33.46 **A piping system transports $500gpm$ of water from one open reservoir to another open reservoir located $80ft$ higher in elevation using a single pump. The suction piping consists of $300ft$ of $6in$ standard weight steel piping with (2) 90-degree elbows and (2) gate valves. The discharge piping consists of $1200ft$ of $5in$ piping with (4) 45-degree elbows, (2) gate valves, and (1) globe valve. All fittings are flanged. What is the total dynamic head for the pump?**

A. $111ft$

B. $149ft$

C. $180ft$

D. $191ft$

Use the modified Bernoulli Equation for head added by a pump.

$$h_A = \frac{P_2 - P_1}{\gamma} + \frac{v_2^2 - v_1^2}{2g} + z_2 - z_1 + h_f$$

The difference in static pressure is zero because both reservoirs are open to the atmosphere.

$$P_2 - P_1 = 0$$

The velocity term is negligible.

$$v_2^2 - v_1^2 \approx 0$$

Calculate the difference in height between the two reservoirs. Consider the source reservoir as State 1 and the destination as State 2.

$$z_2 - z_1 = 80ft$$

The losses are composed of both major and minor losses on both the suction and discharge side of the pump. The pipe size is different on either side of the pump, so the velocity will change even with a constant volume flow rate. Calculate the losses in four separate steps.

$$h_f = h_{f,s,major} + h_{f,d,major} + h_{f,s,minor} + h_{f,d,minor}$$

Use the Steel Pipe Friction Tables to look up typical major losses per $100ft$ of pipe. Obtain the velocity for use in the following step. Start with the major losses for the suction piping.

$$Q = 500gpm$$

$$D = 6in$$

$$v = 5.55\frac{ft}{s}$$

$$h_d = 3.2\frac{ft}{100ft}$$

$$h_{f,s,major} = \left(3.2\frac{ft}{100ft}\right)(300ft) = 9.6ft$$

Find the major losses for the discharge piping.

$$Q = 500gpm$$

$$D = 5in$$

$$v = 8.02\frac{ft}{s}$$

$$h_d = 7.8\frac{ft}{100ft}$$

$$h_{f,s,major} = \left(7.8\frac{ft}{100ft}\right)(1200ft) = 93.6ft$$

Find the minor losses for the suction piping. Use the Flanged Welded Pipe Fittings table to look up the K-factors for various fittings.

$$K = (2)(.29) + (2)(0.1) = 0.78$$

$$h_{f,s,minor} = K\frac{v^2}{2g} = (0.78)\frac{\left(5.55\frac{ft}{s}\right)^2}{2\left(32.2\frac{ft}{s^2}\right)} = 0.37ft$$

Find the minor losses for the discharge piping. Use the Flanged Welded Pipe Fittings table to look up the K-factors for various fittings.

$$K = (4)(0.175) + (2)(0.13) + 6.25 = 7.21$$

$$h_{f,d,minor} = K\frac{v^2}{2g} = (7.21)\frac{\left(8.02\frac{ft}{s}\right)^2}{2\left(32.2\frac{ft}{s^2}\right)} = 7.2ft$$

Calculate the total losses.

$$h_f = 9.6ft + 93.6ft + 0.37ft + 7.2ft = 110.8ft$$

Determine the head added by the pump.

$$h_A = \Delta z + h_f$$

$$h_A = 80ft + 110.8ft = 191ft$$

Answer D