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**Curriculum Development of Master's Degree Program in Industrial Engineering for Thailand Sustainable Smart Industry**

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## MSIE 4.0 Syllabuses

## Course 1: Enterprise Management in Digital Economy

**Course Objective:** a complete paragraph including a brief introduction connecting the course to Sustainable smart industry, and what instructors would like to cover in the course to achieve that.

Digital economy has brought business entities to the limits of their capacity of traditional resources and competences while opening of the new segment of Industry 4.0 possibilities. It is also true for management efforts and their supporting systems. The objective of this course is to provide the students with knowledge and competences on using integrated and system solutions in advancing the management to the requirements of Digital Economy. In this course students will learn on how to adopt management, its strategies and functions to smart and sustainable solutions that 4.0 era has brought to enterprises. Students will learn how to use ICT management tools and solutions to enhance transformation from traditional to digital business operation and models.

**Learning Outcomes:**

The students on the completion of this course would be able to

- Use management systems and assess its usability in company specific context (analyze / apply)
- Define and assess the strategy (strategic objectives, mission and vision, competitive factors, stakeholders and target groups) of I4.0 oriented companies (apply - create?)
- Use management specific functions to implement the strategy (apply)
- Propose organizational structures appropriate for I4.0 set-up (apply)
- Use strategic analysis tools to better understand internal and external determinants influencing the company performance and propose improvements with different approaches and incorporating digital era solutions (evaluate)

**Course Leader:** Dr. Tomasz Nitkiewicz, CUT

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## Course 2: Project Management for Industry 4.0

**Course Objective:** In the new world of Industry 4.0, digitized connectivity may be considered the main driver of change industries have to deal with. This change increases the opportunities to create new business models, exploring network of systems that will allow to increase the cooperation between and across companies and industries. It is expected an increase in customized services that ultimately can become a service for each customer. In this case, we will be dealing with a project service for each customer each time. These projects will be developed by interdisciplinary distributed teams using digital platforms. This course aims to prepare graduates to perform in and manage projects and teams in the new highly agile digitized challenging smart industries.

**Learning Outcomes:**
The students on the completion of this course should be able to
- Defend the importance of project management in the context of IND 4.0, using arguments that relate different models of Project Management and IND4.0 concepts. (Evaluate)
- Plan, develop and manage projects using the adequate techniques.
- Manage projects and high-performance teams applying agile project management tools in the context of IND 4.0. (Create)
- Perform as a member or manage a distributed team. (Create)
- Perform as a member of an extraordinary team, using different interpersonal communication techniques to develop a strong relationship with team members. (Create)
- Argue and support the decision making in accordance with the contingencies and uncertain environment in IND 4.0. (Evaluate)

**Course Leader:** Dr. Rui M. Lima, UMinho

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## Course 3: Smart Operations Management

**Course Objective:**  The objective of this course is to develop competences on design and implementation of continuous and efficient operations while creating a digital copy of the end-to-end process. Using real world data to understand, evaluate, and simulate the end-to-end operation to improve and manage all operations efficiently. Emphasis is on cross-enterprise integration of the physical and virtual systems among various functions including operation strategy, process design, capacity planning, facility location and design, forecasting, production scheduling and inventory control.

**Learning Outcomes:**
The students on the completion of this course would be able to:

- apply knowledge and methods from the advanced science of industrial engineering to model, evaluate and improve industrial processes and systems in relation with company operating efficiency and customer service (create);
- implement smart production and co-created product development concepts in planning and controlling company's operations (create);
- utilize real time data analytics and software systems to support planning, scheduling and control of smart production processes and systems (create);
- manage smart production processes and systems to efficiently respond to changes in operating conditions (create).

**Course Leader:** Dr. Uttapol Smutkupt, CMU

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## Course 4: Quality Management for Extended Enterprise

**Course Objective:** a complete paragraph including a brief introduction connecting the course to Sustainable smart industry, and what instructors would like to cover in the course to achieve that.

Proposed by By Wichai: This course aims to develop technical skill for students to implement quality control and monitoring system that cover both process operation and supply chain operations.

**Learning Outcomes:**
The students on the completion of this course would be able to
1. Apply the Quality Management concepts to improve the operations (Bloom level = Apply )
2. (By Rungchat) understand the impact of quality management to the smart factory
3. (By Rungchat) understand the impact of digitalization on quality management particularly on processes and people.
4. (By Rungchat) embed quality management principles and tools in the value chain.
5. (By Rungchat) use technologies to transform organization, quality culture and processes in order to maximize value.
6. (By Wichai) design and create data visualizations based on Enterprise data (Enterprise Quality Metrics visualization)
7. (By Wichai) Analyze operational quality-related data for process, and Enterprise improvement

**Course Leader:** Dr. Wichai Chattinnawat, CMU

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## Course 5: Sustainable Supply Chain Management

Course Objective:   The main goal of the course is to acquire the ability to create an effective value chain with the use of intelligent and flexible production technologies and modern communication as part of the interaction network between its participants. Gaining knowledge about the main characteristics and levers of Supply Chain 4.0 and its impact over all areas in supply chain management.

This course will enable students to gain / improve knowledge of supply chain management that covers key issues regarding supply network design, inventory control and management, delivery contract, bullwhip and information exchange, distribution strategy, strategic alliance, purchasing strategies, pricing strategies, etc. Sustainable operations of the supply network were also included.

Partial objectives implemented under the main objective (in accordance with the competences achieved at subsequent levels of education within the course):

1. The ability to effectively search for modern technological solutions and implement them as a part of work in a supply chain management team (for example: develop inventory policies for supply chain, analyze the Bullwhip effect in supply chain, make pricing decision using smart pricing and revenue management principles).
2. The ability to adapt modern technological solutions in a sustainable economic environment (for example: make decision on the use of centralized or decentralized distribution strategy, make decision on procurement strategies and outsourcing, develop supply contracts that can help coordinate supply chains).
3. The ability to manage a team conducting research on the implementation of intelligent production systems in the process of sustainable supply chain management (for example: design a sustainable supply network).

Learning Outcomes:

The students on the completion of this course would be able to

- Manage Smart Production Systems and Supply Chains. Redesign the supply chain and key processes to be more flexible, reliable, and efficient. (create)
- Improve sustainability by applying IE related knowledge and competences (create)
- Lead, manage, work and communicate effectively in interdisciplinary, intercultural and distributed teams.  Identify and evaluate transformative strategies to the supply chain network. (evaluate)
- Conduct research in the field of IE (analyze)
- Demonstrate entrepreneurial attitude towards Industry 4.0 related businesses and its problems (analyze)

**Course Leader:** Dr. Anna Wiśniewska-Sałek, CUT

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# Course 6: Digital Factory

**Course Objective:**  Utilization of digital technology for modeling, and communications to configure, model, simulate, assess, and operate a manufacturing process

**Learning Outcomes:**
The students on the completion of this course would be able to
1 Students should understand the principles of digital factories and their relation to real factories. [Understand]
2 Students should understand the application of AI, robotic and automation, material handling, maintenance and their relationship to real factories. [Understand]
3 Students should able to applying IT system to support the facility planning, designing layouts of factory or manufacturing / assembly cells, achieving balanced machine groups with material handling machines. [Apply]
4 Students should able to creating a basic information model of a product and its relations to production process and resource by using simulation modeling, and assess with the manufacturing process. [evaluate]
5 Students should have an ability to communicate effectively to configure and control a manufacturing process [evaluate]
6 Students should have an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and achieve the objectives. [Analyze]
7 Students should have an ability to engage in independent life-long learning in the application of Digital Factory [Apply]

**Course Leader:** Dr. Athakorn Kengpol, KMUTNB

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## Course 7: Advanced Optimization: Techniques and Industrial Applications

**Course Objective:**  The objective of this course is to provide the students knowledge on the application of various optimization techniques which can help making decisions for practical problems in industries.  Modeling concepts and applications of linear, integer, nonlinear, and dynamic programming as well as network models are addressed.  Meta-heuristic techniques are also discussed to obtain good solutions for large scale practical problems in a reasonable time.

**Learning Outcomes:**
The students on the completion of this course would be able to
- Formulate mathematical programs and write code of optimization models using professional optimization software for practical problems in production and supply chain systems (Bloom level: Analyze/Create)
- Apply linear/integer/mixed integer/nonlinear programs to solve practical problems in production and supply chain systems (Bloom level: Create)
- Apply dynamic programming technique to solve specific operational problems when needed (Bloom level: Create)
- Find solutions for practical problems in logistic networks and supply chains that can be modelled as network flow problems (Bloom level: Evaluate)
- Use meta-heuristic techniques to solve NP-hard combinatorial problems (Bloom level: Create)

**Course Leader:** Dr. Kanchana Sethanan, KKU

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## Course 8: Intelligent Decision Support Systems

**Course Objective:** The objective of this course is to give students the up-to-date of decision-making concepts, process, strategies, and technologies that are often used to support decision making in real-world issues coupled with agile approach and industry 4.0 specification, and design decision support system by mini project.

**Learning Outcomes:**
The students on the completion of this course would be able to
- Discuss concepts of a decision support system and its effect on industry 4.0. (Understand)
- Identify the need for and the nature of models in intelligent decision support systems to support smart production. (Understand)
- Apply techniques of intelligent decision support system (e.g. artificial neural networks, machine learning, rule-based systems, etc.) to solve a complex industrial problem. (Apply)
- Design a knowledge-based system using a programming language for a smart production. (Create)

**Course Leader:** Dr.Suriya Jirasatitsin, PSU

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# Course 9: Applied Data Analytics

**Course Objective:** The objective of this course is to impart knowledge on statistical techniques needed for data analysis, and various data mining techniques and algorithms used in practical problems that require processing big data for decision making purpose.

**Learning Outcomes:**
The students on the completion of this course would be able to
- Apply various inferential statistical analysis techniques to describe data sets and withdraw useful conclusions from the data sets (e.g., confidence interval, hypothesis testing, ANOVA)  - Bloom Level: Analyse
- Apply key data mining techniques (e.g., tracking patterns, classification analysis, associate rule learning, anomaly/outlier detection, clustering analysis, regression analysis, prediction) in dealing with big data sets -  Bloom Level: Evaluate
- Implement the analytic algorithms for practical data sets -  Bloom Level: Evaluate
- Perform large scale analytic projects in various industrial sectors - Bloom Level: Evaluate

**Course Leader:** Dr. Huynh Trung Luong, AIT

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## Course 10: Cyber-Physical Industrial Systems

**Course Objective:**   Gaining knowledge about: the main characteristics of the Cyber-Physical Systems, their application areas, components selection rules, programming methodology, specific aspects related to different measured physical parameters, data storage, reporting and communications.

**Learning Outcomes:**
The students on the completion of this course would be able to:
- Identify links between industrial engineering knowledge and methods, on one side, and the design, modeling and management activities related to CPIS, on the other side (Analyze)
- Implement smart production and co-created product design & development concepts in CPIS related activities (Create)
- Identify use cases of big data and real time data analytics applied for CPIS, for supporting smart production, product design & development and advanced manufacturing process (Evaluate)
- Exploit the CPIS online connectivity for strengthening business capability (Apply)
- Applying CPIS related  knowledge and competences for improving sustainability (Apply)

Xxxxxxx (insert Bloom's level inside this parenthesis)

**Course Leader:** Dr. Tom Savu, UPB

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## Course 11: Collaborative Manufacturing Systems

**Course Objective:**

The course is creating knowledge and is developing technical competence for better understanding of future emerging sustainable smart manufacturing systems. **Smart manufacturing has been defined as the fully-integrated, collaborative manufacturing systems that respond in real time to meet changing demands and conditions in the factory, in the supply network, and in customer needs.** Modern manufacturing is at the frontier of new technologies, products and ways of working.

The course is structured around advanced approaches to manufacturing processes, including manufacturing strategies, high-speed machining, flexible tooling, tool-less assembly, generative numerical control, adaptive and predictive process control, embedded sensors, data and simulation, and nanotechnology.

Course is presenting and analyzing modern methods and techniques which will compete on design and operation of agile, lean, green, and sustainable manufacturing systems.

Teaching technique is centered on project based learning type activities allowing flexible learning formats.

**Learning Outcomes:**
The students on the completion of this course would be able to:
● implement smart production solutions for co-created product design concepts (application)
● utilize data analytics for supporting smart production, product design and advanced manufacturing processes (analysis)
● manage smart production systems (synthesis)
● improve sustainability by applying related knowledge and competences (application)

**Course Leader:** Dr. Daniel Manolache, UPB

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## Course 12: Additive Manufacturing for Industry 4.0

**Course Objective:** Additive Manufacturing (AM) is a technology supporting the sustainable rapid development of personalized complex design in various disruptive applications, especially in manufacturing and medical. This course aims to build student competence in AM and related technology. The students will learn fundamental knowledge of Additive Manufacturing and Reverse Engineering and their applications of in manufacturing, medical and other sectors. Besides, they will learn and practice design for additive manufacturing.

**Learning Outcomes:**
The students on the completion of this course would be able to
- apply knowledge learned on these AM and RE technologies in practice (apply)
- analyze principles behind AM and RE techniques available in the market (analyze)
- select the appropriate AM technique. (evaluate)

**Course Leader:** Dr. Pisut Koomsap, AIT

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## Course 13: Innovative Product Design and Development

**Course Objective:**
The subject of the course concerns the creative design of innovative products that are technological innovation or modification of existing technological solutions. As a result, designed products should find their application in Industry 4.0 related businesses and its problems. The implementation of the course subject is based on learning and training methods of effective implementation of innovation, identification and analysis of the strategic elements of new product innovation, e.g. the process, different functions, and individual roles. The goal of this course is discussion of issues related to development and marketing innovative products, including searching for ideas and creating a concept based on creative thinking techniques and methods of entrepreneurial problem solving, selecting ideas and development of prototypes, taking into account user needs and the latest scientific research.

**Learning Outcomes:**
The students on the completion of this course would be able to
- recognize and understand the basic concepts related to innovations and the idea of implementing innovative products *(remember, understand)*
- define and apply the basic techniques of creative thinking and creative problem solving for creating innovative product and marketing strategies *(remember, understand, apply)*
- analyze and evaluate the benefits of implementing innovations *(analyze, evaluate)*
- analyze and evaluate the challenges and opportunities associated with the launch of a new product and propose suitable strategies depending on product and situation *(analyze, evaluate)*
- prepare a conceptual product design taking into account user needs and the latest scientific research *(remember, understand, apply, analyze, evaluate, create)*
- create and co-ordinate cross-disciplinary teams to achieve a common objective *(create)*
- present entrepreneurial and creative attitude towards seeking various problem solutions *(understand, apply)*

**Course Leader:** Dr. Agnieszka Ociepa-Kubicka, Dr. Katarzyna Rozpondek, CUT

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## Course 14: Human-Centric Design for Operator 4.0

**Course Objective:** Human-centric design is a unique approach to solve problems of products, process, environments, and other human operations challenging with incompatibilities of human needs, abilities and limitations. The objective of this course is to evaluate and design tasks, equipment, products, processes, jobs, environments and other elements in working systems in order to optimize human well-being and overall system performance.

**Learning Outcomes:**

The students on the completion of this course would be able to

- Understand human abilities, limitations, needs and other important human characteristics for designing tasks, jobs, equipment, products, environments, processes and other element in working systems.
- Evaluate occupational health and safety (OHS) risks to accidents, injuries, and ill health in a working system.
- Create solutions and opportunities for reducing OHS risks, enhancing operators' performance and preference.
- Design tasks, equipment, workstation, workspace, environment, and other elements in working systems compatible with needs, abilities and limitations of operators for better well-being and performance.

**Course Leader:** Dr. Naris Charoenporn, TU

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## Course 15: Customer Experience-Driven Design

**Course Objective:**  Economic offerings have progressed to the fourth evolution when products and services are used as props and stages for creating memorable experiences to customers. It is important for students to be able to support an industry with this change. This course aims to build student competence in design customer experience with knowledge on a concept of customer experience management (CEM) and on a systematic approach for an experience design process. In this course, the students will learn customer perception, customer involvement, and customer experience. Besides, they will learn and practice how to design customer journey and to prevent failure of offering in a team environment.

**Learning Outcomes:**
The students on the completion of this course would be able to
- Present entrepreneurial and creative attitude towards seeking various problem solutions *(Apply)*
- Identify customer needs (Analyze)
- Identify potential failure of offerings (Analyze)
- Manage customer experience journey (Create)
- Communicate effectively and work in an interdisciplinary team environment (Apply)
- Design a pain point-free, memorable customer experience journey (Create)

**Course Leader:** Dr. Pisut Koomsap, AIT

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## Course 16: Leadership Communication and People Development in Digital Era

**Course Objective:** a complete paragraph including a brief introduction connecting the course to Sustainable smart industry, and what instructors would like to cover in the course to achieve that. The development of people is one of the most important areas in the contexts of any professional practice. In the digital era, developing the best of each person in the context of their professional practice, will create a competitive advantage. Additionally, the communication between different cultures and for different types of audiences will make the best of leaders. This course aims to prepare graduates for leadership in companies, communicating effectively and developing people to their best.

**Learning Outcomes:**
The students on the completion of this course would be able to
- Xxxxxxx (insert Bloom's level inside this parenthesis)
- identify and select emotional intelligence attitudes in different professional situations. (Evaluate)
- Apply leadership strategies in different contexts of IND 4.0, considering the perspectives of all stakeholders involved (Apply)
- Develop a communication process, mobilizing appropriate knowledge and considering the interest of the audience (Create).

**Course Leader:** Dr. Diana Mesquita, UMinho