City University of Hong Kong

Information on a Course
offered by the Department of Physics and Materials Science
with effect from Semester A in 2013 / 2014

Part I

Course Title: Failure Analysis and Case Studies

Course Code: AP6305

Course Duration: One semester

No of Credit Units: 3

Level: P6

Medium of Instruction: English

Prerequisites: Nil

Precursors: Nil

Equivalent Courses: Nil

Exclusive Courses: AP4124 Failure Analysis and Case Studies
AP8124 Failure Analysis and Case Studies
AP7213 Failure Analysis and Case Studies

Part II

1. Course Aims:

To provide the students with an understanding of the various failure mechanisms in materials and to develop their ability in performing failure analysis of engineering components, through the study and practice on actual engineering failure cases.
2. **Course Intended Learning Outcomes (CILOs)**

*Upon successful completion of this course, students should be able to:*

<table>
<thead>
<tr>
<th>No</th>
<th>CILOs</th>
<th>Level of Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Recognize and describe common engineering failure mechanisms.</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Generate the procedures for conducting a failure investigation.</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Innovatively evaluate the choice of instruments and methods of failure analysis.</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>Analyse failed engineering components using instruments.</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Create a list of possible failure causes and generate a plan to discover the root cause of failure.</td>
<td>3</td>
</tr>
</tbody>
</table>

Remarks: 1 is the least importance

3. **Teaching and Learning Activities (TLAs)**

*(designed to facilitate students’ achievement of the CILOs)*

<table>
<thead>
<tr>
<th>TLAs</th>
<th>Large class Activities</th>
<th>Small Class Activities</th>
<th>Laboratory Work</th>
<th>Discussion Board</th>
<th>Total no of hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CILO 1</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>--</td>
<td>8</td>
</tr>
<tr>
<td>CILO 2</td>
<td>3</td>
<td>4</td>
<td>--</td>
<td>--</td>
<td>7</td>
</tr>
<tr>
<td>CILO 3</td>
<td>2</td>
<td>4</td>
<td>--</td>
<td>--</td>
<td>6</td>
</tr>
<tr>
<td>CILO 4</td>
<td>--</td>
<td>--</td>
<td>6</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>CILO 5</td>
<td>4</td>
<td>6</td>
<td>--</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Total (hrs)</td>
<td>12</td>
<td>24</td>
<td>2</td>
<td>2</td>
<td>40</td>
</tr>
</tbody>
</table>

Scheduled activities: First 4 weeks 2 hrs lecture + 1 hr small case study. Remaining weeks 3 hrs per week case studies.

4. **Assessment Tasks/Activities**

*(designed to assess how well the students achieve the CILOs)*

Examination duration: N/A
Percentage of coursework, examination, etc.: 100% coursework

<table>
<thead>
<tr>
<th>ATs</th>
<th>Discussion Board</th>
<th>Group Presentation</th>
<th>Mid-term Test</th>
<th>Mini-project Report</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CILO 1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>CILO 2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>CILO 3</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>CILO 4</td>
<td>--</td>
<td>8</td>
<td>10</td>
<td>8</td>
<td>26</td>
</tr>
<tr>
<td>CILO 5</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td>Total (%)</td>
<td>10</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>
5. **Grading of Student Achievement:** Refer to Grading of Courses in the Academic Regulations for Taught Postgraduate Degrees.

The grading is assigned based on students’ performance in assessment tasks/activities.

**Grade A**
The student completes all assessment tasks/activities and the work demonstrates excellent understanding of the scientific principles and the working mechanisms. He/she can thoroughly identify and explain how the principles are applied to science and technology for solving physics and engineering problems. The student’s work shows strong evidence of original thinking, supported by a variety of properly documented information sources other than taught materials. He/she is able to communicate ideas effectively and persuasively via written texts and/or oral presentation.

**Grade B**
The student completes all assessment tasks/activities and can describe and explain the scientific principles. He/she provides a detailed evaluation of how the principles are applied to science and technology for solving physics and engineering problems. He/she demonstrates an ability to integrate taught concepts, analytical techniques and applications via clear oral and/or written communication.

**Grade C**
The student completes all assessment tasks/activities and can describe and explain some scientific principles. He/she provides simple but accurate evaluations of how the principles are applied to science and technology for solving physics and engineering problems. He/she can communicate ideas clearly in written texts and/or in oral presentations.

**Grade D**
The student completes all assessment tasks/activities but can only briefly describe some scientific principles. Only some of the analysis is appropriate to show how the principles are applied to science and technology for solving physics and engineering problems. He/she can communicate simple ideas in writing and/or orally.

**Grade F**
The student fails to complete all assessment tasks/activities and/or cannot accurately describe and explain the scientific principles. He/she fails to identify and explain how the principles are applied to science and technology for solving physics and engineering problems objectively or systematically. He/she is weak in communicating ideas and/or the student’s work shows evidence of plagiarism.
Part III

Keyword Syllabus:

Lecture

- General procedures of failure analysis, classification of failure sources
  Design deficiencies, material deficiencies, processing deficiencies, assembly
  errors, service conditions, neglect and improper operation.
- Methods and equipment for failure analysis
  Sample selection and treatment, equipment for materials examination,
  materials analysis equipment for failure analysis, commonly used NDT
  methods.
- Failure mechanisms
  Fatigue failures, fractography, effect of variables: part shape, type of loading,
  stress concentration, metallurgical factors, etc. Wear failures, adhesive,
  abrasive, erosive, corrosive wear. Corrosion failures, types of corrosion:
  uniform, pitting, selective leaching, intergranular, crevice, etc. Elevated
  temperature failures, creep, thermal fatigue, microstructural instability,
  oxidation.

Case studies

Examples of case studies: Failure investigation of an exploded gas cylinder.
Failure of a chemical reactor. Failure of a high-power electrical cable. Broken rail
analysis. Failure of multi-layer ceramic capacitors. Failure of copper-to-rail joint
by ‘Cadweld’ joining. Failure of a passenger hoist. Electronic lead-tin solder joint
failures. Failure of a rocker arm. Cargo lift failure.

Laboratory exercise

Examples of laboratory exercises:
SEM examination of a cross-section. SEM examination of a fracture surface.

Mini-project (role play)

Examples of mini-project: Gearbox housing accident. Failure of a laundry
machine. Contaminations in LCD. Galvanizing vat accident. Failure of a drive
shaft in an air-cargo handling vehicle.

Recommended Reading:

Reference Books:
D R H Jones, Engineering Materials 3 – Materials Failure Analysis: Case Studies
D R H Jones, Failure analysis case studies: a sourcebook of case studies selected
from the pages of Engineering failure analysis 1994-1996, Amsterdam; New York:
J A Charles and F A A Crane, Selection and use of engineering materials, 2nd
Case histories in failure analysis, American Society of Metals, 1979. (CityU Lib Cat
TA460.C33)
C L Briant, Metallurgical aspects of environmental failures, Elsevier Science Pub,
1985. (CityU Library Cat No TA460.B69.1985)
H P Block and F K Geitner, Machinery failure analysis and trouble shooting, Gulf
J L McCall and P M French (ed), Metallography in failure analysis, Plenum Press,
W Brostow and R D Corneliussen, Failure of Plastics, Hanser Publishers. (CityU Lib Cat TP1087.F37)

Journals:
Forensic Engineering
Materials and Design
Materials Engineering
Materials Performance
Metals and Materials

Online Resources:
http://www.engr.sjsu.edu/WofMatE/FailureAnaly.htm
http://www.matscieng.sunysb.edu/disaster/