• Be sure to show all your work!

• Be sure to give reasons for your answers!

• Points will probably be taken off if you do not give a clear indication of the method and write your solution neatly, in order, and clearly indicate your final answer.

• Points may be taken off for a correct answer with a mistake in the supporting work.

• No books, notes or calculators of any kind are permitted on the test.

• Write each solution in the space provided, not on scratch paper.

• If you need more room, write on the back of the page.

• Time limit: 1.5 hours (90 minutes). Points may be deducted for exceeding this limit.
1. **In this problem only**, you do not need to give reasons, and only the answer will be graded:

   (a) What are the coordinates of the point in $\mathbb{R}^3$ (3-dimensional space) where the plane $x = 1$ intersects the $x$-axis?

   (b) What is the equation of the sphere with center $(1, 2, 3)$ and radius 4?

   (c) Are the planes $2x - 3y + z = 1$ and $-4x + 6y + z = 0$ parallel?

   (d) Compute $2\mathbf{a} - \mathbf{b}$ if $\mathbf{a} = \langle 1, 3 \rangle$ and $\mathbf{b} = \langle 0, 1 \rangle$.

   (e) Find a unit vector in the direction of $2\mathbf{i} - 3\mathbf{k}$.

   (f) What is the derivative of the vector function $\langle t, t^2, t^3 \rangle$?
2. Let \( \mathbf{a} = 2\mathbf{i} - \mathbf{j} + \mathbf{k} \) and \( \mathbf{b} = \mathbf{i} - 3\mathbf{k} \). Find:

(a) the scalar projection \( \text{comp}_a \mathbf{b} \) of \( \mathbf{b} \) on \( \mathbf{a} \)

(b) the vector projection \( \text{proj}_a \mathbf{b} \) of \( \mathbf{b} \) on \( \mathbf{a} \)

(c) the cosine of the angle between \( \mathbf{a} \) and \( \mathbf{b} \)
3. Let \( \mathbf{a} = (1, -1, 0) \), \( \mathbf{b} = (2, 0, 1) \), and \( \mathbf{c} = (1, 2, 2) \).

   (a) Find the area of a parallelogram with adjacent edges \( \mathbf{b} \) and \( \mathbf{c} \).

   (b) Find the volume of a parallelepiped with adjacent edges \( \mathbf{a} \), \( \mathbf{b} \), and \( \mathbf{c} \).

   (c) Are the vectors \( \mathbf{a} \), \( \mathbf{b} \), and \( \mathbf{c} \) coplanar? Give the reason.
4. (a) Find parametric equations of the line through the point \((1, 2, 3)\) and parallel to the line \(x = 2 - t, y = 3t, z = 5 + t\).

(b) Find an equation of the plane through the point \((1, 5, 1)\) and perpendicular to the vector \((1, -2, 3)\).
5. In parts (a) and (b) of this problem, give a rough sketch of the graph of the equation, and also identify it as one of the following types:

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<table>
<thead>
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<tbody>
<tr>
<td>A</td>
<td>parabolic cylinder</td>
<td>D</td>
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<tr>
<td>B</td>
<td>elliptic cylinder</td>
<td>E</td>
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<tr>
<td>C</td>
<td>hyperbolic cylinder</td>
<td>F</td>
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(a) \( z = y^2 - x^2 \)

(b) \( z^2 = y^2 - x^2 \)
6. Consider the vector function \( \mathbf{r}(t) = (t, \cos t, \sin t) \).

(a) Give a rough sketch of the curve defined by \( \mathbf{r}(t) \), indicating with an arrow the direction in which \( t \) increases.

(b) Find \( \int_0^{\pi/2} \mathbf{r}(t) \, dt \).