6	11.9	11.6	10.7	9	6.4
	η(%)	0	14	34	60	80	80	60

One of the above pumps is required to lift water continuously through 3.2 m of vertical lift and the pipe to be used is 21 m long, 10cm diameter and friction coefficient is 0.005. Select the more suitable pump for this duty and justify your selection. What power input will be required by the selected pump? **(η_2=70%) pump 2 more suitable**

3- A pump has the following characteristics:

H(m)	20.6	21.8	20	17.6	14.5	10.6	4.8
$Q(m^3/s)$	0	0.009	0.018	0.027	0.036	0.045	0.054

The pump supplies water from a lake to a reservoir whose cross sectional area is $40m^2$, via 60 m of 15 cm diameter pipe for which f= 0.025. the pump is switched on when the level in the reservoir is 5 m above the water level in the lake and switched off when the level is 18 m. by plotting the pump characteristics and the system resistance at say 30 min intervals (assuming constant discharge during the chosen time interval), obtain a graph showing a relationship between pump discharge and time for one cycle of operation. How long does the cycle last? **(11 interval)**

4- The characteristics of a centrifugal pump at constant speed are as following:

$Q(m^3/s)$	0	0.012	0.018	0.024	0.03	0.036	0.042
H(m)	22.6	21.3	19.4	16.2	11.6	6.5	0.6
η(%)	0	74	86	85	70	46	8

The pump is used to lift water over vertical distance of 6.5 m by means of a 10 cm diameter pipe , 65 m long and f= 0.005

a- Determine the rate of flow and the power supplied to the pump **(Q=0.027&H=14m &η=0.8 & power = 6.18HP)**

b- If it is required to increase the rate of flow and this may be achieved only be an addition of a second identical pump, investigate whether it should be connected in series or in parallel with the original pump. Justify your answer by determining the increased rate of flow.

5- In a pump station there are two units whose head – discharge characteristics at their constant working speeds can be presented by :

$$H=132+15Q-16Q^2$$

The pumps delivers into a single pipe line in which the static head is 45 m, the pipe is 0.6 m diameter and 800 m long, the value of the pipe friction coefficient is 0.02. Compute the total discharge through the pipe, if the pumps were arranged:

a- In parallel**(Q= 1.63 m^3/s)**

b- In series. **(Q= 1.147 m^3/s)**

6- The characteristics of a centrifugal pump delivering water can be represented by the equation : $H= 125 + 12\ Q -100\ Q^2$ when the two such pump are connected in parallel, the flow rate through the system is the same when they are connected in series. Determine the flow rate that a single pump would deliver if connected to the same system. Assume the system to be purely resistive (no static lift). **(H= 77.75 m)**

7- Estimate the maximum static suction lift in order to avoid cavitation for the given pump installation:

Manometric head = 18.2 m, discharge = 100 lit/s, critical thoma number = 0.2, length of suction pipe = 85 m, diameter of suction pipe = 25 cm, pipe coefficient of friction = 0.004. Altitude of installation is 870 m above sea level.

Atmospheric pressure at the given altitude = $0.91 * 10^5\ N/m^2$

Temperature of water = $51.5\ ^{o}C$

Vapor temperature at given temperature = $0.14* 10^5\ N/m^2$

Density of water at given temperature = $985\ kg/m^3$.

8- A propeller pump consumes 50 HP when discharging 1000 lit/s at a speed of 240 rpm with an overall efficiency of 0.75. The outer diameter of propeller is 80 cm and the inner or hub diameter is 40 cm. the hydraulic efficiency is 0.82.
   a- Calculate the manometric head of the pump
   b- Draw the inlet and outlet velocity diagram at outer and inner diameter and find the impeller and guide blade angles.

9- The rotor of propeller pump has a mean diameter of 2.15 m and it is revolves at 85 rpm. At the mean diameter the blade angle at inlet is 11^{o} and at outlet 14^{o}. the hydraulic efficiency may be assumed to be 0.85. draw to scale the velocity diagram at inlet and outlet at mean diameter and then calculate:
   a- The manometric head generated.
   b- The flow and speed ratios based on the mean diameter
   c- If the boss diameter is 0.4 of the outer diameter, find the main dimensions of the propeller, the discharge and power required to drive the pump. Assume responsible value for the overall efficiency.

10- An axial flow fan having 60 cm outer diameter and 30 cm hub diameter, running at a speed of 2860 rpm. At diameter of 37.5 cm, the whirl component of velocity of air leaving the runner is 7.9 m/s, and the corresponding blade angle at outlet is 15^{o}. The hydraulic efficiency is 0.85 and the overall efficiency is 0.75. The specific weight of air is 1.2 kg/m^{3}. Draw the outlet velocity triangle at the mean diameter and determine the guide blade angle. Determine also the rate of discharge, the pressure head in cm of water and the power required to drive the fan.