GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-III

Course Title: Process Calculation
(Course Code: 4330503)

Diploma programmer in which this course is offered	Semester in which offered
Chemical Engineering	Third

1. RATIONALE

Process calculation provides the fundamental information to determine the material and energy balances for all types of unit operations and unit processes across the equipment and overall chemical plant. Material and energy balance calculations are of prime importance for design and also for conservation of mass and energy to reduce the losses and cost that enhances overall economy of plant. The unit conversions, material and energy balance are the essential part in the practice of other courses such as mechanical operations, fluid flow, heat Transfer, mass transfer etc. Thus this course is a core course for chemical engineers and should be learned sincerely by students.

2. COMPETENCY

The purpose of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Determine material and energy balance for different unit operations and processes**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for theachievement of the following COs:

a) Apply stoichiometric principles for solving chemical engineering problems.
b) Calculate material balance for chemical process.
c) Calculate energy balance for chemical process.
d) Estimate amount of fuel and amount of air required for combustion process.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
4	0	0	4	30	70	0	0	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

***Legends: CI**-Class Room Instructions; **T** – Tutorial/Teacher Guided Theory Practice; **P** - Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** - End Semester Examination..*
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5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) are thesub-components of the Course Outcomes (Cos). Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Not Applicable		

Note
*i.More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*
*ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency*

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Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Question answer or Writing steps exercise	30
2	Executing of exercise	30
3	Result	40
		100

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specificationsfor the PrOsis a guide to procure them by the administrators to user in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Not Applicable	

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample***Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs andPrOs.More could be added to fulfill the development of this course competency.

a) Work as a leader/a team member.

b) Follow ethical practices
c) Practice environmentally friendly methods and processes (environmental related).

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit-I **Unit Systems**	1a. Explain the importance of process calculation. 1b. Define different unit systems. 1c. Explain the importance of physical quantities of Units. 1d. Convert units among different systems.	1.1 Introduction to process calculation 1.2 Dimensions and systems of units 1.3 Fundamental quantities of units, Derived quantities 1.4 Definition and units of force, volume, pressure, work, energy, power, heat 1.5 Unit conversions in FPS, MKS and SI systems
Unit– II **Basic Chemical Calculations**	2a. Calculate important physical quantities. 2b. Calculate composition of mixtures and solutions.	2.1 Definition and calculations of mole, atomic weight, molecular weight, equivalent weight, specific gravity and API gravity 2.2 Expression of composition of mixtures and solutions 2.3 Morality, Normality, Morality, gm/lit and related simple numerical
Unit-III **Ideal Gas Law**	3a. Derive ideal gas law. 3b. State reference conditions. 3c. Calculate important quantities for ideal gas mixture.	3.1 Concept of ideal gas 3.2 Derivation of ideal gas law 3.3 STP and NTP conditions 3.4 Dalton's law, Amagat's law,Raoult's Law and Henry's Law 3.5 Relation between mole%, volume% and pressure% of ideal gases 3.6 Calculation of average molecular weight, density, mole%, weight% in gas mixture in SI/MKS systems
Unit– IV	4a. Explain law of conservation of mass.	4.1 Law of conversation of mass 4.2 Brief description and simple

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Material Balance In Processes Without Chemical Reactions	4b. Calculate mass balance of important unit operations at steady state condition. 4c. Describe purging, recycling and bypassing operations.	material balance calculation of drying, distillation, absorption, mixing, crystallization, evaporation 4.3 Single stage material balance calculation of leaching and extraction 4.4 Brief idea regarding recycling, purging and by passing operation
Unit– V **Material Balance In Processes Involving Chemical Reactions**	5a. Explain basic concepts of material balance with chemical reaction. 5b. Calculate mass balance with chemical reaction.	5.1 Definition: Limiting reactant, Excess reactant, conversion, yield and selectivity 5.2 Simple numerical for finding yield, conversion and composition 5.3 Simple calculation of material Balance based on reaction.
Unit– VI **Energy Balance**	6a. Calculate heat capacity, specific heat, heat capacity of gas mixture and liquid mixture. 6b. Explain concepts of sensible heat and latent heat. 6c. Calculate standard heat of formation and heat of reaction.	6.1 Heat capacity and specific heat 6.2 Mean heat capacity of gases 6.3 Heat capacity of gas mixture and liquid mixture 6.4 Calculations of heat capacity by integral equation up to three terms 6.5 Brief explanation of sensible and latent heat of fusion, sublimation, vaporization 6.6 Calculations of standard heat of formation from heat of combustion data 6.7 Calculations for heat of reaction from heat of formation and heat of combustion data 6.8 Hess's Law and calculations
Unit– VII **Combustion**	7a. Describe combustion. 7b. Describe calorific value. 7c. Calculate calorific value and air requirement for combustion.	7.1 Introduction of combustion 7.2 Types of fuels 7.3 Calorific values of fuels 7.4 Proximate and ultimate analysis of solid fuel 7.5 Numerical related to calorific values of fuel from composition 7.6 Numerical related to air Requirement and composition of flue gases.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks

1	**Unit Systems**	**4**	**2**	**2**	**2**	**06**
2	**Basic Chemical Calculations**	**7**	**2**	**2**	**4**	**08**
3	**Ideal Gas Law**	**7**	**2**	**2**	**4**	**08**
4	**Material Balance In Processes Without Chemical Reactions**	**10**	**0**	**6**	**7**	**13**
5	**Material Balance In Processes Involving Chemical Reactions**	**8**	**2**	**3**	**7**	**12**
6	**Energy Balance**	**12**	**2**	**4**	**8**	**14**
7	**Combustion**	**8**	**2**	**2**	**5**	**09**
TOTAL		**56**	**12**	**21**	**37**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

a) Group assignments based on mass and energy balance of equipments like heat exchanger, boilers, distillation column, evaporator, dryer, reactors, absorption column.
b) Use of MS-Excel in solving numerical.
c) Draw block diagram and write down overall and component material balance for various mass transfer operation and mechanical operations.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a) Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4***means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessedusing different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students for reading data sheets.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects

are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Give a data of different unit operation and calculate material balance.
b) Give a data of different unit operation and calculate energy balance.
c) Prepare chart on molecular weight and equivalent weight.
d) Visit of chemical process plant: Prepare block diagram showing material balance for process equipment used in plant which you have visited.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Stoichiometry	B I Bhatt and S B Thakore	McGraw Hill Education; 5th edition (1 July 2017), ISBN: 978-0070681149
2	Basic Principles and Calculations in Chemical Engineering	Himmelablau David M.	PHI Learning, New Delhi, Year-2003, ISBN: 9789332549623
3	Stoichiometry and Process Calculations	Narayanan K.V. and Lakshmikutty B	PHI; 2nd edition,Year-2016ISBN: 8120352890
4	Introduction to Process Calculations (Stoichiometry)	K. A. Gavhane	NiraliPrakasan, Pune, 2015

14. SOFTWARE/LEARNING WEBSITES

- https://nptel.ac.in/courses/103103165
- Basic Principles & Calculations in Chemical Engg (CD Rom)
- https://www.unitoperation.com/

15. PO-COMPETENCY-CO MAPPING

Semester III	Process Calculation (Course Code : 4330503)
	POs

Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation&Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	**Test various electrical, electronic and pneumatic components and devices using relevant tools and instruments following safe work practices.**						
Course Outcomes CO 1) Apply stoichiometric principles for solving chemical engineering problems.	3	1	2	1	1	-	-
CO 2) Calculate material balance for chemical process.	3	3	3	2	1	-	-
CO 3) Calculate energy balance for chemical process.	3	2	3	2	1	-	1
CO 4) Estimate amount of fuel and amount of air required for combustion process.	3	2	3	2	1	-	1

*Legend: '**3**' for high, '**2**' for medium, '**1**' for low and '**-**' for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1.				

NITTTR Resource Persons

S. No.	Name and Designation	Department	Contact No.	Email
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