

## MODULE OUTLINE

### 1. GENERAL INFORMATION

|   |  |                      |                 |
|---|--|----------------------|-----------------|
| <b>SCHOOL</b>   | SCHOOL OF SCIENCE AND TECHNOLOGY   |                      |                 |
| <b>PROGRAM COURSE</b>   | MASTER IN MATHEMATICS  |                      |                 |
| <b>LEVEL OF STUDY</b>   | POSTGRADUATE   |                      |                 |
| <b>MODULE CODE</b>  | MSM80  | <b>YEAR OF STUDY</b> | 2 <sup>nd</sup> |
| <b>MODULE TITLE</b>   | COMPUTATIONAL METHODS AND SOFTWARE IN MATHEMATICS  |                      |                 |
| <b>INDEPENDENT TEACHING ACTIVITIES</b><br><i>in case credits are awarded for separate components/parts of the course, e.g. in lectures, laboratory exercises, etc. If credits are awarded for the entire course, give the weekly teaching hours and the total credits</i> |  | <b>HOURS</b>         | <b>CREDIS</b>   |
| Weekly workload in hours: 17.5 x 32 weeks   |  | 560                  | 20 ECTS         |
| <b>COURSE TYPE</b><br>Compulsory, Optional, Optional mandatory  | Compulsory   |                      |                 |
| <b>PREREQUISITE MODULES:</b>  |  |                      |                 |
| <b>LANGUAGE OF INSTRUCTION AND EXAMS</b>  | GREEK  |                      |                 |
| <b>THE MODULE IS OFFERED TO ERASMUS STUDENTS</b>  | No (due to the annual duration of the module)  |                      |                 |
| <b>MODULE WEBSITE (URL)</b>   | <a href="https://www.eap.gr/education/postgraduate/annual/postgraduate-studies-in-mathematics/topics/#m80">https://www.eap.gr/education/postgraduate/annual/postgraduate-studies-in-mathematics/topics/#m80</a><br><br>Each module has its own space in the Learning Management System of EAP ( <a href="http://study.eap.gr">http://study.eap.gr</a> ), with controlled access (use of code) for students and teaching staff. |                      |                 |

### 2. LEARNING OUTCOMES

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| <p><b>Learning Outcomes</b></p> <ul style="list-style-type: none"> <li>The course learning outcomes, specific knowledge, skills and competences of an appropriate (certain) level, which students will acquire upon successful completion of the course, are described in detail. It is necessary to consult:</li> </ul>   |
| <p>The successful completion of the module MSM80 "Computational methods and software for Mathematics" provides the opportunity for the student to develop the following skills</p> <ul style="list-style-type: none"> <li>Familiarization with the Mathematica software package and practical experience solving mathematical problems.</li> <li>Ability to use the software to teach mathematics at various educational levels</li> </ul> |

- Ability to study various linear and non-linear problems and solve them using the software.
- Ability to use Fourier series methods and then numerical methods for solving ordinary differential equations.
- Ability to use methods of dimensional analysis and perturbation theory to study otherwise unexaminable problems through the use of software packages.
- Ability to utilize methods drawn from the theory of variations by solving boundary value problems for functionals.
- Ability to develop the basic theory and methods of partial differential equations to solve problems primarily through the use of the software package.
- Ability to solve numerical problems of partial differential equations through the finite difference method.

**General Learning Outcomes:** Upon successful completion of MSMB80, students will have obtained the following:

- Ability to study and solve problems relating to the Natural sciences with various methods of applied mathematics,
- Ability to utilize software packages for both teaching and research purposes,
- Ability to organize and apply the knowledge they have obtained to solve individual problems.

By learning to use the software package, students will obtain a valuable asset for writing both their diploma theses and scientific papers in the fields of Mathematics and the Natural Sciences in general.

### General Competences

*Taking into consideration the general competences that students/graduates must acquire (as those are described in the Diploma Supplement and are mentioned below), at which of the following does the course attendance aim?*

|   |   |
|---|---|
| <i>Search for, analysis and synthesis of data and information by the use of appropriate technologies,</i> | <i>Project planning and management</i>  |
| <i>Adapting to new situations</i>   | <i>Respect for diversity and multiculturalism</i>                                       |
| <i>Decision-making</i>  | <i>Environmental awareness</i>  |
| <i>Individual/Independent work</i>  | <i>Social, professional and ethical responsibility and sensitivity to gender issues</i> |
| <i>Group/Team work</i>  | <i>Critical thinking</i>  |
| <i>Working in an international environment</i>  | <i>Development of free, creative and inductive thinking</i>                             |
| <i>Working in an interdisciplinary environment (Other.....citizenship, spiritual freedom, social</i>      | <i>.....</i>  |
| <i>Introduction of innovative research</i>  | <i>awareness, altruism etc.) .....</i>  |

Search for, analysis and synthesis of data and information by the use of appropriate technologies,  
 Adapting to new situations  
 Decision-making  
 Individual/Independent work  
 Project planning and management  
 Critical thinking  
 Development of free, creative and inductive thinking

### 3. MODULE CONTENT

The principal aim of the module MSM80 is to provide the student with substantial experience in using scientific software packages for symbolic and numerical computations for teaching and research, in order to solve problems stemming from natural sciences corroborating a variety of analytical and computational methods.

The cognitive subjects of the module are the following:

- Computational Mathematics (Numerical & symbolic computing techniques & methods using computing systems - packages).
- Computational Applications in Mathematical Modeling.
- Educational software.

In particular, the curriculum of MSM80 includes the following topics:

Introduction to basic software commands and the Wolfram Language: Definition of functions, symbolic and numerical computation of series and integrals. Functions of several variables, derivatives and partial derivatives. Basic commands for graphical representations, plots of parametric curves in 2D and 3D. Basic commands for handling linear algebra problems (matrix calculus, determinants, eigenvalues and eigenvectors). Lists. Basic symbolic and numerical solving commands for ordinary differential equations. Introduction to the mathematical theory of dynamical systems - Study of non-linear phenomena using software (limit cycles and chaotic phenomena). Basic commands for the study of power series and Fourier series - Implementations of representations by using the software capabilities. Introduction to finite difference numerical methods for partial differential equations. Eigenvalue problems and studies with relevant software commands. Study of partial differential equations by using the software capabilities: Implementations of the representations of the solutions for elliptic, parabolic and hyperbolic equations - Nonlinear problems (nonlinear wave propagation phenomena, reaction-diffusion equations and relevant topics) - Calculus of variations and mathematical software. Integral transformations and mathematical software.

### 4. TEACHING METHODS--ASSESSMENT

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| <p><b>MODES OF DELIVERY</b><br/><i>Face-to-face, in-class lecturing, distance teaching and distance learning etc.</i></p>                          | <p>Distance education with six (6) Group Counseling Meetings [GSM (Greek abbreviation: «ΟΣΣ»)] during the academic year, on weekends.</p>  |
| <p><b>USE OF INFORMATION AND COMMUNICATION TECHNOLOGY</b><br/><i>Use of ICT in teaching, Laboratory Education, Communication with students</i></p> | <ul style="list-style-type: none"> <li>• Cisco Wevex Platform (for the implementation of the Group Counseling Meetings) via teleconference meetings.</li> <li>• Usage of Mathematica software for real-time presentation of examples and problem solving</li> <li>• Presentation software (Powerpoint, LaTeX Beamer) for lecture notes presentation.</li> <li>• Usage of Scientific Databases (Scopus, Web of Science) for research in the existing bibliography.</li> </ul> |

| <p style="text-align: center;"><b>MODULE DESIGN</b></p> <p><i>Description of teaching techniques, practices and methods: Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, Internship, Art Workshop, Interactive teaching, Educational visits, projects, Essay writing, Artistic creativity, etc</i></p> <p><i>The study hours for each learning activity as well as the hours of selfdirected study are given following the principles of the ECTS.</i></p>  | <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center;"><b>Activity</b></th> <th style="text-align: center;"><b>Annual Workload</b></th> </tr> </thead> <tbody> <tr> <td>6 GSM (* 4 hours)</td> <td style="text-align: center;">24</td> </tr> <tr> <td>Preparation of Assignments (6 assignments * 24 hours)</td> <td style="text-align: center;">144</td> </tr> <tr> <td>Examination</td> <td style="text-align: center;">4</td> </tr> <tr> <td>Individual study</td> <td style="text-align: center;">388</td> </tr> <tr> <td style="text-align: center;"><b>Total module workload (hours)</b></td> <td style="text-align: center;"><b>560</b></td> </tr> </tbody> </table>   | <b>Activity</b> | <b>Annual Workload</b> | 6 GSM (* 4 hours) | 24 | Preparation of Assignments (6 assignments * 24 hours) | 144 | Examination | 4 | Individual study | 388 | <b>Total module workload (hours)</b> | <b>560</b> |
|--|--|-----------------|------------------------|-------------------|----|---|-----|-------------|---|------------------|-----|--------------------------------------|------------|
| <b>Activity</b>  | <b>Annual Workload</b>   |                 |                        |                   |    |   |     |             |   |                  |     |                                      |            |
| 6 GSM (* 4 hours)  | 24   |                 |                        |                   |    |   |     |             |   |                  |     |                                      |            |
| Preparation of Assignments (6 assignments * 24 hours)  | 144  |                 |                        |                   |    |   |     |             |   |                  |     |                                      |            |
| Examination  | 4  |                 |                        |                   |    |   |     |             |   |                  |     |                                      |            |
| Individual study   | 388  |                 |                        |                   |    |   |     |             |   |                  |     |                                      |            |
| <b>Total module workload (hours)</b>   | <b>560</b>   |                 |                        |                   |    |   |     |             |   |                  |     |                                      |            |
| <p style="text-align: center;"><b>STUDENT PERFORMANCE EVALUATION/ASSESSMENT METHODS</b></p> <p><i>Detailed description of the evaluation procedures.</i></p> <p><i>Language of evaluation, assessment methods, formative or summative (conclusive), multiple choice tests, short- answer questions, open-ended questions, problem solving, written work, essay/report, oral exam, presentation, laboratory work, other.....etc.</i></p> <p><i>Specifically defined evaluation criteria are stated, as well as if and where they are accessible by the students</i></p> | <p>Elaboration of written assignments during the academic year, the average of the grades of which participates in the formation of the final grade of the module by 30%, under the condition of passing to the stage of the final examinations. The condition for passing to the stage of final examinations is the submission of 5/6 written assignments with grade 50/100. In the final written examinations the grade of the written assignments participates in the formation of the final grade of module by 70%.</p> <p>All the criteria are posted, both in each written assignment (in the LMS study.eap.gr), as well as in the general regulation of HOU at: <a href="https://www.eap.gr/education/study-regulations/">https://www.eap.gr/education/study-regulations/</a></p> |                 |                        |                   |    |   |     |             |   |                  |     |                                      |            |

## (6) SUGGESTED BIBLIOGRAPHY

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| <p>1. Τραχανάς Στ., <i>Mathematica και εφαρμογές</i>, Πανεπ. Εκδόσεις Κρήτης, Α' έκδ. 2001, (τελευταία ανατύπωση 2014) .</p> <p>2. Τραχανάς, Στ., <i>Μερικές Διαφορικές Εξισώσεις, Σειρές Fourier και Προβλήματα Συνοριακών Τιμών</i>, Πανεπ. Εκδ. Κρήτης, Α' έκδ. 2001, (τελευταία ανατύπωση 2015).</p> <p>Συνοδευτικό βιβλίο: <i>Σχεδίαση Εκπαιδευτικού Λογισμικού</i>, ΕΑΠ, Πάτρα 2005</p> <p>Webcast. Προσφορά μέσω πλατφόρμας του ΕΑΠ (study)</p> |
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### **Further suggested reading**

1. I. Shingareva and C. Lizárraga-Celaya, Maple and Mathematica, Springer-Verlag/Wien 2009. <https://doi.org/10.1007/978-3-211-99432-0>
2. I. Shingareva and C. Lizárraga-Celaya, Solving Nonlinear Partial Differential Equations with Maple and Mathematica, Springer-Verlag/Wien (2011). <https://doi.org/10.1007/978-3-7091-0517-7>
3. S. Lynch, Dynamical Systems with Applications using Mathematica, Birkhäuser, Boston 2017. <https://doi.org/10.1007/978-3-319-61485-4>
4. J. Alva, Beginning Mathematica and Wolfram for Data Science Applications in Data Analysis, Machine Learning, and Neural Networks, Apress-Springer, 2021. <https://doi.org/10.1007/978-1-4842-6594-9>

*Remarks: 1. The suggested bibliography in English can be found through the Network of Hellenic Academic Libraries HEAL-LINK. 2. The suggested bibliography in English accompanies the bibliography in Greek provided to the students by the Hellenic Open University. The Hellenic Open University provides authorized licenses for the Mathematica Software, distributed to all students (duration of the license: 1 year).*

### **Relevant Scientific Journals**

*Journal of Symbolic Computation.* <https://www.sciencedirect.com/journal/journal-of-symbolic-computation>

*The Mathematica Journal.* <https://www.mathematica-journal.com/volume/v22/>

*Journal of Scientific Computing.* <https://www.springer.com/journal/10915/>

*ACM Transactions on Mathematical Software.* <https://dl.acm.org/toc/toms/current>

*Studies in Applied Mathematics* <https://onlinelibrary.wiley.com/journal/14679590>

*Communications in Nonlinear Science and Numerical Simulation.*

<https://www.sciencedirect.com/journal/communications-in-nonlinear-science-and-numerical-simulation>