NATIONAL BOARD FOR TECHNICAL EDUCATION

PLOT B, BIDA ROAD, P.M.B. 2239, KADUNA – NIGERIA

HIGHER NATIONAL DIPLOMA (HND)

IN

CHEMICAL ENGINEERING TECHNOLOGY

CURRICULUM AND COURSE SPECIFICATIONS

SEPTEMBER 2002

GENERAL INFORMATION FOR HIGHER NATIONAL DIPLOMA PROGRAMME IN CHEMICAL ENGINEERING TECHNOLOGY

1.0 PHILOSOPHY OF THE CHEMICAL ENGINEERING TECHNOLOGY PROGRAMME

The Chemical Engineering programme is designed to reflect a functional philosophy of education. While seeking to achieve academic excellence and promote the furtherance of knowledge, the Chemical Engineering programme also seeks to aid… the acquisition of appropriate skills, abilities and competence, both mental and physical as equipment for the individual to live in and contribute to the development of his/her society…"

This programme is designed to produce Chemical Engineering Technologists capable of applying Chemical Engineering Principles in various chemical processes; laboratory analysis and industrial productions.

2.0 ENTRY REQUIREMENTS

The general entry requirements for the HND programme include:-

a. All the entry requirements for admission into the ND programme in Chemical Engineering.
b. A minimum of lower credit pass (CGPA of 2.50) and above in the ND examinations in Chemical Engineering Technology; and
c. A minimum of one year cognate work experience.

In exceptional cases, the ND diplomates with a pass grade (CGPA of 2.0-2.49) in the ND examinations that had two or more years of cognate work experience may be considered for admission into the HND programme. However, such candidates should not be more than 10% of the total student intake in each class.

3.0 DURATION

The programme is designed to run for a minimum of two academic sessions (four Semesters) and a maximum of four academic sessions (eight semesters). Each semester is to last for eighteen weeks.

4.0 CURRICULUM

4.1 The curriculum of HND programme consists of four main components. These are: -

a. General studies/Education
b. Foundation courses
c. Professional courses
d. Project.

4.2 The General Studies/Education component shall include courses in:-

English Language, Communication, Industrial Management and Engineer in Society, The General Education component shall account for not more than 15% of the total contact hours for the programme.

4.3 Foundation courses include courses in Mathematics. The number of hours for the programme may account for about 10-15% of the total contact hours.

4.4 Professional courses are core courses of the programme, which give the student the theory, and professional skills he needs to practice in his field of calling at the technologist level. These may account for 60-70% of the contact hours.

5.0 CURRICULUM STRUCTURE

The structure of the Higher National Diploma programme consists of a minimum four semesters of classroom, laboratory and workshop activities in the Polytechnic/Monotechnic. Each semester shall be of 18 weeks duration made up as follows:-

a. 15 weeks of teaching, i.e. recitation, practical exercise, quizzes, test, e.t.c.; and
b. 3 weeks of examinations and registration.

6.0 ACCREDITATION

The Diploma Programme shall be accredited by the National Board for Technical Education before the diplomates can be awarded the Higher National Diploma Certificates. Details about the process of accrediting a programme for the award of the Higher National Diploma are available from the Executive Secretary, National Board for Technical Education, Plot B, Bida
Road, P.M.B. 2239, Kaduna, Nigeria.

7.0 AWARD OF HIGHER NATIONAL DIPLOMA

Conditions for the award of Higher National Diploma include the following:-

a. Satisfactory performance in all prescribed course work, which may include class work, tests, quizzes. Workshop practice and laboratory work.
b. Supervised industrial work experience scheme for four months.
c. Satisfactory performance at all semester examinations.
d. Satisfactory completion of final year project work. Normally, continuous assessment contributes 30%, project work 10% while semester examinations are weighted 60% to make a total of 100%.

Higher National Diploma shall be awarded in four classes:-

(i)	Distinction	-	CGPA of 3.50 and above
(ii)	Upper credit	-	CGPA of 3.00 – 3.49
(iii)	Lower credit	-	CGPA of 2.50 – 2.99
(iv)	Pass	-	CGPA of 2.00 – 2.49

8.0 GUIDANCE NOTES FOR TEACHERS

8.1 The new curriculum is drawn in unit courses. This is in line with the provisions of the National Policy on Education which stress the need to introduce the semester credit units which will enable a student who so wishes to transfer the units already completed in an institution of similar standard from which he/she is transferring.

8.2 In designing the units, the Principle of the modular system by-product has been adopted, thus making each of the professional modules, which when completed provides the student with technologist operative skills, which can be used for employment purposes, self-reliance or otherwise.

8.3 As the success of the credit unit system depends on the articulation of programmes between the institutions and industry, the curriculum content has been written in behavioural objectives, so that it is clear to all the expected performance of the student who successfully completed some of the courses or the diplomates of the programme. This is a slight departure from the presentation of the Performance-based curriculum which required the conditions under which the performances of the students are expected to be carried out and the criteria for the acceptable levels of performance. It is a deliberate attempt to further involve the staff of the department teaching the programme to write their own curriculum stating the conditions existing in their institutions under which performance can take place and to follow that with the criteria for determining an acceptance level of performance.

The Academic Board of the institution may vet departmental submission on the final curriculum.
Our aim is to continue to see to it that a solid internal evaluation system exists in each institution for ensuring minimum standard and quality of education in the programmes offered throughout the Polytechnic system.

8.4 The teaching of the theory and practical work should, as much as possible, be integrated. Practical exercises, especially those in professional courses and laboratory work should not be taught in isolation from the theory. For each course, there should be a balance of theory to practical in the ratio of 50:50 or 60:40.

9.0 FINAL YEAR PROJECT

Final year students in this programme are expected to carry out a project work. This could be on individual basis or group work. The project should, as much as possible incorporate basic element of design, drawing and complete fabrication of a marketable item or something that can be put to use. Project reports should be well presented and be properly supervised.

The departments should make their own arrangement of schedules for project work.

CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)

CURRICULUM TABLE: FIRST SEMESTER(HND I)

CODE	COURSE TITLE	L	T	P	CH	CU
MTH 311	Advanced Algebra	2	1	-	3	2.0
MTH 312	Advanced Calculus	2	1	-	3	2.0
CHE 301	Engineer in Society	2	-	-	2	2.0
CHE 303	Unit Operations 111	2	-	-	2	2.0
CHE 305	Chemical Engineering Laboratory 111	-	-	6	6	3.0
CHE 307	Heat Transfer 11	2	1	-	3	2.0
CHE 309	Chemical Engineering Thermodynamics 11	2	1	-	3	2.0
CHE 311	Mass Transfer 11	2	1	-	3	2.0
MTH 313	Engineering Statistics	2	1	-	3	2.0
GNS 301	Use of English 11	2	-	-	2	2.0
		18	**6**	**6**	**30**	**21.0**

CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)

CURRICULUM TABLE: SECOND SEMESTER (HND I)

CODE	COURSE TITLE	L	T	P	CH	CU
MTH 321	Advanced Numerical Methods	2	1	-	3	2.0
COM 321	Computer Programming	2	1	1	4	3.0
GLT 301	Instrumentation	2		-	3	2.0
CHE 302	Unit Operations IV	2	-	-	2	2.0
CHE 304	Fluid Mechanics 11	2	1	-	3	2.0
CHE 306	Chemical Reaction Engineering 11	2	1	-	3	2.0
CHE 308	Chemical Engineering Laboratory IV	-	-	6	6	3.0
CHE 310	Polymer Science and Technology	2	-	-	2	2.0
CHE 312	Strength of Materials	2	1	-	3	2.0
GNS 302	Communication in English	2	-	-	2	2.0
		18	**5**	**7**	**31**	**22.0**

CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)

CURRICULUM TABLE: THIRD SEMESTER (HND II)

CODE	COURSE TITLE	L	T	P	CH	CU
CHE 401	Process Design	2	1	-	3	3.0
CHE 403	Chemical Plant Economics	2	1	-	3	2.0
CHE 405	Unit Operations V	2	-	-	2	2.0
CHE 407	Food Science & Technology	2	-	-	2	2.0
CHE 409	Chemical Engineering Laboratory V	-	-	6	6	3.0
CHE 411	Chemical Engineering Analysis	2	1	-	3	2.0
CHE 413	Project	2	-	-	2	2.0
CHE 415	Engineering Management	2	-	-	2	2.0
	Elective 1					
CHE 417	Pulp and Paper Technology					
CHE 419	Process Metallurgy					
		18	**3**	**6**	**27**	**22.0**

CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)

CURRICULUM TABLE: FOURTH SEMESTER (HND II)

CODE	COURSE TITLE	L	T	P	CH	CU
CHE 402	Unit Operations VI	2	1	-	3	2.0
CHE 404	Equipment Design	2	1	-	3	2.0
CHE 406	Chemical Process Dynamics & Control	2	-	-	2	2.0
CHE 408	Health, Safety & Environment II	2	-	-	2	2.0
CHE 410	Chemical Engineering Entrepreneurship	2	-	-	2	2.0
CHE 412	Plant Services and Maintenance	2	-	-	2	2.0
CHE 414	Petroleum Refining and Petrochemical Technology	2	-	-	2	2.0
CHE 416	Project	2	2	4	6	2.0
	Elective II					
CHE 418	(i) Biochemical Engineering					
CHE 420	(ii) Gas Processing Technology					
CHE 422	(iii) Reserviour Engineering.					
		16	**4**	**4**	**24**	**20.0**

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: UNIT OPERATIONS III	**Course Code: CHE 303**	**Contact Hours: 2-0-0**	
Course Specification: Theoretical content			
Week	**General Objective**: 1.0: **Understand the applications of humidity data for air-water systems.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-4	1.1 Define the following terms: (a) humidity. (b) percentage humidity. (c) humid heat. (d) humid volume. (e) relative humidity. (f) wet-bulb temperature. (g) adiabatic saturation temperature. 1.2 Describe the use of psychometric charts.	• Ensure that student understand all the technical terms. • Show how the psychometric chart is used. • Give numerical examples of how the psychometric chart is used. • Assess the students.	Recommended texts, psychometric charts, internet services and scientific calculators.

Week	General Objective 2.0: Understand the principles of water cooling.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-8	2.1 Explain the working principles of cooling towers. 2.2 Determine the height of a water-cooling tower. 2.3 Explain the correlation factor 'f' for obtaining driving force in a column. 2.4 Evaluate heat and mass transfer coefficients.	• Discuss thoroughly the cooling tower. • Solve numerical problems on how to use the correlation factor, and how to evaluate heat and mass transfer coefficients. • Assess the students.	Recommended texts, psychometric charts, internet services and scientific calculators.

Week	General Objective 3.0 Understand the theory and methods of investigating drying and enthalpy balances in continous and batch dryers.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-15	3.1 Define moisture content on dry basis. 3.2 Define moisture content on wet basis. 3.3 Explain the various types of moisture. 3.4 Identify the various types of dryers. 3.5 Enumerate conditions for batch scale and scale-up operations. 3.6 Explain drying tests. 3.7 Explain rate of drying curves. 3.8 Explain the techniques for evaluating time of drying. 3.9 Apply graphical and numerical solutions to drying problems. 3.10 Describe features of common industrial drying equipment. 3.11 Explain the operation equipment in item (3.10) above.	• Ensure student understanding of moisture, moisture content, dryers and batch scale and scale-up operations. • Treat drying test and techniques of drying. • Solve numerical and graphical problems of drying.	Recommended texts, psychometric charts, internet services and scientific calculators.

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PROGRAMME: CHEMICAL ENGINEERINGTECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: ENGINEERING MANAGEMENT		**Course Code: CHE 415**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Understand company structures.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 Explain relationship between internal need and external links in developing structure. 1.2 Explain levels of authority. 1.3 Explain supply chain relationship.	• Produce the organizational structure of a small local company and compare it to the polytechnic structure • Assess students.	Recommended textbooks, internet services etc.
	General Objective 2.0: Understand market research and strategy.		
3-6	2.1 Explain forecasting 2.2 Explain sampling, plan-brief, target, question and analysis. 2.3 Explain supply position and customer preference. 2.4 Describe Ansoffs matrix-market penetration/development, product development and diversification 2.5 Describe strategy- segmentation and cooperation.	• Explain future demand for a product and produce a customer perception questionnaire. • Analyse a local company for skills, capacity and competence and develop a market strategy. • Assess the students.	Recommended textbooks, internet services etc.

Week	General Objective 3.0 : Understand investment appraisal		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-8	3.1 Explain payback period. 3.2 Explain annual rate of return. 3.3 Explain discounted cash flow 3.4 Explain time value of money and risks.	• Compare a project's costs and income using at least two methods and comment on risks involved. • Assess the students.	Recommended textbooks, internet services etc.
9 - 10	**General Objective 4.0** : **Understand variance analysis**		
	4.1 Describe marginal costing-contribution analysis and break even analysis. 4.2 Explain standard/estimated costs. 4.3 Explain analysis of actual and expected returns.	• Analyse a local company. • Assess the students.	Recommended textbooks, internet services etc.

Week	General Objective 5.0: Understand contracts.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11-12	5.1 Explain law of contract. 5.2 Explain terms, conditions and warrantee. 5.3 Explain remedies 5.4 Explain liability 5.5 Explain mistake.	• Use contract documents to explain the significance of each term of the contract. • Assess the students.	Contract documents, recommended textbook, and internet services.
13-15	**General Objective 6.0: Understand production planning and control**.		
	6.1 Explain production planning. 6.2 Explain production control. 6.3 Explain network analysis.	• Determine EOQ and EPQ • Assess the students.	Recommended textbooks, internet services etc.

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: UNIT OPERATIONS IV		**Course Code: CHE 302**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Know the principles and practice of evaporative systems.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-5	1.1 Explain evaporation. 1.2 Draw constructional details of the following: (a) Vertical short tube evaporators. (b) Vertical long tube climbing and falling film evaporators. (c) Vertical cylindrical evaporators. (d) Scrapped surface evaporators. 1.3 Identify and describe equipment used for (a) Vapour recompression; (b) Operation under vacuum. 1.4 State the factors governing choice of evaporators and the operating conditions. 1.5 Carry out heat and material balance calculations for single effect evaporators including vapour recompression types. 1.6 Explain the principle of multiple effect evaporators. 1.7 Describe the factors governing the choice of forward, backward, mixed and parallel feed methods for multiple effect evaporators.	• Discuss in detail evaporation and evaporators, including types and conditions governing their choice. • Treat multiple effect evaporators, with emphasis on dulling charts, optimum number of effects, and heat and material balances. • Solve numerical problems highlighting the salient points above.	Recommended texts, scientific calculator, internet services, etc.

	1.8 Explain the effect of boiling point elevation and read duhling charts. 1.9 Explain the optimum number of effects and the steam economy of multiple effect evaporators. 1.10 Carry out heat and mass balances for double effect evaporators. 1.11 Explain the principles of, and the reasons for freeze-drying. 1.12 Evaluate heat and material balance in the case of item (1.11) above. 1.13 Calculate apparent overall heat transfer coefficient for a climbing film evaporator.	• Assess the students.	

Week	General Objective 2.0: Understand filters and filtration operations		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-10	2.1 Classify filters and describe filtration under the following headings: (a) Driving force. (b) Filtration mechanism. (c) Function. (d) Operating cycle. (e) Nature of feed stream. 2.2 Explain the theory of filtration. 2.3 Describe constant pressure filtration. 2.4 Explain the significance of the filtration equations. 2.5 Explain the application of filtration theory to the interpretation of data. 2.6 Draw typical plots of filtration data. 2.7 Draw small-scale filtration tests. 2.8 Describe and carry out vacuum tests, pressure tests, and compression-permeability tests. 2.9 Explain the criteria for the choice of filter media, filter aids and filtration equipment. 2.10 Explain the factors that influence the choice of filter media. 2.11 Explain the functions of filter aids.	• Discuss filtration theory and show why the equations are important. • Show how filters are classified and the reason for doing so. • Explain how vacuum, pressure and compression-permeability tests are carried out. • Solve numerical problems. • Assess the students.	Recommended texts, scientific calculator, internet services, etc.

Week	General Objective 3.0: Understand the principles and practice of crystallization processes.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11-15	3.1 Explain the terms solubility, saturation and super-saturation. 3.2 Describe the effect of temperature on solubility. 3.3 Explain the factors affecting nucleation 3.4 Explain Meier's theory. 3.5 Explain how super saturation may be achieved by (a) Cooling. (b) Evaporation. (c) Salting out. 3.6 Explain the factors affecting the rate of growth of crystals. 3.7 Derive the ΔL for crystallisation 3.8 Work out mass of seed crystals required in a batch process applying the ΔL Law of crystal growth. 3.9 Describe the techniques for producing even-sized crystals by: (a) Shock cooling. (b) Seeding. (c) Fluid sorting.	• Explain the technical terms such as solubility, saturation, super-saturation and nucleation. • Show what leads to the growth of crystals. • Solve numerical problems. • Assess the students.	Recommended texts, scientific calculator, internet services, etc.

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: UNIT OPERATIONS V		**Course Code: CHE 405**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Understand absorption as both stage wise and counter current contacting processes.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Describe the process of absorption. 1.2 Describe the equilibrium data for ideal systems in terms of Raoult's Law. 1.3 Derive equations for the operating lines under dilute and concentrated conditions. 1.4 Explain the principles of pinch and minimum solvent requirement. 1.5 Calculate theoretical plate requirements under dilute conditions using the Kreriser-Brown-Sarders equation: (a) Analytically. (b) graphically. 1.6 Derive the expression for the packed height of an absorption column under dilute conditions. 1.7 Calculate theoretical plate requirements by graphical construction. 1.8 Calculate gas film coefficient from given measurements mode in a wetted column.	• Explain the theory of absorption. • Show how to derive operating line equation with the application of Raoult's law. • Treat Pinch and minimum solvent requirement. • Solve absorption problems using analytical and graphical methods. • Assess the students.	Recommended textbooks, internet services, etc.

Week	General Objective 2.0: Understand the process of liquid-liquid extraction.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-9	2.1 Explain the rate of the feed solvent, the extraction solvents and the solute in an extraction process. 2.2 Distinguish between raffinate and extract solutions. 2.3 Define the rate of an ideal stage in liquid-liquid extraction. 2.4 Evaluate and plot immiscible equilibrium data for water, ternary systems such as water -carbon tetrachloride benzoic system acid. 2.5 Distinguish between immiscible and partially miscible solvent systems. 2.6 Calculate by graphical construction, the stage requirements or extraction performance when the solvents are immiscible. 2.7 Analyse the difference between the methods used in item (2.6) above when the solutions are dilute and concentrated. 2.8 Construct a plot of a typical equilibrium data for ternary systems in triangular co-ordinates. 2.9 Apply the Lever rule in such a diagram in item (2.8) above. 2.10 Analyse the diagram in item (2.8) above to evaluate the performance of a single theoretical stage with subsequent solvent recovery. 2.11 Analyze the diagram for the estimation of stage requirements in counter current contacting device.	• Draw a sketch and explain explicitly feed extraction solvent, solute, reffinate and extract. • Distinguish between immiscible and partially miscible solvent systems. • Solve an appreciable number of problems to highlight particularly, the graphical method of solution. • Assess the students.	Recommended textbooks, internet services, etc.

Week	General Objective 3.0 : Know factors influencing solvent selection.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10	3.1 Explain the effect of selection and solubility on the efficiency of extraction. 3.2 Explain the effects of density, viscosity and interfacial tension on mixing and phase separation. 3.3 Describe the effect of other solvent properties on the operation and economics of extraction process.	• Show the factors affecting the choice of solvents. • Treat the economics of the extraction process.	Recommended textbooks, internet services, etc.
11 - 12	**General Objective 4.0 Know extraction equipment**		
	4.1 Describe mixer- settler equipment. 4.2 Explain the concept of liquid at interface levels in atmospheric equipment. 4.3 Describe the flow pattern in multiple stage mixer- settlers. 4.4 Distinguish between dispersed and continuous phase in spray columns. 4.5 Explain the advantages of plate columns over spray columns. 4.6 Explain the effects of wettability in packed columns. 4.7 Explain the advantages of, and difficulties associated with the input of mechanical energy into counter current columns.	• Explain the concepts of mixers and settlers. • Distinguish between single-stage and multiple stage mixer- settlers, and plate and spray columns. • Solve numerical problems • Assess the students.	Recommended textbooks, internet services, etc.

Week	General Objective 5.0 : Know the principles and applications of leaching operations		
13-15	**Special Learning Objective**	**Teachers Activities**	**Learning Resources**
	5.1 Explain the principles of leaching. 5.2 Explain the significance of leaching equations. 5.3 Describe single- stage and multi- stage leaching operations. 5.4 Calculate single-stage and multi-stage efficiencies. 5.5 State the factors governing the choice of leaching equipment and operating conditions.	• Treat the concept of leaching carefully. • Distinguish between single- stage and multi-stage leaching operations • Solve numerical problems highlighting the understanding of the topic. • Assess the students.	Recommended textbooks, internet services, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOY (HIGHER NATIONAL DIPLOMA)		
COURSE: UNIT OPERATIONS VI	**Course Code: CHE 402**	**Contact Hours: 2-0 -0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0: Understand the principles of separation by distillation**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-6	1.1 Calculate vapour liquid equilibrium data for an ideal binary system. 1.2 Define the term relative volatility. 1.3 Explain the conditions under which relative volatility can be regarded as constant. 1.4 Define theoretical plate in distillation. 1.5 Calculate by graphical construction, the concentration and temperature profile in a column made up of theoretical stage under total reflux. 1.6 Apply Fenske equation to the problem outlined in item (1.5) above. 1.7 State the assumptions necessary for the use of constant molar overflow and constant molar vaporization. 1.8 Derive the material balance equation of the operating lines for continuous distillation. 1.9 Define the q value of the feed. 1.10 Explain the concept of minimum reflux rate by identifying pinch conditions.	• Explain vapour-liquid equilibrium, relative volatility, theoretical stage, total reflux, molar overflow, operating line, molar vaporization, minimum reflux, reflux ratio, Murphree and overall plate efficiencies, etc. • Show explicitly show the graphical method of solving distillation problems. Solve several problems. • Solve numerical problems. • Assess the students.	Recommended texts, graph sheets, scientific calculator, and internet services.

WEEK	Special Learning Objective	Teachers Activities	Learning Resources
	1.11 Calculate stage requirements in continuous distillation using the McCabe-Thiele method. 1.12 Derive an expression for the minimum reflux ratio for the conditions q=1 and x=constant. 1.13 Apply the Gilliland correlation for estimating theoretical stage requirements. 1.14 Describe the effect of reflux ratio on capital and operating costs and hence evolve the concept of optimum reflux ratio. 1.15 Define Murphree and overall plate efficiencies. 1.16 Describe the operations of packed distillation column. 1.17 Calculate height equivalent of a transfer plate (H.E.T.P.).	• Determine the number of theoretical stages using McCabe-Thiele and analytical methods. • Differentiate between packed columns and plate columns. • Solve problems using Gilliland correlation.	

Week	General Objective 2.0: Understand the principles of separation of multi-component systems by distillation.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7 - 11	2.1 Explain vapour-liquid equilibrium for multi-component systems. 2.2 Identify the basis for selecting the relative volatility for multi-component systems. 2.3 Calculate bubble and dew points for ideal multi-component systems. 2.4 Calculate the material balance of product streams compositions for single stage multi-flash vaporization. 2.5 Calculate the distillate and residue composition for a multi-component differential distillation. 2.6 Define and identify key components. 2.7 Identify the concept of minimum reflux ratio by identifying pinch points. 2.8 Calculate minimum reflux. 2.9 Calculate the minimum number of theoretical plates. 2.10 Describe the effect of reflux ratio upon the number of theoretical stages using the Gilliland correlation. 2.11 Derive the equations of the operating lines for continuous rectification. 2.12 Carry out plate-to-plate calculations for rectification and stripping sections of the column. 2.13 Determine feed point location.	• Explain the concept of minimum reflux ratio, theoretical plates, continuous rectification, and stripping section and feed point location. • Solve numerical problems and explain the graphical approach also. • Assess the students.	Recommended texts, graph sheets, scientific calculator, and internet services.

Week	General Objective 3.0 : Understand azeotropic and extractive distillation/ and absorption.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12 - 15	3.1 Describe the principles of separating difficult mixtures by fractional distillation using entrainers or solvents. 3.2 Identify the principles and uses of absorption processes as a means of physical separation. 3.3 Compare separation by absorption to fractional distillation.	• Explain clearly the principles of azeotropic and extractive distillation. • Show how absorption is a physical separation process. • Compare fractional distillation and absorption. • Identify the various entertainers and solvents in typical azeotropic and extractive distillation respectively.	Recommended texts, graph sheets, scientific calculator, and internet services.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: CHEMICAL PLANT ECONOMICS		**Course Code: CHE 403**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content:			
Week	**General Objective 1.0 : Understand the evaluation of investments.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1 - 3	1.1 List factors affecting cash flow. 1.2 Explain time value for money. 1.3 List the various methods available for evaluating cash flow. 1.4 Calculate the rate of return on investment. 1.5 Explain the terms depreciation, service life and working capital.	• Explain carefully cash flow, time value for money return on investment, depreciation, service life and working capital. • Solve numerical problems. • Assess the students.	Recommended textbooks, internet services, etc.

Week	General Objective 2.0: Understand the various methods of capital estimation.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4 - 6	2.1 List the various types and accuracy of estimates. 2.2 Determine cost estimation using cost factor and scaling unit. 2.3 Apply the $6/10^{th}$ rule in scale up cost and capacity. 2.4 Estimate piping, electrical, auxiliaries, steam, water and other systems start up costs. 2.5 Estimate the fixed capital costs. 2.6 Differentiate between direct and indirect costs, and fixed and variable costs.	• Explain estimate accuracy, scale-up cost, capacity, system start up costs, fixed and variable costs. • Solve numerical problems. • Assess the students.	Recommended textbooks, internet services, etc.

Week	**General Objective 3.0 : Understand the methods used in the estimation of manufacturing costs.**		
7 - 9	3.1 Estimate costs of raw materials, chemicals and catalysts. 3.2 Estimate cost of utilities, labour, supervision, maintenance, insurance and taxes. 3.3 Evaluate plant overheads, freight costs, other manufacturing costs and manufacturing costs control.	• Show how to estimate costs of raw materials, chemicals, catalysts, utilities, labour, supervision etc. • Solve numerical problems. • Assess the students.	Recommended textbooks, internet services, etc.
Week	**General Objective 4.0 : Understand profitability measures.**		
10 - 12	4.1 Define profitability. 4.2 Explain the various methods of evaluating profitability. 4.3 Evaluate profitability – pay out time, present worth, interest rate of return, cumulative cash flow position. 4.4 Evaluate sensitivity to major process variables, capitalized costs, and economic balances. 4.5 Evaluate profitability by means of break-even chart. 4.6 Draw the break-even chart.	• Solve problems on profitability and profitability measures. • Assess students understanding of profitability of chemical processes.	Recommended textbooks, internet services, etc.

Week	General Objective 5.0 : Understand optimization as a means of determining the most acceptable cost (minimum cost at high efficiency)		
	Special Learning Objective	Teachers Activities	Learning Resources
13 - 15	5.1 Define optimisation. 5.2 Draw the optimisation diagram for such processes as economic pipe diameter in fluid flow in pipes. 5.3 Determine the optimum operating conditions for such processes involving mass transfer, heat transfer and fluid mechanics.	• Explain optimisation and how to set up an optimisation problem. • Solve numerical problem to determine the optimal operating conditions for a variety of processes. • Assess the students.	Recommended textbooks, internet services, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: PETROLEUM REFINING AND PETROCHEMICAL TECHNOLOGY	**Course Code: CHEM 414**	**Contact Hours: 2-0-0**

Course Specification: Theoretical Content

Week	General Objective 1.0: Know the sources of petrochemical raw materials and their properties.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 Identify the sources, composition, properties of crude oil products. 1.2 State the properties, composition and uses of natural gas.	• Identify crude oil. • Mention the uses of natural gas.	Recommended textbooks, and internet services.
3-5	**General Objective 2.0: Understand different refining processes.**		
	2.1 Define the following refining methods: (a) Catalytic processes (cracking, reforming, alkylation and isomerization). (b) Thermal processes (cracking, vis-breaking and coking). (c) Solvent extraction processes. (d) Hydro-treating processes (hydro-desulphurization, hydro-cracking and hydro-forming)	• Explain the difference between cracking and reforming processes. • Explain the difference between thermal and catalytic processes. • Give examples of applications of hydrotreating and solvent extraction processes in petroleum refining.	Recommended textbooks, and internet services.

Week	General Objective 3.0: Understand the functioning of equipment used in petrochemical industry.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-8	3.1 Describe the following equipment and their functions: - (i) Heaters and furnaces. (ii) Fractionating towers. (iii) Condensers and heat exchangers. (iv) Pumps and compressors. (v) Reactors. 3.2 List materials of construction (resistant materials) of the major equipment in (3.1) above. 3.3 Explain the organization of equipment maintenance in petrochemical industry.	• Differentiate a pump from a compressor. • Ensure the students understand the choice of materials of construction of equipment. • State maintenance procedures for the various equipment.	Recommended textbooks, and internet services.

Week	General Objective 4.0 Know the products of petrochemical processes.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-11	4.1 List major products of petrochemical processes e.g. carbon black, polyethylene, polypropylene, PVC, LAB, Benzene – Toluene and xylene. 4.2 Describe the major sources of raw materials for the products in (4.1) above. 4.3 Describe the manufacturing process and uses of the products in (4.1) above.	• Mention other products of petrochemical processes apart from the ones mention in (4.1). • Mention a few manufacturing industries where products of petrochemical processes are used.	Recommended textbooks, and internet services.
12-15	**General Objective 5.0: Understand oil field techniques.**		
	5.1 Explain the basic elements of petroleum geology and exploration. 5.2 Describe drilling equipment and methods. 5.3 Explain functions of circulating drilling mud and fluids. 5.4 Describe types and design of well casings. 5.5 Explain well completion and list functions of the wellhead. 5.6 Describe the pre-treatment of crude oil. 5.7 Identify the basic elements of oil production facilities and state their functions.	• Efforts to see the equipment by contacting petroleum exploration companies.	Recommended textbooks, and internet services.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: HND CHEMICAL ENGINEERING			
COURSE: CORROSION SCIENCE & CONTROL		**Course Code : CHE 426**	**Contact hours 2.0 hrs/wk**
Course Specification: **Theoretical Content: Theoretical Content**			
Week	**General Objective: 1.0: Know atomic structure and significance of electron and Bonding.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	(e) Hydrogen bonding. 1.1 Explain: (a) structure of metals; (b) Space lattices; © Allotropy; (d) Solid solutions; (e) Intermetallic compounds (alloys); (f) Molecular structures; (g) Crystal structure and lattices; (h) Crystal directions and planes; (i) Noncrystalline (amorphous) structures. 1.2 Explain: (a) crystal imperfections; (b) dislocations; (c) slips; (d) twinning; (e) simple dislocation theory; (f) work hardening; (g) cold working; (h) impure phases.		

Week	General Objective: 2.0: Know the various types of protective treatments applied to materials against corrosion.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-5	2.1 List the types of protective measures taken against materials corrosion. 2.2 Explain anodic and cathodic protection. 2.3 Describe polymer deposition on materials as a protective measure taken against material corrosion. 2.4 Explain the principle of electroplating. 2.5 Define anodizing. 2.6 Describe the anodizing process of alluminium. 2.7 Describe conversion coating.		

Week	General Objective: 3.0: Know the resistant properties of materials used in chemical plant construction.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-8	3.1 Describe the resistance of materials against corrosion. 3.2 Explain the chemical resistance of materials against corrosion. 3.3 Explain the mechanical resistance of materials against corrosion. 3.4 Explain the thermal properties and resistances of materials against corrosition. 3.5 Identify the area of application and the type of materials in the construction of chemical plants		
Week	**General Objective: 4.0: Know the types of forces and their effects on chemical plant components**		
9 - 11	4.1 Explain the effects of various types of forces on chemical plant components. 4.2 Explain the relation between stress and strain in a material. 4.3 Describe simple cases of direct stress, and strain. 4.4 Calculate the stress and strain in simple systems subjected to shear stress.		

Week	General Objective: 5.0: Know and apply knowledge of stress and strain solving simple problems encountered in plant design.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	5.1 Calculate the hoop and axial stress and strain induced in a thin cylindrical shell subjected to internal pressure. 5.2 Calculate the hoop stresses and strains involved in thin spherical shell subjected to internal pressure. 5.3 Define joint efficiency factor for pressure vessels and state the factors involved. 5.4 Define corrosion allowance for pressure vessels and state the factors involved. 5.5 Explain how the safe design stress for a vessel is dependent on operative temperature and factor of safety. 5.6 Describe the effect of external pressure on cylindrical vessels and the resultant compressive stress and buckling effect.		
	General Objective: 6.0: Know the design and calculations of the stress and deflection induced in cantilevers and beams.		
14-15	6.1 Define the terms “Bending Moment” and shear force. 6.2 State the convention of considering 6.1 above to be positive and negative. 6.3 Calculate the values of bending moment and shearing force and produce the bending moment and shearing force diagrams for simple cases.	• Should lay down the convention before the start of the calculation.	Blackboard.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: FLUID MECHANICS II		**Course Code: CHE 304**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0: Understand the principles of momentum transport in fluid flow.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Explain the basic principles of the kinetic theory of gases. 1.2 Describe the deformation of a fluid acted upon by a shearing force. 1.3 Derive Newton's law of viscosity for fluids. 1.4 Explain the elements of boundary layer theory. 1.5 Explain the nature of laminar flow (near solid surfaces). 1.6 Explain Poiseiulle's law 1.7 Draw velocity profiles for fluid flow in pipes. 1.8 Explain the variation of viscosity with temperature. 1.9 Explain the difference between Newtonian and non-Newtonian fluids. 1.10 Describe the effects of non-Newtonian fluids on process operations.	• Explain the boundary layer theory. • Make sketches of the velocity profiles for flow of fluids through pipes.	Recommended texts, scientific calculator, internet services, etc.
	General Objective 2.0: Know the types of fluid flow existing in pipes and other ducts.		
4-5	2.1 Explain Reynold's number as a dimensionless group. 2.2 Calculate Reynold's number for a number of flow systems. 2.3 Describe the nature of turbulent flows. 2.4 Describe velocity profiles for turbulent flow on a duct.	• Solve problems on fluid flow.	Recommended texts, scientific calculator, internet services, etc.

Week	General Objective 3.0 : Know how energy losses occur in pipes as a result of frictional viscous forces.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-9	3.1 Explain the Darcy equation. 3.2 Explain the fanning friction factor. 3.3 Explain the function of Reynolds number. 3.4 Ascertain friction factors using the Stanton plot. 3.5 Calculate pressure drop and energy losses in pipes. 3.6 Calculate pressure drop in pipes making allowances for losses bends, pipefittings, and valves. 3.7 Explain the factors affecting optimum pipe diameter for simple cases. 3.8 Explain the Chezy equation for flow in open channels and hydraulic pumps. 3.9 Calculate flow in various designs of open ducts. 3.10 Design weirs and notches to measure flows in open ducts. 3.11 Calculate coefficient of discharge of a weir. 3.12 Calculate the sizes of pipe required for specific duties using the principles discussed above.	• Mention the various ways through which energy losses are encountered in the flow of fluid through pipes. • Give problems to students to solve.	Recommended texts, scientific calculator, internet services, etc.

Week	General Objective 4.0: Know how energy may be increased in flow systems		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10-13	4.1 Describe the construction and operation of various types of positive displacement pumps. 4.2 Describe the functions of different types of valves used in pumps. 4.3 Describe the construction and operation of different types of rotary pumps. 4.4 Describe an air lift pumps. 4.5 Describe the output characteristics of positive displacement pumps. 4.6 Calculate the energy requirements and pump efficiency of different type of pump. 4.7 Describe the construction and operation of centrifugal pumps. 4.8 Describe the construction and operation of air blowers. 4.9 Determine centrifugal pump characteristics. 4.10 Compare operating characteristics of a centrifugal pump with those of a positive displacement pump. 4.11 Match a centrifugal pump to a pipe network system. 4.12 Define net positive suction head. 4.13 Explain cavitations. 4.14 Calculate power requirements for centrifugal pumps. 4.15 Explain how two centrifugal pumps may be made to work together.	• Mention the various ways through which energy could be added to a flow system. • Let the students see the pumps in operation. • Demonstrate to the students the operations of centrifugal and positive displacement pumps. • Solve problems on determination of pump characteristics, power requirement and pump efficiency.	Recommended texts, scientific calculator, internet services, etc. Pump text rig, recommended textbooks, internet services, etc.

Week	General Objective 5.0: Understand particle mechanics		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14 -15	5.1 Develop the Stokes equation of motion of a single particle in a fluid. 5.2 Develop the concept of drag coefficient as function of Reynolds number. 5.3 Develop the Carman-Kozeny equation for flow through packed beds. 5.4 Calculate the pressure drop for flow of fluids through a packed bed. 5.5 Define fluidisation and explain its mechanism 5.6 Explain the properties of fluidised bed. 5.7 Explain the effects of the following on fluidisation: (a) Minimum porosity (b) Bed height (c) Pressure drop (d) Minimum fluidisation velocity (e) Bed expansion. 5.8 Calculate the parameters of the fluidised bed as in (5.7) above. 5.9 State the advantages of the fluidised bed over the fixed bed. 5.10 List industrial applications of fluidisation.	• Give students problems on calculation of pressure drop for fluid flow through packed beds as a way of assessing them • To be done in the laboratory at the stand of the equipment.	Recommended textbooks, fluidized bed, equipment, internet services, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: HEAT TRANSFER II	**Course Code: CHE 307**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0: Know advanced heat transfer problems.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-4	1.1 Describe and apply the graphical and numerical techniques of solving conductive heat transfer problems in two-dimensional systems. 1.2 Describe detailed mechanism of convective heat transmission in both laminar and turbulent flow systems e.g. two fluids separated by plane, cylindrical and spherical walls. 1.3 Explain the analogy between energy transfer and momentum transfer in flow systems. 1.4 Describe and apply the technique of dimensional analysis to convective heat transfer problems (laminar and turbulent). 1.5 Explain the NTU-effective method of heat exchanger analysis and design. 1.6 Describe the process of gas-radiation heat transfer. 1.7 Solve radiative heat transfer problems involving grey surfaces and gases with and without the significant presence of other modes of heat transfer. 1.8 Explain the significance of view factor. 1.9 Solve momentum transfer problems using analytical analogue technique as appropriate.	• Explain the analogy between energy transfer and momentum transfer in flow systems. • Give students problems to solve on heat transfer in two- dimensional system using graphical and numerical techniques.	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective 2.0: Understand unsteady state heat transfer.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-7	2.1 Explain unsteady state heat transfer theory to the heating and cooling of stirred tanks using isothermal and non-isothermal heating media. 2.2 Derive Time-Temperature relationships for tanks heated or cooled by internal coils. 2.3 Derive Time-Temperature relationships for tanks heated or cooled by circulation through external heat exchanger.	• Compare the sketches of time- temperature relationships for tanks heated or cooled by internal coil to that cooled or heated by circulation through external heat exchange.	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective 3.0: Understand the principles of boiling and condensation.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-11	3.1 Describe modes of boiling as pool and convective. 3.2 Describe the regimes of pool boiling showing heat flux as a function of temperation difference between the liquid and heating surfaces. 3.3 Describe the significance of various types of boiling in terms of heat transfer coefficient values. 3.4 Explain the significance of burn out point. 3.5 Explain the effects of surface roughness and wettability on boiling heat transfers. 3.6 Explain the process of condensation. 3.7 Describe the mechanism of heat transfer in film type and drop-wise condensation of vapours. 3.8 Explain the difference between drop wise and film type condensation and its effect on the values of convective heat transfer coefficient. 3.9 Calculate film coefficients using the Nusselt equation for film type condensation on a (a) Vertical surface (b) Inclined plane (c) Horizontal plane. 3.9 Explain how the Nusselt equation can be modified to allow (a) Sub-cooling of condensate (b) Non-condensate gases (c) Vapour velocity and turbulence (d) Flooding. 3.10Explain how design procedures need to be modified when dealing with mixtures of condensable gases.	• Explain boiling phenomenum in chemical processes. • Explain the significance of burn out point. • Explain the concepts of condensation.	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective: 4.0: Know the feature of heat transfer media and equipment		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-15	4.1 Describe heat transfer media. 4.2 Describe heat transfer equipment e.g. exchangers, heaters, coolers, condensers, reboilers, evaporators, etc. 4.3 Explain radiant heat transmission and resistance concepts.	• Explain the operation of heat exchanger, condenser and reboiler.	Recommended textbooks, Scientific Calculator, internet services etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: MASS TRANSFER II		**Course Code: CHE 311**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0: Understand fundamentals of mass transfer systems.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Describe the following mechanism of diffusion: (a) Molecular diffusion. (b) Eddy diffusion 1.2 Explain the whiteman two-film theory. 1.3 Explain how the resistance to mass transfers lies in a film adjacent to phase interface.	• Demonstrate molecular diffusion by spraying dust particles over water in a basin • Explain from their understanding the Whiteman two film theory	Clean water in white basin, dust particles, recommended textbooks.

Week	General Objective 2.0: Know the applications of dimensionless groups.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-6	2.1 Explain skin friction in flow of gases through porous solids. 2.2 Draw analogy between heat transfer and mass transfer.	• Ensure that students solve problems using dimensionless groups as applied in mass and heat transfer.	Recommended textbooks, Scientific Calculator, internet services.
	General Objective 3.0: Know interphase mass transfer.		
7-9	3.1 Explain resistance relationship. 3.2 Explain the following:- (a) Gas-film control processes; (b) Liquid-film control processes; (c) Reaction control processes. 3.3 Explain the following:- (a) Number of transfer units; (b) Equilibrium curves; (c) Operating curves. 3.4 Evaluate stages in counter-current processes. 3.5 Describe interphase mass transfer equipment.	• Explain the gas-film control processes, the liquid-film control processes and the reaction control processes as a test of their understanding of the lecture • Sketch the mass transfer control process diagram on the chalkboard.	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective 4.0: Understand the concept of individual and overall mass transfer coefficients.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10-12	4.1 Evaluate individual mass transfer coefficients. 4.2 Evaluate overall mass transfer coefficients. 4.3 Carry out material balances for: (a) Co-current (b) Counter-current systems for differential and stage-wise contacts. 4.4 Carry out material balances for cascades.	• Explain mass transfer coefficients. • Give students problems to solve.	Recommended textbooks, Scientific Calculator, internet services etc.
	General Objective 5.0: Know the difference between absorption and stripping		
13 – 15	5.1 Define absorption factor. 5.2 Define stripping factor. 5.3 Classify and describe absorption and stripping equipment.	• Ensure that students understand absorption and stripping factors and their applications in the operation and design of equipment in (5.3).	Recommended textbooks, Scientific Calculator, internet services etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: CHEMICAL ENGINEERING THERMODYNAMICS II	**Course Code: CHE 309**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0: Understand and apply the first law of thermodynamics**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 State the first law of thermodynamics and explain it in terms of internal energy, U, and work, W. 1.2 Describe path-dependent and path-independent functions. 1.3 Explain differences between isothermal and adiabatic processes. 1.4 Explain Enthalpy changes for adiabatic and isothermal processes. 1.5 Explain differences between reactions at constant pressure (isobaric) and constant volume (isochoric) 1.6 Calculate enthalpy change for the processes in 1.5 above. 1.7 Describe experimental methods used in calorimetric. 1.8 Determine enthalpy of combustion experimentally.	• Clear and complete statement of the first law of thermodynamics should be written on the chalkboard for students to copy and learn. • Calculate enthalpy for isobaric and isochoric processes	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective 2.0: Understand the significance and application of entropy concept and the second law of thermodynamics.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3-4	2.1 Explain the concept of thermodynamic reversibility. 2.2 Explain the differences between spontaneous and equilibrium processes. 2.3 State the second Law of thermodynamics. 2.4 Define change in entropy. 2.5 Explain entropy changes for chemical reactions. 2.6 Explain entropy changes for phase transitions. 2.7 Explain Rankine and Carnot cycles. 2.8 Describe the statistical nature of the second law of thermodynamics. 2.9 Explain the role of kinetic factor in determining the feasibility of thermodynamically spontaneous reactions.	• Explain from their understanding the second law processes. • Show how second law differs from first law of thermodynamics. • Distinguish the Rankine cycle from the Carnot cycle. • Ensure that students understand the various applications of the Rankine and Carnot cycles in a typical process.	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective 3.0: Understand the concept of Gibbs free energy.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-7	3.1 Define Gibb's free energy (G) and Gibb's energy change (ΔG) in terms of $\Delta G = H - T\Delta S$; H=Enthalpy; T=Temperature (K), S=Entropy. 3.2 Explain ΔG as the prime factor in predicting the feasibility of a reaction. 3.3 Explain sign and relative magnitudes of ΔH, ΔT and ΔS in determining the sign of ΔG in selected reaction. 3.4 Illustrate diagrammatically the variations of ΔG with extent of reaction. 3.5 Recognize that equilibrium can be described in terms of a minimum ΔG value (ΔG^o) and also in terms of the equilibrium constant (K). 3.6 State and apply the equation $\Delta G^o = -RT \text{ in } k$(in=Natural log.) 3.7 Express the feasibility of a cell reaction: (a) in terms of ΔG, (b) in terms of cell emf (E). 3.8 Explain the equation $\Delta Go = -nFE^o$: n=number of electron transferred; F=Faraday constant, E= Electromotive force 3.9 Derive a relationship between K and E using (3.6) and (3.8) above. 3.10 Calculate value of K and ΔG^o from given standard electrode potentials.	• Explain the feasibility of a reaction depending on the value of ΔG obtained from the equation $\Delta G = H - T\Delta S$ • Give students problems to solve on items (3.1) to (3.10) • Assess the students.	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective 4.0: Understand the behaviour of real gases in terms of departure from ideal gas behaviour		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-9	4.1 Explain Van der Waal's modification of the ideal gas equation. 4.2 Explain virial equations to represent the behaviour of real gases. 4.3 Relate Joule-Thomson effect to the departure of gases from ideal behaviour. 4.4 Explain the use of Joule-Thomson effect in the liquefaction of gases.	• Let the students imagine themselves to be gas molecules in a container within the room with a view to establishing Van der Waal's forces that exist between molecules. • Calculate one problem with students. • Make a sketch.	Students themselves. Recommended textbooks, Scientific Calculator, Internet services.

Week	General Objective 5.0: Know heat capacities of gases.		
10 - 11	5.1 Define molar heat capacities at constant pressure and constant volume. 5.2 Derive and use the equation relating enthalpy changes at two temperatures (Kirchoff's equation). 5.3 Apply Kirchoff's equation to problems where (a) Cp is independent of temperature and (b) Cp is a function of temperature. 5.4 Derive the equation Cp-Cv=R for an ideal gas, where Cp=constant pressure heat capacity. Cv=constant volume heat capacity. And R=ideal gas constant.	• Explain clearly the stages in the derivation of Kirchoff's equation to enable students apply it appropriately. • Give students problems to solve.	Recommended textbooks, Scientific Calculator, internet services etc.

Week	General Objective 6.0: Understand the application of ideal and non-ideal solutions.		
	Special Learning Objective	**Teachers Activities**	Learning Resources
12-13	6.1 Explain the use of chemical potential. 6.2 Explain the relationship between activity and reaction equilibria 6.3 State and apply Raoult's Law. 6.4 State and apply Henry's Law. 6.5 Explain the application of Raoult's and Henry's Laws to ideal and non-ideal solutions respectively. 6.6 State the third Law of thermodynamics.	• Formulate clear statements for the laws. • Solve problems using Raoult's and Henry's laws.	Recommended textbooks, Scientific Calculator, internet services etc.
Week	**General Objective 7.0: Know phase rule and its applications.**		
14-15	7.1 Classify chemical systems. 7.2 Draw temperature-composition diagrams for binary and some multi-component systems. 7.3 Draw pressure-composition diagrams for binary and some multi-component systems. 7.4 Apply diagrams in (7.2) and (7.3) above in separation by crystallization, distillation, steam distillation and extraction.	• Ensure that students know how to draw temperature-composition diagrams for binary and multi-component systems. • Show the students how to apply the drawn temperature-composition diagrams to unit operations in (7.4).	Recommended textbooks, Scientific Calculator, internet services etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: CHEMICAL ENGINEERING ANALYSIS		**Course Code: CHE 411**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0: Review the analytical solutions to model equations.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Explain the use of an analytical solution of differential equation. 1.2 Review the Laplace transform of simple functions as well as the inverse Laplace transform of simple function. Apply laplace transform to solve differential equations e.g. solve by laplace transform the boundary value problem $\frac{du}{dt} = \frac{4d^2}{dx^2}$ $_U(0,t) = 0$; $_U(3,t) = 0$ $_U(x,0) = 10\sin 2x - 6\sin 4x$ 1.4 Review Fourier series	• Solve problems such as (a) Determination of the effectiveness of a porous catalyst. (b) Oxidation rate in a catalytic reactor (c) Transpiration cooling under prescribed heat load at the surface of a porous wall. (d) One dimensional heat flow (e) Heat flow in an infinite bar.	Recommended textbooks, internet services etc.

4-5	1.5 Expand simple functions in Fourier series e.g. (a) simple linear algebraic functions (b) trigonometric and logarithmic functions 1.6 Apply Fourier series to solve problems 1.7 Review the methods of solving homogeneous linear differential equations and non-homogeneous differential equations. 1.8 Apply special functions such as Bessel functions, error functions, Legendre polynomials etc to solve differential equations.	• Apply the solution of problems to heat transfer, mass transfer, fluid flow, reaction engineering, reservoir engineering, etc.	

6-8	**General Objective 2.0: Review the numerical method's solution of equation.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	2.1 Solve Linear algebraic equations using Gauss-Seidel iteration methods. 2.2 Apply Newton-Raphson iteration formula to non-linear equations e.g. find the roots of the equation $Cosx=x^3$ as accurately as your tables permit. 2.3 Define finite difference, forward difference and central difference. 2.4 Apply the forward, central and backward difference formulae or tables in solving related practical problems. 2.5 Apply Euler and Runge- Kutta methods in solving non-linear equations. 2.6 Carry out numerical differentiation and integration. 2.7 Apply numerical methods for solving ordinary and partial differential equations.	• Apply the methods to solution of problems in heat transfer, mass transfer, reaction engineering, etc. • Solve problems like the Hougen and Watson's analysis of Kessel's data for homogeneous vapour-phase dehydrogenation of benzene.	Recommended textbooks, internet services etc.

9	**General Objective 3.0: Understand the application of matrix in analysis**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	3.1 Explain vectors and matrix analysis 3.2 Calculate the determinant, inverse and rank of a matrix. 3.3 Evaluate eigen values and eigen vectors. 3.4 Carry out matrix transposition and diagonalization. 3.5 Matrix formulation of Chemical Engineering problems.	• State the properties of determinants, the adjoint and inverse of a matrix. • Use several examples of the application of matrices to solve linear systems of algebraic equations. • Solve eigen value problem. • Solve problems using special matrices such as unitary, hermitian and skew-hermitian. • Transpose and diagonalize a matrix. • Draw examples from distillation, gas absorption and reaction engineering, e.t.c	Recommended textbooks, internet services etc.

	General Objective 4.0 : Understand the application of statistical methods in Chemical engineering application.		
	Special Learning Objective:	**Teachers Activities**	**Learning Resources**
10	4.1 Apply statistical design methods to design some experiments in Chemical Engineering. 4.2 Accounting for uncertainty in data.	• Apply complete randomized blocks split squares and Graces Latin squares to design experiments. • Treat decision taking under uncertainty using various criteria e.g. minimax, maximin and expected values. Illustrate with examples such as: - (a) Sizing of a catalyst bed in a reactor in presence of inexact knowledge of the activity of the catalyst when used in a reactor environment. (b) The kittrell and Watson design of a backmix reactor in the presence of uncertainty of the rate of chemical reaction.	Recommended textbooks, internet services etc.

11-12	**General Objective 5.0: Understand the principles of modeling of Chemical Engineering System**		
	Special Learning Objective:	**Teachers Activities**	**Learning Resources**
	5.1 Explain the concepts of modeling and mathematical modeling. 5.2 Derive model equation for simple fluid and thermal systems. 5.3 Derive model equations for simple systems involving reactor design, mass transfer e.t.c. 5.4 Apply model equations to dynamic systems.	• Illustrate with examples of the modeling of pneumatic liquid-level and thermal system e.t c.	Recommended textbooks, internet services etc.
13-15	**General Objective 6.0: Understand the basic principles and applications of operational research.**		
	Special Learning Objective:	**Teachers Activities**	**Learning Resources**
	6.1 Explain critical path analysis. 6.2 Explain scheduling and queuing theory. 6.3 Explain the principle of linear programming. 6.4 Explain the replacement theory.	• Applications such as refinery scheduling, plant design and construction should be used.	Recommended textbooks, internet services etc.

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PROGRAMME: HND CHEMICAL ENGINEERING (HIGHER NATIONAL DIPLOMA)			
COURSE: INSTRUMENTATION: GENERAL, CHEMICAL AND BIOLOGICAL		**Course Code: GLT 301**	**Contact Hrs: 2-1-0**
Course Specification: Theoretical /Practical Content			
Week	**General Objective 1.0: Understand the operation, use and care of basic measuring instruments**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1	1.1 Identify measuring instruments e.g. moving coil, moving iron, thermocouple, oscilloscope, digital, e.t.c. 1.2 Classify measuring instrument e.g. analogue, digital e.t.c. 1.3 List an example of type in (1.2) above. 1.4 Describe with the aid of diagrams the construction of the instruments in (1.1) above. 1.5 Describe the principles of operation of the instruments in (1.1) above.	• Identify different types of measuring instruments and classify them as either analogue or digital.	Thermocouple wires, soldering iron, oscilloscope, moving iron and moving coil instruments.

	1.6 Explain the following:- (a) Multimeter. (b) Multirange. (c) Auto ranging. 1.7 Carry out set-zero and calibration adjustments on the instruments in (1.1). 1.8 Measure: - (a) Voltage. (b) Current. (c) Resistance using the appropriate instruments in (1.1) above. 1.9 Measure frequency, amplitude, phase and distortion. 1.10 Construct simple measuring instruments e.g. thermocouple, potentiometer using the oscilloscope. 1.11 Carry out measurements using the instruments in 1.10 above. 1.12 Carry out routine care of the instruments in 1.10 above.	• Carry out calibration adjustments on the in instruments in (1.1) above and make simple measurements. • The students should be assisted to construct simple instruments such as thermocouple, potentiometer etc. • Determine the sensitivity and accuracy of the instrument constructed.	Thermocouple wires, Soldering Iron. Moving Coil instruments, Voltameter etc.

	General Objective 2.0: Understand the workings of different types of signal generators in the laboratory.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
2	2.1 Classify signal generator e.g. low frequency, high frequency, and variable frequency, fixed frequency e.t.c. 2.2 State the different types of wave forms produced by signal generators in (2.1) above e.g. square waves, saw-tooth etc. 2.3 Explain with the aid of suitable diagrams the operation of the signal generators listed in (2.1) above. 2.4 State the typical applications of each type of signal generator listed in 2.1 above. 2.5 Apply the use of a signal generator in fault finding, receiver alignment, etc. 2.6 Carry out routine care of signal generators e.g. calibration of output voltage.	• Classify signal generators as high or low, fixed or variable. • Let the students apply signal generator in fault diagnosis.	Signal generator, toolbox, chalkboard, chalk, etc.

	General Objective 3.0: Understand the applications, principle of operation and routine maintenance of recorders and reproducers.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3	3.1 Identify different types of recorders and reproducers e.g. chart, audio-video projectors etc. 3.2 Describe the principles of operation of the recorders/reproducers commonly used in the laboratory. 3.3 Explain the typical applications of the recorders and reproducers listed in (3.1) above. 3.4 Record and reproduce using the recorders and reproducers in (3.2) above. 3.5 Carry out routine care of recorders/reproducers in (3.2) above.	• List the applications of recorders and reproducers. • Students should record and carry out routine maintenance of recorders and reproducers.	Recorders, reproducers, recommended textbooks, and internet services.

4	**General Objective 4.0 : Understand the operations, construction and maintenance of power supply units in the laboratory.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	4.1 Identify types of power supply units e.g. mains derived (a-c), direct currents, batteries e.t.c. 4.2 Classify direct current supplies e.g. low voltage, high voltage, stabilized voltage. 4.3 Explain with the aid of diagrams, how a.c is converted to d.c. 4.4 Construct typical power supply mains. 4.5 Outline the precautions to be observed when using power supply units. 4.6 Apply the use of power supply units. 4.7 Carry out repair of power supply units.	• Explain how to construct typical power supply mains. • Explain how to repair power supply units.	Power supply units, recommended textbook, internet services etc.

5	**General Objective 5.0: Understand the essentials of trouble-shooting techniques.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	5.1 Identify tools for troubleshooting e.g. service manuals, multimeters, signal generators etc. 5.2 Obtain necessary information from the operator and from service manuals about a given instrument. 5.3 Check (a) continuity (b) availability of power etc in the instruments listed in (5.2) above. 5.4 Detect a defective module/part e.g. by signal injection, part substitution etc in the instruments in (5.2) above using the tools in (5.1) above. 5.5 Repair defective module part in (5.4) above. 5.6 Complete the repair in (5.1) above using flowcharts, and other service aids where necessary. 5.7 Trouble shoot instruments such as overhead-projector, pH meter e.t.c.	• List the tools for troubleshooting. • Explain how to troubleshoot instruments such as pH meter, overhead projector etc.	Service manuals, multimeters, signal generators, toolbox, internet services etc.

Week	General Objective: 6.0: Understand the principles and instrumentation of spectrophotometry.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6	6.1 Explain the term spectrophotometry. 6.2 List the various sources of light for spectrophotometric determination. 6.3 State the wavelength within the electromagnetic spectrum. 6.4 Distinguish between wavelength of light within the visible region and invisible region. 6.5 Explain diffraction grating. 6.6 Explain the functions of diffraction gratings in Spectrophotometer. 6.7 State the functions of optical filters in spectrophotometry. 6.8 State the basic laws of spectrophotometry viz Bouger-Lambet's law, Beer's law etc. 6.9 Explain the working principle of the spectrophotometer. 6.10 List the functions of the parts of the optical system of a Spectrophotometer. 6.11 List the different types of detectors used in Spectrophotometer. 6.12 Determine concentration of samples applying Beer-Lambert's law and using spectrophotometer. 6.13 Carry out minor maintenance work on the Spectrophotomer e.g. dusting, replacement of lamps, e.t.c.	• List the various sources of light for spectrophotometric determination. • Explain the working principles of a spectrophotometer. • List the types of detectors used in spectrophotometer and determine concentration of samples applying Beer-Lambert's law.	Spectrophotometer, recommended textbooks, chalkboard, chalk, internet services, etc. Spectrophotometers, recommended textbooks, toolbox, internet services, etc.

Week	General Objective 7.0: Understand the principles and instrumentation of colorimetry.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7	7.1 Explain the similarities in the working principles of the colorimeter and spectrophotometer. 7.2 Identify the various parts of a colorimeter. 7.3 Explain the functions of the parts in (7.2) above. 7.4 State the basic similarities and differences between a colorimeter and a spectrophotometer. 7.5 Explain the limitations of colorimeters in microbiological studies. 7.6 Carry out measurements using colorimeter. 7.7 Carry out routine maintenance on the colorimeter e.g. care of filters and curvettes.	• Compare the working principles of colorimeter and spectrophotometer. • Carry out routine maintenance of colorimeter.	Colorimeter, spectrophotometer, toolbox, internet services, etc.

Week	General Objective 8.0: Understand the operation and care of flame photometers and Reimann Spectrophotometer.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8	8.1 Explain the principle and operation of flame photometer. 8.2 Identify the various parts of a flame photometer. 8.3 State the functions of the various parts of a carbon rod atomizer. 8.4 State the similarities and differences between the spectrophotometer and the flame photometer. 8.5 List the errors inherent in practical flame photometry and how they can be corrected particularly as applied to biology. 8.6 Correct the errors in (8.5) above. 8.7 Demonstrate the use of a flame photometer. 8.8 Describe and carry out typical maintenance routine for the flame photometer e.g. clearing deposit from the atomizer. 8.9 List radiation sources and detectors. 8.10 Identify parts of the Reimann spectrophotometer. 8.11 Explain the functions of the part in (8.10) above. 8.12 Record spectra of known compounds using Reimann spectrophotometer. 8.13 Carry out routine maintenance of Reimann spectrophotometer.	• Identify the parts of a flame photometer. • Compare and contrast the operations of a flame photometer and Reimann spectrophotometer	Flame, photometer, Reimann spectrophotometer, recommended textbooks, internet services, etc.

Week	General Objective: 9.0: Understand the operation and care of atomic absorption spectrophotometer (AAS) and X-ray spectroscope		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9	9.1 Draw a schematic diagram of the AAS and a block diagram of an X-ray florescence spectrometer. 9.2 Identify the parts of an AAS and X-ray spectroscope. 9.3 Describe the working principles of each of the component parts of the AAS.(especially the hollow cathode lamp) and x-ray spectroscope. 9.4 Outline the steps for operating the AAS. 9.5 Measure the absorption of a sample of known concentration using the AAS and X-ray spectroscope. 9.6 Carry out routine maintenance of AAS. 9.7 Draw non-disperse X-ray absorption motor. 9.8 Carry out routine absorption measurement. 9.9 List the parts of an X-ray fluorescence spectrometer. 9.10 Identify and describe parts of an X-ray fluorescence spectrometer. 9.11 Analyse given samples using the X-ray fluorescence spectrometer. 9.12 Carry out routine maintenance of the instrument e.g. cleaning of filters, verification of optical instruments.	• List the parts of AAS and X-ray spectroscope • The students should be made to measure the absorption of a sample of known concentration using the AAS.	AAS, X-ray fluorescence, Spectrometer, spectroscope, etc.

Week	General Objective 10.0: Understand the operation and care of some analytical instruments.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10	10.1 List the component parts of:- (a) Electrolytic conductivity bridge (b) Coulometric titrator (c) Autotitrator (d) pH meter (e) Polarograph. 10.2 Identify and describe the various parts of the instruments in (10.1) above. 10.3 Explain the principle of operation of the instruments in 10.1 above. 10.4 Carry out various measurements using the instruments in (10.1) above. 10.5 Carry out the routine care of the instruments in (10.1) above by ensuring that:- (a) the cells are properly connected (b) the electrodes are activated (c) the instruments are switched off when not in use.	• The students should be made to apply the instruments in (10.1) to take various measurements. • They should also be asked to carry out routine maintenance of each of the instruments.	Coulometric titrator, autotitrator, pH meter, polarograph, toolbox, internet services, etc.

Week	General Objective 11.0: Understand the operation and care of gas chromatographic equipment, fluorimeter, polarimeter and refractometer.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11	11.1 Explain the concept of gas chromatography. 11.2 Identify the parts of:- (a) Gas chromatograph (b) Fluorimeter (c) Polarimeter (d) Refractometer 11.3 Explain the working principle of each instrument in (11.1) above 11.4 Carry out routine care of the instruments in 11.1 above e.g. cleaning of the prism with lens tissue, ensuring that the polarimeter tubes are clean and do not touch the lens.	• Show students how to operate the gas chromatograph fluorimeter, polarimeter, refractometer and use them for simple measurements • Ensure that the instruments are not mishandled by the students.	Gas chromatograph, fluorimeter, polarimeter and refractometer.

Week	General Objective 12.0: Understand the applications of various types of electrodes used in measuring ions.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12	12.1 Identify ion exchange electrodes. 12.2 State the uses of ion-exchange electrodes. 12.3 Explain the basic principles of operations of an ion-exchange electrode. 12.4 Explain the relationship between activity and concentration of an ion. 12.5 List the various types of gas measuring electrodes. 12.6 Identify an oxygen electrode. 12.7 Identify the various parts of an oxygen electrode. 12.8 Explain the functions of the parts in(12.7) above. 12.9 Measure accurately oxygen concentration using the gas measuring electrodes. 12.10 List and describe electrodes for pH measurements e.g glass combination. 12.11 Describe and apply maintenance for electrodes eg store in distilled water, use correct concentration of reactivator.	• Identify the various types of electrodes. • State their applications • Carry out measurements of ion concentration in solution using the various types of electrodes. • Assess the students.	Ion exchange electrodes, oxygen electrodes, recommended textbooks, internet services, etc.

Week	General Objective 13.0: Understand the uses and application of microscopes, auto radiography and camera Lucida		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13	13.1 Define microscopy and auto radiography. 13.2 List the various techniques of microscopy e.g. bright field dark field etc. 13.3 Identify various types of microscopes. 13.4 Explain the principles of operation of the microscopes in (13.1) above (elementary treatment only). 13.5 View objects under the microscope. 13.6 Carry out routine maintenance of microscope e.g. cleaning and lubrication. 13.7 Identify the components used in auto radiography. 13.8 Describe the application of auto radiography 13.9 List the application of camera lucida. 13.10 Explain the working principles of camera lucida.	• Explain the techniques in 13.2 • Identify the parts of microscopes in (13.1). • Demonstrate the techniques of auto radiography. • Describe the working parts of a camera lucida. • Maintain and carry out minor repairs of camera lucida.	Microscopes, brush, lubricating oil, Camera Lucida recommended textbooks e.t.c.

Week	General Objective 14.0: Understand how to use and maintain autoclave, centrifuge and incubator		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14 - 15	14.1 State the functions of: - (a) Autoclave (b) Centrifuge (c) Incubator 14.2 Identify the parts of the instruments in (14.1) above. 14.3 Explain the functions of the parts in (14.2) above. 14.4 Carry out routine maintenance of the instruments in (14.1) above.	• Sterilize, centrifuge and incubate using autoclave, centrifuge and incubator respectively. • Assess the students.	Autoclave, Centrifuge, Incubator, recommended textbooks, internet services, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: PULP AND PAPER TECHNOLOGY	**Course Code: CHE 417**	**Contact Hours: 2-0-0**
Course Specification: theoretical		

Week	**General Objective 1.0 : Know the raw materials used in pulp and paper industry.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-5	1.1 Identify the raw materials used in pulp and paper production. 1.2 Describe the following properties of the raw materials used in pulp and paper production: (i) Structural properties. (ii) Physical Properties. (iii) Chemical Properties.	• Itemise the raw materials used in Pulp and paper industries. • Explain the structural properties, physical properties, and chemical properties of the raw materials used in pulp and paper industries.	Recommended textbooks and internet services.

Week	General Objective 2.0 : Understand the methods employed in preparation of the wood pulp.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-10	2.1 Describe the following pulp preparation processes. (a) Mechanical process (b) Semi-Chemical process (c) Chemical - Mechanical process (d) Sulphite process (e) Sulphate/Kraft pulping processes. 2.2 Describe the laboratory or pilot scale processes.	• Discuss the various methods of pulp preparation illustrating with an example in each case. • Explain the pilot scale processes of wood pulping	Recommended textbooks, internet services etc.
	General Objective 3.0 : Understand the economics and ecological aspects of pulp and paper manufacture.		
11-15	3.1 Explain the recovery processes of energy and chemicals from pulping process residuals. 3.2 Explain bleaching of pulps and stock preparation. 3.3 Describe paper making and finishing operations.	• Explain the recovery processes of energy and chemicals from pulping process residuals. • Describe the paper making and finishing operations.	Recommended textbooks, internet services etc.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: BIOCHEMICAL ENGINEERING		**Course Code: CHE 418**	**Contact Hours: 2-0-0**
Course Specification: Theoretical			
Week	**General Objective 1.0: Understand methods of solving processing problems.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-5	1.1 Describe problems imposed by physical factors in food industries. 1.2 Describe problems imposed by biological factors in food industries.	• Discuss the problems caused by physical factors in food industries. • Discuss problems imposed by biological factors in food industries.	Recommended textbooks, and internet services.

Week	General Objective 2.0 : Understand the kinetics of enzymes catalyzed reactions.		
	Special Learning Objective	**Teachers Activities**	
6-10	2.1 Derive Michaelis – Menten equation. 2.2 Explain the effects of substrate concentration on the kinetics of enzyme- catalysed reactions. 2.3 Explain the effects of pH, temperature and inhibitors on the rates of enzyme-catalysed reactions.	• Apply Michealis – Menten equation to solve Biochemical engineering problems. • Discuss the effects of pH, temperature and inhibitors on the rates of enzyme catalyzed reactions.	Recommended textbooks, and internet services.
Week	**General Objective 3.0 : Understand the theory and design of microbial culture processes.**		
11-15	3.1 Explain the design microbial culture processes in the manufacture of: (i) Pharmaceuticals (ii) Commercial enzymes (iii) Alcoholic beverages (iv) Biological waste treatment.	• Illustrate with good examples design of a typical microbial culture process.	Recommended textbooks, and internet services.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: PROCESS DESIGN		**Course Code: CHE 401**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Understand how to undertake literature survey and design information data**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-4	1.1 Design data collection using internet services, journals, handbooks encyclopaedia etc. 1.2 Describe manufacturing processes. 1.3 Select appropriate unit process for various unit operations.	• Discuss a typical manufacturing process. • Explain the various unit processes/ unit operations.	Recommended textbooks, internet services, etc.

Week	General Objective 2.0 : Know how to carry out process calculations.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-10	2.1 Estimate materials and energy balance. 2.2 Estimate duty of all major equipment.	• Solve typical problem involving material and energy balance. • Discuss the function or the major equipments.	Recommended textbooks, internet services, etc.
11-15	**General Objective 3.0 : Know how to prepare process flow sheet.**		
	3.1 Draw a flow diagram showing all equipment and process pipe work. 3.2 Draw flow diagram for material and energy balance. 3.3 Indicate major control loops and instrumentation of the process.	• Illustrate a simple technological process, showing all equipments. and process pipe work involved. • Identify the control loops in the process.	Recommended textbooks, internet services, etc.
15	**General Objective 4.0 : Know how to estimate the cost of process.**		
	4.1 Explain the financial viability of processes.	• Discuss the cost involved in processes.	Recommended textbooks, internet services, etc.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: STRENGTH OF MATERIALS		**Course Code: CHE 312**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Understand the concept of stress, strain, Hooke's law and elastic constant (EGK).**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1	1.1 Define stress and strain. 1.2 State Hooke's law.	• Explain stress and strain. • State Hooke's law.	Recommended textbooks, internet services, etc.

Week	General Objective 2.0 : Understand the relationship between the elastic constant's the concept of strain energy and stress in composite bars.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
2	2.1 Determine the relationship between Young Modulus, E, Bulk modulus, G and elastic constant, K. 2.2 Explain the concept of strain energy. 2.3 Evaluate stress in composite bars.	• Determine the relationship between E, G and K. • Explain the concept of strain energy. • Evaluate stresses in composite bars.	Recommended textbooks, internet services, etc.
Week	**General Objective 3.0 : Understand the concept of compatibility equation and the concept of stress strain relationship in two dimensions.**		
3	3.1 Explain the compatibility equation. 3.2 Define stress and strain relationship in 2-dimensions.	• Explain compatibility equation.	Recommended textbooks, internet services, etc.

Week	General Objective 4.0 : Understand the type of stresses and strains developed in thick- walled pressure Vessels and cylinder.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4	4.1 Evaluate principal stresses and strain in planes. 4.2 Determine principal stresses using the Morph's circles.	• Explain the stress and strain relationship in two dimensions. • Evaluate the principal stresses, and strains in planes.	Recommended textbooks, internet services, etc.
5	**General Objective 5.0** : **Understand the construction of sharing force and bending moment diagrams and the computation of shearing force and bending moment.**		
	5.1 Derive the type of stress in pressurized cylinder shells. 5.2 Compare hoop and longitudinal stresses.	• Derive the types of stresses in pressurised cylindrical shells. • Compare hoop and longitudinal stresses	Recommended textbooks, internet services, etc.

Week	General Objective 6.0 : Understand the theory of bending		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6	6.1 Derive the stress in thin spherical shells. 6.2 Analyze the dimensional changes caused by internal pressure.	• Derive the stress in thin spherical shells.	Recommended textbooks, internet services, etc.
Week	**General Objective 7.0 : Know the types of forces and their effects on chemical plant components**		
7-8	7.1 Explain the effects of various types of forces on chemical plant components. 7.2 Describe simple cases of direct stress and strain. 7.3 Calculate the stress and strain in simple systems subjected to shear stress.	• Discuss the effects of various types of forces on chemical plant components. • • Explain direct stress and strain. • Carry out calculations of stress and strain in process vessels. • Assess the students.	Recommended textbooks, internet services, etc.

Week	General Objective 8.0 : Know and apply knowledge of stress and strain solving simple problems encountered in plant design.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-10	8.1 Calculate the hoop and axial stress and strains induced in a thin cylindrical shell subjected to internal pressure. 8.2 Calculate the hoop stresses and strain involved in thin spherical shell subjected to internal pressure. 8.3 Define joint efficiency factor for pressure vessels and state the factors involved. 8.4 Define corrosion allowance for pressure vessels and state the factors involved. 8.5 Explain how the safe design stress for a vessel is dependent on operative temperature and factor of safety.	• Solve problems on hoop, axial stress and strain in pressure vessels. • Make students to understand the need to allow for corrosion in equipment design..	Recommended textbooks, internet services, etc.

Week	General Objective 9.0 : Know the design and calculation of the stresses and deflections induced in cantilevers and beams.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11-15	9.1 Define the terms bending moment and shear force. 9.2 State the convention of considering (9.1) above to be positive and negative. 9.3 Calculate the values of bending moment and shearing forces and produce the bending moment and shearing forces diagrams for simple cases.	• Explain the meaning of bending moments and shear force. • Explain the convention in (9. 2). • Carry out simple calculations involving bending moment and shearing force.	Recommended textbooks, internet services, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: CHEMICAL REACTION ENGINEERING II	**Course Code: CHE 306**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0 : Understand the design of chemical reactors for homogenous system.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Carry out mass and energy balance on a single batch (CSTR)and Plug flow reactors. 1.2 Calculate analytically and graphically from kinetic data the performance measures of reactors- space time, residence time and capacity. 1.3 Adopt the design equation to variable and non variable reaction volume system. 1.4 Obtain kinetic equation for constant volume and variable volume reactions in CSTR. 1.5 Calculate the conversion volume and number and reactor in multiple reactor systems.	• Carry out simple calculations involving mass and energy balance . • Calculate the performance of a typical chemical reactor from kinetic data analytically and graphically. • Calculate conversion, volume and number of reactors in multiple reactor system.	Recommended text books, scientific calculator, internet services, etc.

Week	General Objective 2.0 : Understand the Chemical kinetics of heterogeneous Reactors		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-5	2.1 Distinguish between homogeneous and heterogeneous reaction systems. 2.2 Identify rate processes and develop rate equations for simple heterogeneous reactions. 2.3 Determine the effect of physical phenomena of mass transfer and heat transfer on heterogeneous reactions.	• Discuss the difference between homogeneous and heterogeneous reaction systems. • Develop a simple heterogeneous rate equation. • Specify the effects of physical phenomenon of mass transfer and heat transfer on heterogeneous reactions.	Textbooks, internet services, etc.

Week	General Objective 3.0 : Understand the kinetic models of non-catalysed heterogeneous systems.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-7	3.1 Define Progressive conversion and unreacted core models. 3.2 Apply rate equations based on the unreacted core model for chemical reaction control and diffusion control gas-solid systems.	• Explain the non-catalysed heterogeneous system. • Define progressive conversion and unreacted core models. • Illustrate the models using the given rate equations.	Textbooks, internet services, etc.
8-11	**General Objective 4.0 : Know how to design simple heterogeneous reactors.**		
	4.1 Distinguish between mixed flow and plug flow reactors. 4.2 Explain the use of industrial reactors as an approximation to mixed flow and plug flow reactors. 4.3 Estimate conversion, residence time, and capacity of single fluidized bed reactors and moving bed reactors by applying basic design equations.	• Distinguish between mixed flow and plug flow reactors. • Explain by citing good example the use of industrial reactors as an approximation to mixed flow and plug flow reactors.	Textbooks, internet services, etc.

Week	General Objective 5.0 : Understand the fundamentals of catalysis and catalysed reactions.,		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-15	5.1 Explain the phenomena of catalysis and characteristics of catalysis. 5.2 Distinguish between physical adsorption and chemical adsorption. 5.3 Estimate catalyst surface by applying adsorption isotherms.	• Explain given suitable examples catalyzed reactions and the phenomenon of catalysis. • Distinguish between physical adsorption and chemical adsorption	Textbooks, internet services, etc.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: CHEMICAL ENGINEERING ENTREPRENEURSHIP		**Course Code: CHE 410**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Entrepreneurial theory**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1	1.1 Explain entrepreneurial Theory. 1.2 Explain entrepreneurial roles. 1.3 State the characteristics of an entrepreneur. 1.4 Distinguish between intrapreneurship and management. 1.5 Distinguish between entrepreneurship and intrapreneurship.	• Define entrepreneur, intrapreneur and a manager. • State clearly the differences amongst a manager, an intrapreneur and an entrepreneur.	Recommended textbooks, and internet services.

Week	General Objective:2.0 Understand the importance of the environment on entrepreneurship		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
2-3	2.1 Explain the importance of the economic factors in the environment on entrepreneurship. 2.2 Show the effect of socio-cultural factors in the environment on business.	• Explain the importance of the sources of finance, interest rate and exchange rate on business. • Explain that it is important for the entrepreneur to study the socio-cultural factors in his environment and respond appropriately so as to succeed in business. e.g. an entrepreneur who is involved in producing pork for sale will be out of business in a place where eating of pork is a taboo.	Recommended textbooks, and internet services.

	2.3 Explain the relevance of the legal-political factors in the environment or business. 2.4 The relevance of the technological factors should be stressed.	• Similarly, an entrepreneur who produces chemicals for warfare may be out of business in a country that does not get involved with war. • Ensure that the students understand that it is essential that the entrepreneur must study the relevant laws in the locations where he operates and operate within these laws. • Explain that entrepreneur should submit papers and pay taxes regularly. • Ensure that the students understand that appropriate technology is employed in the business.	

Week	General Objective 3.0 : Understand business ownership types in Nigeria		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-7	3.1 Identify the types of enterprises, sole proprietorship, limited liability, cooperative societies, public corporation, partnership. 3.2 Explain the structure, functions, advantages and disadvantages of each type of business organization. 3.3 Explain the objectives of a business organization. 3.4 Examine private enterprises. 3.5 Evaluate public enterprises 3.6 Appraise the effect of private control of business. 3.7 Analyse the implications of state control of enterprises.	• Explain the objectives of a business organization. • Compare public and private enterprises. • Analyse the implications of state control of enterprises.	Recommended textbooks, and internet services.

Week	General Objective 4.0 : Understand the need for manufacturing & raw materials availability		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8	4.1 Stress the need for careful sourcing of raw materials and needed equipment to ensure continuity of business. 4.2 State the various sources of information. 4.3 Explain the need for research and development on product.	• Give examples of sources of information such as internet, patents, and copyrights e.t.c.	Recommended textbooks, and internet services.
9-10	**General Objective 5.0 : Understand small scale business**		
	5.1 Explain the operations and problems of small scale business. 5.2 Define venture capital. 5.3 Explain sources of capital. 5.4 State the importance of proper record keeping and accounts of business. 5.5 State the measures of the profitability of a venture.	• Give examples of sources of capital such as personal savings, borrowing from friends and banks, stock market e.t.c. • Explain ARR, IRR, NPV, and PI etc.	Recommended textbooks, and internet services.

Week	General Objective 6.0 : Understand federal and state governments regulation on chemical industries.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11	6.1 Identify the various federal government legislations applicable to chemical industries. 6.2 Identify the various state government legislation applicable to the chemical industries.	• Highlight the relevant laws from the FEPA Act, NAFDAC, and SON etc. • Highlight the relevant laws of the various states environmental protection bodies and other relevant bodies.	Recommended textbooks, and internet services.

Week	General Objective:7.0 Understand the elements of marketing.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	7.1 Define marketing and market. 7.2 State the marketing mix: product, price, place and promotion. 7.3 Explain product differentiation. 7.4 Explain the market segmentation. 7.5 Differentiate the industrial market from the consumer market. 7.6 Define a product. 7.7 Identify the stages of product life cycle-introductory, growth, maturity and decline. 7.8 State the features of each stage in (7.7) above. 7.9 Describe the different ways a company can develop a new product e.g. improving the existing products, seeking new products from existing source and inventing a new product.	• Distinguish between market and marketing. • State the marketing mix. • Explain product differentiation and market segmentation. • Assess the students.	Recommended textbooks, and internet services.

Week	General Objective:8.0 Understand market research methods and preparation Of feasibility studies.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14	8.1 Explain the concepts of product development, market analysis, promotion, distribution and pricing. 8.2 Explain the market research process. 8.3 Explain the process of evaluation of research findings. 8.4 Explain how feasibility studies are carried out.	• Emphasize sampling techniques, data collection, analysis and interpretation. • Assess the students. • Show to the students various types of feasibility studies carried out by people. • Assign the students the problem of carrying out feasibility studies on a particular product.	Recommended textbooks, and internet services.

Week	General Objective 9.0 : Understand the personal factors in starting a business.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
15	9.1 State the objectives of starting a business. 9.2 Define the over forcus of a business such as: (i) Define the need for achievement (ii) Define the major entrepreneurial characteristics (iii) Explain the ways to strengthen your achievement/motivation (iv) State the rewards and penalties of owning a business of your own. 9.3 Discuss small scale business case studies.	• Illustrate with cases of people who have succeeded in business.	Recommended textbooks, and internet services.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: CHEMICAL ENGINEERING LAB V	**Course Code: CHE 409**	**Contact Hours: 0-0-6**
Course Specification: Practical Content		

Week	**General Objective 1.0: Know how to carry out experiments on instrumentation and process control, simultaneous heat and mass transfer, chemical reaction engineering and unit operations using engineering equipment and pilot plants.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 Determine drying kinetics of selected solids. 1.2 Describe drying rate regimes, effect of temperature, air velocity and humidity on drying rate for tray drying. 1.3 Verify heat and mass transfer analogies for tray drying. 1.4 Determine efficiency of other dryers leading to dryer selectivity (spray dryers, drum dryers, rotary dryers, Pneumatic dryers and fluidized bed dryers). 1.5 Determine the thermal and adiabatic dryer efficiency of spray dryers and optimize spray-drying conditions for selected products.	• The teacher should discuss these experiments with the students and then supervise them to ensure that they achieve the desired result. • The teacher should ask the students to write and present a formal report on their findings.	Tray dryer, rotary dryer, vertical pneumatic dryer, spray dryer, fluidized bed dryer etc.

3-4	1.6 Observe operation and distribution of water flow pattern of different packing arrangements, different air flow rates and water flow rates on water cooling tower performance. 1.7 Investigate and report the effect of packing surface area on: approach to wet bulb temperatures at inlet, and pressure drop across different packings. 1.8 Investigate and report the effect on the performance of cooling towers for a range of process cooling loads and a range of inlet temperature.	• The teacher should discuss these experiments with the students and then supervise them to ensure that they achieve the desired result. • The teacher should ask the students to write and present a formal report on their findings.	Packed distillation equipment, water cooling tower etc.
5	1.9 Determine the maximum reflux ratio for a binary system in a sieve plate/ and/or bubble cap and /or packed distillation column. 1.10 Determine the minimum reflux ratio based on the feed and top product composition during operation. 1.11 Determine the distillate and bottom product composition and flow rates during operation.	• The teacher should discuss these experiments with the students and then supervise them to ensure that they achieve the desired result. • The teacher should ask the students to write and present a formal report on their findings.	Sieve plate, packed distillation column and bubble cap.

	1.12 Compare predicted and experimental conversion in a continuous tubular flow reactor. 1.13 Investigate and report on the effect of temperature on reaction rate. 1.14 Determine the residence time of tubular flow reactor. 1.15 Observe and report on industrial reactors operation and characteristics (e.g. packed bed reactors, rotary kiln, etc).	• Carry out the experiments.	Tubular flow reactor, packed bed reactors, rotary kiln, batch chemical reactor, heat source etc.
8-9	1.16 Investigate and report on the effect of residence time on conversion. 1.17 Compare the conversions in a mixed flow reactor and tubular reactor. 1.18 Investigate and report on the effect of temperature and agitation on conversion.	• Carry out the experiments.	Mixed flow reactor, tabular reactor.
10	1.19 Measure the kinetic Parameters of homogeneous reactions. 1.20 Evaluate the operation and performance of heterogeneous reactors which approximate to mixed flow fluidized bed Reactors e.g. local combustion in a fluidized bed reactor.	• Carry out the experiments.	Fluidised bed reactor.

11	1.21 Measure pH using various equipment e.g. pH meter and Lovibond comparator. 1.22 Evaluate system response using manual control. 1.23 Maintain the characteristics of control loop instrumentation.	• Carry out the experiments.	pH meter, Lovibond comparator process control training unit etc.
12-13	1.24 Adjust level transducer. 1.25 Conduct amplification from a controller. 1.26 Describe proportional regulation. 1.27 Measure integration time. 1.28 Describe P-I regulation.	• Carry out the experiments.	Controller, level transducer etc.

14	1.29 Evaluate system response to manual control of temperature. 1.30 Describe the characteristics of individual control elements in a controller circuit. 1.31 Evaluate systems response of manual control of pressure.	• Carry out the experiments.	Control elements – control valves, actual controllers, transmitters, solenoid and diaphragm valves etc.
15	1.32 Set up operation for a single three term controller to regulate pressure. 1.33 Determine the characteristics of maintaining a control loop instrumentation.	• Carry out the experiments.	Control elements – control valves, actual controllers, transmitters, solenoid and diaphragm valves etc.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: CHEMICAL ENGINEERING LABORATORY IV		**Course Code: CHE 308**	**Contact Hours: 0-0-6**
Course Specification: Practical Content			
Week	**General Objective 1.0 : Know how to carry out drying operations.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 Dry suitable materials using the following: (v) Rotary dryer. (vi) Tray dryer. (vii) Vertical Pneumatic dryer.	• The teacher should operate these drying devices while the students watch closely and then try to operate them later.	Tray dryer, Rotary dryer, vertical pneumatic dryer

Week	General Objective 2.0: Know how to carry out experiments involving plate and packed columns, flow through pipes, process control and instrumentation equipment.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3-7	2.1 Describe the working of a packed distillation column and a plate distillation column. 2.2 Determine the energy losses, which occur when fluid flows through pipefittings. 2.3 Describe the relationship between pressure drops which occur when a fluid flows through an orifice plate and a venturi meter. 2.4 Determine the drag coefficient for spheres. 2.5 Describe the dynamic behaviour of stirred tanks. 2.6 Determine the controller constant necessary to stabilize a thermal process using its signal curve. 2.7 Characterise the individual control element in a control unit. 2.8 Operate a feedback control loop and examine the effect of the control variable of temperature using a temperature control apparatus. 2.9 Investigate unsteady state behaviour in the absence of control using a flow measurement control apparatus. 2.10 Determine the hydraulic characteristics of a model sedimentation tank, including short-circuiting, average retention times, holdback and flow profiles as a function of flow rate.	• The students should carry out these experiments under the supervision of the teacher. • Students are to write their reports at the end of the experimentations.	Packed distillation column, plate distillation column, process control training unit, temperature control apparatus, sedimentation tank etc.

Week	General Objective 3.0 : Know how to carry out experiments involving gas absorption and liquid-liquid extraction.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-11	3.1 Operate gas absorption equipment e.g. packed towers, plate or tray towers, spray towers, wetted wall absorption column. 3.2 Demonstrate solvent selectivity and solvent recovery. 3.3 Determine the effect of pressure drop, loading and flooding on packed absorption column performance. 3.4 Determine gas/liquid (selected pairs) overall mass transfer coefficients. 3.5 Determine theoretical equilibrium stages for plate tower of gas/liquid systems. 3.6 Determine height equivalent to theoretical stages for packed towers. 3.7 Determine the effect of packing characteristics on gas absorption efficiency. 3.8 Determine Hydrodynamics of liquid-liquid systems in packed towers. 3.9 Determine extraction efficiency for different packings.	• The students should carry out these experiments under the supervision of the teacher. • Students are to write reports at the end of the experiments.	Gas absorption equipment e.g. packed towers, tray, towers, Spray towers etc.

Week	General Objective 4.0 : Know how to carryout experiments involving fixed and fluidized bed and fluid transportation processes.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-15	4.1 Determine pressure drop through packed and fluidized beds for both air and water systems. 4.2 Verify Carman-Kozeny equation. 4.3 Differentiate between particulate and aggregate fluidization. 4.4 Operate centrifugal pumps, gear pumps, axial pumps and positive displacement pumps and measure their operating characteristics including: (a) Pump head and flow characteristics at constant speed (b) Pump performance characteristics. © Determination of the relationship between speed, flow, head and power consumption. (d) Impeller radial pressure distribution.	• The students should carry out these experiments under the supervision of the teacher. • Students are to write reports at the end of the experiments.	Fixed and fluidised bed systems, centrifugal pumps, gear pumps and axial pumps.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: PROCESS METALLURGY		**Course Code: CHE 419**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Understand the dressing of metal ores.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Identify the raw materials used in iron and steel industry. 1.2 Describe ore dressing; crushing, grinding, sizing, sorting, pelletizing, sintering and briquetting.	• Describe the processes in (1.2) with examples and/or illustrations.	Recommended textbooks, internet services etc.
4-6	**General Objective 2.0 : Understand reaction kinetics of extraction processes**		
	2.1 Explain gas-solid reactions: calcinations, roasting and reduction. 2.2 Explain liquid-liquid reactions and leaching leading in extraction 2.3 Explain liquid-liquid reactions at slag metal interface.	• Explain these reaction using appropriate chemical reactions to examplify or illustrate where necessary.	Recommended textbooks, internet services etc.

Week	General Objective 3.0 : Understand steel making processes.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-9	3.1 Explain converter processes, reactions and heat balance, slag effects on melts and refractories. 3.2 Explain direct reduction and open hearth processes.	• Explain the effects of slag on melts and refractories.	Recommended textbooks, internet services etc.
	General Objective 4.0 : Understand refining techniques.		
10 - 12	4.1 Explain electrolytic refining of copper and precious metals. 4.2 Describe evaluation of electrodes, electrolytes and energy requirements.	• Explain the electrolytic refining of metals.	Recommended textbooks, internet services etc.
	General Objective 5.0 : Understand the control of furnace atmosphere.		
13 - 15	5.1 Identify types of furnace atmosphere. 5.2 Explain influence of furnace atmosphere on smelting. 5.3 Explain refining and heat treatment processes.	• Explain the refining and heat treatment processes.	Recommended textbooks, internet services etc.

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PROGRAMME: HIGHER NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: CHEMICAL ENGINEERING LABORATORY III		**Course Code: CHE 305**	**Contact Hours: 0-0-6**
Course Specification: Practical Content			
Week	**General Objective 1.0: Know how to carryout experiments on evaporation.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-4	1.1 Measure the efficiency of climbing film evaporator. 1.2 Determine the effect of concentrating solution on heat transfer. 1.3 Determine heat transfer rates and efficiency of evaporation in single and double effect evaporators. 1.4 Determine the effect of flow rates, pressure and vacuum on single and double effect evaporators.	• The teacher is to guide the students in carrying out these experiments. • Students should write a formal report of their findings.	Single effect evaporator, climbing film evaporator, and other laboratory apparatuses.

Week	General Objective 2.0 : Know how to carry out experiments on filtration.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-7	2.1 Describe the operation of various filter units. 2.2 Determine the effect of vacuum, pressure, slurry feed rate and solid concentration on pressure and vacuum filters e.g. plate and frame filter press, and rotary vacuum filter. 2.3 Determine the specific cake properties of compressible and incompressible cakes by constant pressure and constant volume filtration method.	• The teacher should endeavour to discuss the operation of the various filter units in the laboratory before the students are allowed to engage in these experiments. • The students should write a formal report of their finding and should follow the report writing procedure.	Sedimentation tank, filter press, filterability index apparatus, centrifuge/electrostatic precipitator, etc.

Week	General Objective 3.0 : Know how to carry out experiments on heat transfer.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	3.1 Explain Free (natural) convective heat transfer from a flat plate or finned plate. 3.2 Compare free (or natural) convection and forced convection from vertical flat surface and extended surface of constant cross section (cylinders). 3.3 Determine heat transfer coefficient for free (or natural) and forced convection. 3.4 Determine the rate of heat transfer and heat transfer coefficient for free (or natural) convective boiling heat transfer studies. 3.5 Describe the working of shell and tube heat exchanger, double pipe heat exchanger. 3.6 Determine number of transfer unit. 3.7 Identify the effect of pressure flow rates on heat transfer co-efficient. 3.8 Describe the process of gas radiation, radiative heat transfer. 3.9 Determine radiant surface temperature in a gas combustion chamber e.g. chimneys.	• The teacher should give a lecture on heat transfer and heat transfer equipment before students are allowed to carry out the experiments. • Students are to write a report on the experiments performed.	Heat correction tube apparatus temperature measurement bench, flow control rig, thermal radiation apparatus, Double pipe heat exchanger (concentric tube) etc.

Week	General Objective 4.0 : Know how to perform experiments on chemical engineering thermodynamics.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	4.1 Determine vapour-liquid Equilibria for binary systems, and plot boiling point composition diagrams. 4.2 Measure vapour pressure of different volatile liquids and determine enthalpy of vaporization. 4.3 Determine phase equilibria for a three-component system (saturated/solubility curves and tie lines).	• The students are to perform these experiments under the supervision of the teacher. • The students are to write reports on the experiments performed to enable the teacher assess them appropriately.	Vapour-liquid equilibria apparatus.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: POLYMER SCIENCE AND TECHNOLOGY	**Course Code: CHE 310**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0 : Know the classes of polymers and their raw material sources.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 Classify Polymers. 1.2 Identify sources of Polymer raw materials.	• Mention some sources of polymer raw materials and the eventual final polymers.	Recommended textbooks, internet services, etc.
3-4	**General Objective 2.0 : Understand the chemistry of polymerisation processes.**		
	2.1 Explain addition polymerisation, condensation polymerisation, co-polymerisation and vulcanisation reactions. 2.2 Explain the mechanisms of the reactions in (2.1) above.	• Explain the mechanisms of reactions in addition polymerisation and condensation polymerisation.	Recommended textbooks, internet services, etc.

Week	General Objective 3.0 : Understand principles of polymer manufacture.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-6	3.1 Explain the various classes of polymerisation process including solution polymerisation, suspension polymerisation, emulsion polymerisation, vulcanisation, compounding and reinforcement. 3.2 Explain the effect of heat and mass transfer on the various processes in (3.1) above. 3.3 Explain the basic principles of design of polymer reactors.	• Ensure that students understand the fundamentals of polymer manufacturing process. • Assess the students.	Recommended textbooks, internet services, etc.
	General Objective 4.0 : Understand polymer materials production (synthetic and natural).		
7-8	4.1 Describe the manufacture of natural resin latex. 4.2 Describe the production of thermoplastics, polyvinyl, nylons, acrylic and phenoxy resins. 4.3 Explain the production of thermo setting polymers of phenol, formaldehyde, polyester, amino and epoxy resins.	• Compare the manufacture of natural resin late to the production of synthetic polymers e.g. polyester. • Assess the students.	Recommended textbooks, internet services, etc.

Week	General Objective 5.0 : Know the various methods of processing polymers.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-10	5.1 Describe mastication, mixing, extrusion, calendering, moulding, thermo-forming and sintering Processes. 5.2 Explain the purposes of the various processing methods in (5.1) above.	• Assess the students' understanding of polymer processing methods. • Give examples of products of the methods discussed in (5.1).	Recommended textbooks, internet services, etc.
	General Objective 6.0 : Understand different polymer properties and testing.		
11-13	6.1 Explain rheology of polymers. 6.2 Describe the physical properties of polymers including mechanical, electrical and chemical resistance. 6.3 Describe the testing of basic polymer properties.	• Assess the students understanding of polymer products properties and quality standard .	Recommended textbooks, internet services, etc.

Week	General Objective 7.0 : Know how to modify polymer properties.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14-15	7.1 Explain the purpose of various additives including carbon black and non-carbon black, fillers, plasticizers, extenders, softeners and antioxidants. 7.2 Describe the addition processes required to attain the desired properties.	• Give examples of typical polymer additives and their effects on polymer products quality.	Recommended textbooks, internet services, etc.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: EQUIPMENT DESIGN	**Course Code: CHE 404**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0 : Know how to carry out equipment design and specification**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-5	1.1 Select the appropriate method for the design of equipment. 1.2 Determine the data necessary for the design of equipment. 1.3 Determine the size and configuration of the equipment. 1.4 Select the most appropriate internals for equipment (e.g. trays, and packing etc.) 1.5 Select the most appropriate instrumentation and controls for equipment under design. 1.6 Prepare dimensional sketches suitable for submitting detailed design to components.	• Select an appropriate method for the design of specific equipment. • Calculate the size of the equipment. • Specify the most appropriate internals for the equipment. • List the appropriate instrument for a typical design project.	Recommended texts, graph sheets, scientific calculator, and internet services.

Week	General Objective: 2.0 Know how to make economic analysis of design		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-10	2.1 Prepare an equipment schedule listing major equipment and given sizes, capacity, operating conditions and materials of construction. 2.2 Prepare a design. 2.3 Select plant layout and site for plant location. 2.4 Prepare a design report.	• List the major design equipment giving thier sizes, capacity and operating conditions. • Explain the rudiments of a workable design. • Develop a design report.	Recommended texts, graph sheets, scientific calculator, and internet services.

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PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: FOOD SCIENCE AND TECHNOLOGY	**Course Code: CHE 407**	**Contact Hours: 2.0.0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0 : Understand basic food science and technology**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-5	1.1 Identify basic raw materials in food processing industries. 1.2 Classify raw materials in food processing industries into vegetables, spices, fruits, tubers, grains e.t.c 1.3 Identify the physical and biochemical properties of food.	• Discuss the sources of the basic raw materials in food processing industries. • Specify the physical and biochemical properties of food.	Recommended textbooks, internet services, etc.

Week	General Objective 2.0 : Understand food processing operations.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6 – 11	2.1 Describe mechanical operations in food processing i.e cleaning, sorting and grinding in food processing. 2.2 Describe conservation operations: membrance separation (ultrafiltration, reverse osmosis) and leaching. 2.3 Explain extrusion of food. 2.4 Describe preservation methods in common use in the food industry, sterilization, pasteurization, freeze-drying and freezing. 2.5 Explain food spoilage bymicro-organisms, enzymes, food illness, etc.	• Explain the various mechanical operations carried out in food processing. • Discuss the conservation operations such as membrane separation and leaching. • Discuss the various food preservation methods. • Explain the effects of micro-organisms on food.	Recommended textbooks, internet services, etc.
Week	**General Objective 3.0 : Understand food manufacturing processes**		
12-15	3.1 Describe the manufacturing processes for production of: sugar, cereals, fruit and vegetable juice, food, fats and oils milk products, bakery, beverages (soft drinks, tea, coffees)	• Discuss the manufacturing processes for production of the various types of food products.	Recommended textbooks, internet services, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
COURSE: HEALTH, SAFETY AND ENVIRONMENT II	**Course Code: CHE 408**	**Contact Hours: 2-0 -0**
Course Specification: Theoretical Content		

Week	**General Objective 1.0 : Know the legislations relevant to health and safety at work**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Outline the main provision of the health and safety at work. 1.2 Outline the main provision of the factories Act as regards five precautions. 1.3 State the relevance of common law to health and safety at work. 1.4 Identify the general duties and responsibilities of employers and others in control safety at work. 1.5 Describe the role and functions of executives, the inspectorate and other enforcement authorities in safety at work. 1.6 Outline the principles of developing an effective safety policy. 1.7 Outline the principles of organising and arranging an effective safety policy.	• Show that legislation is relevant to health and safety at work • State the role and functions of the enforcing authorities in safety at work. • Highlight the relevance of an effective safety policy	Recommended textbooks, lecture notes and internet services.

Week	General Objective 2.0 : Understand the importance of industrial relations, team spirit and roles of joint consultations and safety committees		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-5	2.1 Describe the importance of industrial relations in establishing effective safety arrangements. 2.2 State the role of joint consultation and safety representatives. 2.3 Describe the roles and consultation of safety committees. 2.4 Explain committee procedure; including the roles of chairman, members, agenda and papers in safety planning.	• State the importance of industrial relations. • List the role of joint consultation and safety representative. • State the role of committee members.	Recommended textbooks, lecture notes and internet services.

Week	General Objective 3.0: Know the importance of good health and safety in working environment.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-7	3.1 Explain (i) The need for accident prevention (ii) Psychological basis for accident prevention. (iii) Economic basis of accident prevention. 3.2 Categorise potential causes of physical injuries and occupational illness in work places. 3.3 Describe possible preventive measures for (3.2) above. 3.4 Identify personal safety considerations, working practices and hazards associated with processing industries e.g. (i) Personal Safety – protective clothing, lendering, barrier creams, personal hygiene, safety spectacles and mask and breathing equipment. (ii) Special safety measures – permits to work, air testing safety measures regarding pressure and vacuum, electrical and electrostatic hazards and radiation hazards. (iii) Fire and explosion hazards – the factors affecting combustion and the spread of combustion, close and open flash points, ignition temperature, spontaneous combustion, flammable range, use of fire blankets, water foam, vapourising liquids as fire extinguishers, storage of flammable materials, dust and dust explosion, static electricity and its production, methods of obviation and flame proofing.	• Discuss the harzards associated with processing industries, in terms of personal safety. • Explain special safety measures to be taken into consideration in processing • List the factors affecting combustion. • State the flash points of some sample of combustible materials. • Explain the roles of plant manangement and office in achieving the overall objectives. • Discuss the role of relevant specialist in accident prevention. • Elaborate on how to solve emergency cases.	Recommended textbooks, lecture notes and internet services.

	3.5 Explain the role of management, supervisors, safety officers and operators, in the overall objectives. 3.6 State the role of relevant specialist, viz safety officer, medical officer, welfare officer, fire officer in accident prevention. 3.7 Identify the sources of information and materials needed in cases of emergency.		
Week	**General Objective 4.0 : Understand the importance of reports in accident prevention**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-9	4.1 Explain the use of reports in accident prevention. 4.2 List main elements of oral and written reports and their purposes. 4.3 Explain the uses of statistical data e.g. accident incidence, frequency rate in planning prevention of accidents. 4.4 Apply statistics to the Quantitative assessment of risk.	• Discuss the relevance of reports in accident prevention. • List the main elements of oral and written reports. • Explain how statistical data is being used in planning prevention of accident.	Recommended textbooks, lecture notes and internet services.

Week	General Objective 5.0 : Know methods of disposal of liquids, solid and gaseous wastes from industries.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10-12	5.1 Explain how to measure impurities in water and air. 5.2 Explain the disposal of toxic wastes. 5.3 Explain the prevention of Pollution effects of (i) powders (ii) leaking gases (iii) smoke (iv) fibrous materials in Chemical plant (v) industrials waste water. (vi) solid wastes.	• Illustrate with good examples how to measure impurities in air and water. • List government regulations on pollution of environment. • Explain pollution prevention in relation to powders leaking gas smoke.	Recommended textbooks, lecture notes and internet services.
Week	**General Objective 6.0 : Know the method of handling oil spillage**		
13-15	6.1 Explain the spillage of oil in (i) Drilling industry (ii) Mining industry (iii) Petroleum refinery 6.2 Outline methods of handling oil spillage 6.3 State the roles of environmental protection agencies.	• Discuss oil spillage occurrences in the oil industry. • Mention ways or handling oil spillage. • Enumerate the role or environmental protection agencies.	Recommended textbooks, lecture notes and internet services.

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	PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)		
	COURSE: CHEMICAL PROCESS DYNAMICS AND CONTROL	**Course Code: CHE 406**	**Contact Hours: 2-0-0**
	Course Specification: Theoretical Content		
Week	**General Objective 1.0 : Understand the control of a chemical process**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 Explain the reasons for chemical process control. 1.2 Classify the variables in process control. 1.3 Explain the design elements of a control system. 1.4 Describe the hardware for a process control system. 1.5 Explain the development of a mathematical model. 1.6 Explain Linearization of system with one variable. 1.7 Explain Deviation variables. 1.8 Explain Linearization of systems with many variables.	• Ensure understanding of basic control nomenclature. • Show how linearization is carried out for different mathematical models.	Recommended texts, graph sheets, scientific calculator, and internet services.

Week	General Objective 2.0 : Know the basic control concepts		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3-4	2.1 Explain standard terminology and symbols used in process control 2.3 Explain the advantages of the application of automatic control in industry 2.4 Identify the essential elements of an automatic control system 2.5 Describe the purpose of each element in the control system in item (2.3) above. 2.6 Distinguish between open loop, feed forward control and closed loop control. 2.7 Draw and explain block diagram of a chemical plant to illustrate open loop control, feed forward control and closed loop control.	• Discuss the need for process control. • Describe elements of automatic control system. • Solve numerical examples.	Recommended texts, graph sheets, scientific calculator, and internet services.

Week	General Objective 3.0 : Understand the dynamics of a chemical process		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-6	3.1 Explain the advantages and disadvantages of laplace transforms. 3.2 Discuss laplace transforms of simple function such as unit step and ramp etc. 3.3 Discuss solution of differential equations. 3.4 Explain qualitative nature of solutions. 3.5 Explain dynamic behaviour of first order systems. 3.6 Discuss transient response of 1^{st} order systems-step function and impulse function, etc. 3.7 Explain first order systems in series. 3.8 Discuss dynamic behaviour of second order systems. 3.9 Explain transient response of second order systems and lead/lag systems. 3.10 Explain dynamic response of higher order systems.	• Ensure that students understand chemical process dynamics. • Stress to the students the qualitative nature of solutions. • Describe transient behaviour of 1^{st} , 2^{nd} and higher order systems. • Solve numerical examples.	Recommended texts, graph sheets, scientific calculator, and internet services.

Week	General Objective 4.0 : Understand the basic modes of control, their applications and behaviour.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-9	4.1 Explain the need for deviation in control actions. 4.2 Differentiate between the terms action and control. 4.3 Describe two-step action. 4.4 Define overlap and explain the reasons for having an overlap. 4.5 List the practical examples of the effects of overlap and dead time on two-step control action. 4.6 Solve simple problems associated with control action involving linear reaction rates and state dead times. 4.7 Describe multi-step action. 4.8 Describe single speed floating control and multi-speed floating control. 4.9 Describe integrated control action. 4.10 Describe proportional control action. 4.11 Explain proportional band. 4.12 Solve simple numerical proportional band problems 4.13 Explain the limitation of proportional control action in terms of sustained load change producing offset. 4.14 Explain how and why the addition of integral action to proportional action rebuilt in the automatic correction of offset. 4.15 Define integral action time. 4.16 Define derivative action time. 4.17 Explain the reduction of overshoot obtained by addition of derivative action. 4.18 Explain the need for a three-term controller (PID).	• Explain the basic modes of control • Describe their applications and behaviour. • Solve numerical problems. .	Recommended texts, graph sheets, scientific calculator, and internet services.

Week	General Objective 5.0 : Understand complex control systems		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10-12	5.2 Describe a cascade control system and explain the use of a primary controller and a secondary controller. 5.3 Explain the advantages of using a cascade system in place of a simple control loop. 5.4 Describe a typical plant application of cascade control. 5.5 Describe a ratio plant application of cascade control. 5.6 Describe a typical practical application of ratio control. 5.7 Describe digital computer control. 5.8 Explain the difference between on-line and off-line computer. 5.9 Describe direct digital control.	• Ensure understanding of complex control system. • Show advantages and disadvantages of the cascade control. • Explain ratio control. • Solve numerical problems.	Recommended texts, graph sheets, scientific calculator, and internet services.

Week	General Objective 6.0 : Understand practical controllers .		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	6.1 List detecting elements and associated measurements elements for the following variables: a) flow rate, (b) temperature, (c) pressure, (d) level. 6.2 Describe a flapper and nozzle system as a method of generating a pneumatic signal. 6.3 Describe the linkage between the detecting demand and the flapper by reference to temperature, level and pressure controls. 6.4 Describe a pneumatic proportional controller and describe a practical method of adjusting the proportional band. 6.5 Describe a pneumatic two-step controller. 6.6 Describe the generation of plus integral action for a pneumatic controller. 6.7 Describe the generation of proportional plus derivative action for a pneumatic controller. 6.8 Describe the generation of proportional plus integral plus derivative action for a pneumatic controller. 6.9 Explain how proportional integral and derivative actions can be generated electronically. 6.10 Describe the construction and operation of pneumatic control valves. 6.11 Describe a valve positioner and explain its functions.	• Discuss practical controllers, giving enough examples. • Solve numerical problems.	Recommended texts, graph sheets, scientific calculator, and internet services.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: RESERVOIR ENGINEERING	**Course code: CHE 422**	**Contact Hours: 2-0-0**	
	Course Specification: Theoretical Content		
Week	**General Objective 1.0 : Understand the origin of Petroleum**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 Describe the branches of petroleum industry 1.2 Describe origin of petroleum 1.3 Describe petroleum reservoirs 1.4 Describe earth temperature and pressure 1.5 Explain natural gas, LP gas, condensate and crude oil.	• Ensure understanding of the history of petroleum industry. • Describe various types of reservoirs.	Recommended textbooks, and internet services.
Week	**General Objective 2.0 : Understand the properties of rock**		
4-6	2.1 Describe types of rocks. 2.2 Define porosity. 2.2 Define permeability. 2.3 Describe measurement of permeability. 2.4 Explain effects of water on permeability. 2.5 Explain capillary effects.	• Describe types of rocks, with emphasis on porosity and permeability. • Show how permeability can be determined from various methods.	Recommended textbooks, and internet services.

Week	General Objective 3.0 : Understand the properties fluid.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-8	3.1 Explain the properties of oil, gas condensate and gas. 3.2 Explain fluid properties, P,V, T, H and S relationships. 3.3 Describe other fluid properties such as compressibility, formation volume factors, vapour pressure and surface tension.	• Describe fluid properties. • Show with numerical examples how these properties can be determined.	Recommended textbooks, and internet services.
WEEK	**General Objective 4.0: Understand material balance concept**		
8-11	4.1 Explain the term reservoir drive mechanism. 4.2 Develop from first principle the material balance equation. 4.3 Apply the material balance equation to analyse a reservoir	• Derive material balance from first principles. • Show how the material balance can be done for a reservoir. • Solve numerical examples.	Recommended textbooks, and internet services.

Week	General Objective 5.0: Understand methods of calculating hydrocarbons initially in place.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	5.1 Calculate gas and oil reserves. 5.2 Carry out reservoir estimation from geological data. 5.2 Calculate original oil in place. 5.3 Calculate original gas in place. 5.4 Calculate final gas-in-place at abandonment.	• Ensure students know how to determine hydrocarbons in place. • Solve numerical examples.	Recommended textbooks, and internet services.
14-15	**General Objective 6.0 : Understanding well testing principles and techniques**		
	6.1 Explain well testing. 6.12 Enumerate the different types of well testing in practice. 6.13 Enumerate the testing procedures and differentiate between them.	• Describe well testing. • Show how well testing is done in practice. • Solve numerical problems.	Recommended textbooks, and internet services.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: PLANT SERVICES MAINTENANCE		**Course code: CHE 412**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0 : Know the services normally associated with chemical plant.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	1.1 List the services normally associated with given chemical plant and equipment e.g. (a) Boiler houses (b) Compressed air installations © Pump houses (d) Electricity generation (e) Material handling equipment etc. 1.2 Identify physically and/or by sketch a layout of a typical Plant/equipment, the locations of the services as well as storage	• Ensure that students understand the various pieces of equipment and functions employed in steam generation; compressed air services, electricity power generation, general plant material handling and pump houses. • State the importance of the following services in a plant: steam compressed air, pumps and electricity. • Give illustrations and practical examples of the uses of utilities in a plant.	Recommended textbooks, and internet services.

WEEK	General Objective 2.0 : Understand safety precautions to be observed in the installation, operation and maintenance of a chemical plant.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-7	2.1 Identify the safety regulations required for installation, operation and maintenance of plant and equipment. 2.2 Describe the procedure for installation, operation and maintenance of plant and equipment. 2.3 Evaluate the safety precautions prevailing in an installation, operation and/or maintenance of plant and equipment against the statutory standards.	• State the importance of good house keeping and proper storage of materials, tools and anxilliary equipment in a plant. • List typical storage facility for a given plant layout.	Recommended textbooks, and internet services.

WEEK	General Objective 3.0: Know how to anticipate maintenance problems of chemical plants.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-11	3.1 Identify the storage requirements for materials, tools and ancilliary equipment for the installation, operation and maintenance of plant and equipment. 3.2 Identify physically and/or with a sketch the components, parts and ancilliary equipment of a given plant. 3.3 List the faults that are likely to develop in the components in (3.2) above when the plant is in operation and the possible remedies. 3.4 Describe trouble-shooting procedures.	• Mention the components, parts and ancilliary equipment of a given plant. • Mention some faults capable of developing when a plant is in operation and suggest the remedies to these faults.	Recommended textbooks, and internet services.
WEEK	**General Objective 4.0 : Know how to construct the maintenance programme of equipment and plant.**		
12-15	4.1 Distinguish between prevention and breakdown maintenance. 4.2 Define the common terms: reliability, service, overhaul, etc. 4.3 Set up the maintenance programme and keep maintenance records for a given plant and equipment.	• Differentiate between prevention and breakdown maintenance. • Give the students examples of typical maintenance programmes. • Identify the basic components of maintenance programme.	Recommended textbooks, and internet services.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: CHEMICAL ENGINEERING TECHNOLOGY (HIGHER NATIONAL DIPLOMA)			
COURSE: GAS PROCESSING TECHNOLOGY		**Course Code: CHE 420**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective 1.0: Understand Company Structures.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1	1.1 Enumerate sources of natural gas. 1.2 Enumerate and classify types of natural gas. 1.3 Give the composition of natural gas.	• Define the term Natural gas. • Discuss the development of natural gas. • Identify types of Natural gas accumulation.	Recommended textbooks, journals, and INTERNET services.
2	**General Objective 2.0: Know hydrocarbon fluid mechanics and concept of phase behaviour of hydrocarbon system.**		
	2.1 Describe the peculiar behaviour of hydrocarbon fluids; define permeability, porosity, saturation etc. 2.2 Define gas solubility and gas/vapour-liquid equilibrium. 2.3 Explain the terms hydrocarbon behaviour. 2.4 Analyse qualitative phase behaviour; P-V-T plots and meaning, vapour pressure criticals and Pseudo-criticals.	• Explain hydrocarbon phase behaviour. • Define hydrocarbon systems. • Explain multi-phase systems; multi-dimension system. • Define water vapour content of Natural gas. • Define Darcy's law.	Recommended textbooks, journals, and INTERNET services.

Week	General Objective 3.0 : Understand the material balance concept and the mechanics of gas production.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3-4	3.5 Explain the term Reservoir Drive Mechanism. 3.6 Develop from first principles the material balance equation. 3.7 Apply material balance equation to analyse a reservoir. 3.8 Calculate gas reserve from relevant equation. 3.9 Carry out reservoir estimation from geological data. 3.10 Calculate original gas-in-place. 3.11 Calculate gas produced. 3.12 Calculate final gas-in-place at abandonment. 3.13 Determine by prediction analyse the drawdown. 3.14 Explain production operation and equipment.	• Explain general material balance equation. • Give students problems to solve on calculation of gas-in-place, and gas produced from a reservoir. • Explain how natural gas is produced. • Determine fractional reservoir production.	Recommended textbooks, journals, and INTERNET services.
Week	**General Objective 4.0: Understand Gas Well test Procedures.**		
5	4.4 Explain the term well testing. 4.5 Enumerate different types of well testing in practice. 4.6 Enumerate the testing procedures and differentiate between them.	• Define the term “Gas well testing”. • Explain types of well testing. • Assess the students.	Recommended textbooks, journals, and INTERNET services.

Week	General Objective 5.0: Understand retrograde phenomenon and gas condensate vapour-liquid equilibrium		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6	5.1 Explain retrograde phenomenon in hydrocarbon systems. 5.2 Distinguish between liquid retrograde and gas retrograde systems. 5.3 Explain vapor – liquid equilibrium in hydrocarbon systems. 5.4 Define state of substance and differentiate between state and phase.	• Explain retrograde phenomenon in hydrocarbon systems. • Distinguish between liquid retrograde and gas retrograde systems.	Recommended textbooks, journals, and INTERNET services.
Week	**General Objective 6.0: Understand the application of basic thermodynamics concepts to natural gas Processing.**		
7	6.1 Review the basic thermodynamic laws. 6.2 Explain basic thermodynamic accounting on mass and energy. 6.3 Explain enthalpy and entropy application on gas processing. 6.4 Compare ideal and real situations in gas processing thermodynamic variables.	• Explain clearly the 1^{st} and 2^{nd} laws of thermodynamics. • Differentiate between real and ideal gas situations.	Recommended textbooks, journals, and INTERNET services.

Week	General Objective 7.0 Know treatment of purification of Natural gas		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8	7.1 State the purpose of gas treatment. 7.2 Describe purification methods and processes. 7.3 Describe the following treatment facilities, stating their relevance: - Inlet manifold; separators; scrubbers Dehydrators or dryers; Heaters; Compressors coolers; Chemical tanks.	• State the impurities present in natural gas. • Describe some purification methods and processes. • Assess the students.	Recommended textbooks, journals, and INTERNET services.
9	**General Objective 8.0: Know Natural Gas Utilization.**		
	8.1 Enumerate the uses of Natural gas: - As fuels in high temperature operations - As fuels in steam boiler and medium temperature operations - As source for NGL and LNG. - As source for important Chemical derivatives: - Acetylene; Ammonia; methanol carbon black; - Oxo alcohols; Hydrogen cyanide; carbon and - Hydrogen in Iron ore reduction.	• Demonstrate knowledge of principles of utilization of Gas and Gas equipment. • Identify gas appliances used for industrial and house hold purposes. • Describe the use of natural gas as sou7rce for Chemical derivatives like acetylene, ammonia, methanol etc.	Recommended textbooks, journals, and INTERNET services.

Week	General Objective: 9.0 Understand Natural Gas Liquefaction.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10	9.1 Describe liquefaction processes. 9.2 Describe refrigeration systems. 9.3 Describe productions of liquefaction: i) Liquefied Petroleum Gas (LPG) ii) Natural Gas Liquids (NGL) iii) Liquefied Natural gas (LNG) 9.4 Describe storage facilities for LNG. 9.5 Describe shipping facilities for LNG.	• Define LNG. • Describe the process involved in LNG liquefaction. • Describe LNG storage facilities and associated problems. • Assess the students.	Recommended textbooks, journals, and INTERNET services.
	General Objective 10.0 Know Natural Gas Conversion to important chemicals.		
11	10.1 Explain Methane conversion to: (i) acetylene (ii) ammonia (iii) methanol (iv) carbon black (v) Oxo alcohols (vi) Hydrogen and hydrogen cyanide. 10.2 Explain application of methane in Iron are direct reduction plant.	• Uses Chemical equation to explain to conversion of methane to acetylene, methanol, ammonia, carbon black etc. • Use Delta Steel Company, Aladga to explain the application of methane in iron are direct reduction.	Recommended textbooks, journals, and INTERNET services.

Week	General Objective:11.0 Know Natural Gas Application in Fertilizer production as in NAFCON.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	11.1 Describe steam reforming of Natural Gas (Methane) to produce Synthesis Gas. 11.2 Describe Ammonia Production by Haber process. 11.3 Describe the catalytic oxidation of Ammonia to Nitric acid by Ostwald's process. 11.4 Describe Ammonium Nitrate production. 11.5 Describe Sulphuric Acid Production by contact process and Ammoniom Sulphate Production. 11.6 Describe Urea production by reaction between ammonia and carbon dioxide.	• Explain steam reforming of Natural gas. • Describe Ammonia production by Haber process. • Explain Urea production. • Asses the students	Recommended textbooks, journals, and INTERNET services.

Week	General Objective: 12.0 Know Product Specifications.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14	12.1 Explain Gas and Liquid contactors. 12.2 Explain the importance of physical properties especially Reid vapour pressure. 12.3 Explain LNG specification. 12.4 Describe storage of LNG.	• Explain liquid and gas contactors. • Explain the challenges involved in the storage of LNG and proffer the remedies. • Assess the students.	Recommended textbooks, journals, and INTERNET services.
Week	**General Objective.13.0 Know Process Vessel Specifications.**		
15	13.1 Describe shell and heads. 13.2 Explain configurations 13.3 Explain separation: mist extraction, liquid-liquid separation. 13.4 Describe dust scrubbers, absorbers and fractionators, packed towers, relief and venting equipment.	• Explain shell and heads. • Use a relevant systems to explain mist extraction and liquid-liquid separation as separation processes. • Assess the students.	Recommended textbooks, journals, and INTERNET services.

LIST OF EQUIPMENT
CHEMICAL ENGINEERING TECHNOLOGY
HIGHER NATIONAL DIPLOMA

In addition to the equipment listed for the National Diploma Programme, the following are required for the Higher National Diploma Programme in Chemical Engineering Technology:

S/NO	ITEM	QUANTITY
1.	Fluid circuit system	2
2.	Multi pump test rig (Universal)	2
3.	Centrifugal pump test rig	2
4.	Free and Forced convection heat apparatus	2
5.	Fixed and Fluidised bed system	2
6.	Pre cessinulation unit	1
7.	Packed distillation equipment	2
8.	Double effect evaporator	1
9.	Vapour-liquid equilibria apparatus	1
10	Batch chemical reactors	3
11.	Basic climbing film evaporator	2
12.	Multi-function plate distillation column	2
13.	Old refrigerator	21
14.	Process control training plant (Thermo-tutor multi-function)	1
15.	Centrifugal filter	4
16.	Enzyme catalytic reactor	4
17.	Glass blowing kit	4
18.	Gas chromatograph	1
19.	Mass spectrometer	1
20.	Computer simulation softwares in: i). Fluid and Particle Mechanics ii). Unit Operations iii). Heat and Mass Transfer Process Control	

HIGHER NATIONAL DIPLOMA

In addition to the equipment listed for the National Diploma Programme, the following are required for the Higher National Diploma Programme in Chemical Engineering Technology.

S/NO	ITEM	QUANTITY
1.	Fluid circuit system	2
2.	Multi Pump test rig (Universal)	2
3.	Centrifugal Pump test rig	2
4.	Free and forced convection heat apparatus	2
5.	Fixed and fluidized bed system	2
6.	Packed distillation equipment	2
7.	Double effect evaporator	1
8.	Vapour-liquid equilibria apparatus	1
9.	Batch Chemical reactors	3
10.	Basic climbing film evaporator	2
11.	Multi-functional plate distillation column	2
12.	Old refrigerator	2
13.	Process control training plant(Thermo-tutor Multi-function)	1
14.	Centrifugal filter	4
15.	Enzyme catalytic reactor	4
16.	Glass blowing unit	4
17.	Gas Chromatograph	1
18.	Mass spectrometer	1
19.	Computer Simulation soft wares: i) Fluid and Particle Mechanics ii) Unit Operations iii) Heat and Mass transfer iv) Process control	

RESEARCH INSTRUMENTS

Analytical Equipments

(i) Gas (Atomic Absorption Spectrophotometer)
(ii) Infrared Spectrophotometer
(iii) Autoclaves
(iv) Ultraviolet and visible Spectrophotometer
(v) Centrifuge
(vi) Viscometer
(vii) Computer simulation laboratory (equipped with Soft wares)

List of Participants (ND/HND Chemical Engineering)

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