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 1-3, let \( f(x) = \arctan(2x) \) on the interval \( 0 \leq x \leq 1/2 \).

1. Sketch the curve on the given interval. (2 pts)

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

3. 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
   a. with respect to x. (5 pts)
   b. with respect to y. (5 pts)
For problems 4-8 a curve is defined by the parametric equations \( x = 6t - \frac{1}{2}t^3 \) and \\
\( y = \frac{1}{4}t^4 - 4t^2 + 9 \) for \(-4 \leq t \leq 4\).

4. 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. (6 pts)

5. Analytically (without using your calculator) find \( \frac{dy}{dx} \). (6 pts)

6. Analytically (without using your calculator) find all point(s), both \( t \) and \((x, y)\) as exact values, on the interval \(-4 \leq t \leq 4\) where the tangent line is vertical to the curve. Show your work. (7 pts)

7. Analytically (without using your calculator) find all point(s), both \( t \) and \((x, y)\) as exact values, on the interval \(-4 \leq t \leq 4\) where the tangent line is horizontal to the curve. Show your work. (7 pts)
8. Set up (DO NOT EVALUATE OR SIMPLIFY) the integral that gives the length of the curve on the interval \(-4 \leq t \leq 4\). (6 pts)

9. Find a curve through the point (4, 20) whose arc length is \(L = \int_{1}^{4} \sqrt{1 + 9x} \, dx\). (6 points)

10. For the point \((-\sqrt{3}, -1)\), given in Cartesian form, analytically find two sets of polar coordinates. Your answers must be chosen so that the \(\theta\) values lie between 0 and \(2\pi\). (6 pts)
For problems 12-14, use the polar equations \( r_1 = 4(1 - \cos \theta) \) and \( r_2 = \frac{3}{1 + \cos \theta} \) on \([0, 2\pi]\).

11. Accurately sketch and label \( r_1 \) and \( r_2 \). (4 pts)

12. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral that gives the area inside the upper half of the cardioid \( r_1 \). (6 pts)

13. Analytically find and label on the graph above the polar coordinates \((r, \theta)\) as exact values) of all points of intersection of the two curves \( r_1 \) and \( r_2 \) on the interval \([0, 2\pi]\). Show your work. (6 pts)

14. Set up (DO NOT EVALUATE OR SIMPLIFY.) the integral that gives the area of the region inside the cardioid \( r_1 \) and outside the parabola \( r_2 \). Shade this region on the graph. (7 pts)
For problems 15-18, analytically determine if the sequence converges or diverges. Find the limit of each convergent sequence. State your conclusion in a complete sentence. (4 pts each)

15. \(a_n = \frac{\ln n}{\ln(2n)}\)

16. \(a_n = (-1)^n \left(\frac{5}{4}\right)^n\)

17. \(a_n = n \sin\left(\frac{1}{n}\right)\)

18. \(a_n = \frac{(2n-1)!n^2}{(2n+1)!}\)