1. [10 points] Starting from the Product Rule for derivatives derive the formula for Integration by Parts.

2. [10 points] \( \int_{0}^{\infty} e^{-x} \cos(x) \, dx \).

3. [10 points] \( \int_{0}^{4} \frac{1}{x^2 - 4} \, dx \).
4. [15 points] \[ \int \frac{dt}{\sqrt{t^2 - 6t + 13}} \]

5. [10 points] \[ \int \tan^2(x) \sec^4(x) \, dx \]

6. [10 points] Find the limits: (a) \[ \lim_{x \to 1} \frac{\ln x}{x - 1} \] (b) \[ \lim_{\theta \to \pi} \frac{\sin \theta}{1 - \cos \theta} \]
7. [10 points] Find the centroid of the region bounded by \( y = \sqrt{4 - x^2} \) and the \( x \)-axis. Hint: you should recognize the shape of this curve; graph it.

8. [10 points] Use the surface area of rotation integral to derive the formula for the surface area of a sphere of radius \( R \).

9. [5 points] Set up an integral to find the arc length determined by the graph of \( y = \sin x \) from \( x = 0 \) to \( x = \pi \).

10. [10 points] What is the smallest value of \( n \) for which the Trapezoidal Rule approximation for \( \int_1^3 (1/x) \, dx \) to be accurate to within 0.0001? Hint: \( |E_T| \leq \frac{K(b - a)^3}{12n^2} \), where \( K = \max\{|f''(x)| : a \leq x \leq b\} \).
11. [20 BONUS points] An astroid is the shape shown below which is determined by the graph of $x^{2/3} + y^{2/3} = 1$.

(a) Find the total length.
(b) Set up an integral to find the area inside.
(c) Find the surface area generated when it is rotated about the $y$-axis.
(d) Find the volume inside.