2. [12 points] Consider a particle whose trajectory in the xy-plane is given by the parametric curve defined by the equations

$$x(t) = t^4 - 4t^2, \qquad y(t) = t^2 - 2t,$$

for $-3 \leq t \leq 3$. Show all your work to receive full credit.

a. [3 points] Is there any value of t at which the particle ever comes to a stop? Justify.

b. [2 points] For what values of t does the path of the particle have a vertical tangent line?

c. [3 points] What is the lowest point (x, y) on the curve?

d. [2 points] At what values of t does the particle pass through the origin?

e. [2 points] The graph of the curve traced by these parametric equations is shown below. Find an expression for the length of the closed loop marked in the graph.