*This midterm has **7 questions** on **6 pages**, for a total of 50 points.*

Duration: 50 minutes

- Read all the questions carefully before starting to work.
- Give complete arguments and explanations for all your calculations; answers without justifications will not be marked.
- Continue on the back of the previous page if you run out of space.
- This is a closed-book examination. **None of the following are allowed**: documents, cheat sheets or electronic devices of any kind (including calculators, cell phones, etc.)

Full Name (including all middle names): ____________________

Student-No: ____________________

Signature: ____________________

Question:	1	2	3	4	5	6	7	Total
Points:	12	6	4	8	6	8	6	50
Score:								

12 marks

1. Decide whether each of the sets below is open, closed, or neither. What is the boundary and the interior of each set?

   For this question only, an answer without explanation is sufficient.

   (a) $\{(x, y, z) \in \mathbb{R}^3 : \ 0 < \sqrt{x^2 + y^2} \leq 3\}$

   (b) $\{(x, y, z) \in \mathbb{R}^3 : \ x \geq 0, \ x^2 + y^2 + z^2 \geq 4\}$

6 marks

2. A surface in $\mathbb{R}^3$ has the equation $x^2 - y^2 + \frac{z^2}{4} = 1$. Sketch the surface. Find the equations of intersection of the surface with the planes $z = 0$, $z = 1$, $z = 2$, and sketch these curves.

4 marks

3. A surface in $\mathbb{R}^3$ has the equation $R^2 - 4R\sin\phi + 3 = 0$ in spherical coordinates. Find its equation in cylindrical coordinates.

8 marks

4. Find the equations (in whichever form you prefer) of the line of intersection of the planes $3x - y + z = 2$ and $x + 2y - z = -4$.

6 marks

5. Find the volume of the parallelepiped in $\mathbb{R}^3$ spanned by the vectors $\mathbf{i} - \mathbf{j} + 4\mathbf{k}$, $3\mathbf{j} - \mathbf{k}$, $2\mathbf{i} + \mathbf{j}$.

8 marks 6. Write the vector $\mathbf{w} = 3\mathbf{i} - 5\mathbf{j} + \sqrt{2}k$ as a sum of two vectors $\mathbf{w} = \mathbf{u} + \mathbf{v}$ such that $\mathbf{u}$ is parallel to the plane $x + 2y - 2z = 0$ and the other is perpendicular to it.

6 marks 7. Find the equation of the plane that contains the line $x = t, y = 2t, z = 0$, and the point $(3, -1, -1)$.

This page has been left blank for your workings and solutions.