#441

SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ON

COURSE OUTLINE

COURSE TITLE: **METALLURGY**

CODE NO: MET 212-3 SEMESTER: FOUR

PROGRAM: MECHANICAL TECHNOLOGY

AUTHOR: DENNIS SOCCHIA

DATE: DECEMBER 12, 1990 PREVIOUS OUTLINE DATED: MAY 25, 1988

APPROVED: _____ _____
Dean Date

COURSE NAME: METALLURGY CODE NO. **MET** 212-3

TOTAL CREDIT HOURS: 45

PREREQUISITE(S): Grade 12 reading, writing and comprehension skills or equivalent.

I. PHILOSOPHY/GOALS:

To provide students with a reasonable understanding of the concepts and procedures related to the fields of extractive metallurgy, heat treatment, physical metallurgy and the mechanical testing of metals. Ultimately, students should have sufficient background to assist others in the solution of work related (metallurgical) problems.

II. STUDENT PERFORMANCE OBJECTIVES:

Upon successful completion of this course the student will:

1. Understand the process of extractive metallurgy specific to iron and steelmaking.
2. Understand the concepts and procedures related to the heat treatment of carbon steels.
3.. Understand and apply the procedures required for basic mechanical testing of metals.
4. Understand and read simple binary phase diagrams.

III. TOPICS TO BE COVERED:

1. Course introduction and orientation.
2. The production of iron and steel.
3. The heat treatment of carbon steels.
4. The surface treatment of metals.
5. Physical metallurgy.
6. The theory of alloys.

Note: Course 'Objectives[1] and 'Topics' are subject to change due to the following variables;

1) field trips
ii) holidays
iii) equipment failure
iv) illness

COURSE NAME: METALLURGY CODE NO. **MET** 212-3

SPECIFIC OBJECTIVES FOR MET 212-3:

1. INTRODUCTION AND ORIENTATION - 2 HOURS — 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) *du^* 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 HOURS — 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 steeimaking furnaces in use today. — p 29,31,34
7. Compare the 'quality' of steels produced by the various steeimaking 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 and tool steels according to their approximate carbon content, significant alloys and minor constituents. — Handouts
10. List and briefly describe the various grades of ingot poured steels. — p 41-42
11. Explain (briefly) why the making of good ingots is one of the most important steps in the fabrication of steels. — p 39
12. List and briefly describe the major defects found in ingot poured steels — p 39-40

3. HEAT TREATMENT - 8 HOURS

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, temperature — 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 HOURS

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

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	

5. PHYSICAL METALLURGY - 3 HOURS

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	
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 e) segregation of impurities	p 75 p 77-79
5. Explain the difference between 'grains' and 'crystals' when discussing: a) pure metals b) commercial metals	 p 79-80
6. Explain both the concept and the affects of work hardening on the mechanical properties of a metal in terms of: a} slip b) dislocations c) the tensile tests	 WIC module 20 p 13,14,15
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

^ COURSE NAME: METALLURGY CODE NO.: **MET** 212-3

6. THE THEORY OF ALLOYS - 5 HOURS

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 cadmiunbismuth alloy — p 136-139

LAB EXPERIMENTS/OBJECTIVES:

£ 1. ROCKWELL HARDNESS - 2 HOURS — 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 microstructure.
4. Relationship between hardness, microstructure (P.F.C.S.) tensile strength and ductility.

6 **SAMPLES/GROUP REQUIRED**

2. NORMALIZING - 3 HOURS — 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 microsturcture.
6. Explain the changed hardness of a steel in relation to its carbon content, new microstructer and the P.F.C.S. chart.
7. Name the new microstructure.

^^ 8. Describe the new microstructure.

6 SAMPLES/GROUP FROM EXPERIMENT #1

COURSE NAME: METALLURGY CODE NO.: **MET** 212-3

3. QUENCH HARDENING - 3 HOURS 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 HOURS 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 relations to its carbon content, microstructure and P.F.C.S. chart.
6. Name and describe the 'new' microstructure.

3 **SAMPLES/GROUP FROM EXPERIMENT** #3

5. HEAT TREAT REVIEW - 2 HOURS Handouts

The student should be given an opportunity to:
1. Review, compare and discuss the lab data.
2. Discuss changes in hardness and microstructue 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
iv) illness

COURSE NAME: METALLURGY CODE NO.: MET 212-3

V. EVALUATION METHODS: (INCLUDES ASSIGNMENTS, ATTENDANCE, ETC.)

General Assessment	
A+ =	90 - 100%
A =	80 - 89%
B =	70 - 79%
C =	60 - 69%
R =	0 - 59%

Final Mark *	
Test #1	25%
Test #2	25%
Test #3	25%
Report #1	25%
Attendance** (See Attached)	

VI. REQUIRED STUDENT RESOURCES:

'Metallurgy' by Johnson and Weeks
5th Edition - American Technical Publishers

Safety Glasses (Impact Resistant, CSA Approved)

VII. ADDITIONAL RESOURCE MATERIALS AVAILALBE IN THE COLLEGE LIBRARY BOOK SECTION:

To be announced

VIII. SPECIAL NOTES:

* Student evaluations concerning the 'Final Mark' are further affected by the conditions set forth in the printed handout 'Guidelines for Metallurgy'. BE SURE TO OBTAIN A COPY FROM YOUR INSTRUCTOR.

Special guidelines for attendance are included in the above noted paper.