Work = \text{force} \times \text{distance}

English unit of work is a foot-pound.

The work needed to lift a 1 lb object up 1 foot.

Metric units are different.

Force = \text{mass} \times \text{acceleration}

(Neitohn's first law)

Acceleration due to normal gravity on earth = 9.8 m/\text{sec}^2 = g
metric unit of force: 1 Newton = 1 kg m / sec²

It takes a force of 9.8 N to lift an object with mass 1 kg.

Work = force x distance

1 Joule = 1 Newton - meter.
Let $y$ be the distance from the top.

Distance we need to lift a weight of layer of water:

- density $\times$ volume

- $62.5 \text{ lb/ft}^3 \times \text{area} \times \text{thickness}$
\[
\begin{align*}
&= \frac{62.5 \text{ lbs}}{\text{ft}^3} \times 11 \times (15 \text{ ft})^2 \cdot \Delta y \\
&= 62.5 \times 11 \times 225 \Delta y \text{ lbs} \\
&= 44000 \Delta y \text{ lbs}.
\end{align*}
\]

Work needed to lift this layer of H2O to the top is 44000 \( \Delta y \) ft-lbs.

Total work

\[
\begin{align*}
&= \int_{0}^{8} 44000 y \, dy \\
&= \left[ \frac{44000 y^2}{2} \right]_{0}^{8} \\
&= 44000 \times 8^2 - 0 \\
&= 544000 \text{ ft-lbs}.
\end{align*}
\]
This spring exerts a force of 20 lbs for each 1 ft of stretching, i.e., 20 lbs for each ft.

Work = force \times distance

Let \( x \) = distance stretched

\( F = 20x \)

\[ \text{Work} = \int_0^1 20x \, dx \]

\[ = 20 \left[ \frac{x^2}{2} \right]_0^1 \]

\[ = 20 \left( \frac{1^2}{2} \right) = 10 \text{ ft-lb} \]
SPRING WELL

\[ x \rightarrow x + \Delta x \]

\[ 20x \Delta x = \text{work needed to move from } x \text{ to } x + \Delta x \]

Hooke's law: Force required to stretch/compress a spring is proportional to the distance.

\[ \text{Force} = K \times \text{distance} \]

\( K \) is a constant depending on the spring.

\( K = \frac{2}{0.1} = 20 \) in our case
Density = 1540 kg/m³

Let y be distance from bottom.
The layer at height y needs to be lifted 6-y m.

Weight = density x volume
\[
\begin{align*}
&= \frac{1540 \text{ kg}}{\text{m}^2} \times \text{area} \times \text{thickness} \\
&= 1540 \pi (\text{radius})^2 \Delta y \\
&= 1540 \pi \left(\frac{20y}{6}\right)^2 \Delta y \\
&= 1540 \left(\frac{20}{6}\right)^2 y^2 \Delta y \\
&\approx 54,000 \ y^2 \Delta y \ \text{kg} \\
\text{Force needed to lift this layer is} \\
&= 9.8 \ \text{(N)} \\
&= 526,000 \ y^2 \Delta y \ \text{N} \\
\text{Work needed} = \text{force} \times \text{distance}
\end{align*}
\]
Total work = \int_0^5 526,000 \cdot y \cdot (6-y) \, dy