Topic	Description
Module	Higher Mathematics I Tutorial
Module Code	MECH-M-1-HMA-HMA-VO
Semester	WS 2025
Lecturer	Daniel T. McGuiness, Ph.D
ECTS	1
SWS	1
Lecture Type	ILV
Coursework Name	Individual Assignment
Work	Individual
Suggested Private Study	10 hours
Submission Format	Submission via SAKAI
Submission Deadline	06.02.26 17:00
Late Submission	Not accepted
Resubmitting Opportunity	No re submission opportunity

> No lecture time is exclusively devoted to the aforementioned assignment.

A portion of the mark for every assignment will be, where applicable, based on style. Style, in this context, refers to organisation, flow, sentence and paragraph structure, typographical accuracy, grammar, spelling, clarity of expression and use of correct IEEE style for citations and references. Students will find *The Elements of Style (3rd ed.)* (1979) by Strunk & White, published by Macmillan, useful with an alternative recommendation being *Economist Style Guide (12th ed.)* by Ann Wroe.

Submission Format and Requirements with LaTeX

Before submitting your work for assessment please follow the following requirements.

1. **The work must be done using LaTeX and no other format will be accepted.** You are allowed to use whatever software you wish to write (i.e., Overleaf, TeXStudio, LyX, ...). The work must also conform to the **MCI** Documentation guidelines (which is in SAKAI). A template is provided to you here which was written by the author of this document.

   > If you are to use **mcidoc** template, set the `document-state` as `Report`.

   > To learn LaTeX, the author has tutorials which can be accessed here.

   Please treat this assignment as a great practice to learn LaTeX as you will need it when you are writing your thesis.

2. The report (and all its content) **must** be submitted as a `.pdf` along with all the necessary files (`.tex`, `.sty`) to compile it. Submit one (1) `.zip` file containing everything with the following name pattern.

   `[STUDENT-ID]_[STUDENT-NAME]_[STUDENT-SURNAME].zip`

   For example, a student named **Jason Brigham** with a student ID **2710704051** would send their submission as:

   `2710704051_Jason_Brigham.zip`

   and their submission would be in arranged as the following directory:

   ```
   2710704051_Jason_Brigham/
   ├── tex/
   │   ├── 2710704051_Jason_Brigham.tex, *.pdf, mcidoc.cls, custom.sty, ...
   │   └── figures/
   │       └── .jpg, .png, ...
   └── HW_Content/
       └── src/, include/, .cpp, .bash, .py, ...
   ```

   where `...` are any additional requirement (i.e., `.bib`, `.glo`) you may need for TeX and the `HW_Content` is any content which is relevant to the Homework (i.e., if your HW is about python, this is where all the python scripts would be kept, or where your ROS 2 source files would be, or where your C++ codes would be for a project.)

3. The work must be submitted to SAKAI and **no link to personal repo will be accepted.**

> To make sure your submission conform to given requirements, please test out zipping/unzipping and running any code before submission. Any deviations from the requirements will incur penalties to the final grade.

Question	Maximum Point	Received Point
Solving a Separable Differential Equation	5	
An Initial Value Problem	10	
Solving an Exact Differential Equation	10	
Boundary-Value Problems	20	
Inverse of a Matrix	10	
Eigenvalues and Eigenvectors	15	
Curvature of Twisted Cubic	10	
Flux Through a Surface	10	
Verification of the Stokes' Theorem	10	
Sum	100	

[Q1] Solving a Separable Differential Equation — 5

Solve the differential equation:

$$(1+x)\,dy - y\,dx = 0$$

[Q2] An Initial Value Problem — 10

Solve the initial Value problem(s):

i. $\cos x\left(e^{2y} - y\right)\dfrac{dy}{dx} = e^{y}\sin 2x, \quad \text{where} \quad y(0) = 0$ (5)

ii. $\dfrac{dy}{dx} = \dfrac{xy^2 - \cos x \sin x}{y\left(1-x^2\right)}, \quad \text{where} \quad y(0) = 2$ (5)

[Q3] Solving an Exact Differential Equation — 10

Solve the following equation:

i. $2xy\,dx + \left(x^2 - 1\right)\,dy - 0$ (5)

ii. $\left(e^{2y} - y\cos xy\right)\,dx + \left(2xe^{2y} - x\cos xy + 2y\right)\,dy = 0$ (5)

[Q4] Boundary-Value Problems — 20

Solve the following equation:

i. $y'' + 4y = 3, \qquad y'(0) = 0, \quad y(\pi/2) = 0$ (5)

ii. $x^2y'' - 3xy' + 3y = 24x^5, \qquad y(1) = 0, \quad y(2) = 0$ (5)

iii. $y'' - 3y' + 2y = e^{-4t}, \qquad y(0) = 1, \quad y'(0) = 5$ (5)

iv. $\dfrac{dy}{dt} + 3y = 13\sin 2t, \qquad y(0) = 6$ (5)

[Q5] Inverse of a Matrix — 10

Find the inverse of the following matrices:

i. $\begin{bmatrix} 1 & 4 \\ 2 & 10 \end{bmatrix}$ (5)

ii. $\begin{bmatrix} 2 & 2 & 0 \\ -2 & 1 & 1 \\ 3 & 0 & 1 \end{bmatrix}$ (5)

[Q6] Eigenvalues and Eigenvectors — 15

Find the eigenvalues and the eigenvectors of the following matrices:

i. $\begin{bmatrix} 1 & 2 & 1 \\ 6 & -1 & 0 \\ -1 & -2 & -1 \end{bmatrix}$ (5)

ii. $\begin{bmatrix} 3 & 4 \\ -1 & 7 \end{bmatrix}$ (5)

iii. $\begin{bmatrix} 9 & 1 & 1 \\ 1 & 9 & 1 \\ 1 & 1 & 9 \end{bmatrix}$ (5)

[Q7] Curvature of Twisted Cubic — 10

The curve traced by:

$$\boldsymbol{r}(t) = t\mathbf{i} + \frac{1}{2}t^2\mathbf{j} + \frac{1}{3}t^3\mathbf{k},$$

is said to be a twisted cubic. If $\boldsymbol{r}(t)$ is the position vector of a moving particle, find the tangential and normal components of the acceleration at any t and find the curvature.

[Q8] Flux Through a Surface — 10

Let $F(x, y, z) = z\mathbf{j} + z\mathbf{k}$ represent the flow of a liquid. Using this information find the flux $\boldsymbol{F}$ through the surface $\mathcal{S}$ given by that portion of the plane:

$$z = 6 - 3x - 2y,$$

In the first octant oriented upward.

[Q9] Verification of the Stokes' Theorem — 10

Let $\mathcal{S}$ be the part of the cylinder:

$$z = 1 - x^2 \quad \text{where} \quad 0 \leqq x \leqq 1,\ -2 \leqq y \leqq 2$$

Based on these conditions, verify Stokes' theorem for the vector field:

$$\boldsymbol{F} = xy\mathbf{i} + yz\mathbf{j} + xz\mathbf{k}.$$

> Assume $\mathcal{S}$ is oriented upward.

Report You are to write a report on your individual assignment which should explain the calculation used in solving the given questions. A template structure for this assignment could be as follows. Per each question:

- Explanation (i.e, conceptual and mathematical) of the method(s) used in the tackling of the problem. Calculations should be explicit and detailed with proper units and calculations clearly written.

> Before submission, please read **Submission Format and Requirements with LaTeX**.