Smart Systems for Data Acquisition

Course Presentation

UniMORE - LM Digital Automation Engineering

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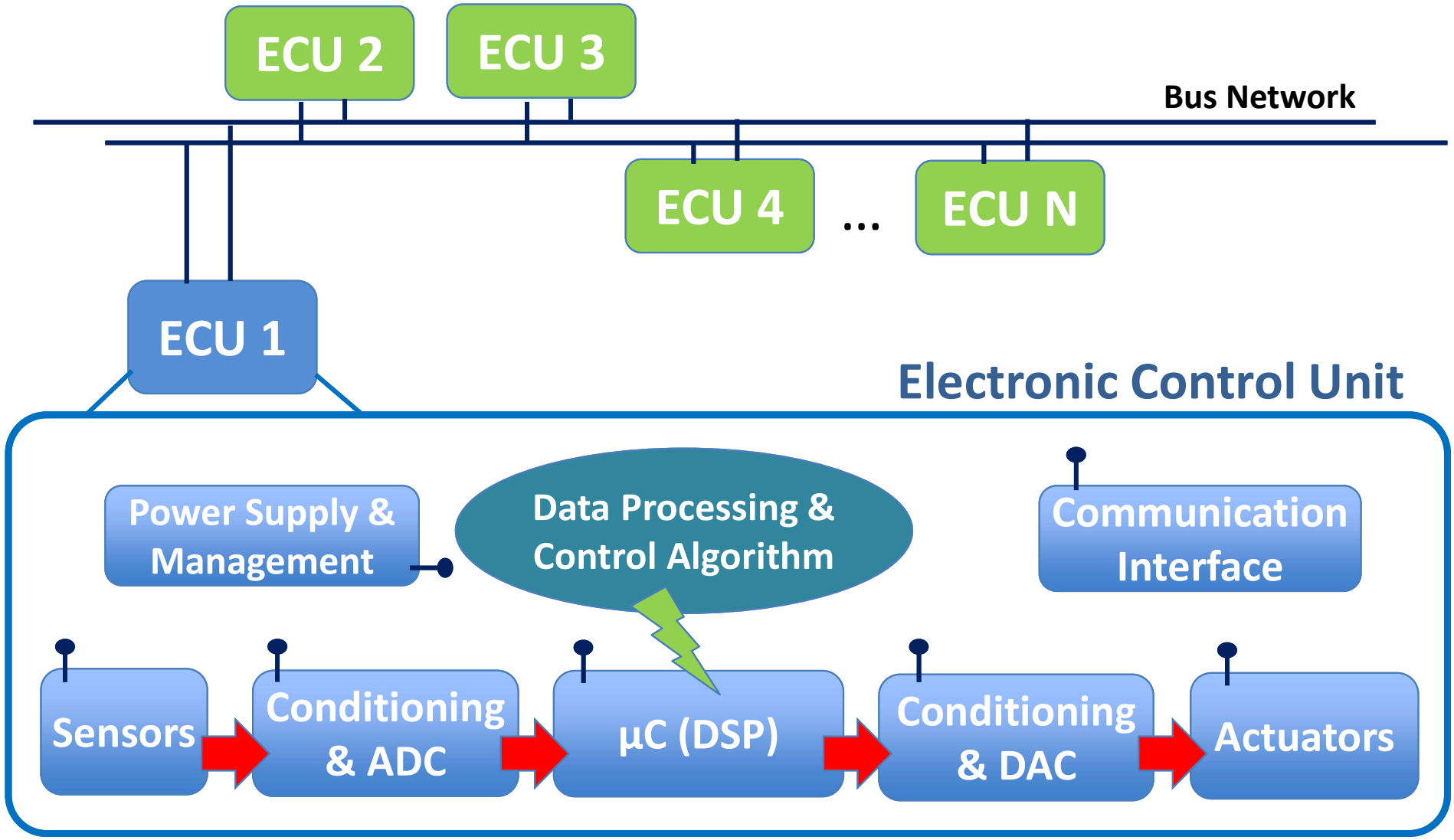
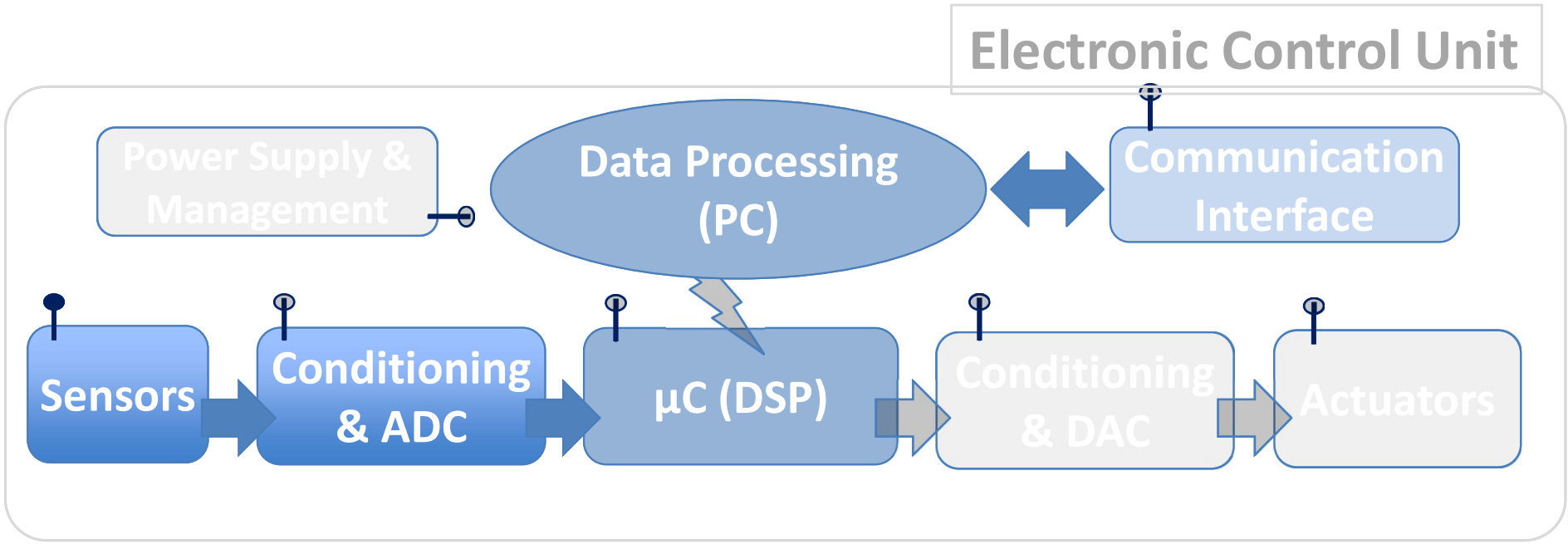
What Inside a Modern Electronic System?



Course's Focus on the Highlighted Building Blocks



…More in detail

GOAL: ***developing specific skills in the electronic design of data acquisition systems for real industrial applications***

Main Topics

1. Sensors & Transducers: definitions, operation principles of the main sensors used in industrial applications, calibration (1 ECTS)
2. Signal conditioning (OpAmps based circuits, analog filters) (1 ECTS)
3. Analog-to-Digital converters (ADC): Fundamentals of A/D conversion, main topologies and operation principles (1 ECTS)
4. Digital Signal Processing: Sampling, quantization, Input-output differential equations, impulse response, Discrete Fourier Transform (DFT), z-Transform, digital filters, Finite impulse response (FIR) filters, (2 ECTS)
5. Design & Development of a Data Acquisition System: Basic Microcontrollers fundamentals (programming and use of the main peripherals), communication between microcontrollers and PC (e.g. USART) (1 ECTS)

Practical Information - 1

- **Prerequisites**
  - Circuit theory, Basic knowledge of programming
  - Attitude to develop multidisciplinary projects
- **Course teaching** consists of
  - lectures in the presence
  - laboratory activities (circuits simulations & hands-on)

  Both held @ Pad. Tamburini – Mechatronic Lab (ground floor)
- **Teaching & Supporting Material**
  - slides, handouts, source codes, datasheets, etc… will be available at the Course's page on the Moodle platform
  - **Moodle is the only OFFICIAL REPOSITORY of the course** **https://moodle.unimore.it/course/view.php?id=12187**

Practical Information - 2

- Student Reception:
  - **by appointment** (via e-mail)
  - at the end of the lectures

- Each communication must be
  - **Sent ONLY by using your account @studenti.unimore.it**
  - **Addressed to both the teachers** with the only exception of technical requests on a specific topic of the program

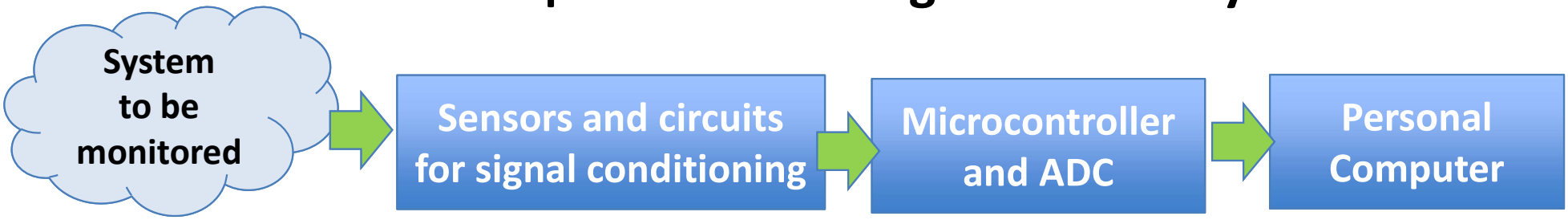
Practical Information - 3

Final Exam is comprised of two parts

- **PART 1: Design and Implementation of a real and working prototype of data acquisition system (team project)**
  - **Team working** (3-4 people per team)
  - Each team proposes a project concerning real applications (subjected to design review with the lecturers after specs definition and before to start the design)
  - General purpose hardware provided by the lecturers (e.g. commonly used commercial sensors, development kits)
  - **One person per team is responsible for the HW**
  - The day of the exam, at the end of the live demo, all the provided HW must be returned in the original condition (i.e. working!)
- **PART2: Individual oral test concerning the course's topics**

Practical Information -4

Expected Block Diagram of the System



Identification of key physical quantities (temperature, humidity, force, acceleration, speed, …)

Sensor(s) choice
Design of the related conditioning stage

Circuits implemented on breadboards using breakout boards, development kits, …

Determination of the minimum data acquisition param. and choice of the right ADC

Design and implementation of the FW suitably developed for the specific application including communication with the PC

Development of SW for signal processing (DFT, filtering, algorithms, …) and HMI

Free choice concerning the development environment (Matlab, Python, QT, …)

Practical Information - 4

- **Learning Assessment & Final Score given by the sum of two scores** (the exam is passed if the total score is ≥ 18/30)

  1. Evaluation of the proposed team project (MAX 15/30)
  - Oral presentation + technical report + live demo (all mandatory)
  - Project presented by all the members of the team the same day
  - Common score for all the team's members

  2. Individual oral test (MAX 16/30 added to the project score)
  - 4/6 questions
    - 1/2 questions Bertacchini (±8/30)
    - 1/2 questions Pancaldi (±8/30)

- **EXAMPLE: Final Score for the Member A of the Team 01**
  - Project 01: **14/30** (common to all the Members of Team 01)
  - Oral Bertacchini: **+5/30** (individual for Member A of Team 01)
  - Oral Pancaldi: **+7/30** (individual for Member A of Team 01)

TOT 26/30

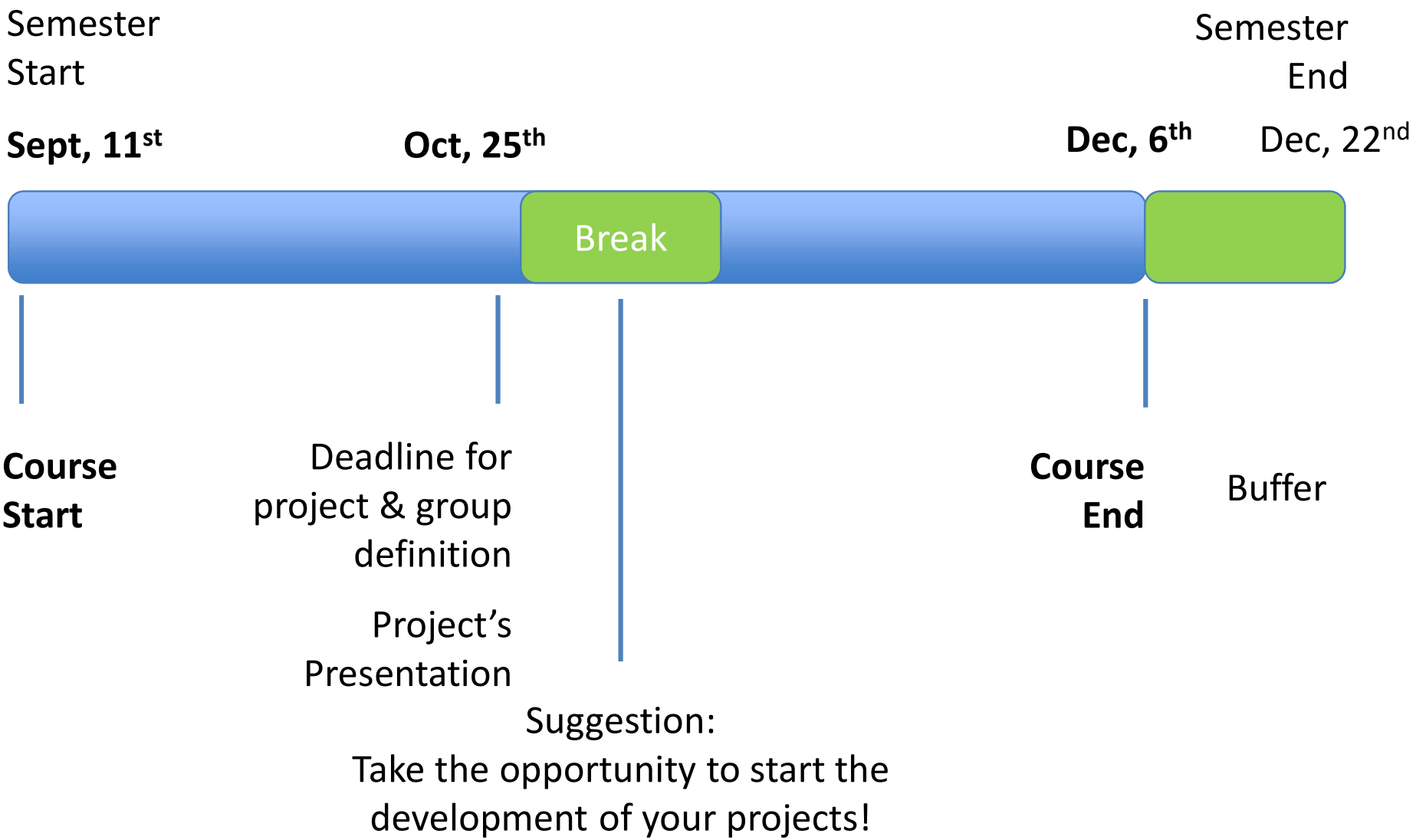
Practical Information - 5

Exam Sessions

- Technical discussion, live demo and oral examination will take place the same day
- **Enrollment on www.esse3.unimore.it is MANDATORY and list closes ONE WEEK BEFORE the scheduled date**
- Report and all the project's files must be sent to both the lecturers **AT LEAST one week before the chosen date**
- Exam sessions in the scheduled dates ONLY (communicated through the normal channels)

- **WINTER (Jan – Feb): 3 dates** (scheduled as soon as possible)
- **2nd SEMESTER BREAK: 1 date**
- **SUMMER (Jun – Sept): 3 dates** (to be defined)
- **1st SEMESTER BREAK 2024/25: 1 date** (to be defined)

Timeline


Semester Start
Semester End
Sept, 11st
Oct, 25th
Dec, 6th
Dec, 22nd
Break
Course Start
Deadline for project & group definition
Project's Presentation
Course End
Buffer
Suggestion:
Take the opportunity to start the development of your projects!

Main References -1

- J.M. Fiore **«Operational Amplifiers & Linear Integrated Circuits: Theory and Application / 3E»,** FREE DOWNLOAD https://www2.mvcc.edu//users/faculty/jfiore/freebooks.html
- A. Kay & T. Green, **«Analog Engineer's Pocket Reference»**, 5th Edition, Texas Instruments, FREE DOWNLOAD, https://www.ti.com/amplifier-circuit/analog-engineers-pocket-reference-guide.html
- AA. VV. **«Analog Engineer's Circuit Cookbook: Amplifiers»**, Texas Instruments, FREE DOWNLOAD, https://www.ti.com/design-resources/design-tools-simulation/analog-circuits/overview.html
- AA. VV. **«Analog Engineer's Circuit Cookbook: Data Converter»**, Texas Instruments, FREE DOWNLOAD, https://www.ti.com/design-resources/design-tools-simulation/analog-circuits/overview.html

Main References -2

- **TI Precision Lab Video Series**, https://www.ti.com/video/series/precision-labs.html
- B. Carter, R. Mancino, **«OpAmps for Everyone»** 5th Ed., Newnes, 2017, ISBN 978-0-12-811648-7
- P. Scherz, S. Monk **«Practical electronics for Inventors»** 4th ed. McGraw Hill, 2016 ISBN 978-1259587542
- L. Tan, J. Jiang **«Digital Signal Processing: Fundamentals and Applications»** 3rd ed. Academic Press, 2018, ISBN: 9780128150719