1. [10 points] For each problem find the limit or show why it diverges.
   
   a. \( \lim_{x \to \infty} \frac{\ln x}{\sqrt{x}} \)
   
   b. \( \lim_{x \to 1} \frac{\arctan(x) - (\pi/4)}{x - 1} \)

2. [15 points] (a) [7 points] Derive the reduction formula
   \[
   \int x^n e^x \, dx = x^n e^x - n \int x^{n-1} e^x \, dx. \quad (n \geq 1)
   \]

   (b) [8 points] Use it to find \( \int x^3 e^x \, dx \). (Simplify your answer.)

3. [10 points] Find \( \int_{-\pi}^{\pi} \cos 3x \cos 2x \, dx \). (Show work, even if you know what it should be.)
4. [20 points] Evaluate $\int \frac{\sqrt{x^2 - 9}}{x} \, dx$. (Remember to put your final answer in terms of $x$.)
5. [15 points] Evaluate \( \int_{3}^{\infty} \frac{1}{x^2 - 4} \, dx \).

6. [5 points] Set up the integrals needed to find the centroid \((\bar{x}, \bar{y})\) of the region bounded by the line \( y = x \) and the curve \( y = x^3 \), with \( x \geq 0 \). DO NOT EVALUATE THEM.

7. [5 points] The arc of the parabola \( y = x^2 \) from \((1,1)\) to \((2,4)\) is rotated about the \( y \)-axis. Set up an integral to find the surface area. DO NOT EVALUATE IT.
8. [20 points; 5 each] Consider the curve given by the parametric equations \( x(t) = t^3 - 3t \), \( y(t) = 3t^2 - 3 \). See figure.

(a) Label the points where \( t = -2 \), \( t = 0 \), and \( t = 2 \). Draw arrows that indicate the direction of the motion.

(b) Find the coordinates where the tangent line is
(i) horizontal, (ii) vertical. (Use calculus; show your work.)

(c) Set up an integral to find the arc length from \( t = -2 \) to \( t = 2 \).

(d) Evaluate this integral. Warning: this requires some tricky algebra, but the final integral is easy.