

**Problem 4.9.4:** Two reservoirs are connected with a long pipe which has characteristics such that the head loss through the pipe is expressed as  $h_L = 0.002 Q^2$ , where  $h_L$  is in ft·lb<sub>f</sub>/lb and  $Q$  is the flow rate in gpm. The water surface elevation in reservoir B is 35 feet above that in reservoir A. Two identical pumps are available to pump the water from A to B. The characteristic curve of the pump when operating at 1800 rpm is given below:

$H$ , ft·lb <sub>f</sub> /lb	100	90	80	60	40	20
$Q$ , gpm	0	110	180	250	300	340

At the point of operation the pump delivers 200 gpm at a head of 75 ft·lb<sub>f</sub>/lb. Find the rate of flow under the following conditions: a) single pump operating at 1800 rpm; b) two pumps in series, each operating at 1800 rpm; and c) two pumps in parallel, each operating at 1800 rpm.

**Solution:** System curve is

$$h = \Delta Z \frac{g}{g_c} + h_L = 35 + 0.002 Q^2$$

$Q$ , gpm	$h$ , ft·lb <sub>f</sub> /lb	Single, $H_a$	Series, $H_b$	Parallel, $H_c$
0	35	100	200	100
110	59.2	90	180	
180	99.8	80	160	
220				90
250	160	60	120	
300	215	40	80	
340	266.2	20	40	
360				80
500				60

The intersection of  $H_a$ ,  $H_b$ , and  $H_c$  curves with the system curve  $h$  occurs at 156 gpm, 224 gpm, and 170 gpm, respectively.