CWR-4204	03/20/25	Almosawi; SA Cadavid; JC
Assignment #4	5.1.3	

Given: An earth dam is in danger of failing. A pump is needed to quickly drain the small lake behind the dam. The total energy required to move water over the top of the dam is 2.43m. The only pump available is an old 10-cm diameter propeller pump. The power requirement for the motor is 1000 W and the pump-motor combination has a low efficiency of 50%.

Find: Estimate the drawdown (how many centimeters the lake goes down) in the first 2-hour period if the lake has a surface area of 5000m². (Note: Assume that the energy head the pump must overcome does not change much as the lake is lowered in the first 2 hours)

Solution:

$H_p = 2.43m$ Pump-Motor efficiency = 50%

$D_p = 0.1m$ Surface Area of lake = $5000 m^2$

$P_{req} = 1000 W$ time = 2 hours

$P_o = e_p P_i = 0.5(1000 W) = 500 W$ | $500 W = 500 \frac{N \cdot m}{s}$, 2 hours = 7200s

$P_o = \gamma Q H_p = 9800 \frac{N}{m^3} \cdot Q \cdot 2.43 m$

$500 \frac{N \cdot m}{s} = 23814 \frac{N}{m^2} Q$

$Q = \frac{500 \frac{N \cdot m}{s}}{23814 \frac{N}{m^2}} = 0.021 \frac{m^3}{s}$

Volume Displaced after 2 hours:

$0.021 \, m^3/s \cdot 7200 s = 151.2 m^3$

$\text{Draw Down} = \frac{151.2 m^3}{5000 m^2} = \underline{0.03024 m \text{ or } 3.024 cm}$

CWR-4204	03/20/25	Almosawi ; SA Cadavid ; JC
Assignment # 4	5.5.4	90/100

∴ Q from A to B

Given: A 1.75 ft diameter pipeline conveys water from reservoir A to B. The pipeline is 13,800 ft long and has a Darcy-Weisbach friction factor of 0.016. The water surface in reservoir A is 14.7 ft than that of B.

Find: Accounting for minor losses (square-edged entrance and exit, swing-type check valve, and two rotary valves), determine the flow rate, pump head, and flow velocity. The pump characteristics are tabulated below.

Q (cfs)	0	5	10	15	20	25
Hp (ft)	300	289	256	201	124	25
HSH (ft)	-14.7	24.73	54.82	104.97	175.18	265.45

(+14.7 means flow from B to A, but it's stated to be from A to B)

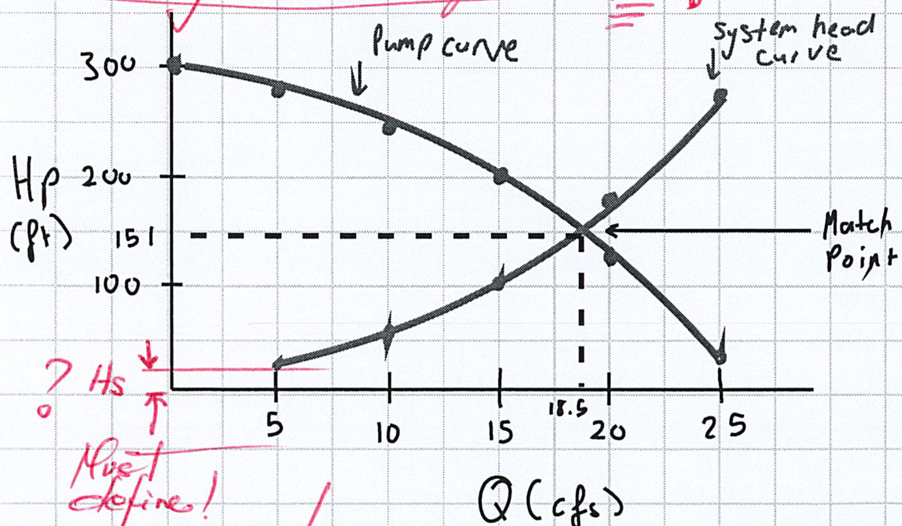
$$H_{SH} = H_s + h_L$$

$$H_{SH} = -14.7\,ft + \frac{Q^2}{2gA^2}\left(f\frac{L}{D} + \Sigma K\right)$$

$$H_{SH} = -14.7\,ft + \frac{Q^2}{2(32.2)\left(\frac{\pi}{4}(1.75)^2\right)^2}\left(0.016\frac{13800\,ft}{1.75\,ft} + (2(0.5) + 2.5 + 2(10))\right)$$

$$H_{SH} = -14.7\,ft + 0.4012Q^2$$

your calc's are from B to A! ← Must revise your calculation to pump from A to B.



At match point:

$Q = 18.5\ ft^3/s$

$H_p = 151\ ft$ a bit high?

$V = 7.69\ ft/s$

Revise your calc's.

-10

CWR-4204	03/20/25	Almosawi ; SA Cadavid ; JC
Assignment # 4	5.6.1	

Given:

Discharge (gpm)	0	200	400	600	800	1000
Dynamic head (ft)	100	96	88	72	46	6

Find:

a) Plot the pump characteristic curve

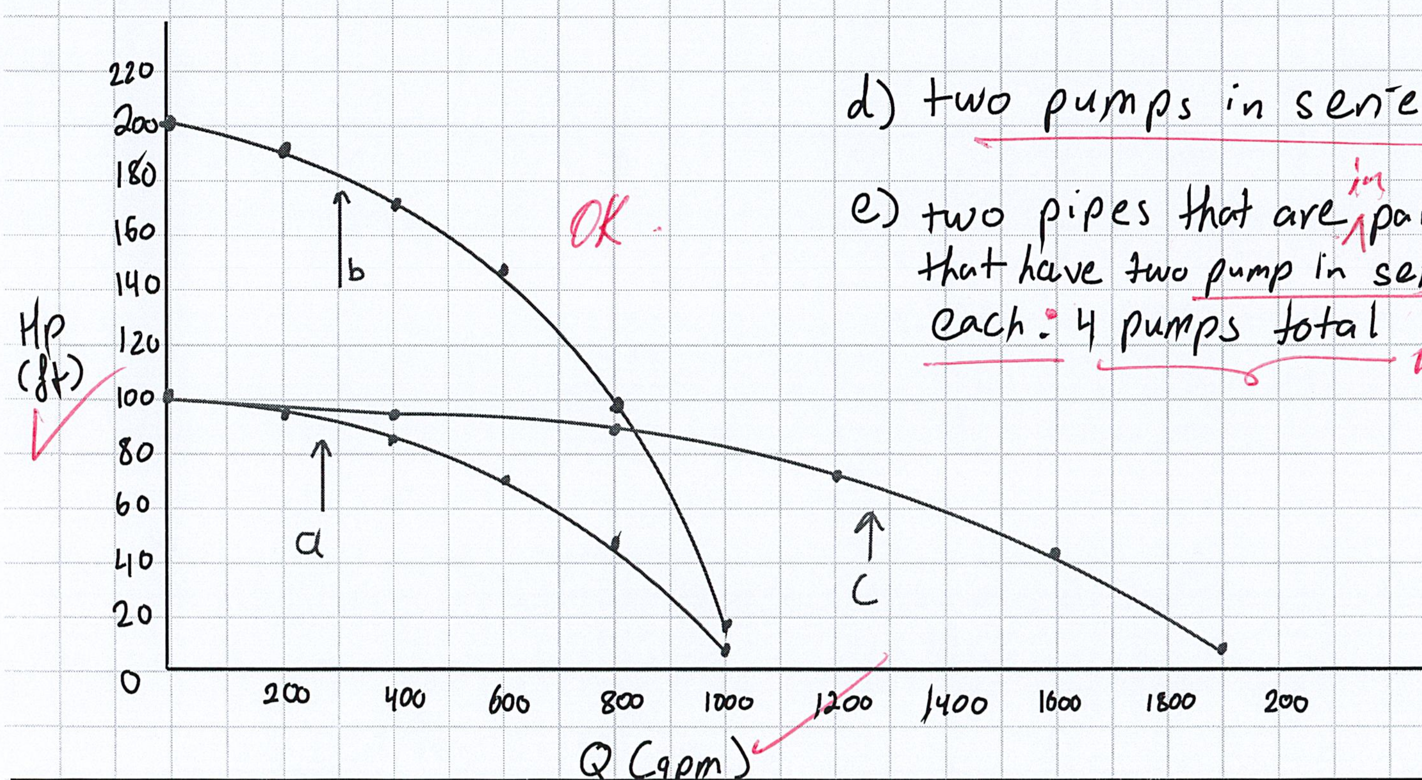
b) Plot the characteristic curve for two pumps in series.

c) Plot the characteristic curve for two pumps in parallel.

d) What pump configuration would work for a required flow of 600 gpm, which must overcome a head of 140 ft?

e) What pump configuration would work for a required flow of 1200 gpm, which must overcome a head of 140 ft?

Solution:



d) two pumps in series

e) two pipes that are in parellel that have two pump in series each: 4 pumps total

CWR-4204	03/20/25	Almosawi; SA Cadavid; JC
Assignment #4	5.9.3	

Given: A pump delivers 6.0 cfs of 68°F water to a holding tank 65 ft above the supply reservoir. The suction side possesses a strainer ($K_s = 2.5$), a foot valve ($K_v = 0.1$), and 35 ft of cast-iron pipe, 10 in in diameter.

Find: Determine the allowable height the pump can be placed above the supply reservoir to avoid cavitation if the NPSH is 15 ft.

Solution:

$$h_p \le \left(\frac{P_{atm}}{\gamma} - \frac{P_{vapor}}{\gamma} \right) - \left(H'_s + \frac{V^2}{2g} + h_L \right)$$

Eq. 5.20 in p. 178. OK ✓

$P_{atm} = 2088.54\ \text{lb/in}^2$
$P_{vapor} = 0.3387\ \text{lb/in}^2$] at 68°F
$\gamma_w = 62.4\ \text{lb/ft}^3$
$H'_s = NPSH = 15\ \text{ft}$

$$V = \frac{Q}{A} = \frac{6.0\ \text{ft}^3/\text{s}}{\frac{\pi}{4}(10/12)^2\ \text{ft}^2} = 11\ \text{ft/s}$$

$$h_L = \left(\frac{fL}{D} + \Sigma k\right)\frac{V^2}{2g} = \left(\frac{0.014(35\ \text{ft})}{(10/12)\ \text{ft}} + 2.6\right)\frac{11^2\ \text{ft}^2/\text{s}^2}{2(32.2)} = 5.989\ \text{ft}$$

Cast Iron $e = 0.00085\ \text{ft}$ $\quad \frac{e}{D} = \frac{0.00085\ \text{ft}}{10/12\ \text{ft}} = 0.00102$

$$N_R = \frac{VD}{\nu} = \frac{11\ \text{ft/s} \cdot (10/12)\ \text{ft}}{1.08 \times 10^{-5}\ \text{ft}^2/\text{s}} = 8.5 \times 10^5$$

$f = 0.02$ (moody)

$$h_p \le \left(\frac{2088.54\ \text{lb/in}^2}{62.4\ \text{lb/ft}^3} - \frac{0.3387\ \text{lb/in}^2}{62.4\ \text{lb/ft}^3} \right) - \left(15\ \text{ft} + \frac{11^2\ \text{ft}^2/\text{s}^2}{2(32.2)} + 5.984\ \text{ft} \right)$$

$$h_p \le 10.6\ \text{ft}$$

~~a bit high! but~~ within range! — revise for accuracy!

CWR-4204	03/20/25	Almosawi; SA Cadavid; JC
Assignment #4	5.11.7	

Given: A pump-pipeline system is designed to transport water (20°c) from a reservoir to an elevated storage tank at a minimum discharge of 300 L/s. The difference in water surface elevations is 15m, and a 1500 m long, wrought-iron pipe that is 40cm in diameter is used.

Find: Select the pump(s) from the set given in Figure 5.24, Determine the number of pumps, the configuration (series or parallel), discharge, total head and efficiency at which the pump operate. Ignore minor losses.

Solution:

$Q = 300 \frac{L}{s} \cdot \frac{1 m^3}{1000 L} = 0.3 \; m^3/s$ | $V = \frac{0.3 \; m^3/s}{\frac{\pi}{4}(0.4)^2 m^2} = 2.387 \; m/s$

$\frac{e}{D} = \frac{0.000045 m}{0.4 m} = 0.000125$

$N_R = \frac{VD}{\nu} = \frac{2.387 \; m/s \cdot 0.4 m}{1 \times 10^{-6} \; m^2/s} = 9.54 \times 10^5$ | $f = 0.0145$ (moody)

$H_{SH} = H_s + h_L = 15m + \left(\frac{0.0145 \times 1500m}{0.4m}\right)\frac{(2.38^2) \; m^2/s^2}{2(9.81 \; m/s^2)} = 30.7m$

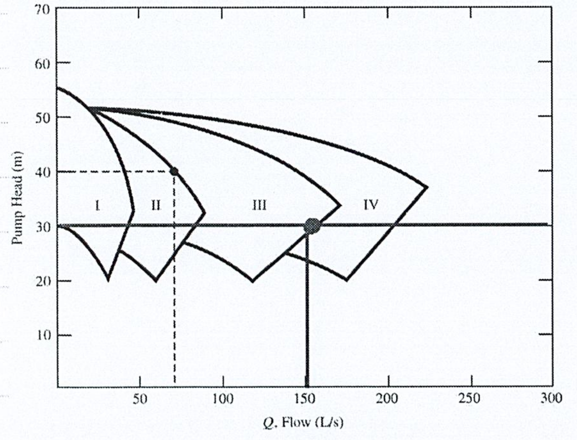
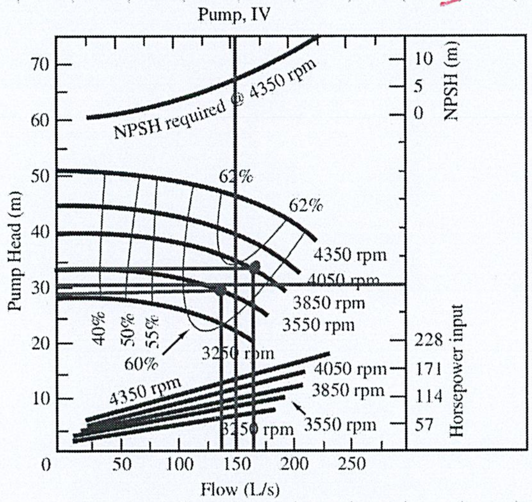


Figure 5.23 Pump model selection chart



Answer: 2 Pump IV in Parallel: w = 3850 rpm e = 61 %
Q = 175 L/s Hp = 34m OK!

Any other solutions using other pump types and their combinations? Objective: highest efficiency at lowest cost(s)!