**Gearbox CSI: Forensic Analysis of Gear & Bearing Failures – Useful Tools for Optimizing Gear Design**

**INSTRUCTOR Information**

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| **COURSE INFORMATION** |

**Course Description**

A good understanding of individual failure modes and the failure scenarios that led to the actual system failure is an essential skill to designing gear/bearing systems that will operate properly for their full design life. In this course, we will define and explain the nature of many gear and bearing failures and we will also discuss and describe various actual failure scenarios. In addition, a detailed primer on bearing technology prefaces the failure scenario discussions. You will gain a better understanding of various types of gears and bearings. Learn about the limitation and capabilities of rolling element bearings and the gears that they support. Grasp an understanding of how to properly apply the best gear-bearing combination to any gearbox from simple to complex.

**It is recommended that you spend a minimum of 1 hour of reading each night.**

**Course Rationale/Students Course Designed to Serve**

Gear and bearing design engineers, management involved with design, maintenance, customer service and sales.

**Learning Objectives:**

* Apply understanding of forensic analysis of gearbox failures in future gearbox designs
* Discuss bearing and gear types
* Explain how bearing selection is influenced by gear type and loading
* Select appropriate bearing types and configurations as influenced by gear type and loading
* Explain how to optimize bearing and gear combination
* Identify seven materials and manufacturing related defects

**Required Textbooks (Provided by AGMA)**

AGMA’s *Gearbox CSI: Forensic Analysis of Gear & Bearing Failures – Useful Tools for Optimizing Gearbox Design* by Raymond J. Drago, PE, and Joseph W. Lenski, Jr.

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| COURSE OUTLINE |

I. Introduction

• Recognize, analyze and correct failures; correlate problems and solutions

• Understand applications; realizing gears, bearings, housing and lubrication interact

• Study failures; “We learn more from failures than successes”

• Diagnosis; recognize the thing that broke may not be thing that caused the failure

• More than one thing can go wrong

• Beware of laboratory analysis

II. Gear design and failure analysis

• Appropriate application of technology

• Failure types; wear, scoring, interference, surface durability and fracture

• Lubrication failure

• Resonance

• Processes and related damage; handling, marking, electric arc, magnetic particle  
 inspection, etc.

• Compound effects; misalignment with spacing errors, poor lubrication distribution

III. Material and manufacturing related effects

• Inclusions

• Hydrogen embrittlement

• Residual tensile stresses

• Voids and porosity

• Forging problems

• Heat treatment and processing controls

• Grinding burns and cracks

IV. Preventive measures

• Detailed gear design, manufacture and quality control specifications

• Advanced technology application

V. Bearing design and failure analysis

• Proper understanding and selection of bearing types and configurations – bearing  
 selection as influenced by gear type and loading

• Design and fabrication controls; how to select a bearing supplier

• Basic bearing B-10 life calculations; standard catalog rating methods and modified load  
 factors

• Methods to reduce manufacturing defects

• Understanding operating conditions as influenced by deflection and load

• Conducting a bearing forensic failure investigation

• Definition of true bearing fatigue failures

• Assembly induced failures

• Operational induced failures; loads, misalignment, lubrication, improper settings and   
 clearance, contamination and dynamics

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| **STUDENT FEEDBACK AND GRADING PROCEDURES** |

**Assignments**

Assignments and learning activities are given and directed at the discretion of the instructor.

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| COURSE MANAGEMENT |

**Weather Delays and Cancelations**

We will communicate any cancellations, delays or other concerns for safety prior to class via email, voicemail, and/or text message. Please be sure that we have all pertinent contact information as you travel to your class location.

**Attendance for Domestic and International Students**

Please be mindful that these are short, accelerated courses. Attendance is extremely important. If you are going to be absent from any class day, please contact the course coordinator.

**Plagiarism, Cheating and other types of Misconduct**Plagiarism[[1]](#footnote-1), cheating and other types of misconduct are unacceptable.

**Students with Disabilities**Students requiring assistance and accommodation should complete the [Special Accommodation Request form](http://www.graduateschool.edu/images/stories/AcademicPrograms/AdmissionsApplicationGuideD3.pdf) and submit it to Stephanie Smialek, Education Manager at [smialek@agma.org](mailto:smialek@agma.org). She can be reached at 773-302-8026.

**Grievance Procedures**Students who have concerns about the class are encouraged to contact Stephanie Smialek, Education Manager, at [smialek@agma.org](mailto:smialek@agma.org) or 773-302-8026.

**Outline Changes**The instructor reserves the right to modify the outline during the course of the class.

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| LEARNING AND OTHER RESOURCES |

**Links for writing resources:**

* grammar.ccc.commnet.edu/grammar
* [www.merriam-webster.com](http://www.merriam-webster.com)

**Links for Math resources:**

* [www.sosmath.com](http://www.sosmath.com)
* Khan Academy on www.youtube.com

**Links for time management, study skills and note taking resources:**

* [www.mindtools.com](http://www.mindtools.com)
* [www.testakingtips.com](http://www.testakingtips.com)

**Links for career resources:**

* <https://www.agma.org/newsroom/jobs/>

**Industry News:**

* https://www.agma.org/newsroom/industry-news/

1. Plagiarism is defined as “the use or close imitation of the language and thoughts of another author and the representation of them as one’s own original work.” [↑](#footnote-ref-1)