NOTE: When asked to set up an integral, do not simplify or evaluate the integral. All limits of integration must be written as exact values.

For problems 1-2, let \( f(x) = \arctan x \) on the interval \( 0 \leq x \leq 1 \).

1. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral that gives the arc length of the curve on the interval.
   a. With respect to \( x \). (5 pts)
   
   
   b. With respect to \( y \). (5 pts)

2. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral that gives the surface area of the solid generated when the curve on the given interval is rotated around the \( x \)-axis. (5 pts)

For problems 3-4, suppose that a spring has natural length of 2 ft and 45 ft-lbs of work are needed to stretch the spring by 9 inches over its natural length. Give the answer with proper units.

3. Find the spring constant. Show your work. (5 pts)

4. Determine how much work is needed to stretch the spring from 2.5 ft to 3 ft. Show your work. (5 pts)
For problems 5-10 a curve is defined by the parametric equations \( x = 4e^{t/2} \) and \( y = e^t - t \) for \(-2 \leq t \leq 2\).

5. Use your calculator to sketch the graph of the parametric curve. Indicate direction and label the initial and terminal points, with both \( t \) and \((x, y)\), as exact values. (5 pts)

6. Analytically (without the use of your calculator) find \( \frac{dy}{dx} \) in parametric form. Show all work. (5 pts)

7. For the interval \([-2,2]\), analytically (without using your calculator) find all points, both \( t \) and \((x, y)\) as exact values, on the curve where the tangent line is horizontal. Show your work. (5 pts)
8. Analytically find the equation of the line tangent to the curve at $t = -1$. Express all coefficients as exact values. Show your work. (5 pts)

9. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral that gives the arc length of the curve on the interval. (5 pts)

10. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral (in terms of t) that gives the surface area of the solid generated when the curve on the given interval is rotated around the x-axis. (5 pts)
For problems 11-14, use the polar equations $r_1 = 1 + \sin \theta$ and $r_2 = 1 - \sin \theta$ on $[0, 2\pi]$.

11. Accurately sketch and label $r_1$ and $r_2$. (3 pts)

12. a. Analytically find and label the polar coordinates $(r, \theta)$, as exact values, of all points of intersection (collision) of the two curves, $r_1$ and $r_2$ on the interval $[0, 2\pi]$. Show your work. (5 pts)

b. Analytically find the Cartesian coordinates $(x, y)$, as exact values, of the polar points you found in part (a). Show your work. (4 pts)

13. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral that gives the area enclosed by the curve $r_1$ above the horizontal axis. (6 pts)

14. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral that gives the area that lies inside the curve $r_1$ and outside the curve $r_2$. Shade this region on the graph. (8 pts)
Note: When discussing convergence, please state (in words) whether you are talking about a sequence or a series.

For problems 15-19, let $a_n = \frac{3}{2n + 7} - \frac{3}{2n + 9}$ for $n \geq 1$.

15. List the first four terms of $\{a_n\}$. Do not simplify. (2 points)

   $a_1 = \underline{} \hspace{2cm} a_2 = \underline{}$

   $a_3 = \underline{} \hspace{2cm} a_4 = \underline{}$

16. Analytically determine if $\{a_n\}$ converges. (3 points)

17. Determine a formula for $s_n = a_1 + a_2 + a_3 + \cdots + a_n$. (3 points)

18. Analytically determine if $\{s_n\}$ converges. (3 points)

19. Does $\sum_{n=1}^{\infty} a_n$ converge? Explain why or why not. (3 points)
For problems 20-21, state if the expression is a sequence or series and determine if it converges or diverges. If a sequence converges, find its limit. If a series converges analytically find its exact sum. Show all work analytically. Summarize your conclusion in sentence form. (5 points each)

20. \[ \sum_{n=0}^{\infty} \frac{(-3)^{n+2}}{7^n} \]

21. \[ \sum_{n=0}^{\infty} \frac{3n^2 + 1}{2n + 1} \]