



MACHAKOS UNIVERSITY

University Examinations 2019/2020 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND STATISTICS

THIRD YEAR SPECIAL /SUPPLEMENTARY EXAMINATION FOR
BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

BACHELOR OF SCIENCE IN (MECHANICAL ENGINEERING)

BACHELOR OF SCIENCE IN (CIVIL ENGINEERING)

ECU 300: ENGINEERING MATHEMATICS IX

DATE: 26/3/2021

TIME: 2.00-4.00 PM

INSTRUCTIONS TO CANDIDATES

Answer question **ONE (compulsory)** and any other **TWO** questions

QUESTION ONE (30 MARKS)

- Find the first and the second partial derivatives of the function $f(x, y) = 2x^3y^2 + y^3$
(5 marks)
- Find the total differential of the function $f(x, y) = ye^{x+y}$
(4 marks)
- Show that $(y + z)dx + xdy + xdz$ is an exact differential
(4 marks)
- Given that $x(u) = 1 + au$ and $y(u) = bu^3$. Find the rate of change of $f(x, y) = xe^{-y}$ with respect to u
(5 marks)
- Show that the differential $df = x^2dy - (y^2 + xy)dx$ is not exact but that $dg = (xy^2)^{-1}df$ is exact
(6 marks)
- Evaluate the double integral $I = \iint_R x^2y dx dy$ where R is the triangular area bounded by the lines $x = 0, y = 0$ and $x + y = 1$. Reverse the order of integration and demonstrate that the same result is obtained
(6 marks)

QUESTION TWO (20 MARKS)

- The moment of inertia of a right circular cone of height, h and radius, a about the z – axis is given by

$$I = \int_{\theta=0}^{2\pi} \int_{r=0}^a \int_{z=0}^{\frac{h(a-r)}{a}} \sigma r^3 dr d\theta dz$$

And the total mass of the cone is

$$M = \int_{\theta=0}^{2\pi} \int_{r=0}^a \int_{z=0}^{\frac{h(a-r)}{a}} \sigma r dr d\theta dz$$

Show that $I = \frac{3}{10} M a^2$ (12 marks)

- b) Find the angle between the vectors $\mathbf{a} = \mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$ and $\mathbf{b} = 2\mathbf{i} + 3\mathbf{j} + 4\mathbf{k}$ (4 marks)
- c) Find the area A of the parallelogram with sides $\mathbf{a} = \mathbf{i} + 2\mathbf{j} + 3\mathbf{k}$ and $\mathbf{b} = 4\mathbf{i} + 5\mathbf{j} + 6\mathbf{k}$ (4 marks)

QUESTION THREE (20 MARKS)

- a) The position vector of a particle at time t in Cartesian coordinates is given by $\mathbf{r}(t) = 2t^2\mathbf{i} + (3t - 2)\mathbf{j} + (3t^2 - 1)\mathbf{k}$. Find the velocity of the particle at $t = 1$ and the components of its acceleration in the direction $\mathbf{s} = \mathbf{i} + 2\mathbf{j} + \mathbf{k}$ (8 marks)
- b) The position vector of a particle in plane polar coordinates is $\mathbf{r}(t) = \rho(t)\hat{\mathbf{e}}_\rho$. Find the expressions for the velocity and acceleration of the particle in these coordinates (8 marks)
- c) Find the gradient of the scalar field $\phi = xy^2z^3$ at the point (1,1,1) (4 marks)

QUESTION FOUR (20 MARKS)

- a) Find the divergence of the vector field $\mathbf{a} = x^2y^2\mathbf{i} + y^2z^2\mathbf{j} + x^2z^2\mathbf{k}$ at the point (2,1,3) (4 marks)
- b) Find the Laplacian of the scalar field $\phi = xy^2z^3$ at the point (1,4,2) (4 marks)
- c) Find the curl of the vector field $\mathbf{b} = x^2y^2z^2\mathbf{i} + y^2z^2\mathbf{j} + x^2z^2\mathbf{k}$ (5 marks)
- d) Express the vector field $\mathbf{p} = yz\mathbf{i} - y\mathbf{j} + xz^2\mathbf{k}$ in cylindrical polar coordinates and hence calculate its divergence (7 marks)

QUESTION FIVE (20 MARKS)

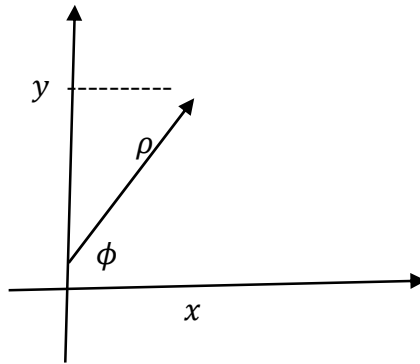
- a) Using change of variable techniques, evaluate the integral

$$I = \frac{1}{2} \pi \sigma \int_{z=0}^h \left\{ a \left(\frac{h-z}{h} \right) \right\}^4 dz \quad (10 \text{ marks})$$

- b) Plane polar coordinates, ρ and ϕ and Cartesian coordinates x and y are related by the expressions $x = \rho \cos \theta$, $y = \rho \sin \theta$ as can be seen in the figure 1 below. An arbitrary function $f(x, y)$ can be re-expressed as a function $g(\rho, \phi)$. Transform the expression

$$\frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \text{ in to one in } \rho \text{ and } \phi$$

Figure 1



(10 marks)