1. (a) **(2 points)** Transform the equation $r = \csc\theta \cot\theta$ into rectangular coordinates and sketch its graph.

   (b) **(3 points)** Transform the polar equatoin $x^2 + y^2 + 4y = 0$ into a polar equation of the form $r = f(\theta)$ and sketch its graph.

   (c) **(2 points each)** Sketch the graphs of the following polar equaions

      i. $r = \cos\theta,\ \frac{\pi}{2} \le \theta \le \pi$

      ii. $r = 1 + \cos\theta,\ -\frac{\pi}{2} \le \theta \le \pi$

      iii. $r = 2\sec\theta,\ 0 \le \theta \le \frac{\pi}{4}$.

2. (a) **(3 points)** Find $\frac{dy}{dx}$ at $t = \frac{\pi}{6}$ for the parametric curve $x = t + \cos t$, $y = 1 - \sin t$.

   (b) **(2 points each)**

      i. Show that the arc length of the cardioid $r = 1 + \cos\theta$ is given by $L = \sqrt{2}\int_0^{2\pi} \sqrt{1 + \cos\theta} d\theta$.

      ii. Using the identity $1 + \cos\theta = 2\cos^2\frac{\theta}{2}$ show how to compute the arc length of the cardioid.

   (c) **(4 points)** Find the equation of the tangent line to the graph of the curve $r = \frac{1}{\theta}$ at $\theta = \frac{\pi}{2}$.

3. (a) **(2 points)** Set up an integral to compute the area of the region in the first quadrant within the cardioid $r = 1 + \sin\theta$.

   (b) **(3 points each)**

      i. Find all points of intersection of the two cardioids $r = 1 + \cos\theta$ and $r = 3(1 - \cos\theta)$.

      ii. Give the common area between the two cardioids in terms of integrals.