Instructions. Attempt all questions. Answers must be justified in order to gain full credit. Calculators are not permitted.
Time allowed: 1 hour

1. (4 points) Find angle BAC if $A = (1, -1, 2), B = (2, 2, 1)$, and $C = (0, 3, 1)$.

2. (5 points) Show that the vectors $(\vec{b} \cdot \vec{c})\vec{a} - (\vec{a} \cdot \vec{c})\vec{b}$ and $\vec{c}$ are orthogonal.

3. Let $P = (1, 1, 0), Q = (1, 2, -1)$, and $R = (-2, 2, 1)$ be three point in $\mathbb{R}^3$.

   (i) (5 points) Find the area of triangle PQR

   (ii) (5 points) Find an equation for the plane that contains the points P, Q and R.

4. Let $f(x, y) = 4x^2 + y^2$.

   (i) (4 points) Sketch a contour diagram for f with four labelled contours.

   (ii) (2 points) Find the vertical cross-sections of f corresponding to $x = 0$ and $y = 0$.

   (iii) (5 points) Use the information found in parts (i) and (ii) to sketch the graph of f.

5. (5 points) Find a formula for a function $f(x, y, z)$ whose level surface $f = 3$ is a sphere of radius 4, centered at the point $(-1, 1, 0)$.

6. (10 points) By approaching the origin $(0, 0)$ along different paths, show that the following limit does not exist:

$$\lim_{(x,y)\to(0,0)} \frac{3x^4 y}{x^6 + y^3}$$

7. (5 points) Determine if there is a value for c making the function below continuous everywhere. If so, find it. If not, explain why not.

$$f(x, y) = \begin{cases} c + y, & x \leq 3 \\ 5 - y, & x > 3 \end{cases}$$