For problems 1-3, find the derivative of the function. (9 points each)

1. \( f(x) = \sqrt{\arcsin(3x)} \)

2. \( y = \ln \left( \frac{\sqrt{\sin x \cos x}}{1 + 2 \ln x} \right) \)

3. \( y = x^{(e^x)} \)
For problems 4-7, evaluate the integral. If the method of substitution is required, be sure to write out \( u \) and \( du \). For a definite integral give the exact value. (9 points each)

4. \[ \int_{0}^{1} \frac{dx}{3x - 2} \]

5. \[ \int \frac{e^{2x}}{\sqrt{1 - e^{4x}}} \, dx \]
6. \( \int \frac{\cos(\ln x)}{x} \, dx \)

7. \( \int_{0}^{1} \frac{\arctan x}{1 + x^2} \, dx \)
For problems 8-9, evaluate the limit. If the limit is indeterminate, give its form. Show all work. (7 points each)

8. \[ \lim_{\theta \to 0} \frac{3 \sin \theta - 1}{\theta} \]

9. \[ \lim_{x \to 0^+} \left( \frac{1}{\sin x} - \frac{1}{x} \right) \]
For the applications, 10-12, give the answers as exact values.

10. At what point on the curve $f(x) = [\ln(x + 4)]^2$ is the tangent line horizontal.
   Analytically justify and show your work. (9 points)

11. Radium has a half-life of 1600 years. How many years does it take for 90% of a given amount of radium to decay? Show all work. Give the answer in a complete sentence. (9 points)
12. Let R be the region bounded by $y = \ln x$, $y = 0$, $x = 1$, and $x = e$. Shade the region R. Find the area of R integrating with respect to y. Show all work. (10 points)