

## TITOLO: MAGNETISMO NEI MATERIALI E MISURE MAGNETICHE

Codice corso: 01LDVRU

ANNO: 2023

DOTTORATO PROPONENTE: METROLOGIA

DURATA (n. ore) 20

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Il corso intende fornire le basi per comprendere gli aspetti metrologici del magnetismo, la fisica dei materiali magnetici e le associate tecniche di misurazione. Dar  una introduzione a

- concetti di base nel magnetismo
- origine quantistica del ferromagnetismo
- teorie del processo di magnetizzazione
- materiali per applicazioni tecnologiche
- tecniche sperimentali

Il corso si svolger  in lingua inglese all'INRIM, Strada delle Cacce 91, e online via la piattaforma del virtual classroom del Politecnico di Torino. Alla fine del corso sar  possibile partecipare alla visita dei laboratori presso l'INRIM.

Il corso   aperto a tutti gli interessati. Chiunque intenda partecipare pu  inviare una e-mail di conferma a [m.kuepferling@inrim.it](mailto:m.kuepferling@inrim.it), [v.basso@inrim.it](mailto:v.basso@inrim.it), per rimanere aggiornato su eventuali cambiamenti.

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### Magnetism, magnetic materials and measurements

The course will provide the basis to understand the metrological aspects of magnetism, the physics of modern magnetic materials and the associated measurement techniques. It will give an introduction to

- basic concepts in magnetism
- quantum origin of ferromagnetism
- theories of magnetization process
- materials for technological applications
- experimental techniques

The course will be held in English language at INRIM, Strada delle Cacce 91, and online via the platform provided by the Politecnico di Torino (virtual classroom). At the end of the course it is possible to participate at a lab visit at INRIM.

Interested students should send a confirmation email to [m.kuepferling@inrim.it](mailto:m.kuepferling@inrim.it), [v.basso@inrim.it](mailto:v.basso@inrim.it), to be updated on last minute changes.

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### Dates:

Mon/Lun	Tue/Mar	Wed/Mer	Thu/Gio	Fri/Ven	Sat/Sab	Sun/Dom
May 15	May 16	May 17	May 18 9-12 L1	May 19	May 20	May 21
May 22	May 23 9-12 L2	May 24 9-12 L3	May 25 9-12 L4	May 26	May 27	May 28
May 29	May 30 9-12 L5	May 31 9-12 L6	June 1 9-12 L7 13-15 Lab visit	June 2	June 3	June 4

## **Program (20 hours – 14 units):**

Each lecture is split in two units of about 45-60min. Before and after each unit there will be time for Q&A and between the units there will be a 15min break.

### **Lecture 1: Introduction to magnetism and magnetic materials**

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- 1.1 Magnetism and technology: importance of magnetic materials (MK)
- 1.2 Magnetic media in Maxwell equations (VB)

### **Lecture 2: Magnetostatics and microscopic origin of magnetism**

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- 2.1 Magnetostatics (VB)
- 2.2 Magnetic Moments; Dia- and Paramagnetism (MK)

### **Lecture 3: Ferromagnetism and magnetic energies**

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- 3.1 Ferro-, antiferro- and ferrimagnetism (MK)
- 3.2 Energy relations (VB)

### **Lecture 4: Micromagnetics and magnetic domains**

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- 4.1 Micromagnetics (VB)
- 4.2 Domains and domain walls (MK)

### **Lecture 5: Magnetization processes and soft magnetic materials**

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- 5.1 Magnetization processes (VB)
- 5.2 Soft magnetic materials (MK)

### **Lecture 6: Hard, magnetostrictive and magnetocaloric materials**

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- 6.1 Hard magnetic materials (MK)
- 6.2 Magnetostrictive and magnetocaloric materials (VB)

### **Lecture 7: Spintronics with magnetic materials**

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- 7.1 Magnetism and electric currents (VB)
- 7.2 Spintronics and spin currents (MK)

### **Lab visit at INRIM (2 hours): Measuring and preparing magnetic materials**

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#### *References:*

- F. Fiorillo, *Measurement and characterization of magnetic materials*, Elsevier, 2004.
- G. Bertotti, *Hysteresis in Magnetism*. Academic Press, 1998
- S. Blundell, *Magnetism in condensed matter*, Oxford University Press, 2001.
- R. O'Handley, *Modern magnetic materials. Principles and applications*, John Wiley & Sons, 2000.
- B.D. Cullity, *Introduction to magnetic materials*, Addison-Wesley, 1972.
- S. Chikazumi *Physics of ferromagnetism*, Oxford University Press, New York, 1997.
- M.D. Coey, *Magnetism and magnetic materials*, Cambridge University Press, 2009.
- R. Skomski, *Simple models of magnetism*, Oxford Graduate Texts, 2008.
- A.H. Morrish, *The physical principles of magnetism*, Wiley, 2001.