

**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**  
**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**  
 Semester- 5  
**Course Title: Petroleum Refining and Petrochemical Technology**  
 (Course Code: 4360502)

Diploma programme in which this course is offered	Semester in which offered
Chemical Engineering	5th Semester

**1. RATIONALE**

Petroleum refining plays a critical role in the global economy. Petroleum refining and petrochemical industries are major industries which essentially produce fuels and other wide varieties of products which are used every day. A diploma chemical engineer has to apply relevant concepts to ensure safe and efficient industrial operation in refineries and petrochemical industries. As environmental regulations are being stringent day by day there is a need to make proper quality checks and testing of petroleum products. This course is designed to develop such competency and skills.

**2. COMPETENCY**

The course should be taught and implemented with the aim to develop required skills in students so that they are able to acquire following competency:

- Supervise petroleum refinery and petro-chemical plant

**3. COURSE OUTCOMES (COs)**

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- Analyze properties of crude petroleum and petroleum products
- Explain fractionation of crude petroleum and treatment techniques
- Apply refinery processes to maximize desired petro products
- Explain manufacturing processes of petrochemicals

**4. TEACHING AND EXAMINATION SCHEME**

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				Total Marks
L	T	P		Theory Marks		Practical Marks		
			C	CA	ESE	CA	ESE	
3	0	2	4	30	70	25	25	150

## 5. SUGGESTED PRACTICAL EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills (Course Outcomes in psychomotor and affective domain) so that students are able to acquire the competencies (Programme Outcomes). Following is the list of practical exercises for guidance. Note: Here only Course Outcomes in the psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of Programme Outcomes/Course Outcomes in affective domain as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain.

S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1.	Prepare a detail chart of modern refinery	I	02
2.	Prepare a detail chart of petrochemical products	V	02
3.	Determine flash point of petroleum product by Penskey Martin method.	I	02
4.	Determine fire point of petroleum product by Penskey Martin method.	II	02
5.	Measure softening point of petroleum product.	II	02
6.	Measure Aniline point of petroleum product.	II	02
7.	Determine penetration number of Grease.	II	02
8.	Determine Carbon residue by Ram's bottom method.	II	02
9.	Determine Carbon residue by conradson method	II	02
10.	Measure smoke point of kerosene.	II	02
11.	Measure cloud point of given petroleum product.	II	02
12.	Measures pour point of given petroleum product.	II	02
13.	Measure initial & final boiling point of petroleum product.	II	02
14.	Measure Viscosity of lube oil by Redwood /Saybolt/Engler viscometer	II	02
			<b>28 Hrs.</b>

S.No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Handling of apparatus for precise measurements	10
2	Record observations correctly	10
3	Practice and adapt good and safe measuring techniques	10
4	Calculations, Interpretation of results and their conclusion	20
5	Prepare report of practical in prescribed format	10
6	Solve assignment questions	20
7	Viva-voce	10
<b>Total</b>		<b>100</b>

#### 6. MAJOR EQUIPMENTS/ INSTRUMENTS REQUIRED

These major equipment/instruments and Software required to develop PrOs are given below with broad specifications to facilitate procurement to them by the administrators/management to the institutes. This will ensure the conduction of practice in all institutions across the state in a proper way other than the desired skills is developing in students.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Penskey Martin Apparatus: Electrical heating with gas test jet and electric heater with energy regulator. Assembly is resting in an air bath which is covered with a dome shaped metal top. The cup is fitted with an insulated handle and locking arrangement. The round shaped heater with a different temperature regulation system suitable for operation on 220 Volts AC mains.	3,4
2	Softening point Apparatus: Ring and Ball Apparatus with electric motorized stirrer and electric heater, concealed hot plate with temperature regulator.	5
3	Penetrometer: A rack, pinion and pointer assembly, dial is graduated from 0-400 in on tenth millimeter sub division. Two sample containers made of Aluminium, round dial fitted on Aluminium painted stand having	7

	adjustable penetration needle, holder sample container and transfer dish.	
4	Ram's bottom Apparatus: It consists of a solid metal bath having walls to accommodate cocking bulbs with heating elements around the bath, the temperature may be controlled by a Pyrometer depending upon the type supplied, and cocking bulbs are supplied with apparatus.	8
5	Conradson Apparatus: The Apparatus consists of a Spun Sheet Iron Crucible, porcelain crucible, and sheet iron hood and sheet iron block on a stand with triangular wire bridge.	9
6	Smoke point apparatus: The complete assembly consists of a brass lamp body with chimney, 0-50mm black glass scale with white markings, brass plated door with curved glass window, a candle socket, plated brass candle with wick tube & air vent, a mirror can be attached to the chimney to aid smoke detection and mounted on a cast iron base with aluminum support rod.	10
7	Cloud and pour point Apparatus: It consists of a main cooling bath made of stainless steel sheet and stand unit with drain plug and cover with provision for fitting thermometer and a filling aperture for adding freezing mixture. A glass jar for containing oils, jacket, disc and gasket.	11, 12
8	Distillation Apparatus: The instrument consists of metal shield fitted with asbestos board to support distillation flask with height adjustable device. It has a slide for the vapor tube and lining with a glass window for clear view of inside objects. The condenser bath is provided with a Mild Steel black painted stand. Electrically operated on 220 volts AC mains.	13
9	Redwood Viscometer: Redwood Viscometer No.1 comprises Stainless steel bath with electrical heating arrangement suitable to operate at 220 Volts AC Mains with tap, oil cup with precision stainless steel jet, cup cover, ball valve, and thermometer-clip. Stirrer and stand.	14
10	Saybolt apparatus: Stainless Steel bath with oil cup which is centrally placed in a water bath. The bath has a lid which contains a Water Cooling Tube, Two handles with Two Stirrer Blades, Thermometer socket, Straight heater; Stirring is done by turntable arrangement.	14
11	Engler Viscometer: It consists of a stainless steel water bath having an oil cup with a double walled lid. The water bath with a stirring device mounted on a stand. A thermometer clip to the water bath and the oil cup	14

	lid has a thermometer socket. The bath is fitted with a 500 watts heater. It is supplied with a wooden or ebonite valve to fit the jet. It can operate on 220 Volts AC mains.	
12	Glassware: Beaker, Thermometer, Measuring cylinder, funnel, Round bottom flask	All
13	Accessories: Burner, Stand	All
14	Materials: Petrol, Diesel, Kerosene, Lube oil, Grease, Aniline	All

### 7. AFFECTIVE DOMAIN OUTCOMES

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

- a) Work as a leader/a team member.
- b) Follow ethical practices
- c) Observe safety measures
- d) Good housekeeping
- e) Time management
- f) Practice environmentally friendly methods and processes.

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

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

### 8. UNDERPINNING THEORY

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
<b>Unit – I Basics of Petroleum and Refinery</b>	1 a. State basic occurrence of petroleum 1 b. Explain composition of petroleum 1 c. Classify Petroleum 1d. Explain various types of refineries 1 e. Explain types of refinery Process  1 f. List Various refinery Products	1.1 Occurrence of petroleum 1.2 Composition of Petroleum 1.3 Classification of Petroleum 1.4 Types of Refineries 1.5 Refinery processes 1.5.1 Physical Changes 1.5.2 Chemical Changes 1.6 Refinery Products

<b>Unit– II Fractionation of Petroleum</b>	2 a. Explain primary treatment of crude oil	2.1 Primary treatment of crude 2.1.1 Dehydration and Desalting of crude oil 2.1.2 Pipe still heaters
	2 b. Explain distillation of crude oil and crude residue	2.2 Atmospheric distillation of crude 2.3 Vacuum distillation of crude residue
	2 c. List important physical properties of various petroleum products 2 d. Define physical properties of petroleum products with their importance 2 e. Explain test methods of important physical properties 2 f. Measure physical properties of petroleum products	2.4 Physical properties of petroleum products and its measurements : 2.5.1 Petrol 2.5.2 Diesel 2.5.3 Kerosene 2.5.4 Lubricant oil 2.5.5 CNG and LPG 2.5.6 Grease
<b>Unit– III Refinery Processes</b>	3a. Compare Cracking methods 3a.1 Explain Purpose of cracking 3a.2 Explain effect of temperature and pressure on Cracking 3a.3 Explain cracking methods  3b. Define reforming 3b.1 Explain need of Reforming 3b.2 Explain Pt catalyst-Reforming  3c. Define green refineries 3c.1 List raw materials and products of green refineries 3c.2 Advantages of green refineries 3c. 3 Explain manufacturing of Hydrogenated vegetable oil or green diesel	3.1 Cracking 3.1.1 Purpose of cracking 3.1.2 Effect of temperature and pressure on Cracking Cracking methods 3.1.3 Thermal cracking 3.1.3.a Visbreaking 3.1.3.b delayed coking and Fluid coking 3.1.4 Catalytic cracking 3.1.5. Fluidized bed catalytic cracking  3.2 Reforming 3.2.1 Purpose of Reforming 3.2.2 Plat forming(Pt catalyst-Reforming)  3.3 Green refineries 3.3.1 Raw materials and products of green refineries 3.3.2 Conversion of conventional refinery to green refinery 3.3.3 Manufacturing of Hydrogenated vegetable oil or green diesel

<p><b>Unit– IV</b> <b>Treatment</b> <b>Techniques</b></p>	<p>4a. Explain the purposes of sulfur removal 4a.1 Explain methods of sulfur removal - Doctor's sweetening, Catalytic desulfurization, MEROX treatment 4b. Explain Treatment of Kerosene by liquid SO<sub>2</sub> extraction  4c. Distinguish solvent extraction processes – Furfural, Phenol 4d. Explain the Purpose of dewaxing 4e. Explain Ketone dewaxing</p>	<p>4.1 Purposes and methods of sulfur removal 4.2 Doctor's sweetening 4.3 Catalytic desulfurization 4.4 MEROX treatment 4.5 Treatment of Kerosene by liquid SO<sub>2</sub> extraction 4.6 Solvent extraction processes 4.6.1 Furfural extraction method 4.6.2 Phenol extraction method  4.7 Purpose of dewaxing Dewaxing Techniques 4.8 Dewaxing with solvent 4.9. Ketone dewaxing</p>
<p><b>Unit– V</b> <b>Petrochemicals</b></p>	<p>5a. Define petrochemicals 5a.1 Classify petrochemicals 5b. Explain manufacturing of - C1 compounds- Methanol and Formaldehyde  -C2 compounds - Vinyl chloride and Ethylene Oxide  - C3 compounds- Propylene oxide  -Chemicals from aromatics- Linear Alkyl Benzene</p>	<p>5.1 Petrochemicals  5.2 Manufacturing of important C1 compounds 5.2.1 Methanol 5.2.2 Formaldehyde 5.3 Manufacturing of important C2 compounds 5.3.1 Vinyl chloride 5.3.2 Ethylene Oxide 5.4 Manufacturing of important C3 compounds 5.4.1 Propylene oxide 5.5 Chemicals from aromatics 5.5.1 Manufacture of Linear Alkyl Benzene</p>

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Petroleum and Refinery	4	4	2	2	8
II	Fractionation of Petroleum	8	4	4	3	11
III	Refinery Processes	9	5	6	3	14
IV	Treatment Techniques	10	6	6	5	17
V	Petrochemicals	11	8	6	6	20
<b>Total</b>		<b>42</b>	<b>27</b>	<b>24</b>	<b>19</b>	<b>70</b>

## 10. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

- i. Course/topic based presentation
- ii. Market survey of various petrochemical products of different manufacturers and their comparison based on their specification, composition and cost
- iii. MCQ/Quiz
- iv. Undertake micro-Project in team/individually

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

- i. Lecture and demonstration of animated videos of refinery and petrochemical plant
- ii. Arrange an industrial visit to nearby petrochemical industry
- iii. Some of the topics/sub-topics which is relatively simpler or descriptive is to be given to the students for self-learning but to be assessed using different assessment methods.
- iv. Massive open online courses (MOOCs) may be used to teach various topics/subtopics.
- v. Guide students to address issues on environment and sustainability with reference to using the knowledge of this course

## 12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to. Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her at the beginning of the semester. In the first four semesters, the micro-project is group-based (group of 3 to 5). However, in the fifth and sixth semesters, the number of students in the group should not exceed three.

The micro-project could be industry application-based, internet-based, workshop-based, laboratory-based, or field-based. Each micro-project should encompass two or more COs which are the integration of PrOs, UOs, and ADOs. Each student will have to maintain a dated work diary consisting

of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about 14-16 (fourteen to sixteen) student engagement hours during the course. The student sought to submit micro-project by the end of the semester (so that they develop industry-oriented COs. A suggestive list of micro-projects is given here. This should relate highly to the competency of the course and the COs. Similar micro-projects could be added by the concerned course teacher.

- 1) Prepare a chart of the properties of a given product petroleum product
- 2) Prepare a chart to demonstrate the refinery process.
- 3) Prepare a chart on classification of petroleum and petrochemicals
- 4) Prepare a chart on Test methods of given petroleum products
- 5) Prepare a power point presentation on fractionation of petroleum
- 6) Prepare a PowerPoint presentation or animation showing different types of refinery operations and processes
- 7) Prepare a report on recent trends in petroleum industries
- 8) Prepare a model of different petrochemical product flow diagram
- 9) Prepare a working/demo model of any petroleum testing equipment

### 13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Modern Petroleum refining Processes	B. K. Bhaskar Rao	Oxford and IBH, 2007
2	Outlines of chemical Technology	M. Gopala Rao, Marshall Sitting	3rd Edition East-West Press Pvt. Ltd, Delhi
3	Shreve's Chemical Process Industries	Austin G.T.	McGraw Hill publication – New Delhi, 5th edition
4	A Text on Petrochemicals	B. K. Bhaskar Rao	2nd Edition, Khanna Publishers, Delhi, 1998
5	Petroleum Refinery Engineering	W. L. Nelson	McGraw Hill, New York, 1958

### 14. SOFTWARE/LEARNING WEBSITES

1. [https://onlinecourses.nptel.ac.in/noc23\\_ch64](https://onlinecourses.nptel.ac.in/noc23_ch64)
2. <https://www.e-education.psu.edu/fsc432/content/overview-refinery-products-and-processes>
3. <http://www.setlab.com/resources/refining/solvent-extraction-dewaxing/#1498503459530-b4e0a336-25dd>
4. <https://thepetrosolutions.com/solvent-extraction-process-in-petroleum-oil-refinery/>
5. <https://www.e-education.psu.edu/fsc432/content/dewaxing>
6. <https://thepetrosolutions.com/thermal-cracking-process-in-oil-refinery/>
7. [https://www.linkedin.com/pulse/sustainable-fuel-production-green-refineries-answer-bpcl?trk=public\\_post](https://www.linkedin.com/pulse/sustainable-fuel-production-green-refineries-answer-bpcl?trk=public_post)
8. <https://decarbonisationtechnology.com/article/132/conversion-to-a-green-refinery>
9. <https://renewable-carbon.eu/news/green-refinery/>

### 15. PO-COMPETENCY-CO MAPPING

Semester	Petroleum Refining and Petrochemical Technology (4360502)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Managemen t	PO 7 Life- long learning
Competency	Supervise petroleum refinery and petro-chemical plant						
CO1: Analyze properties of crude petroleum and petroleum products	3.00	1.00	1.00	3.00	-	2.00	2.00
CO 2 : Explain fractionation of crude petroleum and treatment techniques	2.00	1.00	2.00	-	3.00	-	-
CO 3: Apply refinery processes to maximize desired petro products	3.00	1.00	1.00	-	2.00	-	1.00
CO 4: Explain manufacturing processes of petrochemicals	2.00	-	-	-	2.00	-	1.00

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

### 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

#### GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1	Ms. S. M. Chauhan, Lecturer in Chemical Engineering	Government Polytechnic, Valsad	-----	sejalmchauhan@gmail.com
2	Mr. R. V. Nayak, Lecturer in Chemical Engineering	Shri K. J. Polytechnic, Bharuch	-----	rnayak_79@rediffmaill.com