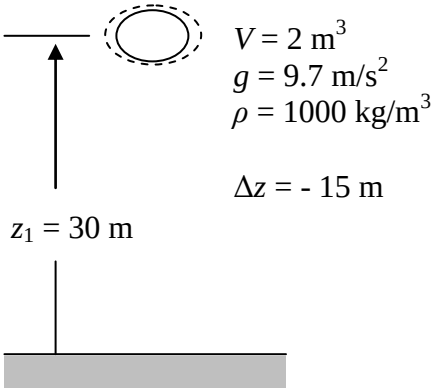
Problem 2.2

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:



ENGINERING 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

$$PE_1 = mgz_1 = (\rho V)gz_1$$

$$= \left(1000\,\frac{\text{kg}}{\text{m}^3}\right)(2\ \text{m}^3)\left(9.7\,\frac{\text{m}}{s^2}\right)(30\ \text{m})\left|\frac{1\ \text{N}}{1\ \text{kg}\cdot\frac{\text{m}}{\text{s}^2}}\right|\left|\frac{1\ \text{kJ}}{10^3\ \text{N}\cdot\text{m}}\right|$$

$$= 582\ \text{kJ} \longleftarrow$$

The change in potential energy is

$$\Delta PE = mg(z_2 - z_1) = mg\Delta z$$

$$= \left(1000\,\frac{\text{kg}}{\text{m}^3}\right)\left(9.7\,\frac{\text{m}}{s^2}\right)(-15\ \text{m})\left|\frac{1\ \text{N}}{1\ \text{kg}\cdot\frac{\text{m}}{\text{s}^2}}\right|\left|\frac{1\ \text{kJ}}{10^3\ \text{N}\cdot\text{m}}\right|$$

$$= -291\ \text{kJ} \longleftarrow$$