1. Compute $\lim_{{x \to 1}} \left( \frac{1}{x - 1} - \frac{1}{\ln(x)} \right)$.

2. Suppose $f$ is the function defined by

$$f(x) = \begin{cases} 
2, & \text{if } 0 < x < 1 \\
1, & \text{if } 1 < x < 2 \\
-1, & \text{if } 2 < x < 3
\end{cases}$$

Sketch the graph of $f$. Then sketch the graph of a continuous function $F$ which is an antiderivative of $f$ on the interval $(0, 3)$.

3. Compute $\int_{{-2}}^{{2}} (3 + \sqrt{4 - x^2}) \, dx$. (Hint: you may wish to sketch the graph of this function first.)

4. Estimate the value of $\int_{{1}}^{{3}} \frac{1}{x^3 + 1} \, dx$ by computing a Riemann sum for this integral. Your Riemann sum must have at least 4 summands. Your final answer may be in the form of unsimplified fractions, e.g. $\frac{2}{3} + \frac{15}{16} + \frac{1}{2}$ would be a suitable form for an answer.

5. Use the properties of integrals to explain why $\int_{{1}}^{{\pi}} \frac{\sin(x^2)}{x} \, dx \leq \ln(\pi)$.

6. If $G(x) = \int_{{2x}}^{{x^2}} \tan(\sqrt{t}) \, dt$, then compute $G'(x)$.

7. Evaluate $\int_{{0}}^{{4}} (4 - t) \sqrt{t} \, dt$.

8. Evaluate $\int_{{-\pi/2}}^{{\pi/2}} x \sin(x^2) \, dx$.

9. Find an antiderivative of $\frac{e^t}{e^t + 3}$

10. What is the volume of the portion of the unit sphere $x^2 + y^2 + z^2 \leq 1$ where $z \geq \frac{1}{2}$? (You could call it the “top half of the northern hemisphere”, although it clearly has less than half the volume even though it has half the height!)