

Problem 2.2

Determine the gravitational potential energy, in kJ, of 2 m^3 of liquid water at an elevation of 30 m above the surface of Earth. The acceleration of gravity is constant at 9.7 m/s^2 and the density of the water is uniform at 1000 kg/m^3 . Determine the change in gravitational potential energy as the elevation decreased by 15 m.

KNOWN: The elevation of a known quantity of water is decreased from a given initial value by a given amount.

FIND: Determine the initial gravitational potential energy and the change in gravitational potential energy.

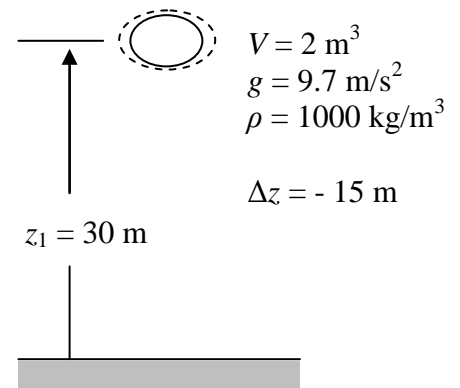
SCHEMATIC AND GIVEN DATA:

ENGINEERING MODEL:

(1) The water is a closed system. (2) The acceleration of gravity is constant. (3) The density of water is uniform.

ANALYSIS: The initial gravitational potential energy is

$$\begin{aligned}
 PE_1 &= mgz_1 = (\rho V)gz_1 \\
 &= \left(1000 \frac{\text{kg}}{\text{m}^3}\right) (2 \text{ m}^3) \left(9.7 \frac{\text{m}}{\text{s}^2}\right) (30 \text{ m}) \left| \frac{1 \text{ N}}{1 \text{ kg} \cdot \frac{\text{m}}{\text{s}^2}} \right| \left| \frac{1 \text{ kJ}}{10^3 \text{ N} \cdot \text{m}} \right| \\
 &= 582 \text{ kJ} \quad \leftarrow
 \end{aligned}$$



The change in potential energy is

$$\begin{aligned}
 \Delta PE &= mg(z_2 - z_1) = mg\Delta z \\
 &= \left(1000 \frac{\text{kg}}{\text{m}^3}\right) \left(9.7 \frac{\text{m}}{\text{s}^2}\right) (-15 \text{ m}) \left| \frac{1 \text{ N}}{1 \text{ kg} \cdot \frac{\text{m}}{\text{s}^2}} \right| \left| \frac{1 \text{ kJ}}{10^3 \text{ N} \cdot \text{m}} \right| \\
 &= -291 \text{ kJ} \quad \leftarrow
 \end{aligned}$$