1. Write an integral which gives the exact length of the curve $f(x) = \cos x$ from $x = 0$ to $x = \pi$. Sketch it. Determine the value of that integral using your graphing calculator.

2. Find the volume of the solid obtained by rotating the region bounded by $y = x^2$, $y = x^3$, $x = 0$, and $x = 1$ around the $x$-axis. Sketch the region.

3. A water tank has the shape of a right circular cylinder, with height 30 ft and radius 8 ft. It is standing on its circular base and is half full of water. Find the work required to take the water out of the tank from the top.

4. A dam has the shape of a trapezoid with horizontal parallel sides measuring 30 meters (bottom) and 40 meters (top). The height of the dam is 30 meters, and one vertical side is perpendicular to both base and top. The dam has water up to the top. Find the total force of the water on the dam.

5. (a) Use to comparison test to determine whether the following integral converges or diverges. Explain your answer carefully.

\[ \int_1^\infty \frac{s^2}{s^3 - s} \, ds \]

(b) Use the definition of improper integrals to determine whether or not the following integral converges or diverges and if it converges, give its value.

\[ \int_3^\infty \frac{1}{5^x} \, dx \]

6. Consider the function $p(x)$ defined by

\[ p(x) = \begin{cases} 
\frac{x^2}{9}, & 0 < x < 3 \\
0, & \text{otherwise}
\end{cases} \]

(a) Show that $p(x)$ is a probability density function (pdf).

(b) What is the probability that if I select a member of the population at random that their $x$ value will be between 1.2 and 1.8?

(c) Compute the mean of this distribution.

7. Find the number $c$ such that the average of $f(x) = 6x - 3x^2$ on the interval $[1, c]$ is equal to 3.

8. Find the area of the region enclosed by the one loop of the curve:

\[ r = 4 + 3 \sin \theta \]