COURSE INFORMATION

School/Faculty:	**Department of Mathematical Sciences/Faculty of Science**		
Program name:	**Bachelor of Science (Mathematics) with Honours**		
Course code:	**SSCM 3793**	**Academic Session/Semester:**	**20242025/02**
Course name:	**Calculus of Variations**	**Pre/co requisite (course name and code, if applicable):**	
Credit hours:	**3**		

Course synopsis	This course discusses mainly the extremals of functionals. Beginning with a review of similar concepts in functions of many variables, the concepts of functional and variational problems are introduced. Topics include analytical methods of solution (extremals of functionals) and selected numerical methods. Upon completion, the students should be able to locate and identify extremizing functions based on the necessary and the sufficient conditions for an extremum, and know how to use the direct methods to solve some basic applied variational problems.
Course coordinator (if applicable)	Dr. Mohamad Shahiir Saidin

Course lecturer(s)	**Name**	**Office**	**Contact no.**	**E-mail**
	Dr. Mohamad Shahiir Saidin	*C17-317*	*(0)134676374*	shahiir@utm.my

Mapping of the Course Learning Outcomes (CLO) to the Programme Learning Outcomes (PLO), Teaching & Learning (T&L) methods and Assessment methods:

No.	CLO*	PLO **(MQF Cluster Code)	***Taxonomies and ****Graduate Attributes	T&L methods	*****Assessment methods
CLO1	Analyse the properties of functionals and conditions for extremals in variational problems	PLO 1 (C1)	C4, SC1	Lecture	T, FE, Q
CLO2	Solve selected applied variational problems using the method of Calculus of Variations discussed in the course	PLO 2 (C2)	C3, SC2	Lecture	IA, T, FE
CLO3	Construct solution to applied variational problems using direct methods introduced in class.	PLO 2 (C2)	C4, SC2	Lecture	F
CLO4	Construct strategies and solution method for application related variational problems based on techniques discussed in class cooperatively in a team.	PLO 4 (C3B)	SI1	Group Presentation/ Discussion	GP

****Graduate Attributes: S= Scholars, SI - Social Intelligence
*****Assessment: T – Test; Q- Quiz; IA – Individual Assignment; GP – Group Project; F – Final Exam

****MQF Cluster Code**
C1 = Knowledge & Understanding, **C2** = Cognitive Skills, **C3B**= Interpersonal Skills

Details on Innovative T&L practices:

No.	Type	Implementation

1	Active learning	Conducted through in-class activities: 1. Post it parade – Students are provided with a question which they need to answer on post-it notes, and post their answers on the board/wall. The students will be given time to walk around and review the ideas posted by their peers 2. Index Card Pass – Each student write down one question on an index card. The cards rotate the through the room. In a group pick one index card question they want to address and then discuss possible answers to the question. 3. One-Minute Papers – Students write for one minute on a specific question (which might be generalized to "what was the most important thing you learned today").
2	Application problem Projects	Conducted through assignments. Students divided into groups have to solve application problems using knowledge from course.
3	Technology Tools	Programming, Kahoot, Padlet, Coggle, Prezi.

Transferable skills (generic skills learning in course of study which can be useful and utilised in other settings) :
Interpersonal and Communication skills

Student learning time (SLT) / Effective Learning Time (ELT) details:

Week/ Meeting	Course Content Outline and Subtopics	CLO*	Learning and Teaching Activities										TOTAL SLT
			Face-to-Face (F2F)								Non F2F Independent Learning		
							Online (Synchronous)				Online (Asynchronous)	Others	
			L	T	P	O	L	T	P	O			
Week 1 17/03/25 - 21/03/25 **Sultan Johor's Birthday:** 23/03/25	**Revision**: The extremum of a function of many variables	1					1			2			3
Week 2 24/03/25 - 28/03/25	**Extrema of Functionals**: Definitions, Continuity	1					2			1		3.25	6.25
Week 3 31/03/25 - 04/04/25 **Aidilfitri Eid:** 31/03/25 - 01/04/25	First Variation of a functional , Alternative definition of the first variation	1					2			1		1.25	4.25
Week 4 07/04/25 - 11/04/25	The second variation, Extremum of a functional – the necessary condition for an extremum	1	2			1						4.5	7.5
Week 5 14/04/25 - 18/04/25	**Elementary Problem in The Calculus of Variations**: Euler's Equation, Integrability of Euler's Equation, Variational problems in parametric form, Geodesic distance	2	2			1						6	9
Week 6 21/04/25 - 25/04/25	**Generalization of the Elementary Problem**: Functionals depending on: - higher derivatives, m functions, and functions of several independent variables, Invariance of Euler's Equation	2	2			1						6	9
Week 7 28/04/25 - 02/05/25	**Field of Extremals**: Jacobi's sufficient condition, Sufficient conditions of Legendre	2	2			1						5	8

Week 8 05/05/25 - 09/05/25	**Midsem break**												
Week 9 12/05/25 - 16/05/25	**Sufficient conditions For the Extremum**: Weierstrass, Legendre , Figuratrix.	2	2			1						5	8
Week 10 19/05/25 - 23/05/25	**Conditional Extremum**: Isoperimetric Problem, The reciprocity law of the isoperimetric problems, The Lagrangian problem, Geodesics	2	1			2						5	8
Week 11 26/05/25 - 30/05/25	**Moving boundary problems**: Transversality conditions	2	2			1						1	4
Week 12 02/06/25 - 06/06/25 **Hari Keputeraan YDP Agong:** 02/06/25	**Discontinuous Problems**: One-sided Variations	2	2			1						1	4
Week 13 9/06/25 - 13/06/25	**The Hamilton-Jacobi Theory**: The canonical form of Euler's Equations, The Hamilton-Jacobi equation	2	2			1						1	4
Week 14 16/06/25 - 20/06/25	**Direct Methods:** Euler's Finite-Difference Method, Ritz Method, Kantorovich	3	2			1						1	4
Week 15 23/06/25 - 27/06/25	Group Project	4				3						4	7
											SUB-TOTAL SLT :		**86**

	Continuous Assessment	**%**	**Face-to-Face (F2F)**		**NF2F Independent Learning for Assessment**		**TOTAL SLT**
			Physical	**Online (Synchronous)**	**Online (Asynchronous)**	**Others**	
1	Test 1	20	1.5			4	5.5
2	Test 2	20	1.5			4	5.5
3	Quiz	10	0.25			1	1.25
4	Group Projects/ Assignment	10	6			5	11
					SUB-TOTAL SLT :		**23.25**

	Summative Assessment	**%**	**Face-to-Face (F2F)**		**NF2F Independent Learning for Assessment**		**TOTAL SLT**
			Physical	**Online (Synchronous)**	**Online (Asynchronous)**	**Others**	
1	Final Exam	40	2.75			8	10.75
2							0
3							0

4							0
5							0
					SUB-TOTAL SLT :		**10.75**
					SLT for Assessment:		**34**
					GRAND TOTAL SLT:		**120**

A	% SLT for F2F Physical Component	37.50
B	% SLT for Online & Independent Learning Component :	62.50
C	%SLT for Online Component:	7.50
D	% SLT for All Practical Component:	0.00
D1	% SLT for F2F Physical Practical Component:	0.00
D2	% SLT for F2F Online Practical Component:	0.00
Please tick (/) if this course is Industrial Training/ Clinical Placement/ Practicum using 50% of Effective Learning Time (ELT)		

Identify special requirement or resources to deliver the course (e.g.,software,nursery, computer lab, simulation room etc)

Lecture room with computer, LCD and internet connection.

References (include required and further readings, and should be the most current)

Text book (if applicable)

Nil

Main references

1. Krasnov,M.L., Makarenko, G.I., and Kiselev, A.I. (1975). Problems and Exercises in the Calculus of Variations. Moscow: Mir Publishers.
2. Gelfand, I.M. and Fomin, S.V. (2000). Calculus of Variations. New York: Dover Publications, Inc.
3. Filippo, D. (2023). A Course in the Calculus of Variations. Springer Nature Switzerland

Additional references

3. Smith, D.R. (1998). Variational Methods in Optimization. New York: Dover Publications, Inc.
4. Wan, F.Y.M, (1995). Introduction to the Calculus of Variations and Its Applications. New York: Chapman & Hall.
5. Kielhofer, H. (2018). Calculus of variations. An Introduction to the One-Dimensional Theory with Examples and Exercises. Springer International Publishing.
6. Van Brunt, B. (2004). The Calculus of Variations. Springer-Verlag, New York.
7. Giaquinta, M and Hildebrandt, S. (2004). Calculus of Variations 1. Springer-Verlag Berlin Heidelberg.

Online

http://elearning.utm.my

Other additional information (if applicable)

Academic honesty and plagiarism:

Attendance is compulsory. Students with less than 80% total attendance are not allowed to sit for the Final Examination.
Any form of plagiarism is not allowed. Copying works (texts, simulation results, etc) from other students/groups or from other sources is not allowed. Brief quotations are allowed and then only if indicated as such. Existing texts should be reformulated with your own words used to explain what you have read. Be warned: students who submit
copied work will obtain a mark of zero for the assignments and the Faculty may take disciplinary steps. It is also unacceptable to do somebody else's work, to lend your work to them or to make your own work available to them to copy.

Other additional information (if applicable)

Assignments must be submitted on due dates. Late submission shall not be accepted and will not be graded.
Students are required to behave and follow the dressing regulation and etiquette as stated in University regulation while in class.

Disclaimer:

ELT = (Theory + Industrial Guidance + Assessment) x 50%

Total of credit for LI/Practical = ELT/40 Notional Hours

Note: For ODL Programme : Courses with mandatory practical requirement imposed by programme standards or any related standards can be exempted from complying to the minimum 80% ODL delivery rule in the SLT.

Prepared by:		**Certified by:**	
Name:	Dr. Mohamad Shahiir Saidin	**Name:**	
Signature:		**Signature:**	
Date:	15 Mar. 2025	**Date:**	