Answer on Question#56928 - Physics - Mechanics - Relativity

Water is pumped from a depth of $h_d = 10\ \text{m}$ and delivered through a pipe of cross section $A = 10^{-2}\ \text{m}^2$ up to a height of $h = 10\ \text{m}$. If it is needed to deliver a volume $Q = 0.2\ \text{m}^3$ per second, find the power required.

Solution:

The pressure difference between the ends of the pipe is given by

$$\Delta p = \rho g(h + h_d),$$

Where $\rho = 1000\frac{\text{kg}}{\text{m}^3}$ – is the density of the water, and $g = 9.8\frac{\text{m}}{\text{s}^2}$ – is the acceleration due to gravity. The speed of water stream is

$$v = \frac{Q}{A}$$

The total power (power to overcome pressure Δp and power to accelerate water to the speed v) is given by

$$P = \Delta pQ + \frac{\rho Q v^2}{2} = \rho g(h + h_d)Q + \frac{\rho Q^3}{2A^2} =$$

$$= 1000\frac{\text{kg}}{\text{m}^3} \cdot 9.8\frac{\text{m}}{\text{s}^2}(10\ \text{m} + 10\ \text{m}) + \frac{1000\frac{\text{kg}}{\text{m}^3}\left(0.2\frac{\text{m}^3}{\text{s}}\right)^3}{2 \cdot (10^{-2}\ \text{m}^2)^2} = 236\ \text{kW}$$

Answer: $236\ \text{kW}$.