# 海洋装备运行与状态监测课程教学大纲

课程代码：74120230

课程中文名称：海洋装备运行与状态监测

课程英文名称：Marine Equipment Operation and Condition Monitoring

学分：1.5　　周学时：1.5-0.0

面向对象：

预修要求：

一、课程介绍

（一）中文简介

选修该课程的学生应该是船舶与海洋工程专业或相关工程专业的硕士研究生或博士研究生。课程采用全英文授课，学生应具备一定的英语听力和阅读水平。专业领域，学生应具备如下方面的基本知识：海上风力发电、船舶设备、传感器及测量技术、数字信号处理等。学生也应具备基本的数值分析与MATLAB编程能力。

（二）英文简介

The students taking this course should be master or doctoral students in the field of marine engineering and technology etc. Courses are taught in English, and students should have the basic knowledge of the following topics: offshore wind power, marine equipment, sensors and measurement technology, digital signal processing, etc. Besides, students should also have basic skills of numerical analysis and MATLAB programming.

**一、课程介绍/Course Introduction**

**（一）中文简介**

本课程为浙江大学海洋学院全英文课程。课程主要介绍国内外海洋设备利用以及前沿技术的研究、开发和应用，风机及船舶关键设备设计过程与安装的国际行业标准，海洋设备运行维护对海洋工程装备制造业市场、国民经济的影响。课程将会讨论适用于海上风力机和船舶的状态监测方法，包括状态监测所用到的传感器技术、数据分析技术、决策技术、运行

与维护技术等。最终通过实际案例分析风机和船舶状态监测方法的有效性，并利用仿真实验完成定量分析。

**（二）English Introduction**

All taught in English, this course introduces marine equipment and systems, including their types, operation, characteristics, maintenance strategies; technical, economic and environmental aspects; installation and maintenance standards. Condition monitoring methods for offshore wind turbines and marine vessels are discussed, including sensor techniques, data processing methods, operation and maintenance strategies etc. The effectiveness of condition based monitoring techniques are evaluated through case studies and numerical simulations.

## 二、教学目标

**(一)学习目标/Learning Objectives**

现代海洋设备系统日趋高性能化、结构模块化，但海洋设备通常工作在恶劣的气候环境下，因此及时发现设备的运行故障以确保设备的安全、可靠运行富有挑战性。围绕发展海洋经济的国家需求，本课程主要讲授海洋装备开发、运行、可靠性、维护、经济的协调发展等内容，目的是为研究生今后参与相关工作打下一个坚实的基础。本课程主要向学生讲授有关测量技术、健康状态监测、故障诊断及预测的基础知识和前沿技术。本课程以海上风机、船舶设备为重点分析对象，讨论的原理与技术对其它海洋能源及海洋设备健康状态监测同具有广阔的应用前景。

- Be able to understand the principles of a range of sensors and select proper sensors based on type, accuracy and requirements; gain competence in the use of embedded sensors and distributed monitors and their applications to marine systems
- Have a deeper level of knowledge, understanding and use of advanced signal processing and data mining methods
- Be able to set up numerical and analytical models in Matlab and simulate different operations of offshore wind turbines including fault conditions
- Become skilled in analyzing the performance and health condition of real wind turbines using practical SCADA (Supervisory Control and Data Acquisition) data
- Ha ve knowledge/understanding of the functionality of the key machineries on the

marine ships and the associated condition-based maintenance technologies

• Understand and suggest necessary strategies for operation, maintenance and decision-making

• Possess competence in undertaking safety, reliability and availability analysis on marine equipment, and understanding of offshore risk and project management

**（二）可测量结果/Assignments and exams**

随堂测试答卷、实验报告、课程设计报告、试卷等内容。

Quiz, reading reports, experiment reports, exams

## 三、课程要求

**（一）授课方式与要求/Teaching methods**

课堂讲授、案例学习、课上实验、分组报告相结合。

Lectures, case studies, simulation experiments, group work etc.

**（二）考试评分与建议/Score**

随堂测试 20% 课程作业 20% 期末试卷 60%

Quiz 20%, Homework 20%, Exam 60%

## 四、教学安排/Teaching schedule

| 周次 | 教学内容（包括课堂讲授、实验、讨论、考试等） | 备注 |
|---|---|---|
| 第一周 | **海洋设备概述**<br>• 海洋设备利用及前沿技术<br>• 风机及船舶关键设备介绍 | 课堂讲授<br>包括课程安排介绍、课程作业布置与分组 |
| | **海洋项目风险管理**<br>• 海洋项目规划、决策、运行及维护<br>• 可靠性分析及风险评估 | 课堂讲授 |
| 第二周 | **海上风力机**<br>• 风力资源评估<br>• 风机类型及静、动态模型<br>• 电场的通信与控制方法<br>• 风力发电机拓朴结构与运行方式 | 课堂讲授 |
| | **海上船舶**<br>• 海洋气候及船舶结构概述<br>• 关键设备的运行特征、效率与管理<br>• 机械、电气故障分析<br>• 基于状态的监控系统与设备维护技术 | 课堂讲授 |
| 第三周 | **案例讨论**-海上船舶能源系统 MATLAB/Simulink 建模与仿真分析 | 课堂讲授及专题 |

| | | |
|---|---|---|
| | | 讨论<br>仿真实验分析 |
| 第四周 | **传感器与测量技术**<br>• 传感器的物理原理、效应和器件<br>• 传感器主要物理量检测及新发展<br>• 数据采集与信号调理 | 课堂讲授 |
| 第五周 | **状态监测技术**<br>• 海上风机状态监测方法概述<br>• 海上风机元件级的状态检测海上风机系统级的状态检测<br>• 海上船舶油料检测与分析<br>• 海上船舶设备振动、噪声检测与分析<br>• 在线远程监测与 SCADA 系统 | 课堂讲授 |
| 第六周 | **案例讨论**-风能试验设备的数据分析 | 课堂讲授及专题讨论<br>仿真实验分析 |
| 第七周 | **故障诊断与预测**<br>• 信号处理及数据分析技术(时域、频域、时频域方法)<br>• 基于数据驱动的故障诊断与分析<br>• 线性、非线性预测模型<br>• 人工智能方法 | 课堂讲授 |
| 第八周 | **案例讨论** - 海上风电场 SCADA 数据分析及故障诊断 | 课堂讲授及专题讨论<br>仿真实验分析 |
| | **课程作业演讲**-评价与圆桌讨论 | 课程作业评分与反馈 |
| 考试 | 笔试 | 考试时间根据学院的要求作安排 |

| Week | Contents<br>（Including lectures, discussion, experiments, exams etc） | Remarks |
|---|---|---|
| 1 | **Marine equipment**<br>• Marine equipment introductions<br>• Introduction of offshore wind turbines and marine ships | Lectures |
| | **Risk assessment and management**<br>• Marine projects operation and maintenance<br>• Reliability analysis and risk assessment and management | Lectures |
| 2 | **Offshore wind turbines**<br>• Wind resource assessment<br>• Wind turbine types and models<br>• Wind turbine control methods<br>• Wind turbine operations | Lectures |
| | **Marine ships**<br>• Diesel-electric propulsion concepts | Lectures |

| | | |
|---|---|---|
| | vs. diesel mechanical configuration Marine ship power systems<br>• Failure Modes and Effects Analysis<br>• Condition monitoring based maintenance | |
| 3 | **Case studies:** Offshore wind turbines and marine ships<br>Resource & s ystem demo, Matlab/Simulink simulation | Case studies and numerical simulations |
| 4 | **Sensors and measurement techniques**<br>• Sensors for condition monitoring<br>• Signal conditioning<br>• Data conversion and acquisition | Lectures |
| 5 | **Condition monitoring techniques**<br>• Discussion of condition monitoring techniques applicable to offshore wind turbines<br>• component level monitoring including blade load, drivetrain, vibration, power electronics and generators<br>• system level monitoring focusing on performance assessment of wind turbines when connected to the grid<br>• SCADA database management and data analysis for fault detection.<br>• Marine ships: lubricant degradation, oil-debris monitoring, moni toring and analysis of engine vibration, turbochargers and propulsion systems<br>• Latest condition-based maintenance techniques. | Lectures |
| 6 | **Case studies** - fault detection of the wind turbine using experimental data | Case studies and numerical simulations |
| 7 | **Fault diagnosis and prognosis**<br>• Signal processing<br>• Artificial neural networks<br>• Data driven fault diagnosis methods<br>• Fuzzy logic and expert systems | Lectures |
| 8 | **Case studies** - Offshore wind turbine SCADA data | Case studies and numerical simulations |
| | **Group work** | Gourp work |
| Exam | Exam | TBD |

## 五、参考教材及相关资料/References


- R. Barron, Engineering Condition Monitoring: Practice, Methods and Applications, Longman, 1996, ISBN: 978-0582246560.
- David A. Spera, Wind Turbine Technology: Fundamental Concepts in Wind Turbine Engineering, 2nd Edition, ASME Press, 2009, ISBN: 978-0791802601.
- Peter Tavner, Offshore Wind Turbines: Reliability, Availability and

Maintenance, Institution of Engineering and Technology, 2012, ISBN: 978-1849192293.

- D. A. Taylor, Introduction to Marine Engineering, Butterworth-Heinemann, 2nd Edition, 1996.
- Nikolay V. Kirianaki et al., Data Acquisition and Signal Processing for Smart Sensors, Wiley-Blackwell, 2002, ISBN: 978-0470843178.
- Tshilidzi, Marwala, Condition Monitoring Using Computational Intelligence Methods, Springer, 2012, ISBN: 978-1447123798.
- H. Sohn, Special Issue on Nonconatct Measurement Technology for Structural Health Monitoring, Structural Health Monitoring - an International Journal, Vol. 12(5-6), 2013, ISSN: 1475-9217.
- BS EN 61400-25-6:2011, Wind turbines Communications for monitoring and control of wind power plants. Logical node classes and data classes for condition monitoring.
- BS ISO 13379-1:2012, Condition monitoring and diagnostics of machines. Data interpretation and diagnostics techniques General guidelines.
- BS ISO 13613:2011. Ships and marine technology - Maintenance and testing to reduce losses in critical systems for propulsion.
- Xiandong Ma, Investigations of the state-of-the-art methods for electromagnetic NDT and electrical condition monitoring, Insight - Non-Destructive Testing and Condition Monitoring (INSIGHT), Vol. 54, No. 9, September 2012, pp. 482 - 488.
- Philip Cross and Xiandong Ma, Nonlinear system identification for model-based condition monitoring of wind turbines, Renewable Energy, 2014.
- David McMillan and Graham W. Ault, Quantification of condition monitoring benefit for offshore wind turbines, Wind Engineering, Vol. 31, No. 4, 2007, pp. 267 - 285.

**六、课程教学网站：**

**将通过校内网络提供必要的课件和文字材料链接**