NATIONAL BOARD FOR TECHNICAL EDUCATION

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

NATIONAL DIPLOMA (ND)

IN

CHEMICAL ENGINEERING TECHNOLOGY

CURRICULUM AND COURSE SPECIFICATIONS

SEPTEMBER 2002

GENERAL INFORMATION FOR ND CHEMICAL ENGINEERING TECHNOLOGY

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…".

The Programme is therefore committed to the production of technicians who should be capable of carrying out and supervising Chemical Processes in Chemical Engineering based industries.

OBJECTIVES OF THE PROGRAMME

Diplomates of this programme should be able to:

Assist in carrying out chemical analysis in industrial laboratories.

Assist in production processes in chemical based industries.

Market industrial chemicals.

Establish and manage cottage process industry.

Carry out routine inspection, maintenance and repairs of chemical process equipment.

MINIMUM ENTRY REQUIREMENTS

Candidates for admission into the programme should have:

i A minimum of four credit level passes in at most two sittings in Senior Secondary School Certificate (NECO or WAEC) or General Certificate of Education (GCE) ordinary level or NTC which must include; Chemistry, Physics and Mathematics and any of the following:-

Biology,
Agricultural Science
Technical Drawing
Further Mathematics
Statistics

Basic Electronics
Metal Work
Economics
Geography and at least a pass in English language.

ii Successfully completed the Board's recognized Pre-National Diploma (Science and Technology) Course may be admitted into the programme. Such candidates must have passed Chemistry, Physics, English Language and Mathematics at SSCE/NTC or GCE O'level before undertaking the course.

4.0 DURATION

The National Diploma in Chemical Engineering Technology Programme is a terminal one, and is structured to last for a minimum of two academic sessions (4 semesters) and a maximum of four academic sessions (8 semesters). Each semester consist of 15 weeks.

5.0 CURRICULUM

The Curriculum of ND Programme consists of four main components. These are:

General Studies courses
Foundation courses
Professional courses
Supervised Industrial Work Experience Scheme (SIWES).

The General studies components shall include courses in:

Art and Humanities- English Language and Communication

Social Studies – Citizenship Education, Political Science, Sociology, Philosophy, Geography, and Entrepreneurship are compulsory.

The General Education component shall account for not more than 15% of the total contact hours for the programme.

Foundation courses include courses in Economics, Mathematics, Pure Science, Technical Drawing, and Statistics, etc. The number of hours for the programme may account for about 10-15% of the total contact hours.

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

Student Industrial Work Experience Scheme (SIWES) shall be taken during the long vacation following the end of the second semester of the first year. See details of SIWES at section 11.0

CURRICULUM STRUCTURE

The structure of the National Diploma Programme consist of four semesters of classroom, laboratory and workshop activities in the college, and a semester (3 – 4 months) of student Industrial Work Experience Scheme (SIWES). Each semester shall be of 18 weeks duration made up as follows:

15 contact weeks of teaching; i.e. recitation, practical exercise, quizzes, tests etc and

3 weeks for examination and registration.

ACCREDITATION

The Diploma Programme shall be accredited by the National Board for Technical Education before the Diplomates can be awarded the National Diploma certificates. Details about the process of accrediting a programme for the award of the National Diploma can be obtained from the Executive Secretary, National Board for Technical Education, Plot 'B', Bida Road, P.M.B. 2239, Kaduna - Nigeria.

AWARD OF NATIONAL DIPLOMA

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

Satisfactory performance in all prescribed course work which may include class work, test, quizzes, workshop practice, laboratory work which should amount to a minimum of between 72 and 80 semester credit units.
Supervised Industrial Work Experience for four months.
Satisfactory performance at all semester examinations.
Satisfactory completion of final year project work, normally continuous assessment contribute 30% while semester examinations are weighted 70% to make a total of 100%. The industrial training is rated based on pass or fail.

National Diploma should be awarded in four classes:

i.	Distinction	-	CGPA of 3.50 and above
ii.	Upper Credit	-	CGPA of 3.0-3.49
iii	Lower Credit	-	CGPA of 2.50-2.99
iv.	Pass	-	CGPA of 2.00-2.49

GUIDANCE NOTE FOR TEACHERS

The new curriculum is drawn in unit courses. This is in keeping with the provisions of the National Policy on Education, which stress the need to introduce the unit course system, which enables a student who wishes to transfer the units already completed in an institution of similar standard from which he/she is transferring.
In designing the units, the principle of the modular system by product has been adopted, thus making each of the professional modules, when completed provides the student with technical operative skills, which can be used for employment purposes self – and otherwise.
As the success of the unit course system depends on the articulation of programmes between the institution 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.

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 institution under which performance can take place and to follow that with the criteria for determing 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 enquiring minimum standard and quality of education in the programmes offered throughout the polytechnic system.

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 practice in the ratio of 50:50 or 60:40 or the reverse.

10.0 LOG BOOK

A personal log-book to be kept by the students shall contain all the day-to-day, weekly summary, and semester summary of all the practical activities from day one to the end of the programme.

This is to be checked and endorsed by the lecturers concerned at the end of every week.

11.0 GUIDELINES ON SIWES PROGRAMMES

For the smooth operation of the SIWES, the following guidelines shall apply:

Responsibility for placement of students.

Institutions offering the National Diploma programme shall arrange to place the students in industry.

By April 30 of each year, six copies of the master-list showing where each student has been placed shall be submitted to the Executive Secretary, National Board for Technical Education, which shall, in turn, authenticate the list and forward it to the Industrial Training Fund, Jos.

The placement officer should discuss and agree with industry on the following:

A task inventory of what the students should be expected to experience during the period of attachment. It may be wise to adopt the one already approved for each field.

There should be an industry based supervisor for the students during the period. It should be noted that the final grading of the students during the period of attachment should be weighted more on the evaluation by his/her industry-based supervisor.

Evaluation of students during SIWES. In the evaluation of students, cognizance should be taken of the following items:

Punctuality.
Attendance.
General attitude to work.
Respect for authority.
Interest in the field/technical area.
Technical competence as a potential technician in his/her field.

Grading of SIWES: To ensure uniformity of grading seals, the institution should ensure that the uniform grading of students work, which has been agreed to by all polytechnics, is adopted.

The Institution-Based Supervisor: The institution-based supervisor should initial the log-book during each visit. This will enable him to check area being met and to assist students having any problems regarding the specific assignments given to them by their industry-based supervisor.

Frequency of visit: Institution should ensure that students placed on attachment are visited within one month of their placement.

Other visits shall be arranged so that:

there is another visit 6-8 weeks after the first visit; and
a final visit in the last month of the attachment.

Stipend for students in SIWES: The rate of stipend payable shall be determined from time-to-time by the Federal Government after due consultation with the Federal Ministry of Education, the Industrial Training Fund and the National Board for Technical Education.

SIWES as a component of the Curriculum: The completion of SIWES is important in the final determination of whether the student is successful in the programme or not. Failure in the SIWES is an indication that the student has not shown interest in the field or has no potential to become a skilled technician in his/her field. The SIWES should be graded on a fail or pass basis. Where a student has satisfied all other requirements but failed SIWES, he may only be allowed to repeat another four months' SIWES at his/her own expense. The SIWES shall carry 4.0 credit units

12.0 **FINAL YEAR PROJECT**

Final year students in this programme are expected to carryout a project work. This could be on individual basis or group work. The project should, as much as possible incorporate basic elements 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 should be properly supervised.

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

CHEMICAL ENGINEERING TECHNOLOGY

CURRICULUM TABLE.
NATIONAL DIPLOMA 1ST SEMESTER

CODE	COURSE TITLE	L	T	P	CH	CU
BPH 111	Basic Physics I (Mechanics & Properties of Matter)	2	-	3	5	3.0
BCH 111	Basic Chemistry I (General & Physical Chemistry)	2	-	3	5	3.0
STA 111	Introduction to Statistics	2	-	-	2	2.0
MTH 111	Elementary Mathematics I (Algebra & Trigonometry)	2	1	-	3	3.0
CHE 101	Introduction to Chemical Engineering I	2	1	-	3	3.0
MEC 112	Technical Drawing	1	-	3	4	2.0
MEC 112	Basic Workshop Practice	1	-	3	4	3.0
GNS 101	Use of English I	2	-	-	2	2.0
GNS102	Citizenship Education	2	-	-	2	2.0
ICT 111	Information and Communication Technology	2	-	-	2	2.0
		18	**2**	**12**	**32**	**24.0**

NATIONAL DIPLOMA 2ST SEMESTER

CODE	COURSE TITLE	L	T	P	CH	CU
BPH 121	Basic physics II (Optics, Waves, Electricity & Magnetism)	2	-	3	5	3.0
BCH 121	Basic Chemistry II (Organic & Inorganic Chemistry)	2	-	3	5	3.0
MTH121	Elementary Mathematics II	2	1	-	3	3.0
ICT 121	Computer Systems and Programming	2	-	-	2	2.0
GLT 111	General laboratory Techniques					
	(i) Care & Maintenance of Laboratory wares and Simple Equipment	1	-	-	1	1.0
	(ii) Safety in the Laboratory	1	-	-	1	1.0
CHE 102	Introduction to chemical Engineering II	2	1	-	3	3.0
CHE 104	Electrical Engineering Science	2	-	3	5	3.0
CHE 106	Introduction to chemical engineering plant services and maintenance	1	-	3	4	2.0
CHE 108	Chemical Engineering Drawing	1	-	3	4	2.0
GNS 102	Communication in English 1	2	-	-	2	2.0
		18	**2**	**15**	**30**	**25**

NATIONAL DIPLOMA 3RD SEMESTER

CODE	COURSE TITLE	L	T	P	CH	CU
CHE 201	Introduction to Engineering Analysis	2	-	-	2	2.0
CHE 203	Chemical Engineering Thermodynamics I	2	-	-	2	2.0
CHE 205	Unit Operations I	2	-	-	2	2.0
CHE 207	Mass Transfer I	2	-	-	2	2.0
CHE 209	Heat Transfer I	2	-	-	2	2.0
CHE 211	Fluid Mechanics	2	-	-	2	2.0
CHE 213	Chemical Engineering Laboratory I	-	-	6	6	3.0
CHE 215	Corrosion and Material Science	2	-	-	2	2.0
CHE 217	Project Seminar	-	-	6	2	2.0
CHE 219	SIWES	-	-	-	-	4.0
		14	**-**	**12**	**22**	**23.0**

NATIONAL DIPLOMA 4Th SEMESTER

CODE	COURSE TITLE	L	T	P	CH	CU
CHE 202	Engineering Management I	2	-	-	2	2.0
CHE 204	Chemical Reaction Engineering I	2	-	-	2	2.0
CHE 206	Unit Operations II	2	-	-	2	2.0
CHE 208	Instrumentation and Process Control	2	-	-	2	2.0
CHE 210	Health, Safety and Environment	2	-	-	2	2.0
CHE 212	Chemical Engineering Laboratory II	-	-	6	6	3.0
CHE 214	Project	-	-	-	-	4.0
	ELECTIVE	2	-	-	2	2.0
CHE 216	Introduction to Bio-technology					
CHE 218	Polymer Science and technology					
CHE 220	Fuel technology					
CHE 222	Petroleum processing technology					
		12	**-**	**6**	**18**	**19**

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING			
COURSE: INTRODUCTION TO CHEMICAL ENGINEERING I		**Course Code:** CHE 101	**Contact Hours: 2-1-0**
Course Specification: THEORETICAL CONTENT			
Week	**General Objective** 1.0 **: Know the scope of chemical engineering profession**		
	Specific Learning Objective	**Teachers Activities**	**Resources**
1-2	Outline the historical development of Chemical Engineering. Explain the role of Chemical Engineering in the society. Discuss Chemical Engineering career opportunities.	• Discuss the history of Chemical Engineering. • Show how a Chemical Engineer fits into the Society. • Show clearly the career opportunities in Chemical Engineering.	Recommended texts, Scientific Calculator, Internet, Technical Journal.
	General Objective: 2.0: Understand flow sheeting		
3 – 5	Develop typical flow diagrams of industrial processes. Identify the Unit Operations, Unit Processes and transfer operations involved in item (2.1) above.	• Show clearly how flow diagrams are developed. Give examples of several industrial processes. • Teach how unit Operations, unit processes and transfer operations could be identified.	Recommended texts, large size graph papers, internet, technical journals.

Week	General Objective: 3.0 Know the units for mass balance calculations		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-7	State the units of mass involved in Industrial Processes. Define mole, Kmole, molar volume, Kmolar volume, etc.	• Give the unit of Mass used for mass balance calculation for different unit systems. • Define clearly the mole, molar • volume, etc. • Use numerical problems to highlight conversion from one unit to another.	Recommended texts, Scientific Calculator, Internet, Technical Journal.

Week	General Objective: 4.0 Know mass (material) balance calculations for unit operations		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-13	Explain the principles and practice of conducting mass balances for unit operations and processes with and without chemical reactions. Define steady state and unsteady-state processes and specify advantages of assuming the forms. Define mass input, mass output, mass inventory and state the mass balance equations according to the law of conservation of mass. Define recycle, bye pass, reflux ratio, co-current processes. Define the single operating process and consecutive current processes. Calculate mass and material entering and leaving a process by component balances Calculate masses of materials entering and leaving a process in consecutive operating process by component balances Calculate the masses of materials entering and leaving a process when there is a recycle stream.	• Show clearly how a mass balance is carried out. • Distinguish steady and unsteady state processes, mass input, mass output. Recycle bye pass, reflux ratio, etc. • Use enough numerical examples to ensure proper understanding of the above concepts.	Recommended texts, Scientific Calculator, Internet, Technical Journal.

Week	General Objective: 5.0 Understand the nature of manufacturing process for various chemicals and intermediates		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14-15	Identify the uses of chemicals intermediates and end-products selected from the following industries, viz: *Industry:* — *Key Product* Oil based petrochemicals — Ethylene, propylene Butadiene, Benzene P-xylene. (b) Natural gas based Petrochemicals — Ammonia, Urea, Menthol, formaldehyde. (c) Chloro-alkali — Chlorine, caustic soda, Soda ash (d) Acids — tetraoxosulphate (VI)acid tetraoxophosphate (V) acid (e) Industrial gases — Oxygen, nitrogen, carbon(IV)oxide, hydrogen (f) Mineral based in-organics — Lime, sulphur, potash, phosphorous (g) Plastics monomers — Styrene, Vinyl chloride, propylene, oxide, toluene. (h) Fiber monomers — Dimethyl phthalate, purified terephthalic acid, ethylene oxide, cyclohexane (i) Adhesives and coating monomers — Phenol, vinyl ethanoate	• Ensure each of these industries is covered adequately	Recommended texts, Scientific Calculator, Internet, Technical Journal.

	Special Learning Objective	Teachers Activities	Learning Resources
	(j) Pigments — Carbon black, titanium Chloride (k) Solvents — acetone, ethylene chloride 1,1,1-trichloro ethane (l) Foods and Pharmaceuticals — Sugar, vitamins, antibiotics. (m) Cement industry — cement (n) Soaps and detergents. — Soap & detergents Outline the methods of industrial manufacture of products in item (5.1) above. Describe the basic reactions involved in the processes in item (5.2) above. Outline the processes for conversion into other chemical intermediates and products in the industries in item (3.1) above.		

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: GENERAL LABORATORY TECHNIQUES 1(Safety in the Laboratory)		**Course Code: GLT 111**	**Contact Hours: I-0-0**
Course Specification: THEORETICAL/PRACTICAL CONTENT			
Week	**General Objective: 1.0 Know common laboratory hazards.**		
	Special Learning Objective	Teachers Activities	Resources
1-2	List different types of laboratory hazards: electrical, chemical, fire, biological, mechanical, etc. Describe the nature and causes of hazards in item (1.1) above. List examples of each type of hazard in item (1.1) above.	Explain the various laboratory hazards, their nature. State their causes.	Textbooks.

Week	General Objective: 2.0 Understand basic safety rules and procedures in the laboratory.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3-6	List the basic laboratory safety rules. Display charts showing safety symbols and rules in the laboratory. Interprete the symbols in item (2.2) above. Describe the procedure for treating acid burns in the laboratory. Describe the procedure for treating cases of inhalation or swallowing of toxic gases and liquids in the laboratory. Classify fires. Extinguish various types of fires using fire extinguisher. Describe the procedure for treating burns in the laboratory. List possible sources of microbial contamination of laboratory workers. Describe the procedure to be adopted in the prevention of microbial contamination in the laboratory. Describe first aid measures to be taken in case of microbial contamination in the laboratory. Describe the precaution against electric shock in the laboratory. Describe the procedure for the treatment of electric shock in the laboratory. List the content of a first aid box in the laboratory. Describe the various methods of artificial respiration for the injured in the laboratory, e.g. mouth to mouth, cardiac compression.	Show how a case of swallowing of toxic liquid could be treated in the laboratory. Demonstrate how to extinguish fire using the fire extinguisher. Explain how microbial contamination could be avoided in the laboratory. Describe the various methods of artificial respiration for the injured.	Charts safety symbols, textbooks. Fire extinguisher.

Week	General Objective: 3.0 Understand radiations.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-8	Define radiation. List and describe types of radiation e.g. X-ray, Gamma ray, etc. Enumerate various types of radioactive sources, e.g. Uranium, Thorium, etc. Explain sealed and unsealed radioactive sources. Define basic radiation terms such as radiation absorbed dose, maximum permissible level, etc.	Explain what is radiation. Give examples of radiations. Differentiate the term maximum permissible level as regards to radiation.	Textbooks.
9-11	**General Objective: 4.0 Understand the safety precautions against radiation hazards from sealed and unsealed sources.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Explain shielding as a precaution against ionizing radiation. List the properties of shielding materials. Identify some shielding materials e.g. lead. Describe radioactive dust as a major source of hazards. Explain the need for wearing dust mask, protective clothing and shield protection against radiation hazards. Explain the need to keep a safe distance from radioactive sources.	Explain the properties that make lead (Pb) a good shielding material. Discuss the need for protective clothing against radiation hazards.	Textbooks.

Week	General Objective: 5.0 Know the general and personal rules in the radiation laboratory.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	List the various general and personal rules to be observed in a radiation laboratory, e.g. wearing of film badges and pocket dose meter. Explain the importance of each rule in item (5.1) above. Describe and apply the use of the pocket dose meter and film badges.	List the various general and personal rules to be observed in a radiation laboratory.	Textbooks.
	General Objective: 6.0 Know the disposal of radioactive wastes.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14-15	List different types of radioactive wastes e.g. solid and liquid wastes. Explain radioactive waste as a potential source of radiation hazard. Describe the procedure for disposing radioactive wastes.	Explain how some named radioactive wastes could be disposed off.	Textbooks.

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: GENERAL LABORATORY TECHNIQUES I (Care & Maintenance of Laboratory Wares & Simple equipment)		**Course Code: GLT 111**	**Contact Hours: 1-0-0**
Course Specification: THEORETICAL/PRACTICAL CONTENT			
Week	**General Objective: 1.0 Know the use of laboratory wares.**		
	Special Learning Objective:	**Teachers Activities:**	**Learning Resources:**
1-2	1.1 Identify the different types of laboratory glass wares e.g. beakers, test tubes, funnels, flasks (different types), etc. 1.2 State the use of the different laboratory wares in item (1.1) above. 1.3 Identify different types of fittings in the laboratory e.g. for water, gas, light. 1.4 Identify the different types of greases and their application on joints. 1.5 Prepare cleansing reagents for laboratory wares. 1.6 Explain the use of porcelain, sintered glass, nickel and platinium crucibles. 1.7 Clean laboratory wares using cleansing reagent. 1.8 Store and maintain laboratory wares	• Discuss the various glass wares in the laboratory and state their uses. • Mention the types of greases and their function on joints. • Identify porcelain, sintered glass, nickel and platinium crucibles • State their uses. • Explain why it is necessary to clean laboratory wares using cleansing reagents. • Explain various laboratory storage devices and handling of laboratory wares.	Laboratory reagents, internet, technical journals.

Week	General Objective: 2.0 Understand the calibration of glass wares'		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3	2.1 Define calibration. 2.2 Distinguish between calibration and graduation. 2.3 Explain the effect of heat on calibrated glass wares. 2.4 Read fluid levels of calibrated glass wares, e.g. water level, mercury level. 2.5 Graduate simple laboratory glass wares using standard volumes.	• Explain the difference between calibration and graduation. • Explain what will happen to the calibration on a glassware when it is exposed to heat.	Mercury-in-glass thermometer, water, test tubes, etc.
	General Objective: 3.0 Know the various uses of glass wares in the laboratory.		
	3.1 Identify types of glassware suitable for storage in the laboratory. 3.2 Identify types of glassware suitable as containers, e.g. for storage of photosensitive reagents and acids. 3.3 Identify other laboratory storage containers, e.g. plastics and ceramics. 3.4 State the precautions necessary in the storage of chemicals e.g. hydrofluoric acid in plastic containers, sodium metal in paraffin and silver nitrate in amber containers.	• Explain how sodium metal is stored. • Give reasons for doing so.	Textbooks.

Week	General Objective: 4.0 Know the maintenance of laboratory balances		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-6	4.1 Identify the various types of balances in use in the laboratory. 4.2 Explain the working principles of each laboratory balance in item (4.1) above 4.3 Distinguish between accuracy and precision of a balance. 4.4 Determine the sensitivity of a balance. 4.5 Compare and contrast analytical and beam balances. 4.6 Describe the effect of shock, temperature, and chemicals on the operation of the balances. 4.7 Re-calibrate weights. 4.8 Weigh substances using various balances. 4.9 Check balances to know when they require service. 4.10 Describe the considerable factors in the installation of balances. 4.11 Carry out minor adjustments, repairs or replacement of parts on a balance.	• Distinguish between accuracy and precision of balance. • Let the students describe from their own understanding the capable effect of shock, chemicals and temperature on the operation of the balances. • Make the students weigh some substances using various balances and then compare their results.	Textbooks Varying weights. Various Laboratory Balances.

Week	General Objective: 5.0 Understand the principles, applications and maintenance of microscopes.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7	5.1 Identify simple microscope and its parts. 5.2 List the various types of microscopes in use in the laboratory. 5.3 Describe the use of the various microscopes in item (5.2) above. 5.4 State the ranges of magnification of microscopes. 5.5 Outline the principles of operation of various types of microscopes. 5.6 Describe and apply the various procedures in the routine maintenance and minor repair of microscopes,	• Identify the parts of the various microscopes in use in the laboratory. • Explain the meaning of magnification.	Textbooks. Microscopes.
	General Objective: 6.0 Know the maintenance of heating apparatus in the laboratory.		
	6.1 Identify the various heating apparatus like Bunsen burners, hot plates, autoclaves, etc. 6.2 Describe the application of each type in item (6.1) above. 6.3 Heat water and other liquids; powder etc using Bunsen burner, hot plates, etc, to establish their effectiveness. 6.4 Use the oven to sterilize various objects. 6.5 Use the oven to heat various objects to determine its effectiveness. 6.6 Describe and apply the various procedures in the routine maintenance and minor repair of autoclaves, ovens and other laboratory heating apparatus.	• Explain why it is necessary to have different types of heating apparatus. • Discuss how sterilization is done. • State reason for sterilization.	Textbooks. Bunsen Burner, Hot Plates, Autoclaves, etc.

Week	General Objective: 7.0 Know the maintenance of cooling equipment in the laboratory.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9	7.1 Identify apparatus for cooling, e.g. refrigerators, freeze-driers, water circulators. 7.2 Explain the principle of freezing. 7.3 Explain the different application of cooling systems in item (7.2) above. 7.4 Identify the various parts of the apparatus in item (7.1) above. 7.5 Describe and apply the procedure for the routine maintenance and minor repair of the apparatuses in (7.1) above.	• Identify the various parts of the refrigerator. • Explain clearly the principles of freezing.	Textbooks. Bunsen Burner, Hot Plates, Autoclaves, etc.
	General Objective: 8.0 Know the maintenance of temperature measurement equipments.		
	8.1 Identify apparatus for temperature measurement e.g. thermometers, pyrometers, thermocouples. 8.2 Explain the operating principles of temperature measuring devices listed in item (8.1) above. 8.3 Distinguish between the various temperature scales, e.g. Fahrenheit, Kelvin, and Celsius etc. 8.4 Measure temperature using scales in item (8.3) above. 8.5 Describe and apply the procedure for the routine maintenance and minor repair of the apparatus identified in item (8.1) above.	• Explain how thermometer, pyrometer and thermocouple are used to measure temperature. • Describe the conversion of temperature from one scale to another.	Textbooks. Thermometers.

Week	General Objective: 9.0 Understand microtomy and the maintenance of micro-tomes		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11-12	9.1 Identify different types of microtomes. 9.2 Identify different parts of microtomes and explain their functions. 9.3 Explain the working principle of microtomes. 9.4 Identify types of knives used in microtomy. 9.5 Describe paraffin wax embedded tissue. 9.6 Identify faults in section cutting and remedy the faults. 9.7 Explain the care of microtomes and knives.	• Identify the various parts of the microtomes and explain their functions. • Explain how microtomes and knives could be taken care of. • Describe how to sharpen microtome knives. • Show how to cut sections.	Textbooks. Internet. Technical Journals.
13-14	**General Objective: 10.0 Know basic electrical appliances.**		
	10.1 Explain the following terms: AC and DC supplies, LT and HT. 10.2 Identify various types of distribution and connection. 10.3 Identify standard colour code and wiring. 10.4 Explain the result of wiring. 10.5 Identify the different types of wiring. 10.6 Explain the methods and importance of proper earthing. 10.7 Identify different types of switches e.g. SPDT, DPDT, control gear relays, cut outs, etc. 10.8 Identify different types of protective wiring devices, e.g. relays, cut outs, fuses, etc. 10.9 Draw the various electrical symbols. 10.10 Apply such symbols in item (10.9) above for circuit diagrams.	• Identify and explain the various types of distribution. • Explain the principles of earthing. • State the importance of proper earthing, revealing the dangers of improper earthing. .	Textbooks

Week	General Objective: 11.0 Understand the care and maintenance of audio-visual aids.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
15	11.1 Describe the methods and undertake proper care and routine maintenance of (iii) overhead projectors; (iv) Lenses, recording and play back heads. 11.2 Describe the precautionary measures involved in the handling of projectors, tape recorders, etc. 11.3 Mend tapes and films.	• Describe the precautionary measures involved in the handling of projectors and tape recorders.	Textbooks

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING			
COURSE: INTRODUCTION TO CHEMICAL ENGINEERING II		**Course Code: CHE 102**	**Contact Hours: 2-1-0**
Course Specification : Theoretical Content			
Week	**General Objective: 1.0 Know the units for energy balance calculations in Industrial Processes**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	1.1 State the units for energy involved in industrial processes. 1.2 Define mole, Kmol, molar volume, and Kmolar volume.	• Explain the various units used for energy in different unit systems. • Give numerical examples.	Textbooks.
	General Objective: **2.0 Know some basic thermodynamics and thermo-chemistry**.		
	Define specific heat capacity, molar heat capacity and mean molar heat capacity Define integral heat of solution and mixing. Calculate heat of mixing using published heat of solution data. Determine thermodynamic parameters, e.g. humidity, enthalpy and heat capacity, using monographs and charts.	Explain thermodynamic concept and terms. Solve numerical examples.	Textbooks

Week	General Objective: 3.0 Know energy balance calculations for unit operations.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-11	3.1 Explain the principles and practice of conducting energy balances for unit operations and processes. 3.2 Define energy input, energy output and energy inventory. State the energy balance equations according to the law of conservation of energy. Calculate the energy entering and leaving a process in a variety of streams in a single operating process. Calculate the energy entering and leaving a process in a consecutive operating process. Calculate the energy entering and leaving a process when there is a recycle stream. Enthalpy changes, with and without phase changes. Energy balances with chemical reaction.	• Show how energy balance calculations are done. • Define the various terms. • Solve numerical examples.	Textbooks, chalkboard, chalk
12-15	**General Objective: 4.0 Know simultaneous mass and energy balances**.		
	4.1 Explain the principles and practice of conducting simultaneous mass and energy balances for unit operations and processes.	Discuss spontaneous energy and mass balances. Solve numerical examples.	Textbooks, chalkboard, chalk

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: ELECTRICAL ENGINEERING SCIENCE		**Course Code: CHE 104**	**Contact Hours: 2-0-2**
Course Specification :THEORETICAL/PRACTICAL CONTENT			
Week	**General Objective: 1.0 Understand the analysis and application of alternating current**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1 - 3	1.1 Represent alternating electrical quantities by phasors 1.2 Define phase angle, phase difference, lag and lead. 1.3 Draw phasor diagrams for alternating quantities having phase differences. 1.4 Define peak value, mean value, root mean square value, frequency and periodic time 1.5 Solve problems involving item (1.4) above for sinusoidal wave forms.	• Show how phasors represent alternating electrical quantities and explain phasor diagram. • Give correct definitions of peak value, mean values, root mean square value, frequency and periodic time • Solve problems.	Recommended texts, chalk board, chalk, charts.

Week	General Objective: 2.0 Understand the principles of single phase a.c. circuit theory		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4 - 7	2.1 Sketch the current and potential differences as a function of time across: (i) an inductor in series L – R a. c. circuit; (ii) a capacitor in series C – R a.c circuit 2.2 Relate the sketches in item (2.1) above to phasors in a phasor diagram. 2.3 Define reactance in inductive and capacitive circuit. 2.4 Describe the significance of reactance and the factors affecting it. 2.5 Define impedance in inductive and capacitive a.c. circuits. 2.6 Determine active and reactive components of circuits comprising: (i) L, R and C in series; (ii) Two branches in parallel with C in one branch and L – R and C – R in the other. 2.7 Determine power in circuits comprising R only, L – R and C – R in series and in circuits comprising: (i) L, R and C in series; (ii) Two branches in parallel with C in one branch and L – R and C – R in the other. 2.8 Define power factor and determine power factor in the circuit of item (2.7) above. 2.9 Explain the reasons for reducing power factor and methods of achieving this.	• Use sketches to explain current and potential differences, and their relation to phasor diagrams. • Define reactance, impedance and explain their inter-relationship • Solve problems • Assess the students.	Textbooks

Week	General Objective: 3.0 Understand phase diagram		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8 - 11	Describe the method of producing a 3 – phase alternating e.m.f. Sketch e.m.f. as a function of time with a phase angle of 120 Describe 4-wire Star and 3-wire delta connection of 3-phase system. Define line current and voltage in a 3-phase system. State the Relationships between line current and phase current, and between line voltage and phase voltage in 4-wire star and 3-wire star connected system. Determine power in a balanced 4-wire star and 3-wire delta connected systems. Explain the applications of 3-phase systems.	• Explain a three – phase alternating e.m.f. with sketches • Discuss 4-wire star and 3-delta connections of a 3-phase system • Show the differences between line and phase current and between line and phase voltage.	Textbooks

Week	General Objective: 4.0 Know electrical machines and transformers and their applications		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12 - 15	List types of electrical machines e.g. transformer, generator, motor, etc. Describe an electrical machine as being a system having an input and an output. Describe a motor and a generator as being the same type of system, but with the inputs and outputs reversed. Describe the input/output Relationships of d.c shunt series motors. 3 – phase a.c. synchronous and induction motors Describe machine hazardous situation motors Select the appropriate motor for: d.c. shunt series; 3-phase a.c. synchronous and induction motors; machine hazardous situation. Describe a transformer as being a system having an input and output. Describe input/output relationships in terms of: voltage and turns ratios. current and turns ratios. Select the best transformers for determining: voltage and turns ratios. current and turns ratios. 4.10 Describe the electrical isolation function of transformer.	Explain the different types of electrical motors, particularly in terms of their input and output. Discuss the input/output relationships of motors and transformers in terms of voltage and turns ratio, and current and turns ratio. Solve problems explaining above. Assess the students.	Resistors, capacitors, voltmeter, ammeter, ohmmeter, cable, emf sources, thermometer.

***Assessment**: The practical class will be awarded 40% of the total score: The continuous assessment, tests and quizzes will take 10% of the total score, while the Remaining 50% will be for the end of semester* examination score

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PROGRAMME: ND CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: INTRODUCTION TO CHEMICAL ENGINEERING PLANT SERVICES & MAINTENANCE		**Course Code: CHE 106**	**Contact Hours: 2-0-1**
Course Specification: THEORETICAL/PRACTICAL			
Week	**General Objective: 1.0 Know the scope and function of plant maintenance**		
1	**Special Learning Objective**	**Teachers Activities**	**Learning Resources**
	Describe the scope of maintenance activities. Discuss the functions of maintenance department in the industry.	Define maintenance Explain the factors determing maintenance activities. List the primary functions of maintenance department. Discuss the primary functions of maintenance department. List the secondary functions of maintenance department. Discuss the secondary functions of maintenance department.	Textbooks

Week	General Objective: 2.0 Methods of maintenance		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	2.1 Know the types of maintenance. State the objectives of productive maintenance. Explain how the determination of optimum maintenance schedule is done Explain the safety consideration in maintenance	Explain the various types of maintenance. List the objectives of the predictive maintenance	Textbooks
	General Objective: 3.0 Principles of organization		
	Define organization. Classify organizations in terms of line, function and staff. State the principles of organization Explain the elements of stock control system.	Expantiate on the definition of organization. Explain the three classes of organization List the principles of organization. Explain the concept of grouping and staffing function.	Textbooks.

Week	General Objective: 4.0 Understand plant installation principles		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3	Explain the principles of alignment and alignment corrections; use of straight edge, rigging lines and plum bobs. Explain the principles and use of the precision level, alignment telescope and dinometer. Explain location, levelling, fixing, and mounting of machines on proper foundations. Explain alignment of shafts, couplings and bearings.	Explain alignment of shafts, couplings and bearings.	Textbooks
	General Objective: 5.0 Understand mechanical handling system.		
	Identify types and uses of mechanical handling systems to include belt chain, roller types of elevators and conveyors. Sketch mechanical handling systems in item (4.1) above with particular reference to drive systems and bearing arrangements. Explain alignment of shafts, wheels and tracks for conveyor systems.	Explain the applications of the various mechanical handling systems from sketches.	Textbooks

Week	General Objective: 6.0 Understand power transmission systems.		
5-6	Carry out special couplings to allow for misalignment and flexibility, to include: flexible dix coupling; belt and pin coupling; steel spring coupling (bibby coupling); old ham coupling; duplex chain coupling; rubber tyre coupling; fluid drive coupling. Test alignment for flexible and rigid couplings, to include the principle and application of : preload bearing; non-metallic bearing; impregnated bearing; oil retraining bearing; constant centre line bearing.	Demonstrate couplings to allow for misalignment and flexibility. Explain the causes of the gear failures, pitting, abrasive wear, spalling and scuffing	Textbooks

	Explain the principles of hydrodynamic lubrication related to bearings. Explain the types of gear drive including: spur gears; helical gears; double helical gear; level gears; worm reduction gears. Explain the problems associated with the lubrication of gear systems in item (5.4) above. Identify reasons for the following types of gear failure: pitting; spalling; abrasive wear; scuffing.		

Week	General Objective: 7.0 Know plant service		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7	Identify types of water pumps, valves, strainers, filters, heat exchangers, and receivers. Explain distribution systems for H.P and L.P steam including: expansion joints and bends, types of steam traps and their maintenance; types and uses of control, reducing and safety valve. Identify components used in pneumatic systems including compressors, valves, lubricators, pistons, seals and gland packings. list causes of common faults in pneumatic systems. Identify types of receivers and vacuum pumps. Explain basic vapour compression, refrigeration, cycle, the characteristics of refrigerants, methods of leak testing, defrosting by natural and chemical methods and safety regulations when using refrigerants.	Mention the various types of water pumps, valves, strainers, filters, heat exchangers and receivers. List the various safety regulations when using refrigerants.	Textbooks

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PROGRAMME: ND CHEMICAL ENGINEERING			
COURSE: CHEMICAL ENGINEERING DRAWING	**COURSE CODE: CHE 108**		**CONTACT HOURS: 1-0-3**
Course Specification: Theoretical/Practical Content			
Week	**General Objective: 1.0 Understand the importance of engineering drawing**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1	State the need for engineering drawing in terms of communication and organisation.	Explain the basic concept of engineering drawing.	Textbooks
	General Objective: 2.0 Understand the need for standards in engineering drawing		
	Describe the various standards used in production of engineering drawings e.g BS, ISO, DIN, AISI, SON etc. 2.2 Recognise the standard used in an engineering drawing.	Illustrate items (2.1) to (2.2) and ask students to draw various types of fasteners and locking devices to British standard (BS) specification and state their applications, e.g. set screw and bolts, nuts, pins, rivets, etc. Assess the students	Textbooks

Week	General Objective: 3.0: Produce component and assembly drawings in accordance with BS 308, 1972 suitable for use in production of installation.		
	Special Learning Objective	Teachers Activities	Learning Resources
3-4	Explain the need for the following types of drawing for the individual plant components: component drawings. sub-assembly drawings. general assembly drawings. installation drawings. Recognise and represent various types of fasteners and locking devices.	Prepare simple illustration of sub-assembly drawing using techniques such as construction of spherical surfaces, counter-sunk and counter bore holes or flanged out hole, rounded edges, intersections, sections, etc.	Drawing board, T- Square, 45o set square 60o set squares, drawing set. Textbooks.
	General Objective: 4.0 Understand orthographic projection (1st and 3rd angle projections)		
	Explain with the aid of drawings the meaning of orthographic projection in terms of Principal planes of projection (H.P and V.P). Auxiliary vertical plane (A.V.P). Explain with the aid of drawings: points in space. lines in space, viz: (*i) true (ii) foreshortened* plane surface. 3-dimensional objects, based on rectangular block.	Sketch from an object (with changer, round holes, stepped blocks, etc) the plan and elevations and also sketch the view in first and third angle orthographic projection. Explain the properties of a point, line and a plane in space. Describe how to locate points, lines and planes in space on the projection planes. Determine the true length of a line in space using auxiliary method.	Drawing board, T- Square, 45o set square 60o set squares, drawing set. Textbooks.

	Relate the foregoing spatial concepts with regards to economics of views and in terms of views laid out in:- 1st angle projection. 3rd angle projection. Draw orthographic views of various machine components and figures in both 1st and 3rd angle projections.	Explain with aid of diagrams 4.3 & 4.4.	Drawing board, T- Square, 45o set square 60o set squares, drawing set. Textbooks.
	General Objective: 5.0 Understand the developments and intersections of regular solids and planes		
	Explain dihedral angle and give examples of where it is commonly used, hipped roofs, hoppers, etc. Determine the dihedral angle of two intersecting surfaces. Define development Draw the development of regular solids such as truncated prism, prism circular cylinder, truncated cylinder, frustum of a pyramid, truncated cone, etc. Draw the line of intersections of the following regular solids and planes in both first and third angles; (a) a cylinder meeting a square pyramid at a right angle. (B) a cylinder meeting a cone, the cone at an angle. (c) a cylinder meeting a cone, the cone enveloping the cylinder. (d) a cylinder and a cone, the cylinder enveloping the cone. (e) a square prism meeting a rectangular plane at an angle. (f) a square prism meeting an ellipse at an angle	Apply successive auxiliary projections to determine the shortest distance between two lines. Apply successive auxiliary projections to determine the angle of inclination of a line inclined to two given planes. Determine the dihedral angle of two intersecting surfaces. Develop patterns of regular solids such as truncated prism, circular cylinder truncated cylinder, frustum of a pyramid, truncated cone, etc. Draw the line of intersection of a cylinder meeting a square pyramid at right angles in both first and third angle projections.	Drawing board, T- Square, 45o set square 60o set squares, drawing set. Textbooks.

Week	General Objective: 6.0 Understand the drawing at 1st angle projections of simple items of chemical plants.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	Draw the first angle projections of items of chemical plants such as distillation columns, chemical reactors, heat exchangers, pumps, compressors, and filters.	Illustrate by making sketches the reason for hidden detail in terms of: (i) Internal features; (ii) Selection of views containing the minimum detail. Illustrate using sketches the advantages of sectioning of components in terms of: Clarification of interior detail; (ii) Ease of dimensioning. Select from BS 308, 1972, section (8.1) to (8.6) inclusive the appropriate conventions suited to a set of pre-prepared drawings. Assess the students.	Drawing board, T- Square, 45o set square 60o set squares, drawing set. Textbooks.

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PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: INTRODUCTION TO ENGINEERING ANALYSIS		**Course Code: CHE 201**	**Contact Hours: 2-0-0**
Course Specification: THEORETICAL CONTENT			
Week	**General Objective: 1.0 Understanding modeling of systems**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	Define what a model is. Explain the nature of theoretical mathematical modeling. Explain the types of mathematical modeling. State the application of modeling to various chemical engineering systems.	• Stress the fact that a model is an abstraction from reality. • Stress the importance of making appropriate assumptions in order to arrive at a suitable solution. • Show the differences between discrete and continuous modeling systems. • Examples should be drawn from such processes as fluid flow, heat transfer, reaction engineering, etc.	Models of various types of plans and systems.

Week	General Objective: 2.0: Review simple cases of differential equations		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3 – 5	Write differential equations in simple cases for rectangular, spherical and cylindrical coordinates. Transform differential equations into dimensionless forms. Apply differential equation to solve simple cases in various chemical engineering systems.	Evolve methods for solving equations involving variables separables exact differential equations, applications of integrating factors, e.t.c. Illustrate with several examples. Give students problems involving the transformation of equation to dimensionless forms. Solve several examples for the students and examine them.	Recommended texts, chalk and chalkboard.

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Week	General Objective: 3.0 Understand various modeling equations		
	Special Learning Objective	***Teachers Activities***	***Learning Resources***
6-8	Modeling through algebraic equations and geometry. Modeling through difference equations. Modeling through ordinary differential equations. Modeling through graph functional and integral equations.	Illustrate with suitable examples from isothermal reactors at steady state, etc. Illustrate with examples from unsteady state adiabatic reactors and unsteady state temperature distribution in a rod. Solve several numerical examples for the students.	Textbooks.
	General Objective: **4.0 Understand modeling of heat transfer system**		
	Develop model equations for heat conduction in an isotropic medium. Develop Poisson and Laplace equation from Fourier field equations.	State the necessary assumptions. Carry out an energy balance Develop the necessary model equation Solve problems involving rectangular, cylindrical and spherical coordinates for simple cases only.	Textbooks.

Week	General Objective: 5.0 Modeling of mass transfer systems		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10-11	Develop the model equation for the net molal flux for steady state diffusion in fluids at rest and in laminar flow. Develop a model for the material balance fields' equation for unsteady state mass transfer.	Apply the model equations in item (6.1) to determine the net molal flux for steady state equimolar counter diffusion. Apply the model equation in item (6.1) to determine the net molal flux for steady state diffusion through a stagnant film. Apply the model to various types of coordinate systems viz-rectangular, cylindrical and spherical. Solve simple numerical problems in unidirectional field only.	Textbooks.
	General Objective: 6.0 Understand modeling of chemical reactions (simple cases only)		
	Derive the model equation for isothermal batch reactors. Derive the model equation for isothermal CSTR. Derive the model equation for isothermal plug flow reactors. Derive the model equation for adiabatic CSTR.	The importance of reasonable assumptions should be stressed. Apply the model equations to solve simple problems involving various types of reactors.	Textbooks.

Week	General Objective: 7.0 Understand application of computer programme to solve simple problem.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14-15	Write simple computer programs in either BASIC or FORTRAN language to solve problems.	Write simple programs to solve problems in either BASIC or FORTRAN and run the program. Give the students problems to solve, which will require computer solution.	Computer with appropriate software loaded.

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PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: CHEMICAL ENGINEERING THERMODYNAMICS I		**Course Code: CHE 203**	**Contact Hours: 2-0-0**
Course Specification: THEORETICAL CONTENT			
Week	**General Objective: 1.0 Know the applications of perfect gas laws to mixtures of gases and vapours.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	Convert partial pressure to mole fraction, to volume percent or any combination and convert weight percent to volume percent. Calculate average weight of gas mixtures. Define vapour pressure and distinguish between vapour and gas. Define critical conditions (pressure, volume and temperature). Calculate the pressure, volume and temperature of gases using compressibility factors. Convert gas composition from dry to wet basis and vice versa.	• Explain perfect gas laws by means of calculations involving conversions such as partial pressure to mole fraction, weight percent to volume percent, average weight of gas mixtures, use of compressibility factors to calculate pressure, volume and temperature of gases. • Define vapour, and vapour pressure, gas, and critical conditions (pressure, volume and temperature).	Textbooks.

Week	General Objective: 2.0 Understand the first law of thermodynamics.		
	Special Learning Objective	**Teachers Activities**	Learning resources
4-6	Define open and closed systems, environment, phase, isothermal, adiabatic, intensive properties, state, path functions and internal energy. Define heat and work as applied to thermodynamic systems and the signs associated with them. State the first law of thermodynamics for flow and non-flow system. Define heat capacity at constant volume and constant pressure. Define enthalpy. Carry out calculations on conservation of energy for batch and continuous processes.	• Explain what a closed system is and how it differs from an open system. • Give students problems on conservation of energy for batch and continuous processes to solve.	Textbooks.

Week	General Objective: 3.0 Understand the second law of thermodynamics.		
	Special Learning Objective	**Teachers Activities**	**Learning resources**
7-9	Explain the second law of thermodynamics. Explain the thermodynamics basis for temperature scale. Define spontaneous, reversible and irreversible changes, equilibrium and maximum work. Explain the functions H, A, G, S and their properties where H=enthalpy, A= Internal Energy, G= Gibbs free energy and S= entropy. Explain the concepts of heat engines, refrigerator, cycles, indicator diagrams, T-S diagrams, P-H, etc. Describe the thermodynamic efficiency in respect of heat engines.	• Explain the following functions: Entropy(S), Enthalpy (H), Gibbs free Energy (G) and Internal Energy (A). • Give their properties	Textbooks.
10-12	**General Objective: 4.0 Know basic calculation in thermo-chemistry.**		
	Calculate change in enthalpy of a gas with temperature by integration and by using mean heat capacities. Define heats of formation, reaction, and combustion and state the sign conventions associated with them. Calculate heat of reaction and combustion from heat of formation and vice versa at 25C. Calculate heat of reaction at various temperatures and adiabatic reaction temperatures.	• Solve suitable examples to explain each formula and symbol. • Use numerical examples to further explain 4.2.	Enthalpy and Heat Capacity Tables.

Week	General Objective: 5.0 Understand steam as a thermodynamic fluid.		
	Special Learning Objective	**Teachers Activities**	**Learning resources**
13-15	Define saturated and unsaturated liquid and vapour, saturation temperatures, saturation pressure, due point, bubble point, wet, dry and super-heated vapour, dryness fraction. Sketch the T-S diagram for steam. Calculate various properties using steam tables and given relevant data. Carry out calculations involving flashing of condensate, throttling and de-super heating of steam.	• Explain in detail the terms in 5.1. • Solve numerical examples.	Textbooks. .

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PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: UNIT OPERATION I		**Course Code: CHE 205**	**Contact Hours: 2-0-2**
Course Specification: THEORETICAL CONTENT			
Week	**General Objective: 1.0 Know the techniques of particle size analysis**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1 - 2	Explain the reasons for and methods of particle size analysis Identify the range of particle sizes found in dusts, powders, slurries and mists. Explain the meaning of particle size and shape Explain cumulative and frequency particle size distribution for common distributions (Gaussian, Poisson, etc). Define various means particle diameters. Analyse particle using probability graph papers. Apply a number of particle size measurement techniques such as (a) sieving, (b) microscopy, (c) Sediment and (d) permeability, to experimental results. Determine average particle size and standard deviation of a sample. • Discuss particle in terms of sizes, method of analysis and cumulative and frequency particle size distribution. • Show how to use probability graph papers • Show how to apply a number of particle size measurement techniques. • Solve numerical problems.		Textbooks.

Week	General Objective: 2.0 Understand the principles and practice of industrial screening		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3 – 4	Explain the need for industrial screening. Describe fixed, oscillating and rotating screens. Calculate screen capacity and effectiveness.	• Discuss industrial screening clearly showing the differences between fixed, oscillating and rotating screens • Solve numerical problems depicting screen capacity and effectiveness.	Textbooks.

Week	General Objective: 3.0 Know the principles and practice of size reduction processes.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5 – 6	Explain the need for size reduction. Describe the common types of communition equipment, e.g., Jaw crushers; gyratory crushers; roll mills, ball mills, disc mills, etc. Explain the behaviour of materials subjected to size reduction. Estimates power requirements of a size reduction process applying Bond's, Kicks, Rittinger's laws and the work index. Explain open and closed circuit processes. List and explain the factors affecting performance of equipment.	• Treat size reduction, explaining its behaviour. • Differentiate between different types of communition equipment. • Solve numerical problems showing the application of Bond's, Kick's and Rittinger's Laws.	Textbooks.

Week	General Objective: 4.0 Know particle separation processes		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7 - 8	Describe the features and operation of: horizontal flow settling tanks. settling chamber for dust removal. gas cyclone. solid bowl centrifuge. electrostatic precipitator. Describe the settling zones of separation. Describe the effect of flocculation on suspension. Describe the measurement of settling rates for different concentration's of a suspension Evaluate maximum settling rate using given experimental data. State the factors which affect the design and operation of thickeners.	• Explain the features of settling tanks, cyclones, centrifuges and precipitators. • Clearly show the settling zones, effect of flocculation and measurement of settling rates. • Solve numerical problems to evaluate all of the above. • Assess the students.	Textbooks.

Week	General Objective: 5.0 Know the features and operation of solid conveying systems		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9 - 10	Describe the features and operations of the following solid conveying systems: Screw Conveyors. Bucket conveyors. Belt Conveyors. Pneumatic conveyors. Describe methods of maintaining and servicing conveyors.	• Explain clearly the features of screw, buckets, belt, vibrator and pneumatic conveyors. • Show how conveyors can be serviced and maintained.	Textbooks.
11 - 12	**General Objective: 6.0 Know the principles of filtration**		
	Explain the reasons for filtration. Explain the factors affecting the choice of filter media. Explain the use of filter aids. Explain the principle of cake filtration Describe the essential features of filters.	• State clearly the reasons for filtration, factors affecting filter media choice and use of filter aids. • Solve numerical problems	Textbooks.

Week	General Objective: 7.0 Know the principles of liquid and solid mixing		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13 - 15	Describe typical agitation equipment. Explain the effects of baffles in agitation vessels. Classify impellers into axial and radial flow types, Describe the following impellers: Propellers; Paddles; Turbines. Explain the effect of viscosity on the selection of mixers. Describe mixers for mixing thick pastes, e.g. kneeders, mixer extruders, etc. Describe mixers for powders.	• Explain the typical agitation equipment • Show how impellers are classified and describe the action of propellers, paddles and turbines. • Explain a typical mixer, and the other types based on duty	Textbooks.

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PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: MASS TRANSFER I	**Course Code: CHE 207**	**Contact Hours: 2-0-0**	
Course Specification : THEORETICAL CONTENT			
Week	**General Objective: 1.0 Know the fundamentals of mass transfer operations**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-4	Differentiate between transport and transfer processes. Explain the meaning of a mass transfer operation. Differentiate between direct and indirect phase contact operations. Explain criteria for choice of specific mass transfer operation or solvent for specific purposes. Explain steady state, unsteady state, stage-wise, and continuous contact operation. Explain design factors for mass transfer equipment.	• Cite relevant processes in differentiating transport and transfer processes. • Explain steady state and unsteady state operation.	Recommended textbooks.

Week	General Objective: 2.0 Understand molecular diffusion in fluids..		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-9	Explain the meaning of molar flux and molar average velocity relative to velocity of motion and to a stationary frame of reference for a system of components. State and explain the Fick's first law of diffusion for a binary system. Develop the general expression for net molar flux for steady state diffusion in fluids at rest and in laminar flow. Determine the net molar flux for steady state equimolar counter diffusion. Determine the net flux for steady state diffusion through a stagnant medium. Determine the diffusion coefficient for liquids and gases using empirical equation and formulae. Develop, by using material balance, field equation for unsteady mass transfer. Compare Fick's first law in mass transfer to Fourier's first law in heat transfer and to Newton's equation of fluid viscosity for momentum transfer. Define molecular, thermal and momentum diffusivity.	• Asses the students • Explain in detail and relate appropriately using simple illustrations where necessary.	Textbooks.

Week	General Objective:3.0 Know how to evaluate mass transfer coefficients.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10-15	Define the mass transfer coefficient and relate it to net molar flux and concentration driving force. Differentiate between mass transfer coefficient defined with respect to mole faction, partial pressure and concentration in liquid and gas phases. Differentiate between mass transfer coefficient for equimolar counter diffusion and diffusion in a stagnant medium. Show how to convert one mass transfer coefficient from one form to another. Define Schmidt, Prandtl, Reynolds and Stanton numbers. Estimate mass transfer coefficients from empirical equations and formular for laminar and turbulent flows. Calculate net molar flux using mass transfer coefficients for simple situation, e.g. wetted wall column, etc. Define overall mass transfer coefficient. Explain the terms: (i) gas film control; (ii) liquid film control.	• Explain what mass transfer coefficient is and how its value affects molar flux and concentration drive.	Textbooks.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: HEAT TRANSFER I	**Course Code: CHE 209**	**Contact Hours: 2-0-0**	
Course Specification: Theoretical Content			
Week	**General Objective: 1.0 Understand basic heat transfer phenomena**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	Explain the importance of heat transfer science in Chemical Engineering. Explain the phenomena and mechanism of heat transfer by conduction, convection, and radiation. Explain the characteristic behaviour and properties of materials vis-à-vis heat conduction, convection and radiation.	• Give examples of heat transfer in every day life.	Chalkboard, chalk, recommended textbooks, lecture notes, etc.

Week	General Objective: 2.0 Understand the analysis of heat conduction.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-7	Explain Fourier's first law. Develop Fourier's field equation for heat conduction in an isotropic medium by an energy balance. Develop the Poisson and Laplace equation from Fourier's field equation. Explain thermal conductivity for isotropic and anisotropic media. Calculate thermal conductivities for solids, liquids and gases from empirical equations and formulae. Apply one dimenstional Laplace equation to heat conduction through single and composite flat plates and cylinders. Apply Poisson equation to steady state heat transfer in a cylinder. State the equation for heat transfer in a cylinder with internal heat generation.		Textbooks.

Week	General Objective:3.0 Understand the concepts of heat convection.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-11	Explain natural and forced convection mechanisms of heat transfer. Define the heat transfer coefficient. Explain the dependence of heat transfer coefficient on the fluid flow regions. Define overall heat transfer coefficient. Describe heat exchange equipment. Define temperature gradient, heat transfer resistance, effectiveness and NTU concepts. Determine exchanger surface through simple performance and design calculations. Explain exchange diagrams to co-current and counter-current heat exchangers. Apply exchange diagrams to simple heat exchange networks.	Explain with sketches.	Textbooks.

Week	General Objective:4.0 Understand basic radioactive heat transfer		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-15	Explain ideal or black body radiation. Define transmitivity, reflectivity, emissivity and absorptivity. Differentiate between spectral and total values of intensity, emissive power and parameters in black body radiation. Develop Lambert's Cosine law, Wien's displacement law Stefan-Boltsman law and Kirchoff's law. Differentiate between black and grey surfaces. Determine radiant heat exchange between ideal isothermal surfaces. Explain view factors and direct radiant interchange areas. Determine view factors and radiant exchange between ideal rectangular surfaces in various configurations. Determine view factors in radiant exchange systems.	• Use drying rates of black and white cloth for illustration. • Students should know which one dries quicker under identical conditions. • Statement of each of the laws should be given to the class.	Textbooks.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: Introduction to fluid and particle mechanics		**Course Code: CHE 211**	**Contact Hours 2-0-0**
Course Specification :Theoretical Content			
Week	**General Objective: 1.0 Know the important fluid properties**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	Definition and classification of fluids. Explanation of fluid viscosity, density, vapor pressure, surface tension, bulk modulus of elasticity.	• Write out the definitions on the chalkboard.	Text.
3 – 4	**General Objective: 2.0 Know fluid pressure.**		
	2.1 Explain the concept of pressure at a point. Develop the fundamental equations for pressure. 2.3 Explain the units and scales of pressure measurement.	• Demonstrate the concept of pressure by pressing a finger on someone's body. • Write the equation on the chalkboard.	Textbooks.

Week	General Objective: 3.0 Understand the principles of manometry.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-6	Describe the manometer and explain its use. Develop a general procedure for solving all manometry problems. Apply the procedure in 3.2 above to single or multiple fluid, such as (a) simple u-tube manometer, (b) differential or micro-manometer.	• Show the manometer to the class while describing it. • Involve the class in using the manometer. • Solve numerical examples.	A manometer .

Week	General Objective: 4.0 Understand the fundamentals of fluid flow.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-8	Define system and control volume. Define streamlines and streamtubes. Develop the continuity, the Euler's, Bernoulli's' energy and linear momentum equations for fluid flow. Apply 4.3 above to simple steady flow situations, siphon, impact of jets, force on fixed vanes, expansion losses, contraction losses and other head losses, etc.	• Use a small container and water to illustrate use of examples. • Solve numerical examples.	Textbooks.

Week	General Objective: 5.0 Understand fluid measurement and control.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-10	Explain the importance of flow measurements and control. Distinguish between velocity and quantity measurement. Explain pressure, force and optical measurements of flow. Describe positive displacement meters, rate meter and electromagnetic flow devices. Describe the measurement of viscosity. Explain the principle of pressure and flow control.	• Use examples chosen from the laboratory and the industry. • Built a model out of a container and a measurable quantity of matter. • Show the flow measurement devices to the class if available. • Use a viscometer.	A model, Flow meters and other flow devices, viscometer, etc.

Week	General Objective: 6.0 Know the characteristics of fluid machinery important in chemical engineering.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11-12	Explain the fundamental principles of fluid machinery. Explain the operation of pumps and blowers, turbines and compressors. Explain pump characteristics such as head-capacity curves. Explain power, head, speed, capacity and efficiency relationships for pumps and compressors. Apply these relationships in 6.4 above to practical situations.	• Use suitable examples to explain the operation of these devices.	Textbooks, lecture notes, etc.

Week	General Objective: 7.0 Understand the elements of particle mechanics.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	Explain Lagrangian and Eulerian concepts of relative motion between a particle and a fluid. State stoke's equation of motion of a single particle in a fluid. Explain the concept of drag coefficient and describe it as a function of Reynolds number. Determine terminal settling velocity. Apply the concepts in 7.1, 7.2, 7.3 and 7.4, above to relative motion between a fluid and a system of particles of different density and particle diameters.	• Give Students Simple problems to solve using stoke's equation.	Textbooks, lecture notes, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: CHEMICAL ENGINEERING LABORATORY 1		**Course Code: CHE 213**	**Contact Hours: 0-0-6**
Course Specification: Practical			
Week	**General Objective: 1.0 Know how to write reports of experiments**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	Write reports of experiments under the following headings: (i) Title of experiment. (ii) Introduction. Theory of experiment. Experimental Method. Experimental Observations/results. Discussions and Conclusion. References.	Explain to students how to source for information in course of their experimental report writing.	Lecture notes, textbooks, etc.

Week	General Objective: 2.0 Know how to operate some unit operations basic equipment.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3-4	Carry out experimental on screen analysis. Determine energy and power requirement in communition. Carry out batch sedimentation studies by varying sedimentation rate with concentration and with height of suspension. Estimate particle size and identify settling regimes. Determine milling efficiency Operate cyclones and pneumatic conveyors. Determine experimentally factors affecting thickener design and performance.	Show how to separate particles of different sizes mixed together in screen analysis.	Screen, sieves cyclones, pneumatic conveyors, sand particles of varying sizes.

Week	General Objective: 3.0 Know how to operate equipment in chemical engineering thermodynamics.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-6	Determine heats of reaction and solution experimentally. 3.2 Determine heat of combustion.	Set the apparatus for determining heat of reaction and allow the students to run it under supervision. Do the same for heat of solution and heat of combustion.	Apparatus for heat of reaction, heat of solution and heat of combustion determination experiments.

Week	General Objective: 4.0 Know how to operate equipment in mass transfer		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-8	Measure the rate of diffusion of gaseous components evaporating into air stream e.g. acetone in air. Measure equimolar counter diffusion of liquid component into a liquid solvent Measure diffusivities of gases and liquids and the effect of temperature on them.	The students should be allowed to do the actual experimental measure of rate of diffusion of the gas evaporating into air under the supervision. Make the students write reports on the measure of diffusivities of gases and liquids and the effect of temperature on them.	Laboratory apparatus for experiments in 4.1, 4.2 & 4.3.

Week	General Objective: 5.0 Know how to operate equipment on heat transfer		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-11	Obtain linear and radial temperature profiles applying Fourier's law of heat conduction. Determine the effect of individual thermal conductivities, surface contacts and insulation on thermal conductivity. Determine heat transfer area. Demonstrate temperature profiles in a concurrent and counter-current flow system. Determine log mean temperature difference. Measure heat transfer coefficient. Determine heat exchange surface. Demonstrate laws of radiation (Stefan-Boltzmann and Kirchoff's).	Ensure that the students write reports on all these experiments observing the standard procedure of report writing.	Laboratory apparatus.

Week	General Objective: 6.0 Know how to operate the equipment on fluid and particle mechanics.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-15	Describe Bernoulli's theorem experimentally. Describe Reynold's experiment practically. Determine friction losses in flow through pipes, bends and fittings. Measure drag coefficient of spheres. Describe experimentally the effect of particle shape on rate of fall and drag coefficients. Measure the change in laws of resistance from laminar to turbulent, and establish critical Reynold's number. Measure static head distribution along a venture meter and orifice meter. Measure meter coefficients for various flow rates using orifice and ventori meter. Calibrate flow meter, orifice place, rotameter, venture meter and pitot tube.	Ensure that the students carry out these experiments and write report on them.	Laboratory apparatus, science note books, calculators, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING		
COURSE: CORROSION AND MATERIAL SCIENCE	**Course Code: CHE 215**	**Contact Hours: 2-0-0**
Course Specification: **Theoretical Content: Theoretical Content**		

General Objective: 1.0 Know atomic structure and the significance of electrons and bonding.

Special Learning Objective	**Teachers Activities**	**Learning Resources**
Explain electron waves and particles. Explain electronic structure or atoms. Explain : Interatomic attractions. Ionic bonding. Covalent bonding. Metallic bonding. Vander Waals bonding. Hydrogen bonding.	Discuss electron waves & particles Discuss the mobility of electrons. Explain: ionic bonding, covalent Bonding, metallic bonding, Van der Waal bonding, Hydrogen bonding.	Recommended textbooks, etc.

	Explain: Structure of metals. Space lattices. Allotropy. Solid solutions. Inter-metallic compound (alloys). Molecular structures. Crystal direction and lattice. Crystal direction and planes. Non-crystalline (amorphous) structure. Explain: Crystal imperfections. Dislocations. Slips. Twining. Simple dislocation theory. Work hardening. Cold working.	Explain given examples the concept of allotropy. * List different alloys. Discuss molecular structure. Explain crystal direction and planes. Explain the meaning of crystal imperfection, dislocation, slips twining. Discuss simple dislocation theory.	Lectures notes, etc.

Week	**General Objective:** 2.0 **Understand properties of materials**.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Explain physical properties of materials, viz: thermal conductivity, electrical conductivity, melting density, etc. Explain mechanical properties of materials, viz: ductility, malleability, toughness, strength, brittleness, hardness and elasticity. Compare the cost, strength, rigidity, electrical conductivity, temperature-stability and ease of production of common plastic and metallic materials. State the difference in composition and properties of low, medium and high carbon steel and cast iron. State the individual stages of heat treatment processes annealing, normalizing, Harding and tempering as applied to simple plain carbon steels. Describe the modification to the properties of steel produced by heat treatment. Relate materials listed in 1.4 above to given engineering applications	• Make the students explain from their own understanding the various mechanical properties of materials.	Recommended texts, lecture notes, etc.

	Identify differences in composition, properties and use of copper, brass and bronze. List the forms of supply application and the advantages of aluminium alloys. Identify the differences in composition, properties and uses of tin/lead soldering alloys. List the forms of supply, application and advantages of magnesium-based alloys. Identify the differences in bearing properties of phosphor-bronze, cast iron, P.T.F.E, nylon and graphite bearing materials. Identify the difference between thermoplastics and thermosetting plastics. List the engineering uses and properties of typical thermoplastics and thermosetting plastics.	• Tabulate the differences in composition and properties between low, medium and high carbon steel and cast iron. • Identify and note the differences that exist between thermoplastics and thermosetting plastics.	

	General Objective: 3.0 Know the properties and uses of the main metallic materials for constructing process plants.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Describe the composition of carbon steel. Explain the iron-carbon diagram and its relevance to structure and heat treatment of steel. List the uses and limitations of carbon steel in process plant. Describe the composition and properties and uses of cast iron, malleable cast iron and alloy cast iron. Describe the composition, properties and uses of the following metals and alloys: Chrome- molybdenum and nickel steels. High alloys stainless and heat resisting steels. Nickel and high nickel alloys. Alluminium and its alloys. Lead. Titanium, Tantalum, Zirconium and other precious metals. Explain protective coatings for metal plant and the use of zinc/aluminum/nickel alloys and chromium as coating materials.	List the content of carbon. Highlight the relevance of heat treatment of steel. Mention the limitations of carbon steel in process plant. Draw up a table showing the various composition of iron, malleable cast iron and alloy cast irons. Discuss the importance of alloys. List all the alloys known to them Discuss the importance of having a protective coating for metals.	Lecture note, etc.

Week	General Objective: 4.0 Know the properties and uses of major polymer materials in process plants.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Explain the nature of chemical attacks of plastics and rubbers. Describe the composition, fabrication and uses of rubber thermoplastics and thermosetting plastics. Describe the use of reinforcement to produce composite Materials. List the advantages of using polymeric materials for coating metal.	Discuss the different properties of polymeric materials with the students. Explain the relevance of simple domestic appliances. Discuss the importance of polymeric materials.	Textbook, lecture note, etc.
	General Objective: 5.0 Criteria for selection of materials for construction.		
	Identify the relevant properties of chemical plant construction materials: (a) physical properties (b) corrosion resistance (c) fabrication properties (d) cost. Explain relative costs and merits of metallic and non-metallic construction materials.	• Make choices of materials for construction of chemical plant on the various bases of physical properties, corrosion resistance, fabrication properties and cost.	Lecture notes, textbook, etc.

	General Objective: 6.0 Know the properties and uses of major ceramic materials in process plant equipment.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Describe the composition, chemical resistance, physical properties, fabrication and uses of: glass. graphite. cement and acid resistant bricks. List the uses of ceramic coatings applied to metals. Describe the composition, properties and uses of refractory and hot insulating materials for process plant furnaces and fired heaters.	Ask the students to explain the properties of ceramic materials. Discuss the physical and chemical properties of glass, graphite, cement and acid with the students. Ask the students the importance of ceramic coatings applied to metals. Ask the students why refractory materials are used in furnaces.	Lecture notes, textbook, etc.

Week	General Objective: 7.0 Know how to work on plastics.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Describe the solvent and welding techniques of joining thermoplastics indicating their applications. Explain the problems associated with the machinery of plastics and the necessary speed and feeds. Describe the use of heat bending techniques for forming plastics. Describe the use of casting techniques forming plastics with special reference to encapsulating techniques for electrical components.	• Let the students explain clearly the solvent and welding techniques of joining thermoplastics. they are also to indicate their applications.	Recommended texts, lecture notes, etc.

Week	General Objective: 8.0 Know the problems and principles of corrosion in the process industries.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Explain uniform corrosion in low and high temperature environments including effects of oxidation and scaling. Explain bi-metallic concentration cell, pitting, selective leaching, stress, erosion and cavitation fatigue and intragranular corrosion. Explain embrittlement of metals as a result of hydrogen diffusion and low temperature. Explain the creep of metals at high temperature.	• Explanation to be aided by sketches.	

	General Objective: 9.0 Know the various methods of protecting materials against corrosion.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	List the type of protective measures taken against material corrosion. Explain anodic and cathodic protection. Describe polymer deposition on materials as a protective measure taken against materials corrosion. Explain the principle of electroplating. Define anodizing. Describe anodizing process of alluminium. Describe covert ion coating.	Itemize the protective measures taken against material corrosion. Discuss anodic and cathodic protection. Discuss polymer deposition on materials as a protective measure against corrosion. Discuss the principle of electroplating. Explain the meaning of anodizing.	Recommended textbooks, etc.

	General Objective: 10.0 Know the corrosion resistant properties of materials in chemical plant construction.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	Describe the resistance of materials against corrosion. Explain the chemical resistance of materials against corrosion Explain the mechanical resistance of materials against corrosion. Explain the thermal properties and resistances of materials against corrosion. Identify the area of application and type of corrosion resistant materials in the construction of chemical plants.	Explain the term corrosion. Explain chemical resistance of materials against corrosion Explain mechanical resistance of materials against corrosion. Discuss the thermal properties and resistances of materials against corrosion. Select materials suitable for the construction of a chemical plant.	Lecture note, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING			
COURSE: Engineering Management 1	**Course Code: CHE 202**	**Contact Hours: 2-0-0**	
Course Specification: : Theoretical Content			
Week	**General Objective: 1.0 Understand the basic concept of management**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	Define management. Define a manager. Learn the concepts of authority, responsibility, accountability and administration.	State the concepts of management and stress the importance of each.	Organizational charts, Recommended text, etc.
	General Objective: 2.0 Understand the concept of engineering management		
3-4	The importance of management in engineering. Define engineering management. Draw similarity between the processes of management and engineering.	Stress the fact that engineering practice is essentially management.	Lecture notes, textbooks, etc.

Week	General Objective: 3.0 Understand management process		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-6	State the functions performed by managers, their rationale and their limits in controlling business activities and behaviour. Describe the basic skills of a good manager: innovative leadership, motivating personnel and decision making Conduct the first test for the students	Explain the functions of setting objectives, planning, organizing resources, controlling, directing, coordinating activities. List the skills expected of a good manager Conduct the first test for the students	Recommended texts,

7-8	**General Objective: 4.0 Understanding the Nigerian business environment** Define the concept of business environment and relate it to chemical engineering. Define the concept of organization. Explain the interaction between organization and the relevant business environment. Show that the environment of an organisation is a source of inputs and a repository for the outputs of the organisation. Describe the Nigerian business system.	Show that examples of given business environments could be the classroom, department, faculty, schools, polytechnics, state and the country. List examples of the environments for various types of businesses. List examples of various types of organizations. Illustrate with example from the chemical process industries.	Recommended texts.

		List examples of interaction of business with the environments and illustrate with the supply of petroleum products in the country. Explain the business systems in Nigeria with charts, facts and figures stress the role of government. Ensure that as much as possible examples are drawn from the chemical engineering environment.	Lecture notes and Textbooks.

	General Objectives: 5.0 Understand methods of financing business		
9-10	Discuss the nature and risk of finance. State the functions of finance and the objective of financial decisions. State the sources of finance-short, medium and long term.	List the various types of risky business they would like to venture into. Explain the functions of investment, financing and dividend. Illustrate with examples such as short term and long-term borrowing, investment in shares and bonds, etc. List examples of the types of investment they are interested in.	Lecture notes and Textbooks etc.

11-12	**General Objective; 6.0 Understanding simple accounting records of business** Discuss the various types of accounting record books. State the importance of double entry of accounts. State the principles underlying the preparation and presentation of cost accounts for various types of business.	Explain the importance of the cash book, the ledgers, etc. Perform simple calculations to show the principles of double entry of accounts. Give students simple problems to solve involving the principle of double entry of accounts. Explain cost accounting for materials, labour, over head and equipment. Show examples of various accounting record books to the students. Conduct the final test for the student.	Recommended texts, chalkboard, and chalk etc.	

	General Objective: 7.0 Understand basic concept of economic analysis in chemical engineering.		
13-15	Discuss the concepts of cost interest, time value of money, salvage value, capitalized cost armotization, depreciation, discounted cash flows analysis and measures of profitability. Explain the annual cost comparisons, internal rate of return, average or arithmetic rate of return, net present value and productivity index of investments. State the methods of evaluating alternatives in 7.2 and apply them in the selection of materials and choice of process equipment.	Illustrate with examples from reaction engineering, heat transfer, fluid mechanics, mass transfer, e.t.c. Carry out calculation to show the application of each of these methods. Give assignments to students to solve using the above criteria.	Annuity tables, engineering cost tables and charts, annual reports of companies. Annuity tables, Engineering Cost tables and Charts Annual Report of Companies.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: CHEMICAL REACTION ENGINEERING I		**Course Code: CHE 204**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective: 1.0 Understand the importance of the chemical reactor system in manufacturing processes.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-4	1.1 Define chemical reaction engineering. Identify the chemical reactors as the core of every manufacturing process involving chemical reaction. Identify the scientific and engineering subjects relevant to reactor design such as: a. chemical kinetics; b. thermodynamics; c. material science d. heat transfer; e. mass transfer; f. corrosion engineering; g. economics h. mathematics and i. computer science, etc.	Explain the effects of a poorly designed reactor on manufactured products. Stress the factors to be considered in reactor design. Explain using suitable examples and illustrations the relevance of each of the items in 1.3 (a-i) to reactor design.	Recommended textbook, lecture notes, etc.

Week	General Objective: 2.0 Understand the fundamental principles of reaction		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-8	Define reaction rate. State the main factors governing rate of reactions as:- a. a. concentration b. temperature. c. catalyst. d. state of sub division of solids. Distinguished between the following concepts: homogenous and heterogenous reactions reversible and irreversible reactions elementary and non-elementary reactions molecularity and stoichiometry overall order of a reaction and the order of a reaction with respect to one reactant. Derive and explain the rate equation as a product of temperature and concentration dependent functions.	Illustrate with several examples. Determine the values of Ea and A for typical chemical reactions at suitable temperatures. State the effect of a catalyst on Ea and K in item 2.5 Illustrate the steps involve in free radical chain mechanism with several examples. Determine the rates of reactions from proposed mechanisms in simple cases only.	Recommended textbooks, Lecture notes etc.

	Special Learning Objective	Teachers Activities	Learning Resources
	Explain the effect of temperature on the rate constant by the Arherius equation K= A exp (-Ea/RT) Where A=pre-exponential factor. K= rate constant. Ea= activation energy. Explain the meaning of A and Ea in 2.5 above using both the collision and transition state theories of chemical reactions. Explain the effect of catalyst on Ea and K in item 2.5 above and hence, on the reaction rate. Explain the concept of mechanism and the significance of the rate determining step		

Week	General Objective: 3.0 Understand the use and application of kinetic data		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-12	Derive the integrated rate equation for zero, first and second order reactions. Determine the order of a reaction and the appropriate rate constants from experimental data Derive and apply the expressions for the half-lives of zero, first and second order reactions. Determine the energy of activation of a reaction from given data.	Explain to the students how to use the differential and integral methods of analysis to determine the order of a reaction from given data Determine the order of a reaction and its rate constant from given data. Assess the students.	Recommended textbooks, Lecture notes.

Week	General Objective: 4.0 Understanding how to design single homogenous ideal reactors.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	Explain the basis of classification of reactors. Define an ideal reactor. Explain the factors that alter the performance of a reactor from being ideal. Derive the basic design equation for batch, continuous stirred tank, and plug flow reactors. Define and explain the performance measures of reactors e.g. space time. residence time and capacity. Compare the performance of continuous stirred tank reactors and plug flow reactors.	Illustrate with several examples using both numerical and graphical techniques. Assess the students.	Recommended textbooks, Lecture notes etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING			
COURSE: UNIT OPERATION II		**Course Code:** CHE 206	**Contact Hours:** 2-0-0
Course Specification :Theoretical Content:			
Week	**General Objective: 1.0 Understand leaching and extraction processes**		
	Special Learning Objectives	**Teachers Activities**	**Learning Resources**
1 - 3	Explain liquid-liquid and liquid-solid equilibria. Explain the need for feed pre-treatment and solvent recovery. Differentiate between batch and continuous operations. Explain the Shank's system of counter-current contacting. Identify arrangements and equipment for continuous counter-current contacting. Classify and describe liquid – liquid extraction equipment. Develop and apply the graphical diagrams for multi-stage calculations.	• Discuss liquid-liquid and solid – liquid equilibria • Show the need for feed pre-treatment and differentiate between batch and continuous operations. • Show step-by-step, the graphical solution methods for multi-stage calculation. • Solve numerical problems. • Assess students.	Recommended texts, Large size graph paper, etc.

Week	General Objective: 2.0 Understand separation by distillation		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4 – 6	Calculate vapour – liquid equilibrium data for ideal binary systems. Define relative volatility. Calculate the material balance for simple batch distillation. Explain batch distillation with rectification Develop and apply calculation procedures for batch rectification at: constant reflux; constant overhead composition. Explain the operating and control parameters for batch distillation.	• Show how to calculate vapour liquid equilibrium data, and material balance for a simple batch distillation. • Treat different types of batch distillation • Use numerical examples to explain the application of calculation procedures for batch rectification. • Assess the students.	Recommended texts, large size graph paper, etc.

Week	General Objective: 3.0 Understand the principles of gas absorption operations		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7 – 8	Define solubility of gases. Define absorption and stripping Explain the properties and types of tower packings. Describe gas absorption tower construction. Explain the factors affecting the selection of solvents in gas absorption operations. Describe examples of operations for: stage-wise gas absorption equipment; continuous gas absorption equipment.	• Explain clearly solubility of gases, absorption and stripping, tower packings and towers construction. • Discuss the factors affecting solvent selection. • Solve numerical examples.	Recommended texts, large size graph paper, etc.

Week	General Objective: 4.0 Understand the principles of evaporation		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9 – 10	Explain the mechanism of evaporation. Describe single and multiple effect evaporators. Explain the following terms: Forward feed; Backward feed; Parallel feed.	• Clearly explain the mechanism of evaporation, single and multiple effect evaporators. • Show the differences between forward, backward and parallel feeds.	Recommended texts, large size graph paper, etc.

Week	General Objective: 5.0 Understand the principles of humidification and drying		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
11 – 13	Explain humidification and dehumidification. Distinguish between wet bulb and adiabatic saturation temperatures. Determine humidity, dew point, etc, using psychometric charts. Explain the principles and operation of a cooling tower. Explain the mechanism of drying operations. Define the following terms: bond and unbond moisture, free moisture, critical moisture content and equilibrium moisture content. State examples of equipment used for batch and continuous drying.	• Show the difference between humidification and dehumidification, and wet bulb and adiabatic saturation temperatures. • Discuss clearly the principles and operation of cooling towers. • Define the various technical teams clearly. • Solve numerical problems. • Assess the students.	Recommended texts, large size graph paper, etc.

Week	General Objective: 6.0 Understand the principles of crystallisation operation		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14 – 15	Explain the mechanism of crystallisation. Explain the effects of the following on crystallisation: temperatures; impurities. State examples of batch and continuous crystallizers.	• Describe crystallization in detail showing its mechanism and the effect of temperature and impurities. • Give examples of batch and continuous crystallization • Solve numerical problems. • Assess the students.	Recommended texts large size graph paper, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING			
COURSE: INSTRUMENTATION AND PROCESS CONTROL		**Course Code: CHE 208**	**Contact Hours: 2-1-0**
Course Specification: Theoretical Content			
Week	**General Objective: 1.Understand the static and dynamic characteristics of measurement system.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1	Explain the following static characteristics: accuracy, sensitivity, linearity, resolution, threshold, hysteresis, drift, stability, dead bard, readability and range. Explain the following dynamic characteristics: system response and frequency response. Explain the criteria for selecting instruments for a particular measurement.	Ensure students' understanding of static and dynamic characteristics. Show how to select particular measurement. Give numerical examples.	Recommended textbooks, scientific calculator, etc.

Week	General Objective: 2.0 Know the methods of pressure measurement		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
2-3	2.1 Explain the working principle and the application of the manometer. 2.2 Explain the principle and application of the bourdon tube gauge. 2.3 Explain the principle and application of the diaphragm bellow type gauge. Explain the principle and application of pressure recorders. Describe the calibration of the pressure measuring devices. Explain the principle and application of differential pressure measuring devices. Explain the principle and application of pressure regulators. Describe the installation of the pressure recording systems to include –recorders, indicators, drain regulator and air drying chamber.	Sketch the manometer, bourdon tube gauge, bellow type gauge and show their differences. Show how pressure measuring devices work. Solve numerical examples.	Recommended textbook, Scientific Calculator etc.

Week	General Objective: 3.0 Know the relationship between level height and volume.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-5	3.1 Define level in terms of height, weight and volume. Explain the design and application of sight glasses. Describe the use of pressure devices as level measuring devices. Describe the operation and use of buoyancy type gauges. Describe the operation and use of float-operated gauges. Describe the operation and use of differential pressure transmitter system for measuring level under the following conditions: Open tank, Closed tank (dry leg), Closed tank (wet leg) and Closed tank (purged dip-pipe system) Describe the operation and use of purged dip pipe systems. Describe the operation and use of electrical level measuring devices.	Distinguish between height, weight and volume. Solve numerical examples.	Recommended textbook, Scientific Calculator etc.

Week	General Objective: 4.0: Understand the principles of volumetric flow meter.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6	4.1 Describe the Construction and operation of liquid and gas flow meters such as: (a) reciprocating piston; (b)oscillating piston; (c) oval gear; (d) bellows; (e)liquid sealed drum; (f)rotating impeller; (g) deflecting vane; (h)rotating vane and (i)turbine.	Explain the working of a volumetric flow meter Give numerical examples.	Recommended textbook.
Week	**General Objective**: **5.0 Know the primary elements of differential pressure devices**.		
7	5.1 Describe the calibration and the use of the following primary elements for measuring fluid flow rate: (a) venturi meter ; (b) nozzle; (c) pitot tube; (d) orifice plate and (e) pitot- static tube.	Explain the differential pressure devices. Solve numerical problems.	Recommended textbook, Lecture notes.

Week	General Objective: 6.0 Understand the principles of variable area constant head devices		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8	6.1 Describe the operation and calibration of: (a) Float and tapered tube meter. (b) Orifice meter	Explain tapered tube meter and orifice meter. Solve numerical examples.	Recommended textbook, Lecture notes.
Week	**General Objective: 7.0 Know the methods of temperature measurement**		
9 – 11	7.1 Explain the principle and application of bi-metallic thermometers and thermostats. 7.2 Explain the principle and application of liquid in glass thermometers. 7.3 Explain the principle and application of gas filled thermometers. Explain the principle and application of vapour pressure thermometers. Explain the principle and application of thermocouple thermometers. Explain the principle and application of radiation and optical pyrometers. Describe the calibration of temperature measuring instruments to known standards. Describe the installation of temperature measuring devices.	• Explain the working of thermometers and thermostats – distinguishing the various types.	Recommended textbook, Lecture notes etc.

Week	General Objective: 8.0 Understand basic plant control concepts.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	8.1 Explain the objectives of the control systems. 8.2 Describe the purpose of each element in a control system. 8.3 Define open and closed loop systems and distinguish between their separate characteristics. Explain the improvement of out-put linearity by the application of negative feedback. Describe inherent regulation as a plant characteristic. Identify and distinguish between distance velocity and transfer lags. Identify where and why lags occur in a system.	• Ensure students' understanding of plant control concepts. • Solve numerical examples.	Lecture notes, recommended textbooks etc.
Week	**General Objective**: **9.0 Understand modes of control and their applications**		
14	9.1 Describe the behaviour of the following control actions: (a) step, (b) proportional, (c) integral, (d) Derivative,	• List examples of step, proportional, integral and derivative control actions.	Lecture notes, recommended textbooks etc.

Week	General Objective: 10.0 Understand the construction and operation of practical controllers.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
15	10.1 Explain the principles of the following (a) pneumatic controllers. (b) electronic controllers. (c) transducers. 10.2 Describe the construction and operation of the following: (a) diaphragm control valves. (b) butterfly valves. (c) dampers. (d) power cylinders.	Ensure students understanding of the principles of pneumatic controllers, electronic controllers and transducers.	Lecture notes, recommended textbooks etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING			
COURSE: HEALTH, SAFETY AND ENVIRONMENT CONTROL		**Course Code: CHE 210**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective: 1.0 Know the factors affecting health and safety at work.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-4	Health and Safety at Work 1.1 Explain the need for accident prevention in the laboratory, workshop and processing plants. 1.2 Explain the psychological, physiological and economic basis for accident prevention 1.3 Know the factories act as regards health and safety at work.	Discuss with the students the cost implication and psychological effects of accidents. Highlight the psychological, physiological and economic basis for accident prevention. Discuss the potential sources of indisposition, complaint and inefficiency among workers.	lecture notes, textbooks, etc.

	1.4 State the levels at which the following became potential sources of indisposition, complaint or inefficiency among workers: Excessive noise. Excess heat. Low humidity. Excessive cold. Unpleasant odours. Draughts. Dirt. Excessive standing. Bad lighting. Claustrophobia. 1.5 List possible prevention measures for I.4 above. 1.6 Identify the following as potential causes of physical injury and accident: falls on levels. falls from heights. moving machinery. unsafe storage of materials. thermal burns.	Mention the preventive measures for 1.3 above. Explain the potential causes of physical injury and accident.	

	Special Learning Objective	Teachers Activities	Learning Resources
5-11	chemical burns electricity strains from lifting injuries from vehicles deficient lighting fires and explosions maintenance problems flying particles sharp, rugged or rough particles 1.7 List possible preventive measures for 1.6 above. 1.8 Explain the following as potential sources of long term occupational illness: inhalation. ingestion. skin contamination. physical injury. radiation.. 1.9 Understand toxicity and individual susceptibility	Explain possible preventive measures for 1.6 above. Discuss the potential sources of long term occupational illness.	Recommended textbooks Lecture notes, etc.

Week	General Objective: 2.0 Understand safety in the process industry.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	2.1 Know the various types of personnel safety wears. 2.2 Understand special safety rules in the process industry 2.3 Know the inherent fire and explosion hazards in the process industry 2.4 Understand fire safety and prevention.	List personnel safety wears. Ensure the students know special safety rules in the process industry. Understand that pressure and temperature handling equipment are sources of fire and explosion Ensure that students understand the occurrence of fire, its prevention and the theory of fire appliances.	Recommended textbook, Lecture notes etc.

Week	General Objective: 3.0 Understand environmental pollution and control.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
	3.1 understand the difference between emission, effluent and solid waste. 3.2 Know the concept of environmental pollution 3.3 Understand the different toxic components in gaseous emission. 3.4 Understand the components of effluents for some process industries. 3.5 Understand solid waste and its management techniques.	List pollutants from some domestic and industrial activities. List items considered as pollutions in their immediate surrounding. Assess the student by asking them to name some pollutant. List solid waste management equipment/ machinery. Ensure the students understand the concept of recycling as a waste management technique.	Recommended textbooks, Lecture notes etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: CHEMICAL ENGINEERING LABORATORY II		**Course Code: CHE 212**	**Contact Hours:0-0-6**
Course Specification: PRACTICAL CONTENT			
Week	**General Objective:** 1.0 **Understand the design of chemical reactors for homogenous systems.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	Select solvents and test for extraction efficiency. Determine the effect of agitation, particle size, temperature, and feed rate on extraction efficiency for batch and continuous leaching operation. Compare concurrent and counter-current leaching. Determine mass transfer rates for organic and aqueous leaching . Determine vapour liquid equilibria data for binary liquid mixture. Determine minimum reflux ratio liquid system using bubble cap or packed bed or sieve tray distillation column. Carry single batch distillation at total reflux for sieve tray or packed bed or bubble cap distillation column. Carry out experiments on column hydraulics to determine pressure drop, weeping, flooding using entrainment of plate or packed or bubble cap batch distillation.	• Supervise the students in performing this experiment. • Grade the students from report of their experimental work.	Laboratory apparatuses and reagents, etc.

Week	General Objective:2.0 Know how to operate equipment and obtain experimental data in instrumentation and process control		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-8	Construct and calibrate differential manometers, u-tube, inclined u- tube and industrial manometers. Calibrate pressure gauges by dead weight method. Compare flow measurements by orifice plate, venturi meter, and rotameter. Determine the effect of Reynold's number on individual coefficient (orifice, venturi and rotameter) Determine average duct flow rate by pitot tube transverse. Calibrate and use basic types of temperature measuring devices, including liquid-in-glass thermometers, filled system thermometers (gas filled, liquid filled and vapour filled; resistance thermometer, thermocouples, thermopiles and radiation pyrometers. Operate and determine characteristics of pH measuring devices. Determine experimentally a system's pressure, flow and temperature in the absence of control action. Compare manual and automatic control performance.	• Ensure that the students perform the experiments under supervision and make reports of their findings.	Laboratory apparatus and reagent.

Week	General Objective:3.0 Know how to operate equipment and obtain experimental data in corrosion and material Science		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-9	Determine the effect of pH level on corrosion rate. Determine the effect of dissolved oxygen concentration on corrosion rates. Identify other factors affecting corrosion rates.	• Grade the experimental report submitted by each students.	Laboratory apparatus and reagents etc.
Week	**General Objective:4.0 Know how to operate equipment and obtain data in chemical reaction engineering.**		
10 - 12	Obtain batch reactor date and kinetics parameters for selected reactions, e.g. acid-catalysed by hydrolysis of ester. decomposition of hydrogen peroxide. lodination of acetone. decomposition of benzene diazonium chloride.	• Carry out the experiments and write reports at the end	Laboratory apparatus and reagent.

Week	General Objective: 5.0: Know how to operate equipment and obtain experimental data in fuel technology.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	Determine the following liquid fuel properties for different grade classification points: water content; cloud-point; smoke point, flammability and specific gravity. Determine high and low heating values of solid, liquid and gaseous fuels. Describe the effect of air-fuels ratio and composition of fuels on combustion efficiency.	• Show how to write a standard report of each experiment.	Laboratory apparatus and reagent.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: INTRODUCTION TO BIO-TECHNOLOGY	**Course Code: 216**	**Contact Hours: 2- 0-0**	
Course Specification: Theoretical Content			
Week	**General Objective:** 1.**0 Understand the cell as the basic unit of life.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	Explain the classification and growth of micro-organisms. Explain the cell as a unit of life and the cell theory. Differentiate between prokaryotic and eucarryotic cells. Observe and draw samples of plant cells and animal cells from appropriate sources under the microscope. Viz: check cells, blood cells, etc. Differentiate between animal and plant cells. Describe cell inclusions and organelles. Explain the functions of cell organelles described in item 1.5 above	• Discuss the classification and growth of micro-organisms. • Explain prokaryotic and eukaryotic cells. • Discuss the difference between animal and plant cells. • Explain cells inclusions and organelles.	Lecture notes, recommended textbooks, etc.

Week	General Objective: 2.0 Know the different types of cell divisions and their significance.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4 – 5	Explain cell division. Identify various types of cell division Define mitosis and meiosis. Describe the stages of mitotic and meiotic division. Explain the significance of mitosis and meiosis to plants and animals.	• Discuss the various types of cells divisions. • Explain the stages of mitotic and meiotic divisions.	Lecture notes, recommended textbooks, etc.

Week	General Objective: 3.0 Know the composition of the nucleous and the cytoplasm of the cell		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6 – 7	Describe the structure and functions of the components of cell nucleus. Describe the structure and functions of DNA and RNA. Explain the building blocks of nucleic acid (nucleotides), sugar, phosphoric acid. Describe the biochemical components of the cytoplasm and the nucleus. Describe the replication of the DNA molecule and the significance of the replication. Explain the role of RNA in protein synthesis.	• Explain the structure and functions of nucleus. • Discuss the structure and functions of DNA and RNA.	Lecture notes, recommended textbooks, etc.

Week	General Objective: 4.0 Understand chemical reactions in the cell		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
8-10	Explain the importance of hydrogen ion concentration (pH), buffers, crystalloids and colloidal suspensions to cell. Explain the importance of water to normal life functioning. List the chemical substances (organic and inorganic) in the cell e.g. enzymes of biological importance. Explain the role of the following compounds in the cell: (a) carbohydrates; (b) lipids; (c) proteins; (d) ribonucleic acid. Describe the chemical structure of carbohydrates:- simple sugar, monosaccharides, disaccharides, polysaccharides. Describe the basic unit of proteins, its structure and functions.	• Discuss the importance of water to normal life. • Discuss the role of the following compounds in the cell: carbohydrates, lipids, proteins and ribonucleic acid.	Lecture notes, recommended textbooks, etc.
Week	**General Objective: 5.0 Understand the process of growth.**		
11 – 12	5.1 Define growth. 5.2 Explain the growth regions and phase of growth. 5.3 List the parameters used to assess growth e.g. dry weight, fresh weight, leaf area, etc. 5.4 List and explain the factors affecting growth.	• Discuss growth regions and phases of growth. • Explain and use the factors affecting growth.	Lecture notes, recommended textbooks, etc.

Week	General Objective: 6.0 Understand enzymes of biological engineering importance.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-14	Explain important enzymes in bio-chemical engineering. Explain enzymatic kinetics. Explain enzymatic catalysed reactions.	• List and explain useful enzymes in bio-chemical engineering. • Explain enzymatic catalysed reaction.	Lecture notes, recommended textbooks, etc.
Week	**General Objective: 7.0 Understand microbial processes.**		
15	Identify microbial processes involving enzymes. Explain the application of enzymes in industrial processes. Explain bio-technology and bio-mass.	• Identify microbial processes. • Discuss given suitable example application of enzymes in industrial process.	Lecture notes, recommended textbooks, etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING TECHNOLOGY			
COURSE: POLYMER SCIENCE TECHNOLOGY		**Course Code: CHE 218**	**Contact Hours: 2-0-0**
Course Specification Theoretical Content			
Week	**General Objective:** 1.0 **Know the classes of polymers and draw material sources**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	Classify polymers Identify sources of polymeric raw materials.	• Mention some sources of polymeric raw materials and the eventual products.	Recommended textbooks, lecture note, etc.
Week	**General Objective: 2.0 Know the classes of polymers and draw material sources.**		
3 – 4	Explain addition polymerization, condensation polymerization and co-polymerization reactions. 2.2 Explain the mechanisms of the reactions in 2.1 above.	• Make the students to explain explicitly condensation and addition Polymerization reactions.	Recommended textbooks.

Week	General Objective:3.0 Understand principles of polymer manufacture.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
5-8	Explain the various classes of polymerization processes including solution polymerization, suspension polymerization, emulsion polymerization, vulcanization, compounding and reinforcement. Explain the effect of heat and mass transfer on the various processes in 3.1 above. Explain the basic principles of designing of Polymer reactors.	• Asses the students.	Lecture notes, recommended textbooks, etc.
Week	**General Objective: 4.0 Understand polymer materials production (synthetic and natural).**		
9 – 12	Describe the manufacture of natural resin e.g. latex. Describe the production of thermoplastics, polyvinyl, nylons, acrylic and phenoxy resins. Explain the production of thermosetting polymers of phenol formaldehyde, polyester, amino and epoxy resins.	Assess the students.	Textbooks, Lecture note etc.

Week	General Objective: 5.0 Know the various methods of processing polymers.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
13-15	Describe mastication, mixing, extrusion, calendaring, moulding, thermo-forming and sintering processes. Explain the purposes of the various processing methods in 5.1 above.	Assess the students.	Lecture note, Textbooks

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: NATIONAL DIPLOMA IN CHEMICAL ENGINEERING			
COURSE: FUEL TECHNOLOGY		**Course Code: CHE 220**	**Contact Hours: 2-0-0**
Course Specification Theoretical Content:			
Week	**General Objective:** 1.0 **Understand the important factors in the use of available energy**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-2	Describe the pattern, extent of availability and demand of world energy resources. Classify fuels into solids, liquids and gasses. Explain the pattern of exploitation and use of Nigerian fuel reserves. Identify the effects of cost and government regulations on the choice of industrial fuels in Nigeria. Explain the analysis, characterization and specification of fuels. Determine the following properties of liquid fuel:- water content cloud point smoke point flammability specific gravity flash points. ignition point.	• Explain clearly oil, gas, and other fossil fuels. • Explain why gas is flared in Nigeria during oil production and suggest ways to eradicate this practice. • Asses the students.	Recommended textbooks, chalkboard, chalk, duster, etc.

Week	General Objective: 2.0 Understand the nature and uses of solid fuels.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
3-5	Identify forms of solid fuels such as coal, wood, baggase, etc.. Describe the nature and properties of coal. Identify the commercial uses of coal such as power generation, heating,raw material for chemical manufacture etc. Explain the methods of handling, storage, and particulate size reduction of bituminous coal. Outline the methods of producing metallurgical and foundry coke. State the properties and quality requirement of coke. Explain the combustion characteristics of coal in modern steam generating plants. Explain the principles of fluidized bed combustion. Describe pulverized coal firing.	• List the various forms of solid fuels. • List the properties of coal. • State the commercial uses of coal. • List the properties and quality requirement of coke. • List the combustion characteristics of coal in generating plants. • Assess the students.	Recommended textbooks.

Week	General Objective: 3.0 Understand the nature and uses of liquid fuels.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
6-8	Identify the various types of liquid fuels. Explain the origin and locations of crude petroleum. State the primary fractions derived from crude petroleum such as petroleum gases, naphtha, kerosene, diesel, LPFO, HPFO, etc. Explain the applications of the refined fractions. Explain the properties of the refined fractions. Identify the relationship between product quality and end use.	• Give examples such as petrol, kerosene, diesel, etc. • Give examples of liquid fuels. • State the conditions for favorable formation of crude as dead and decaying organic matter trapped underneath the earth surface for several years under pressure in favourable formations of sedimentary rocks.	Recommended textbooks, Lecture note.

		• Ask the students to List the primary fractions derived from crude oil. • Give the applications of the various fractions; LPG- cooking, Petrol- automotive fuel, Diesel – automotive fuel and to power generators, lubricating oils – lubrication etc. • Give the properties of each of the refined fractions.	Recommended textbooks, Lecture note, Duster.

Week	General Objective: 4.0 Understand the nature and uses of gaseous fuels.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
9-11	Identify the various forms of gaseous fuels such as LPG, LNG, water gas, etc. Give the uses of gaseous fuels. Explain the occurrence and properties of natural gas. Explain the production and storage of liquefied petroleum gas (LPG). Explain the production and storage of liquefied natural gas (LNG). Explain gaseous combustion behaviour. Explain the inter-changeability of industrial gases. Describe the form and operation of gas combustion equipment.	• Let the students give examples of gaseous fuels. • List the uses of various types of gaseous fuels. • Compare and contrast the storage and production of LPG and LNG. • Assess the students.	Recommended textbooks, Lecture note.

Week	General Objective: 5.0 Understand the layout and operations of modern fuel burning plants.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	Describe be the method of use of the following modern fuel burning equipment: Water tube steam generators. Coke oven battery. Blast furnace. Metallurgical furnaces. Cement kilns. Reformer furnaces. Refinery heaters. Explain the method of furnace drafting. Explain the method of oxidant admission. Explain how combustion products are removed. Describe fuel gas sampling and analysis.	• Compare the performance of items in 5.1 (a) – (g) with one another. • Assess the students.	Recommended textbooks, Lecture note.

Week	General Objective: 6.0 Understand how to solve problems on combustion.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14-15	State equations of reaction between fuels and oxygen. Explain how to determine the stoichiometyric air requirement. Explain how to determine the excess air requirement. Explain how to determine the amounts and composition of combustion products. Explain how to determine furnace temperature. Perform material and energy balances across the furnace.	• Illustrate combustion with at least five examples. • Give students several problems and ask them to determine: the limiting reactant. (ii) the excess reactant. (v) percentage excess. (vi) the composition of effluent gases. • Perform material and energy balances across the furnace. • Assess the student.	Recommended textbooks, Lecture note etc.

NATIONAL BOARD FOR TECHNICAL EDUCATION, KADUNA

PROGRAMME: ND CHEMICAL ENGINEERING			
COURSE: Petroleum Processing Technology		**Course Code: CHE 222**	**Contact Hours: 2-0-0**
Course Specification: Theoretical Content			
Week	**General Objective: 1.0 Know procedure of crude oil preparation for primary processing.**		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
1-3	Define petroleum refining. List out refinery products. State roles of refinery in the petroleum industry. Draw refinery overall block flow diagram. Describe crude oil composition, physical properties, and classification. Explain the following methods: Degassing; Desalting; Dewatering; Caustic washing; Heating; Preflashing; State the relevance of the methods in 1.6 above Prepare samples of crude oil for primary processing according to 1.6 above.	Give a brief history of crude oil Classify methods by pointing out when which is desirable.	Recommended textbooks, lecture notes, etc.

Week	General Objective: 2.0 Understand primary processing		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
4-6	Define and explain the principles of distillation: bearing in mind the following terms: ebullition; fractionation; refluxing reboiling. State the functions of steam and vacuum distillation. Explain the principles of steam stripping Describe the atmospheric distillation unit (ADU) and enumerate the products Describe the vacuum distillation unit (VDU) and enumerate the products.	Draws sketches to show differences between ADU and VDU	Recommended textbooks, lecture notes, etc.

Week	General Objective: 3.0 Understand secondary processing		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
7-9	Compare and contrast the products of primary processing with final refinery products. List out the processing methods to upgrade, convert or purify primary products. Define catalysis in secondary processing. Explain the role of catalysis in secondary processing. Describe the following secondary processes. Catalytic reforming; Catalytic cracking; Alkylation.	Explain the process of catalytic cracking giving its advantages.	Recommended textbooks, lecture notes.

Week	General Objective: 4.0 Know petroleum product treatment processes		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
10-11	Enumerate the purpose of treatment. Describe the following treatment methods: Hydro treatment (Hydro sulphurisation); Meraux sweetening; Amine treatment.	Explain the meaning of sweetening and how it can be achieved.	Recommended textbooks, lecture notes.

Week	General Objective: 5.0 Know product blending techniques.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
12-13	State the purpose of product blending. Describe and compare tank blending and in-line blending. Describe blending for gasoline and fuel oil.	Start by explaining the meaning of blending. Mention (write on the board) obvious and non-obvious reasons for blending	Recommended textbooks, lecture notes.

Week	General Objective: 6.0 Know auxiliary refining systems.		
	Special Learning Objective	**Teachers Activities**	**Learning Resources**
14-15	Explain sulphur recovery processes. Explain control of noise in the refinery. Explain control of atmospheric pollution. Describe the refinery effluent treatment system.	Explain where sulphur is needed where it is not needed. Explain the effects of noise on the nervous system of human beings. Examples of some atmospheric pollutants should be given.	Recommended textbooks, lecture notes.

LIST OF EQUIPMENT
CHEMICAL ENGINEERING TECHNOLOGY

The following is the minimum list of equipment for ND Programme in Chemical Engineering Technology.

NATIONAL DIPLOMA

S/NO	ITEM	QUANTITY
(a).	**FLUID AND PARTICLE MECHANICS**	
1	Fluid and hydrostatic bench	5
2	Fluid friction apparatus	5
3	Flow meter demonstration apparatus	3
4	Fluid flow demonstration apparatus	2
5	Compressible flow bench	5
6	Reynolds number demonstration apparatus	1
7	Reciprocating pumps	2
8	Precission Pressure guage	5
(b).	**HEAT TRANSFER**	
1	Temperature measurement bench and flow controlling	5
2	Heat convection apparatus	
3	Heat conduction apparatus	2
4	Thermal radiation apparatus	2
5	Heat exchange test rig unit	2
6	Concentric tube Heat exchanger (Double pipe system)	2
		2

(c).	**MASS TRANSFER**	
1.	Gas diffusion apparatus	2
2.	Liquid diffusion coefficient apparatus	2
3.	Water cooling tower	2
S/NO	**ITEM**	**QUANTITY**
(d).	**SEPARATION PROCESSES**	
1.	Steam generators	2
2.	Packed absorption Column	2
3.	Solid – liquid extraction apparatus	2
4.	Solvent extraction apparatus (Soxhlet)	4
5	Gas absorption equipment	2
6.	Liquid – liquid extraction column	2
7.	Distillation column with sieve trays and valve tray	2
(e).	**DRYING**	
1	Tray drier	2
2	Spray drier	2
(f).	**MIXING**	
1.	Multi purpose mixer/stirrer (liquid-liquid and solid-liquid)	
2.	Magnetic Stirrers	2
(g).	**FILTRATION**	4
	Sedimentation tank	
	Fitter Press (Plate frame)	
	Centrifuge/Electrostatic Precipitator	1

		2
	SOLID HANDLING, SIZE REDUCTION AND CLASSIFICATION	2
	Solid handling bench	
(h).	Sieve Shaker and sieve tests/cyclones	
	Jaw crusher/roll mills.	
1.	Solid conveying system (Bucket/Belt/Pneumatic)	1
2.		2
3.	AUTOMATION AND PROCESS CONTROL	2
4.	Pressure control apparatus	1
	Temperature control apparatus	
	P^H Controller	
(i)	Typical control elements- control valves	
1.	Actual controllers, transmitters, solenoid and diaphragm valves	2
2.	CHEMICAL REACTION ENGINEERING	2
3.	Liquid-phase batch reactor	2
4.	Corrosion studies apparatus	2
5.	Isothermal electric calorimeter	2
	Gas turbine or Mechanical heat pump(optional)	
(j)		
1.	EVAPORATION	1
2.	Single effect evaporator	2
3.	Climbing film evaporator	4
4.		1
	CHEMICAL TECHNOLOGY AND GENERAL LABORATORY	
(k)	Autoclave	
1.	P^H meters and electrodes	1
2.	Conductivity and electrodes	1

	Abbe refractometer	
(l)	Bomb calorimeter	
	Resistance thermometer for liquid	
1.	Resistance thermometer for gas	2
2.	Digital temperature indicator	4
3.	Water de-ioniser	4
4.	Constant Temperature water bath	3
5.	Electronic balances	4
6.	Stop watch/clock	10
7.	Manometers	10
8.	Wet and dry bulb hydrometer	4
9.	Calorimeter	2
10.	Pitot tubes	2
11.	Cartridge de-ioniser	4
12.		10
13.		5
14.		3
15.		3
16.		10
17.		1

List of Participants (ND/HND Chemical Engineering)

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