

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

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



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