

4. Consider the function $f(x, y) := 3(x^2 + y^2 + 1) - (x + y)^2$.

- Find all the critical points of the function f .
- Determine the nature (point of local max/min, saddle point) of the critical point $(-1/3, -1/3)$.

[3, 3]

5. Consider the function $f(x, y) := \ln(x^2 y^{10})$.

- Write down the cartesian equation of the tangent plane to the graph of f at the point $(-2, 1, 6)$.
- Deduce from (a) an approximation of $\ln(x^{2.01}) \ln(y^{10.01})$.

[3, 3]

6. Let $f: \mathbb{R}^2 \rightarrow \mathbb{R}$ be a continuous function. Let D be domain in \mathbb{R}^2 such that

$$\iint_D f(x, y) dx dy = \int_{-2}^2 \int_0^{\sqrt{4-x^2}} f(x, y) dy dx \quad (*)$$

- Sketch the domain D .
- Change the order of integration in (*).
- Convert the double integral $\iint_D f(x, y) dx dy$ into polar coordinates

[2, 4, 3]

7. Consider the surface S described by the vector function $\mathbf{r}: D \rightarrow \mathbb{R}^3$, defined by

$$\mathbf{r}(s, t) = (s \cos t, s \sin t, 3s) \text{ where } D := \{(s, t) \in \mathbb{R}^2 : 1 \leq s \leq 2, 0 \leq t \leq 2\pi\}.$$

- Show that S is a regular surface.
- Find the cartesian equation of the tangent plane to the surface S at the point $(\sqrt{2}, \sqrt{2}, 6)$.
- Find the area $A(S)$ of the surface S .

[2, 3, 3]

8. Let $a > 0$

- Let $R := \{(x, y, z) \in \mathbb{R}^3 : x^2 + y^2 + z^2 \leq a^2, x^2 + y^2 + (z - a)^2 \leq a^2, z \geq 0\}$. Convert the triple integral $\iiint_R 2xz dx dy dz$ into a triple integral in cylindrical coordinates. (Do not evaluate the integral!)
- Let R be the region enclosed by the cones $z = a - \sqrt{x^2 + y^2}$ and $z = \sqrt{x^2 + y^2}$. Write down the volume of $V(R)$ of R as a triple integral in spherical coordinates. (Do not evaluate the integral!)

[4, 4]

9. Let S be the part of the sphere $x^2 + y^2 + z^2 = 25$ lying below the plane $z = 4$ and oriented with the outward-pointing normal.

If $\mathbf{F}(x, y, z) = (-y, x, z)$, then find the surface integral $\iint_S \text{Curl} \mathbf{F} \cdot d\mathbf{R}$. (Hint: Stokes Theorem)

[8]

Time: 3 hrs

Marks available: 60 Full Marks: 75

Note: Only calculators which have been approved by the Department of Mathematics and Applied Mathematics may be used.

If you would like to access your examination script(s) please see the coordinator in the Mathematics Building for application details or alternatively go to <http://www.uct.ac.za>.

This paper consists of 4 pages of questions. Answer all questions

Section A: Full Marks: 67

In this section full answers are expected. Marks will be deducted for incomplete solutions.

1. Consider the curve \mathcal{C} described by the vector function $\mathbf{r}(t) := (3 \cos t - 1, 1 + t^2, \sin t + t)$ with $t \in \mathbb{R}$.

- Show that the curve \mathcal{C} is regular.
- Find the unit tangent vector \mathbf{T} at the point $(-1, 1, 0)$.
- Show that the curvature κ of the curve \mathcal{C} at the point in (b) is equal to $\frac{\sqrt{2}}{\sqrt{2}}$.
- Write down the cartesian equation of the normal plane to the curve \mathcal{C} at the point in (b).

[2, 3, 3, 3]

2. Consider the function $f(x, y) := \begin{cases} \frac{y^2 \sin x}{\sqrt{x^2 + y^2}} & \text{if } (x, y) \neq (0, 0), \\ 0 & \text{if } (x, y) = (0, 0). \end{cases}$

- Study the continuity of f at $(0, 0)$.
- Find $f_x(0, 0)$ and $f_y(0, 0)$ if they exist.
- Is the function f differentiable at $(0, 0)$? Explain clearly your answer.

[2, 3, 3]

3. Find the points on the cone $z^2 = x^2 + y^2$ which are the closest to the point $(4, 2, 0)$.

[8]

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