1. A particle moving along a curve in the plane has a position \((x(t), y(t))\) at time \(t\), where \(\frac{dx}{dt} = \sqrt{t^2 - 1}\) and \(\frac{dy}{dt} = e^{4t}\) for all real values of \(t\). At time \(t = 3\), the particle is at \((-4,6)\).
   a. Find the speed of the particle and the acceleration vector at \(t = 3\).
   speed: \(\sqrt{26 + (e^{13})^2} = 5e^{13}\) \(\approx 2.648, 4e^{13}\)
   b. Find the equation of the line tangent to the path of the particle at time \(t = 3\).
      \(y - 6 = \frac{e^{13}}{\sqrt{26}} (x + 4)\)
   c. Find the integral that will give you total distance traveled of the particle over the time \(3 \leq t \leq 6\), do not evaluate the definite integral.
      \(\int_3^6 \sqrt{(\sqrt{t^3 - 1})^2 + (e^{4t+1})^2} \, dt\)
   d. Find the \(y\)-coordinate of the position of the particle at time \(t = 3\), do not evaluate the definite integral.
      \(y(1) = \int_3^6 e^{4t+1} \, dt + 6\)

2. Given \(r = 3 - 5\sin \theta\)
   a. Write an integral to find the area of the polar region from \(0 \leq \theta \leq \pi\), do not evaluate it.
      \(A = \frac{1}{2} \int_0^\pi (3 - 5\sin \theta)^2 \, d\theta\)
   b. Find \(\frac{dx}{d\theta}\) and \(\frac{dy}{d\theta}\) in terms of \(\theta\).
      \(y'(\theta) = 5\cos \theta (\sin \theta) + (3 - 5\sin \theta) (\cos \theta)\)
      \(x'(\theta) = -5 \cos \theta (\cos \theta) + (3 - 5\sin \theta) (-\sin \theta)\)
   c. Find the equation of the tangent line in terms of \(x\) and \(y\) when \(\theta = \frac{\pi}{4}\).
      \(y - (3 - \frac{5\sqrt{2}}{2}) (\frac{\sqrt{2}}{2}) = \frac{3\sqrt{2}}{10 + 3\sqrt{2}} \left( x - (3 - \frac{5\sqrt{2}}{2}) (\frac{\sqrt{2}}{2}) \right)\)
3. A particle moving along a curve in the plane has a position \((x(t), y(t))\) at time \(t\), where \(x(t) = -2t + \frac{t^2}{2}\) and \(y(t) = -t^2 + 6t\) for all real values of \(t\).

a. Find the velocity vector at any time \(t\), and find the speed of the particle at \(t=1\).
   \[
   \text{vel} = \left<-1, 4\right> \quad \text{speed} = \sqrt{17}
   \]

b. Is the particle moving to the left or right at time \(t=1\)? Is the particle moving up or down at time \(t=1\)? Justify your answer!
   \[
   \text{Left, up} \\
   \text{(neg. velocity, pos. velocity)}
   \]

c. What is the slope of the tangent line at time \(t=1\)?
   \[
   \text{slope} = -4
   \]

d. Is the particle ever completely at rest, if so when?
   \[
   t=2, t=3
   \]
   \[
   \text{NO}
   \]

4. What is the area of the region enclosed by the lemniscate \(r^2 = 18 \cos(2\theta)\)?
   \[
   A = 2 \cdot \int_{\pi/4}^{3\pi/4} 18 \cos(2\theta) d\theta
   \]

5. Set up but do not evaluate the integral expression the gives area enclosed by the smaller loop of the graph of \(r = 1 + 2\sin\theta\).
   \[
   A = \frac{1}{2} \int_{\pi/4}^{3\pi/4} (1 + 2\sin\theta)^2 d\theta
   \]

6. Set up but do not evaluate the integral expression the gives area of one loop of the graph of \(r = 2\sin(3\theta)\).
   \[
   A = \frac{1}{2} \int_{0}^{\pi/3} (2\sin 3\theta)^2 d\theta
   \]

7. Find the area of the region inside the polar curve \(r = 4\sin\theta\) and outside the curve \(r = 2\).
   \[
   A = \frac{1}{2} \int_{\pi/6}^{7\pi/6} \left((4\sin\theta)^2 - 2\right) d\theta
   \]

8. In the xy plane the graph of the parametric equations \(x = 5t + 2\) and \(y = 3t\) for \(-3 \leq t \leq 3\) is a line segment with slope \(\frac{3}{5}\).

9. A particle moves in the xy plane so that its position at any time \(t\) is given by \(x(t) = t^2\) and \(y(t) = \sin(4t)\). What is the speed of the particle when \(t = 3\)?
   \[
   \text{speed} = \sqrt{16^2 + (4\cos12)^2} \approx 6.88
   \]