Syllabus for Open Electives (OE)
Offered by
Department Of Mathematics
Institute of Chemical Technology, Mumbai
Under the National Education Policy (NEP 2020)

A. List of Open Electives offered by the Department of Mathematics

Subject Code	Semester	Subject	Credit	Hours/ Week			Marks for various Exams			
				L	T	P	CA	MS	ES	Total
MAT1302	III	Differential Equations and Numerical Methods	4	4	0	0	20	30	50	100
MAT2232	III	Optimization Techniques	4	4	0	0	20	30	50	100
MATXXXX	IV	Discrete Mathematics	2	2	0	0	20	30	50	100
MATXXXX	IV	Statistical Inference	2	2	0	0	20	30	50	100
MATXXXX	V	Machine Learning	2	2	0	0	20	30	50	100
MATXXXX	V	Mathematical Modelling	2	2	0	0	20	30	50	100

B. Eligibility criteria:

Subject Code	Semester	Subject	Open for	Comment
MAT1302	III	Differential Equations and Numerical Methods	Bachelor of Technology	
MAT2232	III	Optimization Techniques	Bachelor of Chemical Engineering	
MATXXXX	IV	Discrete Mathematics	Bachelor of Technology Bachelor of Chemical Engineering	
MATXXXX	IV	Statistical Inference	Bachelor of Technology Bachelor of Chemical Engineering	Not available for students enrolled in MDM in Machine Learning and Artificial Intelligence
MATXXXX	V	Machine Learning	Bachelor of Technology Bachelor of Chemical Engineering	Not available for students enrolled in MDM in Machine Learning and Artificial Intelligence
MATXXXX	V	Mathematical Modelling	Bachelor of Technology Bachelor of Chemical Engineering	

A. Program Outcomes as defined by the National Board of Accreditation (NBA): 12 Graduate Attributes

PO1	**Engineering knowledge**	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem analysis**	Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
PO3	**Design/development of solutions**	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
PO4	**Conduct investigations of complex problems**	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5	**Modern tool usage**	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations
PO6	**The engineer and society**	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7	**Environment and sustainability**	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
PO8	**Ethics**	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
PO9	**Individual and teamwork**	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**Communication**	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11	**Project management and finance**	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
PO12	**Life-long learning**	Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

C. Detailed Syllabus for Open Electives

	Course Code: MAT 1302	**Course Title: Differential Equation and Numerical Methods**	**Credits = 4**		
			L	**T**	**P**
	Semester: III (Open Elective) (Only for BTECH)	**Total contact hours: 60**	**4**	**0**	**0**

List of Prerequisite Courses	
Engineering Mathematics (MAT 1205) (For Bachelor of Technology courses only)	
List of Courses where this course will be prerequisite	
Courses in UG Engineering programs in ICT that require mathematical modelling and numerical computations	

Description of relevance of this course in the B. Tech. Program		
This is an elective course which will give interested students an exposure to understand the foundations of applications of the differential equations and various numerical methods in engineering problems.		
Course Contents (Topics and subtopics)		**Hours**
1	**Differential Equations - I:** Solution of Higher order ODE with constant and variable coefficients and its applications to boundary and initial value problems, Series solution of differential equations, Bessel functions, Legendre Polynomials, Error function.	15
2	**Differential Equations – II:** Fourier series, Laplace Transforms and their application in differential equation (both ODEs PDEs). Partial Differential Equations, Classification of higher order PDEs, Solution of parabolic equation using separation of variables	15
3	**Numerical Methods - I:** Solutions of system of linear equations (Gauss-elimination, LU-decomposition etc.), Numerical methods for solving non-linear algebraic / transcendental etc. Newton's method, Secant, Regula Falsi methods. Numerical solution set of linear algebraic equations: Jacobi, Gauss Siedel, and under / over relaxation methods	15
4	**Numerical Methods - II:** Interpolation and extrapolation for equal and non-equal spaced data (Newtons Forward, Newtons backward and Lagrange), Least squares method of approximation, Numerical integration (trapezoidal rule, Simpson's Rule) Numerical methods for solution of initial values problems using RK method, Euler's method, and Taylor series method.	15
	Total	**60**
List of Textbooks/ Reference books		
1	E. Kreyszig, Advanced Engineering Mathematics (8th Edition), John Wiley (1999). (Officially prescribed)	
2	S. R. K. Iyengar, R. K. Jain, Advanced Engineering Mathematics Narosa.	
3	M. K. Jain, S R K Iyengar and R K Jain, Numerical Methods: For Scientific and Engineering Computation, New Age International Publication	
4	W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005).	
5	R. V. Churchill and J. W. Brown, Fourier series and boundary value problems (7th Edition), McGraw-Hill (2006).	
6	Dennis G. Zill, Advanced Engineering Mathematics, 6th Edition, Jones, and Bartlett Learning (2016)	
Course Outcomes (students will be able to….)		
CO1	Solve higher order ordinary differential equations using different analytical and numerical techniques	K1, K2, K3
CO2	Apply Fourier and Laplace transform to solve ordinary and partial differential equations arising from various engineering problems	K3, K4
CO3	Build basic mathematical models governed by differential equations to formulate engineering problems and solve the equation using appropriate numerical or analytical techniques	K2, K4, K5
CO4	Solve the systems of linear equations using various numerical techniques	K2, K3
CO5	Approximate appropriate mathematical functions from equal an unequally spaced data and perform integration using various numerical methods	K2, K3, K4
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	0	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	2	0	0	0	0	0	0	3
CO4	2	2	1	1	1	0	0	0	0	0	0	3

CO5	2	3	3	1	2	1	0	0	0	0	0	3

	Course Code: MAT 2232	Course Title: Optimization Techniques	Credits = 4		
			L	T	P
	Semester: III (Open Elective) (Only for BCHEM ENG)	Total contact hours: 60	4	0	0

List of Prerequisite Courses

Applied Mathematics – I (MAT 1101), Applied Mathematics – II (MAT 1102)

List of Courses where this course will be prerequisite

NIL

Description of relevance of this course in the

This course aims to provide students with a deep understanding of large-scale computational techniques applied to optimization problems in engineering. By focusing on both theoretical foundations and practical applications, participants will gain the skills necessary to address complex challenges in various industry verticals. The course encourages hands-on experience through real-world projects, ensuring that students can apply their knowledge to solve engineering optimization problems effectively.

	Course Contents (Topics and subtopics)	Hours
1	Introduction to Optimization problems and formulations	4
2	**One dimensional Optimization:** Golden Section method, Fibonacci search Method, Polynomial interpolation method, Iterative methods	8
3	**Classical optimization Techniques:** Unconstrained optimization, Constrained Optimizations: Method of Lagrange multiplier, Kuhn-Tucker method	8
4	**Linear Programming:** Simplex Method, Revised Simplex Method and other advanced Methods, Duality, Dual Simplex Method, Integer Programming Problems and applications.	12
5	**Unconstrained Optimization Techniques:** Direct search methods such as Powel's method, Simplex method, etc	4
6	**Gradient Search Methods:** Steepest descent method, Conjugate gradient method, Newton's method, Quasi-Newton's method, DFP, BFGS method etc	12
7	Dynamic Programming Problems	4
8	Genetic Algorithms, Simulated Annealing, Ant Colony Optimization	8

List of Textbooks/ Reference Books

1	Edvin K. P. Chong & Stanislab H. Zak, An Introduction to Optimization, John Wiley.
2	Leunberger, Linear and Nonlinear Programming, Springer
3	Jorge Nocedal, Stephen J. Wright, Numerical Optimization, Springer
4	S.S. Rao, Engineering Optimization: theory and practices, New Age International Pvt. Ltd,
5	K. Deb, Optimization for Engineering Design, Prentice Hall, India
6	L. Davis, Handbook of genetic Algorithm, New York Van Nostrand Reinhold
7	Z. Michaleuwicz, Genetic Algorithm+Data Structure=Evolution Programme, Springer-Verlag
8	R. K. Belew and M. D. Foundations of Genetic Algorithms, Vose, San Francisco, CA: Morgan Kaufmann.

Course Outcomes (students will be able to….)

CO1	Formulate optimization problems.	K1, K2

CO2	Understand the standard methods to solve unconstrained and constrained optimization problems.	K1, K2
CO3	Understand linear programming problems and apply in appropriate contexts	K2, K3
CO4	Solve optimization problems using various algorithms.	K3
CO5	Apply various algorithms in optimization techniques to solve real life problems.	K3
K1 – Remembering, K2 – Understanding, K3 – Applying, K4 – Analyzing, K5 – Evaluating, K6 – Creating		

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	0	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	3	0	0	0	0	0	0	3
CO4	2	2	1	1	2	0	0	0	0	0	0	3
CO5	2	3	3	1	2	1	0	0	2	0	0	3

	Course Code: MAT XXXX	**Course Title: Discrete Mathematics**	**Credits = 2**		
			L	**T**	**P**
	Semester: IV (Open Elective)	**Total contact hours: 30**	**2**	**0**	**0**

List of Prerequisite Courses

Applied Mathematics – I (MAT1101) (For Bachelor of Chemical Engineering), Engineering Mathematics (MAT1205) (For Bachelor of Technology)

List of Courses where this course will be prerequisite

Description of relevance of this course in the UG programs in ICT Mumbai

This course will be useful in solving complex problems related to network analysis in engineering problems, computational chemistry, and simulations.

	Course Contents (Topics and subtopics)	**Hours**
1	Divisibility, Primes, Division Algorithm, GCD, Euclidean Algorithm, Fundamental Theorem of Arithmetic.	6
2	Linear Diophantine Equations, Congruences modulo n, Divisibility Tests, Wilson, Euler and Fermat Little Theorems with Applications	8
3	Graphs, Isomorphisms, Sub-Graphs, Degree, adjacency and incidence matrix	6
4	Paths, circuits, Eulerian graphs, connected graphs, shortest path algorithms	6
5	Dijkstra's Algorithm (introduction and examples only, Rubik's cube), Applications to Computational Modelling and Optimization problems in Chemical Engineering and Simulations	4
	Total	**30**

List of Textbooks/ Reference Books

1	J. A. Bondy and U. S. R. Murty: Graph Theory and Applications (Freely downloadable from Bondy's website)
2	Agnarsson, Geir, and Raymond Greenlaw, Graph Theory - Modeling, Applications, and Algorithms, Pearson.
3	G.A. Jones and J.M. Jones: Elementary Number Theory, Springer.

4	David Burton, Elementary Number Theory, McGraw-Hill	
5	Thomas Koshy, Elementary Number Theory with Applications, 2nd Edition, Elsevier, 2007	
Course Outcomes (students will be able to….)		
CO 1	Understand basic concepts of arithmetic	K1
CO 2	Collect and use numerical data to understand patterns and make conjectures for integers.	K2, K3
CO 3	Understand basic concepts in Graph Theory and apply them to model real life problems	K1, K3

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	0	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	2	0	0	0	0	0	0	3

	Course Code: MAT XXXX	**Course Title: Statistical Inference**	**Credits = 2**		
			L	**T**	**P**
	Semester: IV (Open Elective)	**Total contact hours: 30**	**2**	**0**	**0**
List of Prerequisite Courses					
Applied Mathematics – I (MAT1101) (For Bachelor of Chemical Engineering), Engineering Mathematics (MAT1205) (For Bachelor of Technology)					
List of Courses where this course will be prerequisite					
Courses in UG Engineering programs in Institute of Chemical Technology (ICT) that that deals with statistical modelling and real data analysis. This course is designed to clarify the fundamental concepts of statistical estimation theory and testing problems to the students.					
Description of relevance of this course in the UG programs in ICT Mumbai					
This course is required for graduating engineers to function effectively in real data analysis from industry or academia					
Course Contents (Topics and subtopics)			**Hours**		
1	**Descriptive statistics:** Numerical summaries of data, frequency distributions and histograms, boxplots, probability plots.		4		
2	**Point estimation:** Sample and population, Estimators and their sampling distributions, Unbiased estimation, Mean squared error of estimators, Method of moments, Method of maximum likelihood, Central Limit theorem, Chi-square, t and F distributions		8		
3	**Testing of hypothesis:** General concepts related to statistical hypothesis testing, null and alternative hypothesis, p-values, type – I and type – II error. Tests related to normal distribution: tests of hypothesis for mean (one sided and two sided), type – II error and sample size computation, one sample and two sample t-test, paired t test, F test for equality of variance, Testing for goodness of fit, Tests for proportion, Confidence interval and testing problem, Nonparametric tests: Sign Test, Wilcoxon Signed-Rank test for both single and two sample problems.		8		
4	**Linear regression:** Correlation and simple linear regression, fitting regression model using least squares method, hypothesis test for simple linear regression, Confidence interval for regression coefficients, sampling distribution of least squares estimators of regression coefficients, Regression diagnostics, Prediction of new observations:		10		

	prediction and confidence intervals, regression with multiple predictors: data analysis and interpretations, Logistic regression and associated testing problems. Case studies for both linear regression and logistic regression	
5	Demonstration using Python/R/Excel	
	Total	**30**
	List of Textbooks/ Reference Books	
1	Douglas C. Montgomery and Hunter, W.G. Applied Statistics and Probability for Engineers, 6th Edition, John Wiley & Sons, Inc. 2013	
2	Box, G. E., Hunter, W.G., Hunter, J.S., Hunter, W.G., Statistics for Experimenters: Design, Innovation, and Discovery, 2nd Edition, Wiley, 2005.	
3	G. Casella and R. L. Berger, Statistical Inference, Second Edition, Duxbury.	
4	Daniel Sabanés Bové and Leonhard Held, Applied Statistical Inference: Likelihood and Bayes, Springer	
5	V. Robert Hogg, T. Allen Craig. Introduction to Mathematical Statistics, McMillan Publication.	
Course Outcomes (students will be able to….)		
CO 1	Understand data visualization and various descriptive statistics concepts	K1, K2, K3
CO 2	Compute sampling distribution of the estimators	K3, K4, K5
CO 3	Estimate parameters of a population distribution using maximum likelihood and method of moments	K4, K6
CO 4	Apply basic testing procedure to solve data analysis problems	K5, K6
CO 5	Compute interval estimators for population parameters and apply it to solve real life problems.	K4
CO 6	Apply linear and logistic regression models to solve real life data analysis problems	K5, K6

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	1	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	2	0	0	0	0	0	0	3
CO4	2	2	1	1	1	0	0	0	0	0	0	3
CO5	2	3	3	1	2	0	0	0	2	2	0	3
CO6	2	3	3	1	2	1	0	0	3	2	0	3

	Course Code: MAT XXXX	**Course Title: Machine Learning**	**Credits = 2**		
			L	**T**	**P**
	Semester: V (Open Elective)	**Total contact hours: 30**	**2**	**0**	**0**
List of Prerequisite Courses					
Statistical Inference (MAT XXXX)					
List of Courses where this course will be prerequisite					
NIL					
Description of relevance of this course in the UG programs in ICT Mumbai					

Machine learning algorithms are at the core of modern computational techniques. This course helps the students to understand the mathematical and statistical concepts behind the machine learning algorithms. Students also get exposure to various challenges in solving real life problems.		
Course Contents (Topics and subtopics)		**Hours**
1	Introduction to Machine Learning, Distinction between supervised and unsupervised learning problems, prediction accuracy, Training Error, Test Error, Bias-variance trade-off, Measuring the quality of fit. Regression techniques, Understanding the concept of model flexibility and prediction accuracy, Universal behaviour of Training and Test MSE. Case study of linear regression with K-nearest neighbour regression. (Emphasize on understanding the universal patterns using simulated realizations) Classification problems: Training and test error rates, Logistic regression, Linear and quadratic discriminant analysis	8
2	Model Selection and Regularization: Multiple Linear Regression, Validation set approach, Leave-One-Out-Cross-Validation, K-fold cross validation, best subset selection, Forward Selection, Backward selection, Hybrid selection, shrinkage methods: Ridge regression, Lasso, Resampling methods and its application in real data analysis, Nonlinear regression and its engineering applications	12
3	Decision Trees, Bagging and Boosting, Random Forests, Gradient Boosting	6
4	Support Vector Machines: support vector classifier, SVM and for regression, Kernel tricks	4
	Total	**30**
List of Textbooks/ Reference Books		
1	Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python: David Barber A Guide for Data Scientists, O'Reilly Media.	
2	Hands on Machine Learning with R by Bradley Boehmke and Brandon Greenwell, CRC Press.	
3	Introduction to Statistical Learning with Application in R by James, G., Witten, D., Hastie, T. and Tibshirani, R.	
4	All of Statistics: A concise course on Statistical Inference by Larry Wasserman.	
5	The Elements of Statistical Learning by Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie, Springer.	
6	Ethem Alpaydin, Introduction to Machine Learning, The MIT Press, Cambridge.	
7	Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques by Elsevier	
8	Machine Learning: A Probabilistic Perspective (Adaptive Computation and Machine Learning series) by Kevin P. Murphy.	
Course Outcomes (students will be able to….)		
CO1	Understand advantages of machine learning algorithms.	K1, K2
CO2	Apply machine learning techniques to solve regression problems involving real data.	K3, K4, K5
CO3	Apply machine learning techniques to solve classification problems involving real data.	K3, K4, K5
CO4	Apply ensemble learning methods to solve real life data analysis problems.	K5, K6
CO5	Use software to build machine learning models and interpret the results.	K6

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	0	0	1	0	0	3
CO2	2	2	1	1	1	0	0	0	3	2	1	3
CO3	2	2	1	1	2	0	0	0	3	2	1	3

CO4	2	2	1	1	1	0	0	0	3	2	1	3
CO5	2	3	3	1	2	0	0	2	3	2	1	3
CO6	2	3	3	1	2	1	0	3	3	3	2	3

	Course Code: MAT XXXX	**Course Title: Mathematical Modelling**	**Credits = 2**		
			L	**T**	**P**
	Semester: V (Open elective)	**Total contact hours: 30**	**2**	**0**	**0**

List of Prerequisite Courses

For Bachelor of Technology: Engineering Mathematics (MAT1205), Differential Equations and Numerical Methods (MAT 1302)
For Bachelor of Chemical Engineering: Applied Mathematics – I (MAT1101), Applied Mathematics – II (MAT1102)

List of Courses where this course will be prerequisite

NIL

Description of relevance of this course in the UG programs in ICT Mumbai

This course enables the students to apply the theory of ordinary and partial differential equations to solve real life problems arising from engineering, biology, medicine etc.

	Course Contents (Topics and subtopics)	**Hours**
1	Introduction to Mathematical modelling using linear and nonlinear discrete dynamical systems: qualitative analysis of discrete dynamical systems, One dimensional map, two dimensional maps, Lyapunov exponents and chaotic attractor, examples from engineering and natural sciences.	8
2	Qualitative analysis of mathematical models governed by differential equations: Planar Systems: Canonical forms, Eigenvectors defining stable and unstable manifolds, Phase portraits, Linearization and Hartman's theorem, Construction of phase plane diagram, Lyapunov functions, applications to natural and engineering sciences	8
3	Stability analysis for mathematical models: Equilibrium points and their classifications, Lyapunov and asymptotic stability. Limit cycles: Existence and uniqueness of limit cycles in the plane, stability of limit cycles, Poincare- Bendixson theorem, worked examples from chemical kinetics, ecology, disease models	8
4	Elements of bifurcation theory and applications to analyze mathematical models: diverse types of bifurcations and their analysis using computational software tools (Python/MATLAB)	6
	Total	30

List of Textbooks/ Reference Books

1	Sandip Banerjee, 2022, Mathematical Modelling: Models, Analysis and Applications, Second Edition, CRC Press
2	Stephen Lynch, 2014. Dynamical Systems with Applications using MATLAB. Springer.
3	Yuri A. Kuznetsov, 1998. Elements of Applied Bifurcation Theory, Second Edition, Springer.
4	L. Perko, Differential Equations and Dynamical Systems, Vol. 7, 2nd Ed., Springer Verlag.
5	Reinhard Illner, C. Sean Bohun, Samantha McCollum, Thea Van Roode, 2005, Mathematical Modelling: A Case studies approach, American Mathematical Society.
6	James T Sandefur, Discrete dynamical systems Theory and applications, Clarendon press.

7	M W Hirsch and S Smale - Differential Equations, Dynamical Systems, Academic.
8	R. Clark Robinson. An Introduction to Dynamical Systems Continuous and Discrete, Second edition. American Mathematical Society, Rhode Island.
9	Rudiger Seydel, Practical Bifurcation and Stability analysis. Springer (3rd Ed).
10	Alligood, Sauer, and Yorke. Chaos: An Introduction to Dynamical Systems. Springer, Springer-Verlag New York.

Course Outcomes (students will be able to….)		
CO1	Construct mathematical models for real life problems	K1, K2, K3
CO2	Analyse the qualitative features of mathematical models using techniques from dynamical systems	K3, K4, K5
CO3	Perform local and global stability analysis of the mathematical models	K4, K6
CO4	Perform local and global bifurcation analysis for nonlinear systems.	K5, K6
CO5	Use symbolic mathematical software to analyze the mathematical models	K5, K6

Mapping of Course Outcomes (COs) with Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	0	1	0	1	0	0	3
CO2	2	2	1	1	1	0	0	0	0	0	0	3
CO3	2	2	1	1	2	0	0	0	0	0	0	3
CO4	2	2	1	1	1	0	0	0	0	0	0	3
CO5	2	3	3	1	2	0	0	0	0	0	0	3
CO6	2	3	3	1	2	1	0	0	3	0	0	3