SAULT COLLEGE OF *APPLIED ARTS * TECHNOLOGY*

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

COURSE TITLE: METALLURGY

CODE NO.: MET 212--3

PROGRAM: MECHANICAL TECHNOLOGIST

SEMESTER: FOUR

DATE: 1987 06 08

AUTHOR. DENNIS SOCCHIA

NEW: *REVISION:* XX

APPROVED: ^ ***/ Ufa/yui&***

Chairperson *Date*

METALLURGY **MET 212-3**

Course Name **Course Number**

PHILOSOPHY/GOALS:

When the student has successfully completed this course of study, he/she should have a reasonable understanding of the material presented. The intention (therefore) is to provide students with sufficient background to assist others in the solution of work related (metallurgical) problems.

METHODS OF ASSESSMENT (GRADING METHOD):

3 Theory Tests	70%
1 Lab Report	20%
Attendance/Attitude	10%
(with NO incompletes)	

TEXTBOOK(S):

"Metallurgy" by John and Weeks
(5th edition) American Technical Publishers.

OBJECTIVES;

The basic objective is to develop within the student an understanding of the concepts and procedures involved with this course of study as well as an ability to use them in the solution of problems. Theory tests and lab exercises are designed with this in mind.

The basic level of competency demanded is an over-all course average of 55% with no incompletes.

SPECIFIC OBJECTIVES

FOR

METALLURGY - MET 212-3

1) INTRODUCTION AND ORIENTATION - 2 HRS. Handouts

The student should be given an opportunity to:

1) Identify and list the topics covered in this course.
2) Identify and list the general objectives of this course.
3) Identify and list the various methods of evaluation used in this course outline.
4) Identify the grading system used in this course outline with respect to A, B, C, R, I, X.
5) Identify the policy of this course with respect to:
   a) attendance
   b) attitude
   c) due dates
   d) re-writes
   e) testing policies
   f) partial course credits
   g) employed students
6) Identify and list the various teaching % methods used in this course outline.

2) PRODUCTION OF IRON AND STEEL - 4 HRS. Text

The student should be given the opportunity to:

1) Name 4 iron ore minerals found in nature. p 14
2) Write the chemical formula that represents each of the iron ore minerals.
3) List the various impurities and gangue materials found in iron ores.
4) Name the furnace used to produce pig iron. p 19
5) Define the term **"reduction"** with respect to the blast furnace operation.
6) List 3 major steelmaking furnaces in use today. p 29-31-34
7) Compare the **"quality"** of steels produced by the various steelmaking furnaces.
8) List the general types of cast irons, cast steels, and rolled steels in use today. Notes

9)	Identify cast irons, cast steels, plain carbon steels, low alloy steels, stainless steels and tool steels according to their approximate carbon content, significant alloys and minor constituents.	Handouts
10)	State the main metallurgical reason for pouring molten steel into ingots.	Notes
11)	List and briefly describe the various grades of ingot poured steels,	p 41-42
12)	Explain (briefly) why the making of good ingots is one of the most important steps in the fabrication of steels.	p 39
13)	List and briefly describe the major defects found in ingot poured steels.	p 39-40

HEAT **TREATMENT** - **8** HRS.

The student should be given an opportunity to:

1)	Develop a general understanding of the iron-carbide system for steels with respect to: a) Lower Critical Temperature b) Upper Critical Temperature c) Eutectoid Point and Composition d) Existing Equilibrium Structures e) The effects of Heating and Cooling with respect to Critical Temperatures,	p 147, 160, 162
2)	Explain the changes in eutectoid, hypoeutectoid and hypereutectoid steels when they are heated from room temperature to above the upper critical temperature-	Handouts
3)	Identify and select the proper temperature ranges for the following heat treating operations: anneal normalize harden temper	p 166
4)	List the three requirements necessary to successfully harden steels.	p 171-173
5)	Explain the formation of martensite as a non-equilibrium structure.	
6)	State the theory that explains why martensite has such a high hardness.	
7)	Compare the hardness for the following ferrous crystalline structures: ferrite pearlite martensite cementite	Handout

4) SURFACE TREATMENTS - 2 HRS.

The student should be given an opportunity to:

1) State the purpose for which carburizing operations are carried out. p 205-206
2) State the 3 main carburizing processes.
3) State the initial carbon content of steels used in carburizing operations.
4) Describe the effects of carburizing process on:
   a) The **"final"** carbon content of the steels.
   b) The **"final"** microstructure and hardness of the steels.
5) State which gas is used in the nitriding process.
6) State the relationship between the temperatures used in the nitriding process as compared to the carburizing process.
7) Identify the type of steel used in the nitriding process. p 214
8) State which elements (in addition to carbon, manganese and silicon) are contained in steels used for the nitriding process. p 215
9) Briefly explain how **"free"** nitrogen is produced. p 216
10) Briefly explain how these nitrides harden the steel.
11) Describe the effects of the nitriding process on:
   a) The depth of case.
   b) The hardness of the core.
12) State the purpose for which flame hardening and induction hardening operations are carried out. p 220-223
13) State the initial carbon content of steels used in the flame and induction hardening processes.
14) Describe the effects of the flame and induction hardening processes on:
   a) The **"final"** carbon content of the steels.
   b) The **"final"** microstructure and hardness of the steels.

PHYSICAL METALLURGY - 3 HRS.

The student should be given an opportunity to:

1) State and briefly explain the two structural factors which govern the characteristics of metals. p 74-75
2) Explain and define the solid or "crystalline structure" of metals in terms of:
   a) the arrangement of atoms
   b) the space lattice of atoms p 75
3) List, draw and label the following three common space lattice types:
   a) body-centered cubic
   b) face-centered cubic
   c) close-packed hexagonal p 75
4) Explain the manner of crystallization of metals by means of the following progressive stages:
   a) liquid
   b) nucleation
   c) crystal formation
   d) grain growth p 77-79
   e) segregation of impurities "grains"
5) Explain the difference between and "crystals" when discussing
   a) pure metals p 79-80
   b) commercial metals and the affects mechanical
6) Explain both the concept terms of: of work hardening on the properties of a metal in
   a) slip WIC Module 20
   b) dislocations p 13,14,15
   c) the tensile tests
7) Explain the process of recrystallization and its' effect on a work hardened metal. p 83
8) Explain the process of grain growth. p 83-84

6. THE THEORY OF ALLOYS - 5 HRS.

The student should be given an opportunity to:

1)	State and describe both substitutional and interstitial solid solution theories.	WIC Module 20 p 16-17
2)	Explain how it is possible to obtain a thermal curve for every metal,	p 132
3)	Draw and identify a time-temperature curve for: a) a metal undergoing no thermal change b) a pure metal undergoing a thermal change c) an alloy undergoing a thermal change over a range of temperatures	p 133
4)	Explain the process of formation for a solid solution alloy using a 50-50 copper-nickel alloy.	p 134-136
5)	State how the heterogeneous (ie. non-uniform) cored structure of a solid solution alloy: a) comes into being b) can be corrected	p 136
6)	Explain the process of formation for a eutectic alloy using a 25-75 cadmiun-bismuth alloy.	p 136-139
7)	Explain the process of formation of a type III alloy using an 80-20 copper-silver alloy.	p 141-142

NOTE: Course objectives are subject to change due to the following variables:

i) field trips

ii) holidays

LAB EXPERIMENTS/OBJECTIVES

FOR

METALLURGY - MET 212-3

ROCKWELL HARDNESS - 2 HRS. Handouts

The student should be given an opportunity to:

1) Prepare and test steels for their initial hardness.
2) Explain the initial hardness of a steel in relation to its carbon content and the P.F.C.S. chart.
3) Estimate the initial micrestructure.

6 SAMPLES/GROUP REQUIRED

NORMALIZING - 3 HRS. Handouts

The student should be given an opportunity to:

1) Determine the proper soaking time and temperature for his/her steel.
2) Heat treat steels for the purpose of changing their microstructure and hardness.
3) Prepare and test steels for their normalized hardness.
4) Recognize and explain a change in hardness due to normalizing.
5) Prepare and examine samples for microstructure.
6) Explain the changed hardness of a steel in relation to its carbon content, new microstructure and the P.F.C.S. chart.
7) Name the new microstructure.
8) Describe the new microstructure.

6 SAMPLES/GROUP FROM EXPERIMENT #1

3. QUENCH HARDENING - 3 HRS. Handouts

The student should be given an opportunity to:

1) Determine the proper soaking time and temperature for his/her steel.
2) Heat treat steels for the purpose of changing their microstructure and increasing the hardness,
3) Prepare and test samples for their quenched hardness.
4) Recognize and explain an increase in hardness due to water and oil quenching.
5) Prepare and examine samples for microstructure.
6) Explain the increased hardness of a steel in relation to its carbon content, new microstructure and the P.F.C.S. chart.
7) Name and describe the new microstructure.

3 SAMPLES/GROUP FROM EXPERIMENT #2

4. TEMPERING - 3 HRS. Handouts

The student should be given the opportunity to:

1) Determine the proper tempering time and temperature for his/her steel.
2) Heat treat steels for the purpose of reducing their quenched hardness.
3) Prepare and test samples for reduced hardness.
4) Prepare and examine samples for microstructure.
5) Explain the steels reduced hardness in relation to its carbon content, microstructure and P.F.C,S. chart.
6) Name and describe the "new" microstructure.

3 SAMPLES/GROUP FROM EXPERIMENT #3

I

5. HEAT TREAT REVIEW - 2 **HRS.** Handouts

The student should be given an opportunity to:

1) Review, compare and discuss the lab data,
2) Discuss changes in hardness and microstructure with respect to:
   - P-F.C.S. chart
   - Iron-carbide system
   - continuous cooling transformation phase diagrams.
3) Define the terms:
   - normalize
   - quench harden
   - temper
4) Discuss lab reports and format.

NOTE: Lab experiments and objectives are subject to change due to such variables as:

i) field trips
ii) holidays
iii) equipment failure

SUMMARY OF OUTLINE

TOPIC NO.	PERIODS	TOPIC DESCRIPTION	REFERENCE
	2-T	**INTRODUCTION AND ORIENTATION** - course topics - general objectives - methods of evaluation - grading system - teaching methods - policy regarding: a) attendance b) attitude c) due dates d) re-writes e) testing f) partial course credits g) [illegible] standards	handout
	4-T	**PRODUCTION OF IRON AND STEEL** - iron ore minerals, chemical formula and gangue materials - iron production via blast furnace reduction - types of steelmaking furnaces - general types of commercial ferrous metals and their chemical analysis - grades of ingot poured steels	Text - Chp. 2 & 3 Handouts Notes
	2-T	**THEORY TEST #1 FOR TOPICS 1 & 2**	
	8-T 13-T	**HEAT TREATMENT** - general understanding of the iron-carbide system for steels - changes in steels as they are heated - requirements to harden steels - formation and hardness of martensite - comparative hardness of ferrous crystalline structures	Text - Chp. 8 & 9 Handouts

TOPIC NO.	PERIODS	TOPIC DESCRIPTION	REFERENCE
	2-T	**SURFACE TREATMENTS** - purpose and methods of carburizing - effects of carburizing on steels - purpose of flame and induction hardening - effects of flame and induction hardening on steels - the nitriding process - effects of nitriding process	Text Chp. 10
	2-T	**THEORY TEST #2 FOR TOPICS 3 & 4**	
	3-T	**PHYSICAL METALLURGY** - the crystalline nature of metals - the manner of recrystallization - work hardening of metals - recrystallization and grain growth	Text Chp. 5
	5-T	**THEORY OF ALLOYS** - the types of solid solutions - time temperature curves - type I_f II, III binary alloy systems	Text Chp. 8
	2-T	**THEORY TEST #3 FOR TOPICS 5 & 6**	

NOTE: Objectives are subject to change due to such variables as

i) field trips
ii) holidays
iii) equipment failure