COURSE: : NUMERICAL METHODS IN BIOMEDICINE		
DEGREE: BIOMEDICAL ENGINEERING	**YEAR: 2**	**TERM:2**

WEEKLY PLANNING									
WEEK	**SESSION**	**DESCRIPTION**	**GROUPS (mark X)**		**SPECIAL ROOM FOR SESSION (Computer class room, audio-visual class room)**	**Indicate YES/NO If the session needs 2 teachers**	**WEEKLY PROGRAMMING FOR STUDENT**		
			LECTURES	SEMINARS			DESCRIPTION	CLASS HOURS	HOMEWORK HOURS (Max. 7h week)
1	1	I- PRINCIPLES OF NUMERICAL MATHEMATICS. • Well-Posedness and Condition Number of a Problem • Stability of Numerical Methods. • Relations between Stability and Convergence. • Sources of Error in Computational Models.	X			NO	Study Sections 2.1, 2.2 and 2.4 of QSS and Chapter 3 of DCM.	1,66	6,5

1	2	Review of the capabilities of Matlab.		X	Compu ter room	NO	Working with the computer. Appendix A of DCM.	1,66	
2	3	• Machine Representation of Numbers. • The Positional System. • The floating-Point Number System. • Distribution of Floating-Point Number in Its Machine Representation. • Machine Floating-Point Operations.	X			NO	Study Section 2.5 of QSS and Chapter 3 of DCM.	1,66	
2	4	Taylor Series. Keeping Errors Small. The IEEE standard for floating-point representation. Roundoff error accumulation and cancellation error.		X	Compu ter room	NO	Working with the computer. Solve Numerical Examples of Chapter 3 of DCM.	1,66	6,5
3	5	II- ROOTFINDING OF NONLINEAR EQUATIONS. • Conditioning of a Nonlinear Equation. • The Newton-Raphson Method. • Newton´s Methods for Simultaneous Nonlinear Equations.	X			NO	Study Sections 6.1 and 6.2 of QSS. Section 5.6 of DCM.	1,66	
3	6	Full implementation of Newton-Raphson Method for a nonlinear equation. Plot the trajectory to the root. Two-Dimensional Graphics. Multiple Plots in a Figure.		X	Compu ter room	NO	Working with the computer. Solve Numerical Examples of Chapter 5 of DCM and Section 8.1 of HH.	1,66	6,5
4	7	III- UNCONSTRAINED OPTIMIZATION. • Necessary and Sufficient conditions for Optimality. Convexity. • Basis Concepts: Starting Design, Direction Vector, and Step Size.	X			NO	Study Sections 7.2.1 and 7.2.2 of QSS and Chapter 3 of BC.	1,66	6,5

		• The Steepest Descent Methods.							
4	8	Three-Dimensional Graphics .Specialized Graphs for Displaying.Data . Saving and Printing.		X	Compu ter room	NO	Working with the computer. Applying sentences of Sections 8.2, 8.3 and 8.4 of HH.	1,66	
5	9	• The Conjugate Gradient Methods. • Newton's Methods.	X			NO	Study Sections 7.2.4 and 7.2.5 of QSS and Chapter 3 of BC.	1,66	
5	10	Implementation of Newton, Conjugate Directions FR or PR Algorithms, pros and cons.		X	Compu ter room	NO	Working with the computer. Applying algorithms of Chapters 3 and 4 of [FJNT]	1,66	6,5
6	11	• Quasi-Newton Methods. Approximate Line Search.	X			N0	Study Sections 7.2.7 and 7.2.3 of QSS. Chapter 3 of BC.	1,66	
6	12	Implementation of Broyden Method, DFP and BFGS Algorithms, pros and cons.		X	Compu ter room	NO	Working with the computer. Applying algorithms of Chapters 3 and 5 of [FJNT].	1,66	6,5
7	13	IV- FINITE DIFFERENCE METHODS: INTERPOLATION, DIFFERENTIATON AND INTEGRATION. • Backward, Forward, and Central Differences. • Interpolating Polynomials. • The interpolation Error. • Interpolating of Equally Spaced Points	X			NO	Study Sections 8.1 and 8.2 of QSS. Sections 6.3, 6.4, 6.5 and 6.7 of DCM.	1,66	
7	14	Perform function of Gregory-Newton method for interpolation of equally spaced data.		X	Compu ter room	NO	Working with the computer. Solve Numerical Examples of Section 6.7 of DCM.	1,66	6,5
8	15	• Interpolation of Unequally Spaced Points • Lagrange interpolation.	X			NO	Study Sections 8.3 and 8.6 of QSS. Section 6.8 of DCM.	1,66	6,5

		• Spline interpolation.							
8	16	Interpolation of Runge´s function using cubic splines.		X	Computer room	NO	Working with the computer. Solve Numerical Examples of Section 8.6.1 of QSS.	1,66	
9	17	• Integration Formulas. • Newton-Cotes Formulae. • Richardson Extrapolation. • Romberg Integration.	X			NO	Study Sections 9.1, 9.2 and 9.6 of QSS. Sections 6.9, 6.10 of DCM.	1,66	
9	18	Implementation of Composite Trapezoidal, Closed Newton-Cotes Formula and Romberg Integration.		X	Computer room	NO	Working with the computer. Applying programs of Sections 9.2, 9.3, 9.4, 9.5 and 9.6 of QSS.	1,66	6,5
10	19	V- NUMERICAL SOLUTIONS OF ORDINARY DIFFERENTIAL EQUATIONS. • ODEs and Lipschitz Condition. • One Step Numerical Methods. Zero-Stability, Convergence Analysis and Absolute Stability.	X			NO	Study Sections 11.1, 11.2 and 11.3 of QSS.	1,66	
10	20	Implementation of One-Step Methods.		X	Computer room	NO	Working with the computer. Solve Numerical Examples of Chapter 7 of DCM. Plotting stability regions.	1,66	6,5
11	21	• Multistep Methods 1- Adams Method. 2- BDF Methods. 3- Consistency. The root condition.	X			NO	Study Sections 11.5 and 11.6 of QSS.	1,66	
11	22	Implementation of Multi-Step Methods.		X	Computer room	NO	Working with the computer. Solve Numerical Examples of Chapter 7 of DCM. Plotting stability regions.	1,66	6,5

12	23	4- Stability and Convergence. 5- Absolute Stability. Predictor-Corrector Methods.	X				Study	1,66	
12	24	Implementation of Predictor-Corrector Scheme.		X	Compu ter room	NO	Working with the computer. Applying Matlab program of Section 11.7 of QSS.	1,66	6,5
13	25	• Runge Kutta Methods. 1- Derivation of an Explicit RK. 2- Stepsize Adaptivity for RK. 3- Implicit RK. 4- Regions of Absolute Stability 5- Systems of ODEs. 6- Stiff Problems.	X			NO	Study Sections 11.9 and 11.10 of QSS.	1,66	
13	26	Implementation of Runge-Kutta Methods.		X	Compu ter room	NO	Working with the computer. Solve Numerical Examples of Chapter 7 of DCM.	1,66	6,5
14	27	VI- APROXIMATION THEORY. • Fourier Transform.	X			NO	Study Section 10.7, 10.8 and 10.9 of QSS.	1,66	
14	28	Implementation of FFT.		X	Compu ter room	NO	Working with the computer. Applying Matlab programs of Section 10.9 of QSS.	1,66	6,5
	29	Review and tutoring.	X			NO		1,66	
							Subtotal 1	**48,14**	**91**
							Total 1 *(Hours of class plus student homework hours between weeks 1-14)*	139,14	

15		Tutorials, handing in, etc				N0		2	6

16		Assessment				N0		3	6
17									
18									
							Subtotal 2	**5**	**12**
		Total 2 *(Hours of class plus student homework hours between weeks 15-18)*						17	

TOTAL *(Total 1 + Total 2)*	**156.14**

[BC] A. Belegundu and T. Chandrupatla: “Optimization Concepts and Applications in Engineering”,

Cambridge University Press**, Second Edition**. 2011.

[DCM] S. Dunn, A. Constantinides and P. Moghe: “Numerical Methods in Biomedical Engineering”, 2010.

[FJNT] P.E. Frandsen, K. Jonasson, H.B. Nielsen, O. Tingleff: "Unconstrained Optimization", IMM, DTU. 1999.

[HH] D. Higham and N. Higham: “Matlab Guide”, SIAM, Second Edition. 2005.

[K] C. Kelley: “Iterative Methods for Optimization”, SIAM, 1999.

[QSS] A. Quarteroni, R. Sacco and F. Saleri: “Numerical Mathematics”, Springer. 2007.

[DH] P. Deuflhard and A. Hohmann : “Introduction to Scientific Computing”, Second Edition, Springer. 2002.

[DB] P. Deuflhard and Bornemann : “Scientific Computing with Ordinary Differential Equations”, Springer. 2001.