

**Problem:**

What is the flow rate in GPM (gallons per minute) for water to run through each of the reversible turbine generators (6 of them) in Ludington's hydro pumped system, assuming the average height at 300 ft and 312 MW (mega watt) power rating for each generator. How long will it take to drain the entire reservoir with a capacity of 27 billions gallons?

**Solution:**

Turbines produces power because water falls and transfer its potential energy to kinetic energy of the turbines motion. Thus:

$$\frac{dm}{dt} gh = P$$

$$\rho * \frac{dV}{dt} gh = P$$

$$\frac{dV}{dt} = \frac{P}{\rho gh} = \frac{312 \text{ MW}}{1000 \frac{\text{kg}}{\text{m}^3} * 9.8 \frac{\text{m}}{\text{s}^2} * 300 * 0.3 \text{ m}} = 353.5 \frac{\text{m}^3}{\text{s}} = 353.5 \frac{264.2 \text{ gallons}}{\frac{1}{60} \text{ min}}$$

$$= 5.6 * 10^6 \text{ GPM}$$

To drain the entire reservoir with a capacity of 27 billions gallons will take:

$$t = \frac{V}{6 * \frac{dV}{dt}} = \frac{27 * 10^9 \text{ gallons}}{6 * 5.6 * 10^6 \text{ GPM}} = 804 \text{ min} = 13.4 \text{ hours}$$

**Answer:**  $\frac{dV}{dt} = 5.6 * 10^6 \text{ GPM}; t = 13.4 \text{ hours}.$