1. Evaluate and simplify the derivatives of the following functions of $x$.

(a) (7 pts) $f(x) = (3x^2 - 1)4^x$

(b) (7 pts) $g(x) = \ln \sqrt{e^{x^2}}$

(c) (7 pts) $h(x) = x^2 \tan^{-1} x$

(d) (7 pts) $j(x) = e^{-4x} \sin(3x)$

(e) (7 pts) $k(x) = \log_3(1 + e^x)$
2. Evaluate and simplify the following integrals:

(a) (8 pts) \( \int x \ln x \, dx \)

(b) (8 pts) \( \int_{1}^{\pi} \frac{dx}{x \sqrt{1 - (\ln x)^2}} \)

(c) (8 pts) \( \int \frac{t - 3}{t^2 + 16} \, dt \)
(d) (8 pts) \( \int (1 + \tan^2 x)e^{\tan x} \, dx \)

3. Use l’Hopital’s Rule to evaluate:

(a) (7 pts) \( \lim_{x \to 0} \left( \frac{1}{x} - \frac{1}{\sin x} \right) \)

(b) (6 pts) \( \lim_{x \to \frac{\pi}{2}} (1 + 4 \cot x)^{\tan x} \)
4. Consider the function $f(x) = \cosh(e^x)$.

(a) (7 pts) Show that $f(x)$ has an inverse on its whole domain.

(b) (6 pts) Find the slope of the tangent line to $y = f^{-1}(x)$ at the point $\left(\frac{e^2 + e^{-2}}{2}, \ln 2\right)$.

5. (9 pts) Use logarithmic differentiation to find the derivative of

$$f(x) = \cos^5 x \sqrt{\frac{x^2 - 1}{x^2 + 1}}$$