1. Write out the chain rule for each of the following functions and justify your answer in each case using this following Theorem.

Theorem: Chain Rule

Let and be given functions such that maps into , so that is defined. Suppose is differentiable at and is differentiable at . Then is differentiable at and . The right-hand side is the matrix product of with .

1. where
2. where
3. where
4. Verify the chain rule for , where and

, , .

1. Suppose that the temperature at the point in space is . Let a particle follow the right-circular helix and let be its temperature at time . What is ?
2. Captain Ralph is in trouble near the sunny side of Mercury. The temperature of the ship’s hull when he is at location will be given by , where and are measured in meters. He is currently at
3. In what direction should he proceed in order to decrease the temperature most rapidly?
4. If the ship travels at meters per second, how fast will be the temperature decrease if the proceeds in that direction?
5. Unfortunately, the metal of the hull will crack if cooled at a rate greater than degrees per second. Describe the set of possible directions in which he may proceed to bring the temperature down at no more than that rate.