

# Multivariable and Vector Calculus: Homework 3

Alvin Lin

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## Section 12.6

### Exercise 11

Use traces to sketch and identify the surface.

$$x = y^2 + 4z^2$$

$$\begin{array}{cccc} x = 0 & x = 1 & x = 5 & y = 0 \\ 0 = y^2 + 4z^2 & 1 = y^2 + 4z^2 & 5 = y^2 + 4z^2 & x = 4z^2 \end{array}$$

The surface is an elliptic paraboloid expanding along the positive x-axis.

### Exercise 13

Use traces to sketch and identify the surface.

$$x^2 = 4y^2 + z^2$$

$$\begin{array}{cccc} x = 0 & x = 1 & x = 2 & y = 0 \\ 0 = 4y^2 + z^2 & 1 = 4y^2 + z^2 & 4 = 4y^2 + z^2 & x^2 = 4z^2 \\ & & & x = \pm 2z \end{array}$$

This surface is a cone defined by ellipses along the x-axis.

### Exercise 15

Use traces to sketch and identify the surface.

$$9y^2 + 4z^2 = x^2 + 36$$

$$\begin{array}{cccccc} x = 0 & x = 1 & x = 2 & y = 0 & y = 2 & \\ 9y^2 + 4z^2 = 36 & 9y^2 + 4z^2 = 37 & 9y^2 + 4z^2 = 40 & 4z^2 - x^2 = 36 & 36 + 4z^2 = x^2 + 36 & \\ & & & & 4z^2 - x^2 = 0 & \end{array}$$

This surface is a hyperboloid of one sheet.

### Exercise 47

Find an equation for the surface consisting of all points that are equidistant from the point  $(-1,0,0)$  and the plane  $x = 1$ . Identify the surface.

$$\text{Plane} \equiv 1x + 0y + 0z - 1 = 0$$

$$\begin{aligned} d_1 &= d_2 \\ \sqrt{(x+1)^2 + y^2 + z^2} &= \frac{|1x - 1|}{\sqrt{1^2}} \\ (x+1)^2 + y^2 + z^2 &= (x-1)^2 \\ x^2 + 2x + 1 + y^2 + z^2 &= x^2 - 2x + 1 \\ y^2 + z^2 &= -4x \end{aligned}$$

The surface is a series of expanding circles along the negative x-axis. The cross section of the circles is a parabola. The surface is a elliptic paraboloid.

## Section 13.1

### Exercise 31

At what points does the curve  $\vec{r}(t) = t\hat{i} + (2t - t^2)\hat{k}$  intersect the the paraboloid  $z = x^2 + y^2$ ?

$$\begin{aligned} \vec{r}(t) &= \begin{cases} x &= t \\ y &= 2t - t^2 \\ z &= 0 \end{cases} \\ z &= x^2 + y^2 \\ 0 &= t^2 + (2t - t^2)^2 \\ 0 &= t^2 + (4t^2 - 4t^3 + t^4) \\ t^4 - 4t^3 + 5t^2 &= 0 \\ t^2(t - 4)(t - 1) &= 0 \\ t = 4 \quad t = 1 \quad t = 0 & \\ \vec{r}(0) &= \langle 0, 0, 0 \rangle \\ \vec{r}(1) &= \langle 1, 1, 0 \rangle \\ \vec{r}(4) &= \langle 4, -8, 0 \rangle \end{aligned}$$

### Exercise 41

Show that the curve with parametric equations  $x = t^2, y = 1 - 3t, z = 1 + 3t^2$  passes through the points  $(1,4,0)$  and  $(9,-8,28)$  but not through the point  $(4,7,-6)$ .

$$\begin{aligned} 1 = t^2 \quad t = \pm 1 & & 9 = t^2 \quad t = \pm 3 & & 4 = t^2 \quad t = \pm 2 \\ 4 = 1 - 3t \quad t = -1 & & -8 = 1 - 3t \quad t = 3 & & 7 = 1 - 3t \quad t = -2 \\ 0 = 1 + t^3 \quad t = -1 & & 28 = 1 + t^3 \quad t = 3 & & -6 = 1 + t^3 \quad t = \sqrt[3]{-7} \end{aligned}$$

The equation does not solve to the same  $t$  for the point  $(4,7,-6)$ .

### Exercise 43

Find a vector function that represents the curve of intersection of the cone  $z = \sqrt{x^2 + y^2}$  and the plane  $z = 1 + y$ .

$$\begin{aligned} \sqrt{x^2 + y^2} &= 1 + y \\ x^2 + y^2 &= (1 + y)^2 \\ x^2 + y^2 &= 1 + 2y + y^2 \\ x^2 - 2y &= 1 \\ x &= \cos(t) \\ -2y &= \sin^2(t) \\ z &= 1 - \frac{\sin^2(t)}{2} \\ \vec{r}(t) &= \left\langle \cos(t), \frac{-\sin^2(t)}{2}, 1 - \frac{\sin^2(t)}{2} \right\rangle \end{aligned}$$

### Exercise 45

Find a vector function that represents the curve of intersection of the hyperboloid  $z = x^2 - y^2$  and the cylinder  $x^2 + y^2 = 1$ .

$$\begin{aligned} x &= \cos(t) \\ y &= \sin(t) \\ z &= x^2 - y^2 \\ &= \cos^2(t) - \sin^2(t) \\ \vec{r}(t) &= \langle \cos(t), \sin(t), \cos^2(t) - \sin^2(t) \rangle \end{aligned}$$

## Section 13.2

### Exercise 23

Find the parametric equations for the tangent line to the curve with the given parametric equations at the specified point.

$$\begin{aligned} x &= t^2 + 1 \quad y = 4\sqrt{t} \quad z = e^{t^2-t} \quad \text{at } (2, 4, 1) \\ x' &= 2t \quad y' = \frac{2}{\sqrt{t}} \quad z' = (2t - 1)e^{t^2-t} \\ x'(2) &= 4 \quad y'(4) = 1 \quad z'(1) = e^0 = 1 \end{aligned}$$

$$l = \begin{cases} x &= 2 + 4t \\ y &= 4 + t \\ z &= 1 + t \end{cases}$$

### Exercise 27

Find a vector equation for the tangent line to the curve of intersection of the cylinders  $x^2 + y^2 = 25$  and  $y^2 + z^2 = 20$  at the point  $(3,4,2)$ .

$$\frac{x^2}{25} = \cos^2(t)$$

$$x = 5 \cos(t)$$

$$\frac{y^2}{25} = \sin^2(t)$$

$$y = 5 \sin(t)$$

$$z^2 = 20 - y^2 = 20 - 25 \sin^2(t)$$

$$z = \sqrt{20 - 25 \sin^2(t)}$$

$$\vec{r}(t) = \left\langle 5 \cos(t), 5 \sin(t), \sqrt{20 - 25 \sin^2(t)} \right\rangle$$

$$\vec{r}(x) = \langle 3, 4, 2 \rangle$$

$$\cos(x) = \frac{3}{5}$$

$$\sin(x) = \frac{4}{5}$$

$$\vec{r}'(t) = \left\langle -5 \sin(t), 5 \cos(t), \frac{-25 \sin(t) \cos(t)}{\sqrt{20 - 25 \sin^2(t)}} \right\rangle$$

$$\vec{r}'(x) = \left\langle -4, 3, \frac{-12}{\sqrt{4}} \right\rangle$$

$$= \langle -4, 3, -6 \rangle$$

$$\vec{l}(t) = \langle 3 - 4t, 4 + 3t, 2 - 6t \rangle$$

If you have any questions, comments, or concerns, please contact me at [alvin@omgimanerd.tech](mailto:alvin@omgimanerd.tech)