Module title1:	Predictive Modelling and Risk Assessment		
Module code:	BSEN 40470		
Module coordinator:	Dr. Enda Cummins		
Other contributors:	Dr. Serafim Bakalis, Prof. Kostas Koutsoumanis, Dr. Filip Logist, Dr. Jeanne-Marie Membré , Laure Pujol Dr. Vasilis P. Valdramidis, Dr. Jan Van Impe		
Semester:	2		
Credits:	5	Level:	4
Overview of module:	The specific objectives of this module are: (i) to develop each participants capacity to design and generate informative experimental data, (ii) to build skills in developing or selecting modelling structures appropriate to describe quantitatively chemical, microbiological and physical phenomena and develop capabilities for quantifying accurately the sources of stochasticity, (iii) to make participants familiar with optimisation software and model simulation in research, that can be exploited for developing decision-making and quantitative risk assessment tools. Theoretical lectures will be alternated with problem-based learning (PBL). Theoretical lectures will cover all the fundamentals and basic principles of predictive modelling. Additionally, PBL pedagogical tools will be used in which students will work in groups to solve realistic multifaceted problems with the use of computer programming software. These problems will include the construction of experimental designs, model development, regression analysis, sensitivity analysis and safety risk scenarios.		
Learning outcomes:	By the end of the programme students will:		

	(i) have attained a fundamental understanding of the substantial body of applied modelling, statistics and recent developments in the field of Predictive Modelling and Quantitative Risk Assessment of foods, (ii) have exercised personal responsibility and autonomous initiative in solving complex microbiological problems that are solved in a rigorous and professional approach, (iii) have engaged in critical dialogue and learned to criticise the broader implication of Applied Modelling approaches in Food Science through interactive teaching, (iv) have exploited available software packages and quantitative approaches for enriching current studies in the field in order to communicate results and innovations of research to peers.
Assessments:	Assessment will consist of a number of assignments, MCQs, group projects and continuous assessments. This is broken down as follows: 1. Student preparation activity- Brief presentation by students detailing research area and the role mathematical modelling has/can play in their research area. Coupled with this will be the requirement to submit a representative list of 10 relevant publications in their subject area. (All - 15%) 2. Experimental design and model development in Bioscience and Food – A practical exercise is to be completed by the end of the session with a spreadsheeet submission (Van Impe - 10%) 3. MCQ on theoritical elements of risk assessment and the use of probability distributions (Cummins - 10%) 4. Quantitative risk assessment during food processes - spreadsheeet submission (Membré - 10%) 5. Quantitative risk assessment during food storage - spreadsheeet submission (Koutsoumanis - 10%) 6. Optimisation and design on microbial-quality modelling - spreadsheeet submission (Valdramidis - 10%)

	7. Process modelling - spreadsheeet submission (Bakalis – 10%) 8. Group project in applying all knowledge to solve a food safety problem (All - 25%)
Workload	Hours Lectures 15 Computer laboratory 40 Learning activities (in class assignments) 25 Autonomous student learning 30 Total workload 110

Day, time	Major topics covered in lectures	Laboratory activity	Other activity	Assessment
Monday 25.03 9-9.20 am	**Introduction (E. Cummins)** 1. Overview 2. Expectations 3. Reporting requirements			
9.20 -12.30am	**Student preparation activity (All) (cont.)** 1. Student overview presentations 2. List of relevant publications		Student presentations and reference of a list of 10 relevant scientific papers	Presentations and publication list graded by teachers (15%)
2-5.30pm	**Lecture: Experimental design and model development in Bioscience and Food (Prof. J. Van Impe & co)** 3. Model structure selection 4. Regression analysis techniques		Designated student activity	

Tuesday 26.03 9-12.30am 2-5.30pm	**Lecture: Experimental design and model development in Bioscience and Food (Prof. J. Van Impe & co)** 5. Description of problem statement 6. Construction of biological/ chemical informative experiments **Computer lab work : Experimental design and model development in Bioscience and Food (Prof. J. Van Impe & co)** 7. Introduction to MatLab 8. Stabilisation of data variance, 9. Construction of experimental designs on specific food treatments	Computer laboratory, with in class tasks	Designated student activity	
Wednesday 27.03 9-12.30 am	**Computer lab work: Data analysis (Prof. Van Impe & co)** 10. Regression analysis 11. Calculation of statistical indices	Computer laboratory, with inclass tasks		Submission of spread sheet anaysis (10%)

2-5.30 pm	**Lecture: Risk analysis (Cummins)** 12. Overview, Risk management, risk communication, risk assessment 13. Stages in risk assessment 14. Why do a risk assessment 15. Risk Ranking 16. Uncertainty vs variability 17. Qualitative vs Quantitative risk assessment 18. Deterministic vs stochastic 19. Distributions – uncertainty and variability **Computer lab work: Risk Assessment (Cummins)** 20. Introduction to modelling tools – Introduction to @Risk	Solve food safety problem using risk assessment tools	Designated student activity	

Thursday 28.03 9-12.30am 2-5.30pm	**Computer lab work: Risk Assessment (Cummins)** 21. Monte Carlo simulation 22. Overview of binomial process and application of probability distributions (beta, binomial, neg-binomial) to solve food safety problems. **Computer lab work: Risk Assessment (Cummins)** 23. Problem solving excercises	Computer laboratory to solve solve food safety problem using risk assessment tools		End of session MCQ (10%)
Friday 29.03 **11-15.00 pm**	**Student preparation activity (All)** 24. Student learning		Consolidation of individual students	
Saturday 30.03	**Cultural activities**			
Saturday 31.03	**Free time**			

Monday 1.04 9-12.30am 2-5.30pm	**Lecture: Quantitative Microbial Risk Assessment during Food Processing (Dr. J.-M. Membré & co)** 25. Risk-based food safety management 26. Introduction to FSO/PO/PC 27. Process and Product criteria to achieve a given FSO/PO/PC **Computer lab work: Quantitative Microbial Risk Assessment during Food Processing (Dr. J.-M. Membré & co)** 28. Introduction to the case study: *Bacillus cereus* in cooked chilled products (REPFEDs)	Optimization of the thermal pasteurization settings (process criteria) to achieve a given PO (PO defined as "no outgrowth of injured spores at the manufacture product release")	Designated student activity	

	29. Model conceptual framework 30. Model development	Raw material analysis, thermal reduction, thermal inactivation (spore lag time). Implementation of inputs: deterministic/ probabilistic, expert elicitation, data collection….		
Tuesday 2.04 9-12.30 am	**Computer lab work: Quantitative Microbial Risk Assessment during Food Processing (Dr. J.-M. Membré & co)** 31. Validation and sensitivity analysis:	Impact of variability and uncertainty associated with each input to the results, finalization of the QMRA model		

2-5.30pm	32. Scenario analysis: **Lecture: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis)** 33. The use of Predictive Microbiology in Quantitative Microbial Risk Assessment during Food Storage -Predicting microbial growth during distribution and storage of foods -Sources of variability in microbial growth -Stochastic models of microbial growth during distribution and storage of foods	Presentation of results - optimization of process criteria (thermal pasteurization settings) for different product formulations (pH and aw)	Designated student activity	Submission of spread sheet anaysis (10%)

Wednesday 3.04 9-12.30am 2-5.30pm	**Lecture: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis)** 34. A risk-based approach to evaluate the compliance of foods with the food safety criteria **Computer lab work: Quantitative Microbial Risk Assessment during Food Storage (Prof. K. Koutsoumanis)** 35. Hand-on training on available software for predictive microbiology and risk assessment 36. Risk-based Shelf life assessment of foods		Designated student activity	Submission of spread sheet anaysis (10%)
Thursday 4.04 9-12.30am	**Lecture: Optimisation and design of food processes based on microbial and quality kinetics (Dr. V.** Valdramidis) 37. Model based design of food processes 38. Quantitative evaluation of shelf-life based on kinetic modelling	Shelf-life calculation excercise.	Designated student activity	Submission of spread sheet anaysis (10%)

2-5.30pm	**Lecture: Integrating process modelling approaches in Microbial Modelling (Dr. S. Bakalis)** 39. Introduction to Food processing 40. Heat and mass transfer 41. Microbial inactivation under heat transfer limitations	Model development exercise	Designated student activity	Submission of spread sheet analysis (10%)
Friday 5.04 9-12.30am	**Teacher directed learning activities and combined problem:** 42. Working example using knowledge from previous classes. Preparation and presentation of working example		Designated student activity	Submission of all projects (20%)