GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

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

Course Title: Destructive Testing
(Course Code: 4342102)

Diploma Programme in which this course is offered	Semester in which offered
Metallurgy Engineering	4th Semester

1. RATIONALE

Engineers use different materials for various engineering purposes. These materials and solid objects are subjected to various kinds of forces and stresses and often involve the risk of breaking in service and in that situation, they cannot be welded or molded instantly. It may take long to further rework on the same to give them shape or they may not be re-shaped at all. Hence, it is necessary to make the material and objects by considering factor of safety. To ensure this, these solid objects require various types of destructive testing during the manufacturing process so that the risk factor is reduced, facilitating durability and long-lasting capacity (or endurance). This course deals with various types of destructive test.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire the following competency:

- **Select a suitable destructive testing method for required properties of the materials.**

3. COURSE OUTCOMES (COs)

After completion of this course the student will be able to:

1. Understand fundamental of various destructive testing methods and illustrate tensile, compression, and shear tests to estimate various mechanical properties.
2. Select different hardness testing methods to determine the hardness of a given material.
3. Describe the concept of different impact test and its application based on requirements of mechanical properties.
4. Illustrate creep and fatigue properties and behavior of engineering materials and their importance in engineering application.
5. Understand other important testing methods and examine health & safety aspects in destructive testing.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
2	0	4	4	30*	70	50	50	200

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

***Legends: L**-Lecture; **T**–Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit; **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTEDPRACTICAL EXERCISES

Sr. No.	Practical	Unit No.	Approx. Hrs. Required
1.	Determine Tensile Strength of a different ferrous and non-ferrous specimen using Universal Tensile Machine (UTM). *(Suggested Specimen Materials: Mild Steel, Cast Iron, Aluminum, Copper, Brass etc.)*	1 & 2	6
2.	Determine Compression Strength of a different ferrous and non-ferrous specimen using Universal Tensile Machine (UTM). *(Suggested Specimen Materials: Mild Steel, Cast Iron, Aluminum, Copper, Brass etc)*	1 & 2	6
3.	Determine Shear Strength of a different ferrous and non-ferrous specimen using Universal Tensile Machine (UTM). *(Suggested Specimen Materials: Mild Steel, Cast Iron, Aluminum, Copper, Brass etc)*	1 & 2	6
4.	To study the Rockwell hardness tester and determine the hardness number of the given specimens. *Suggested Specimen Materials: different ferrous and non-ferrous materials under heat treated and as received condition)*	3	4
5.	To study the Brinell hardness tester and determine the hardness number of the given specimens. *Suggested Specimen Materials: different ferrous and non-ferrous materials under heat treated and as received condition)*	3	4
6.	To study the Vickers hardness tester and determine the hardness number of the given specimens. *Suggested Specimen Materials: different ferrous and non-ferrous materials under heat treated and as received condition)*	3	4

7.	To determine the impact energy/Impact strength of a given test specimen by (a) Izod test (b) Charpy test *Suggested Specimen Materials: different ferrous and non-ferrous materials under heat treated and as received condition)*	4	8
8.	To study the fatigue-testing machine and to determine the fatigue limit and the fatigue strength.	5	4
9.	Draw and interpret Creep curve based on given data.	5	4
10.	To study the wear properties of the given specimen and determine the wear factor.	6	4
11.	To study the behavior of given specimen subjected to pure bending and to determine the young's modulus of elasticity and modulus of rupture.	6	6
		TOTAL	56

Notes:

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

Sr. No.	Sample Performance Indicators for the PrOs.	Weightage in %
1	Identification of the component and Preparation of experimental Set-up	20
2	Operate equipment set-up	10
3	Observation and recording of the data correctly	10
4	Interpretation of the result and conclusion	20
5	Safety precaution and safety gadgets used	20
6	Submission of report within time limit and attendance in the laboratory	20

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the guide to procure them by the administrators to use in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	Practical No.
1.	Universal Testing Machine (Analogue)	**1, 2, 3**
2.	Rockwell cum Brinell hardness testing machine	**4, 5**
3.	Vickers cum Brinell hardness testing machine	**5, 6**

4.	Micro Vickers hardness testing machine	**6**
5.	Impact Testing Machine (Pendulum)	**7**
6.	Fatigue testing Machine	**8**
7.	Creep Testing Machine	**9**
8.	Wear Testing Machine (Pin and Disc Type)	**10**
9.	Bend Test Machine	**11**

7. AFFECTIVE DOMAIN OUTCOMES

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

- Aware about the concept of mechanical properties and select different destructive testing methods as per the requirements.
- Participates in class discussion on Destructive testing methods and its application.
- Knows the importance of safety equipment used in equipment used for the destructive testing.
- Proposes a plan or ideas to reduce environmental issues arises due to Testing related activities.
- Work as independently individuals, displays teamwork, displays leadership quality and professional commitment to ethical practice on daily basis.

8. UNDERPINNING THEORY

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

Unit	Major Learning Outcomes	Topics and Sub-topics
UNIT – I Introduction to Destructive Testing	1.a. Classify Material Testing 1.b. Discuss Importance of Material Testing 1.c. List out Mechanical Properties of materials 1.d. Explain Destructive testing 1.e. Discuss Merits and demerits of Destructive Testing 1.f. Discussing various Testing Organizations, Testing Standards and its importance in destructive testing	1.1. Overview, classification, and importance of Material Testing 1.2. Mechanical Properties of various materials 1.3. Introduction of Destructive testing 1.4. Merits and demerits of Destructive Testing 1.5. Testing Organizations, Testing Standards and its importance in destructive testing
UNIT – II Tensile – Compression-Shear Testing	2.a. Compare stress strain relationship 2.b. Discussing tensile stress 2.c. Discussing compression stress 2.d. Discussing shear stress	2.1. Stress – strain Relationship: Engineering Stress – Strain Curve, True Stress – True Strain, Stress-strain curve for ductile and brittle material 2.2. Tensile Test: Machine, Procedure, Measurement of properties, for ductile and brittle material 2.3. Compression test: Machine, Procedure, Measurement of properties, for ductile and brittle material 2.4. Shear Test: Shear stress and its type, purpose types of shear test, Types of materials tested in shear.
UNIT – III Hardness of Materials	3.a. Explain hardness and hardenability 3.b. Discuss various hardness testing methods 3.c. Explain hardness conversion 3.d. Suggest hardness method for specific materials	3.1. Introduction to hardness and hardenability 3.2. Types of hardness test: Indenter Test (Brinell, Rockwell, Vicker's, Micro-hardness), Scratch (Moh test) 3.3. Hardness Conversion relationships 3.4. Hardness Test Selection for Specific Materials

Unit	Major Learning Outcomes	Topics and Sub-topics
UNIT – IV Toughness testing of materials	4.a. Enlist various method of toughness test 4.b. Discuss Izod and Charpy Impact test	4.1. Classification of toughness test 4.2. Izod Impact Test and Charpy Impact Test: Principle, mechanism, equipment, and comparison.
UNIT – V Fatigue and Creep testing of materials	5.a. Compare fatigue and creep 5.b. Discuss fatigue phenomenon and test 5.c. Discuss creep phenomenon and test	5.1. Introduction and comparison of fatigue and creep. 5.2. Fatigue test, S-N Curve, endurance limit, Effect of various factors on fatigue 5.3. Creep test - Definition, importance, salient features of creep curve and mechanism of creep
UNIT – VI Other Important testing, Inspection and safety aspects in Destructive testing	6.a. Describe other important test for metals and alloys 6.b. Describe safety aspects, human health issues in Mechanical Testing	6.1 Bend Test: Importance and Procedure 6.2 Wear Test: Importance and Procedure 6.3 Human health and safety aspects in mechanical testing

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of theory marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Destructive Testing	4	5	3	2	10
II	Tensile – Compression-Shear Testing	8	3	5	6	14
III	Hardness of Materials	6	3	5	6	14
IV	Toughness testing of materials	3	2	4	4	10
V	Fatigue and Creep testing of materials	4	3	4	5	12
VI	Other Important testing, Inspection and safety aspects in Destructive testing	3	2	4	4	10
	Total	**28**	**18**	**25**	**27**	**70**

Legends: *R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)*

Notes:

a) This specification table shall be treated as a general guideline for students and

Teachers. The actual distribution of marks in the question paper may slightly vary from the above Table.

b) Ask the questions from each topic as per marks weightage. Numerical questions are tobe asked only if it is specified. Optional questions must be asked from the same topic.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggestedstudent-related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group.

a) Visit nearby testing laboratory engaged in third party inspection of materials (if any) and study the processes are being used.
b) Perform any DT on unknown materials and prepare a report.
c) Prepare safety plan to be used in the event of an accident.
d) Develop a checklist for precaution prior to use of any equipment used for destructive testing.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

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

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit a micro-project by the end of the semester to develop the industry-oriented COs.

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

1. Prepare a model of any one Destructive testing setup.
2. Prepare a chart on different destructive testing methods based on industrial application.
3. Test unknown materials with various DT and prepare report for same.

13.SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author / Editor	Publication with place, year and ISBN
1	"The Mechanical Testing of Metals and Alloys" 7th Edition	P. Field Foster	Cousens Press ,2007 (ISBN: 1-40-673479-9)
2	Metals Handbook: Mechanical testing, (Volume 8)	ASM Handbook Committee, 9th Edition	ASM International Materials Park, OH 44073-0002 ISBN 0-87170-389-0
3	The testing of metallic Materials	A.V.K. Suryanarayana	BS Publications (ISBN: 9352300378, 9789352300372)
4	Mechanical Metallurgy by G.E. Dieter	George Ellwood Dieter, D. J. Bacon, David Bacon	McGraw-Hill (ISBN: 9780071004060, 0071004068)
5	Principles of metallographic Laboratory Practice by	George Louis KEHL	McGraw-Hill (ISBN: 9780070334793, 007033479X)

14. SOFTWARE/LEARNING WEBSITES

1. https://eerc01-iiith.vlabs.ac.in/List%20of%20experiments.html
2. https://youtu.be/geqRGNIZGq8
3. https://youtu.be/4bDf_MB3ygU

4. https://www.youtube.com/@TheEfficientEngineer
5. https://www.nde-ed.org/Physics/index.xhtml
6. https://rtlabs.nitk.ac.in/?q=page/strength-materials-lab

15.PO-COMPETENCY-CO MAPPING

Semester IV		Destructive Testing [Course Code: 4342102]						
		POs						
Competency & Course Outcomes		PO 1Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design / development of solutions	PO 4 Engineering tools, Experimentation & Testing	PO 5 Engineering practices for society, Sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency		Select a suitable destructive testing method for required properties of the materials.						
Course Outcomes								
CO1:	Understand fundamental of various destructive testing methods and illustrate tensile, compression, and shear tests to estimate various mechanical properties.	3	-	2	2	-	-	2
CO2:	Select different hardness testing methods to determine the hardness of a given material.	3	1	2	1	-	-	2
CO3:	Describe the concept of different impact test and its application based on requirements of mechanical properties.	3	1	2	1	2	-	2

CO4:	Illustrate creep and fatigue properties and behavior of engineering materials and their importance in engineering application.	3	1	2	1	1	-	2
CO5:	Understand other important testing methods and examine health & safety aspects in destructive testing.	2	1	2	1	2	2	2

*Legend: '**3'** for high, '**2**' for medium, **'1'** for low or **'-'** for the relevant correlation of each competency, CO, with PO/ PS.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons:

Sr. No.	Name and Designation	Institute	Email
1	Dr. Naishadhkumar P. Patel Lecturer – Metallurgy Engineering	L. E. College (Diploma), Morbi	naishad.patel27@gmail.com
2	Mr. Mandar J. Joshi Lecturer – Metallurgy Engineering	Dr. S. & S. S. Ghandhy College of Engineering & Technology, Surat	mandarjoshi999@gmail.com
3	Mr. Kartik H. Raj, Lecturer – Metallurgy Engineering	L. E. College (Diploma), Morbi	rajkartikh@gmail.com

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