

HOMEWORK 3 SOLUTIONS

All questions are from Vector Calculus by Marsden and Tromba

Question 1: 2.2.12 Compute the following limits if they exist:

(a) $\lim_{x \rightarrow 0} \frac{\sin 2x - 2x}{x^3}.$

(b) $\lim_{(x,y) \rightarrow (0,0)} \frac{\sin 2x - 2x + y}{x^3 + y}.$

(c) $\lim_{(x,y,z) \rightarrow (0,0,0)} \frac{2x^2y \cos z}{x^2 + y^2}.$

Solution:

(a) By L'Hopital's rule,

$$\begin{aligned} \lim_{x \rightarrow 0} \frac{\sin 2x - 2x}{x^3} &= \lim_{x \rightarrow 0} \frac{2 \cos 2x - 2}{3x^2} \\ &= \lim_{x \rightarrow 0} \frac{-4 \sin 2x}{6x} \quad (\text{again by L'Hopital}) \\ &= -\left(\frac{4}{3}\right) \lim_{x \rightarrow 0} \frac{\sin 2x}{2x} = -\frac{4}{3} \end{aligned}$$

since

$$\lim_{\theta \rightarrow 0} \frac{\sin \theta}{\theta} = 1.$$

(b) From (a), for $y = 0$

$$\frac{\sin 2x - 2x}{x^3} \quad \text{approaches} \quad -\frac{4}{3}$$

as $(x, 0)$ approaches $(0, 0)$. Setting $y = 2x$, we see that

$$\frac{\sin 2x - 2x + y}{x^3 + y} = \frac{\sin 2x}{x^3 + 2x} = \frac{\sin 2x}{2x} \left(\frac{2}{x^2 + 2} \right)$$

and hence

$$\lim_{(x, 2x) \rightarrow 0} \frac{\sin 2x - 2x + y}{x^3 + y} = \lim_{x \rightarrow 0} \frac{\sin 2x}{2x} \cdot \frac{2}{x^2 + 2} = 1 \cdot 1 = 1.$$

Therefore,

$$\frac{\sin 2x - 2x + y}{x^3 + y}$$

has two different limits along two different rays approaching the origin $(0, 0)$, and consequently

$$\lim_{(x,y) \rightarrow (0,0)} \frac{\sin 2x - 2x + y}{x^3 + y}$$

does not exist.

Multivariable Calculus Marsden Tromba Solutions Manual

Brian E. Blank, Steven G. Krantz



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
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