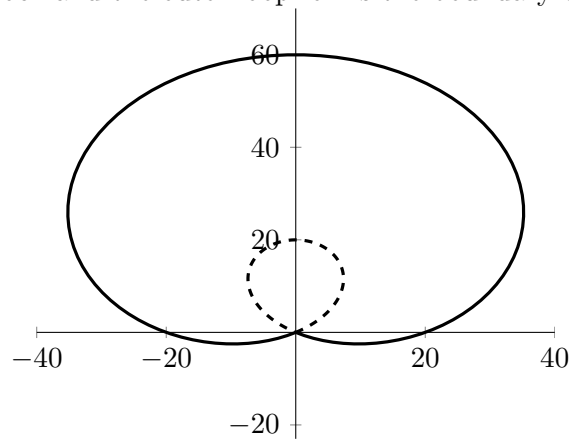


9. [10 points] Linda is designing a pond with a flat rock at one end. The rock plus the pond are in the shape of a cardioid. Plans for her pond design are depicted below. The cardioid has equation  $r = 20 + 40 \sin \theta$  where  $r$  is in feet and  $\theta$  is in radians. The inner loop of the cardioid forms the shape of the rock and the outer loop forms the boundary of the pond.



- a. [2 points] Find all values of  $\theta$  between 0 and  $2\pi$  for which  $r = 0$ .
- b. [4 points] Write an integral or sum of integrals which give(s) the perimeter of the boundary of the pond. Note this is the perimeter of the part of the cardioid drawn with a solid line.
- c. [4 points] Write an integral or sum of integrals which give(s) the area of the top of the rock. Note this is the area enclosed by the dashed part of the cardioid.