Directions:

1. Section: Math251 007
2. Write your name with one character in each box below.
3. Show all work. No credit for answers without work.

1. **[10 points]** Use matrices and row operations to give a simple description for the set of solutions to the following system.

$$\begin{aligned} x_1 &- 2x_2 &- 9x_3 &= 5 \\ 3x_1 &+ x_2 &- 13x_3 &= 8 \end{aligned}$$

2. Let S be the sphere $x^2 + 3x + y^2 - 2y + z^2 + 4z = 13$.

   (a) **[10 points]** Find the center and radius of S.

   (b) **[6 points]** Give a full geometric description of the curve obtained at the intersection of S and the plane $z = 0$.

3. **[4 parts, 4 points each]** Let $\mathbf{a} = \langle 1, -5, 2\rangle$ and $\mathbf{b} = \langle 1, -1, -2\rangle$. Compute the following.

   (a) $3\mathbf{a} - 2\mathbf{b}$

   (b) $|\mathbf{a}|$

   (c) $\mathbf{a} \cdot \mathbf{b}$

   (d) $\text{proj}_{\mathbf{a}}\mathbf{b}$

4. **[6 points]** Find numbers h and k such that $\langle 3, 2, -5\rangle$ and $\langle h, -1, k\rangle$ are parallel.

5. Let $\mathbf{a} = \langle 2, 1, 0\rangle$ and $\mathbf{b} = \langle -1, 3, 5\rangle$.

   (a) **[8 points]** Find the angle between $\mathbf{a}$ and $\mathbf{b}$. Leave your answer in terms of inverse trigonometric functions.

   (b) **[2 points]** Is the angle between $\mathbf{a}$ and $\mathbf{b}$ acute, obtuse, or right? Explain.

6. Let T be the triangle with vertices $(2, 1, 0)$, $(3, 1, 4)$ and $(1, 5, 1)$.

   (a) **[10 points]** Find a simple equation for the plane containing T.

   (b) **[6 points]** Find the area of T.

7. **[10 points]** If the following lines intersect, then find the point of intersection. If the lines do not intersect, determine if they are parallel or skew.

$$\mathbf{r}_1 = \langle 9, 3, -16\rangle + t\langle 1, 1, 4\rangle \qquad \mathbf{r}_2 = \langle 5, 14, -5\rangle + t\langle -2, 3, 1\rangle$$

8. Consider the surface $\frac{x^2}{4} + y + \frac{z^2}{9} = 1$.

   (a) **[6 points]** Describe the axis-aligned traces.

   (b) **[10 points]** Classify the surface and sketch it, labeling any significant points.