Course: Smart factories (Questions related to the lectures)

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Quiz example: Mark a, b or c before the statement. Claims marked or crossed out multiple times do not count. There are no negative points for a wrong answer.

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1. The MAIN characteristic of Smart factory is:
   a. Agility, and flexibility of systems and processes
   b. Stability of systems and processes
   c. Centralized approach

2. The Industry 4.0 and the smart factories rely on:
   a. Mass production and use of ERP, MES systems
   b. Use of IT and automatization of processes
   c. CPS, IoT, AI, data analytics

3. The term ERP system is used for:
   a. Accurate resource planning
   b. Product lifecycle management
   c. Manufacturing planning and control

4. Mark the Industry 4.0 related pillars or technologies:
   a. IT technology, Automatization, Robotics
   b. Modelling and simulation of systems and processes
   c. IoT, cloud and edge computing, big data, digital twins

5. What will be the most important for the factories of the future?
   a. Software and AI based algorithms
   b. Human involvement
   c. Automatization of processes

6. What is currently the MAIN PROBLEM related to Smart factory:
   a. The of advanced technologies
   b. Cybersecurity
   c. Small number of IT engineers

7. The most suitable structure of the smart factory is:
   a. Centralized
   b. Decentralized
   c. Distributed

~~8. What type of tree product structure is suitable for variant and personalized products?~~
   ~~a. Simple two-level structure~~
   ~~b. Multilevel linear structure~~
   ~~c. Multilevel branched structure~~

9. The main difference between “traditional modelling and simulation” vs. “Digital twin technology” is:
    a. Uni-directional connection of real and virtual world and off-line simulation
    b. Bi-directional connection of real and virtual world and real time data gathering/analytics and feed-back control
    c. Bi-directional connection of real and virtual world and real time data gathering for visualization

~~10. The PULL approach:~~
    ~~a. Is typical MRP approach~~
    ~~b. Is typical JIT approach~~
    ~~c. Is typical RFID approach~~

11. The main difference between traditional and smart factory in terms of product, systems and components is:
    a. Precisions
    b. Producibility and performance
    c. Self-awareness, Self-prediction and Self-configuration

12. The main principle of smart factory is:
    a. Centralized interconnection and central server
    b. Cloud based integrated smart networks
    c. Internet of Things (IoT) approach used in industrial environment

13. The standardized communication and data transfer protocol in smart factories between Machine/PLC (factory floor) layer and SCADA, MES, ERP layer is:
    a. Accurate resource planning
    b. Product lifecycle management
    c. OPC UA

14. The most common wireless technology for data transfer in smart factory is:
    a. Modbus and Ethernet
    b. RFID
    c. OEE

15. What is unclear in RAMI 4.0 architectural model and is integrated in LASFA model?
    a. Location of global and local digital agents and data clouds
    b. Interconnection between layers
    c. Interconnection between levels

16. Architectural model RAMI 4.0 has:
    a. 2 axes
    b. 3 axes
    c. 4 axes

17. Administration shell of product, system/component or process represents:
    a. Digital information about the product, system/component or process.
    b. Digital information about the product, system/component or process, type of data transfer and communication and data structuring.
    c. Combined digital and paper-based data about the product, system/component or process.

18. The modular smart factory consists of three stages. Mark the correct order.
    a. Synthesis, Decomposition and Manifestation
    b. Decomposition, Manifestation and Synthesis
    c. Decomposition, Synthesis and Manifestation

19. The main characteristic of distributed system in smart factories is:
    a. Each node makes its own decisions.
    b. Some nodes (computers, mobiles, servers) are always available/online for work, leading to high availability.
    c. Each node makes its own decisions in agreement or coordination with other nodes.

20. Mark the correct statement for Top-down approach.
    a. From the whole to the details using the Toolbox Industry 4.0 for implementing solutions.
    b. From the detail to the whole by integrating VSM approach and digital LEAN.
    c. From the whole to the details using the Industry 4.0 solutions and VSM approach.

21. Mark the correct statement for Bottom-up approach.
    a. From the whole to the details using the Toolbox Industry 4.0 for implementing solutions.
    b. From the detail to the whole by integrating VSM approach and digital LEAN.
    c. From the whole to the details using the Industry 4.0 solutions and VSM approach.

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Writing question example (please answer the question on blank paper you received, you do not need to rewrite the question).

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Please explain the concept of factory 4.0, smart factory ecosystem. List the key enablers, the key technologies and their importance for the Smart factory. Draw at least a diagram of factory 4.0 ecosystem with involved crucial elements. How nine pillars of I4.0 technologies are integrated in the concept?

How would you start transforming traditional factory into Smart factory? You can take the Industry 4.0 Ecosystem as a base and explain which technologies are the most important (Industry 4.0 pillars/technologies).

Why traceability and transparency (information, material flow, processes) are so important for the smart factory? How we achieve wireless traceability and transparency – technologies, sensors?

Why referential architecture models of smart factory are important? Explain the Reference Architectural Model Industry 4.0 – RAMI 4.0 (3D structure, axis, standards – short explanation of each standard, the main content).

Explain the »top-down« and »bottom-up« approaches in implementing I 4.0 solutions (the principle, the main difference).

Explain the »top-down« approach in implementing I 4.0 solutions in more detail (guidelines for Industrie 4.0, Toolbox Industrie 4.0). Please use the supporting material and write, draw, show the main parts directly on the tables (student receive the VDMA Toolbox table).

Explain the levels How would you develop a Digital twin

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Other specific questions related to lectures topics.

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Question	**Where to find answer: lectures, slides**
What is the main challenge on the market that initiate the idea of Smart factory?	Introduction to Industry 4.0 Slide 4
What is Agile manufacturing, Agile production, what is important?	Introduction to Industry 4.0 Slide 5
What is the main goal in Smart factory in terms of agility, market demands? What should be the base (the principle of LEAN manufacturing, the use of digital technologies)	Introduction to Industry 4.0 Slides 6, 8, 10, 15
What the companies are looking for, their goals, what to improve within the processes?	Introduction to Industry 4.0 Slides 17, 18
What are the main technologies of I4.0, the main components of I4.0? Digitalization, Robotics, Sensorics, Digital twins, CPS, optimization through simulation, discrete event simulation	Introduction to Industry 4.0 Slides 23 to 29, short description of each technology, component Disciplines, systems and technologies for I 4.0 Slide 5, 6, 8, 9, 12

What will be for the factory of the future very important?	Introduction to Industry 4.0 Slide 32
What are the main steps to achieve active transformation of traditional factory towards the Smart Factory	Introduction to Industry 4.0 Slide 33, 34, 50, 51
What could be the problem when operating with big and important data in smart factory, cloud approach, security.	Introduction to Industry 4.0 Slide 37
Why holistic approach is important when designing a smart factory (smart production, sustainability, impact on environment, urban production)?	Introduction to Industry 4.0 Slide 38
What is Smart factory, what are the functional levels. Definition of ERP, MES, MRP, PLM, etc.	Introduction to Industry 4.0 Slide 45 to 49, slide 52, 53 Definition of smart factory concepts Slide 18, 19, 22, 23, 24,

Question	**Where to find answer: lectures, slides**
What are the enablers of digitalization and I4.0 implementation?	Definition of smart factory concepts Slide 4
Explain the main difference between traditional and smart factory	Definition of smart factory concepts Slide 9 – 12, 14, 15
The working principle of Smart factory (from IoT, connectivity, data gathering and analysis, decision making and action execution)	Definition of smart factory concepts Slide 16
What are the future products, the products suitable for the smart factory?	Definition of smart factory concepts Slide 25
Explain the distributed structure in Smart factory in terms of architecture, connections, systems, role of employees	Definition of smart factory concepts Slide 26, 27, 28
What are the main components of Smart factory?	Definition of smart factory concepts Slide 29
What the digital supply chain involves, covers?	Definition of smart factory concepts Slide 30, 31

Question	**Where to find answer: lectures, slides**
What are the new technologies in different domains, which one is the most important (virtual industrialization)?	Disciplines, systems and technologies for I 4.0 Slide 4
What is benefit of using simulation, digital twins? What can be the result? Different improvements!	Disciplines, systems and technologies for I 4.0 Slide 15 (examples: slide 16 – 21)
How can we implement digital twin approach to support traditional manufacturing (automation pyramid and digital twins)?	Disciplines, systems and technologies for I 4.0 Slide 25
Explain the main difference between off-line and real-time simulation (using of expert system for what?) it is possible to give you the scheme and you should describe the scheme.	Disciplines, systems and technologies for I 4.0 Slide 27, 28

What approach is the most suitable to integrate it in the simulation (Heuristics) and why is better compared to other exact numerical approaches?	Disciplines, systems and technologies for I 4.0 Slide 35
What are the trends in robotics? Grippers Machine vision as supporting subsystem AGVs, AMRs (what is the difference)	Disciplines, systems and technologies for I 4.0 Slide 45, 49, 53, 54, 60, 62

Question	**Where to find answer: lectures, slides**
Explain Hierarchical structure of the factory - Automation pyramid and what structure is suitable for Smart factory?	Key approaches to smart factory development 1, slides 2, 3, 4, 5, 6, 7, 8, 9, 10
What are the main components of IoT?	Key approaches to smart factory development 1, slides 14
How IIoT is different compared to IoT?	Key approaches to smart factory development 1, slides 19,
Explain the Horizontal and Vertical integration of smart factory (components, definition, key properties,…)	Key approaches to smart factory development 1, slides 21, 22, 23
Why traceability and transparency is so important for the smart factory (how we achieve transparency – sensors, material, information flow, sensors technology, …?	Key approaches to smart factory development 2, slides 2, 3, 4, 9, 10, 12
What is RFID and why is so important for the smart factory?	Key approaches to smart factory development 2, slides 5 - 8
Explain the communication in smart factory (key aspects, communication protocols – OPC UA, wired, wireless, M2M and IoT communication)	Key approaches to smart factory development 2, slides, 13 – 20, 22
Why referential architecture models of smart factory are important (starting point to bould the factory, structure)?	Referential architectural models of smart factories, slide 2
Explain the Reference Architectural Model Industry 4.0 – RAMI 4.0 (the structure, 3D, axis, standards integrated into the axis – only explanation, main content of the standard).	Referential architectural models of smart factories, slides 4, 5 , 6 , 7, 8, 9, 10, 11, 14, 16, 17)
What is administration shell? Digital data of products, systems, processes; data saving in local or global servers, importance of data structuring and communications between layers.	Referential architectural models of smart factories, slides 18, 19, 20.
What is global and local digital agent? The function and use of digital agents in different layers, for different levels?	Referential architectural models of smart factories, slides 26, 28 – 31, example of LASFA model and integration of digital agents. Additional material for understanding the RAMI 4.0 and LASFA: Resman, M.; Pipan, M.; Simic, M.; Herakovic, N. (2019), *A new architecture model for smart*

	manufacturing: A performance analysis and comparison with the RAMI 4.0 reference model, https://doi.org/10.14743/apem2019.2.318
Why the factory of the future should be a vision and not only the technological advancement?	The concept of distributed systems, slide 3, 6
How plant structure is important in terms to have distributed network, how modular design helps in achieving the distributed structure.	The concept of distributed systems, slide 4, 5, 6
What means a Customer - Centric Strategy when implementing the smart factory	The concept of distributed systems, slides 7, 8 , 9
Explain the concept of modular smart factory (modular products – modular factory, how planning is simplified, development methodology – steps, description, standardization…).	The concept of distributed systems, slides 11, 12, 13, 14, 15, 16, 17
What is smart module in modular smart factory? CPS, fundamental principles, characteristics, how we can build smart factory from smart modules, standardization in different levels!?, plug and produce concept.	The concept of distributed systems, slides 19 - 22

Question	**Where to find answer: lectures**
What is the main difference between digital model (simulation model) and the digital twin?	The concept of digital twins (DT)
Explain the digital twin evolution from digital model towards real functional digital twin.	The concept of digital twins (DT)
What type of digital twins we are facing in the smart manufacturing? Any common uses, examples (product, process, systems)?	The concept of digital twins (DT)
What is important when you develop a digital twin (refer to digital twin in product lifecycle). How would you explain the digital thread in the digital twin of product lifecycle)?	The concept of digital twins (DT)
List at least 5 important contributions of DT in manufacturing. List at least 5 challenges in implementation of DT in manufacturing, production processes.	The concept of digital twins (DT)
Explain the difference between 3-dimensional and 5-dimensional digital twin concept.	The concept of digital twins (DT)
Explain the main components of 5-dimensional digital twin and explain the working principle.	The concept of digital twins (DT)