Modern Physics for Engineers (9 CFU)
MS Course on Energy Engineering

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Academic Year 2018-19

Materials:

Lecture Notes by S. Atzeni (download: "gaps.ing2.uniroma1.it/atzeni/" then click on "didattica")

I. *Lecture Notes on Quantum Mechanics*, updated Sep 23, 2018 (QM2018, in the following)

Lecture notes by F. V. Frazzoli, edited and translated by S. Atzeni
(download: from the googledrive link communicated to the registered students)

II. *Interaction of charged particles and X- and gamma-radiation with matter*
III. *The atomic nucleus: fundamental properties*
IV. *Radioactivity*

Lecture notes by F. V. Frazzoli, edited and translated by R. Gatto
(download: from the googledrive link communicated to the registered students)

V. *Nuclear reactions*
VI. *Neutron interaction with matter*
VII. *Nuclear fission*
VIII. *Nuclear fusion*

Exercises (download: from the googledrive link communicated to the registered students)

IX. Modern Physics for Engineers - Exercises

Text covering most course topics: K. S. Krane, *Introductory Nuclear Physics*, John Wiley & Sons (1988)
Another useful text (in French): F. Mayet, *Physique nucléaire appliquée*, 2nd Ed. De Boek Supérieur (2017)

Elements of kinetic theory of gases • Microscopic interpretation of temperature and pressure • Equipartition principle • Maxwell velocity distribution function • Boltzmann's factor	QM2018, Appendix H
Crisis of classical physics	QM2018, Ch. 1
Elements of special relativity • Critique of simultaneity • Postulates • Time dilatation and space contraction • Lorentz transformations • Momentum, mass, energy	QM2018, Ch. 2
Particle behaviour and "old quantum theory" • Black body and energy quantization • Photoelectric effect and photon • Compton effect • Bohr's model of the hydrogen atom	QM2018, Ch. 3
Material waves (De Broglie waves) • De Broglie waves • Complementarity • Wave packets • Uncertainty principle	QM2018, Ch. 4

Elements of quantum mechanics
• Postulates and Schroedinger equation
• One-dimensional problems
  o Infinite potential well (quantization)
  o Finite potential well (bound states and free states)
  o Potential step and barrier (tunnelling)
• Elementary atomic physics
  o Angular momentum, hydrogen atom, energy levels, quantum numbers
  o Concept of spin, exclusion principle, indistinguishability
	QM2018, Ch.5
	QM2018, Ch. 6
	
	QM2018, Ch. 7

Interaction of charged Particles and gamma radiation with matter
• Charged Particles
  o Coulomb diffusion
  o Ionization energy loss (Bethe-Bloch formula)
  o Stopping power, range and trajectory
  o Energy loss by radiation
• Gamma rays
  o Photoelectric effect
  o Compton effect
  o Pair creation
	notes on "Interaction of charged particles and X- and gamma-radiation with matter"

Nuclei: fundamental properties • Mass, size, intrinsic angular momentum • Mss defect, binding energy, separation energy • Stable nuclei systematics • Drop model and semi-empirical mass formula • Notions on shell model • Width of excited levels and Breit-Wigner formula	Notes on "Nuclei: fundamental properties"
Radioactivity • Radioactive decay law, activity, mean life • Chain decays, secular equilibrium • Elements of statistics of decay • Alpha decay: semiclassical interpretation (Gamow) • Beta decay • Gamma decay: semiclassical interpretation; selection rules.	Notes on "Radioactivity"

Nuclear reactions
• Energy balance; threshold energy for endo-energetic reactions
• Cross-sections: differential, microscopic, macroscopic
• Spherical wave expansion
• Elementary s-wave cross-section theory
  o Potential diffusion
  o Breit and Wigner cross-section
  o "1/v" Law
	notes on "Nuclear reactions"

Neutron induced reactions • Compound-nucleus reactions: mechanism, discussion of the cross-section • Doppler effect • Fission: qualitative description; isotope classification • Fission reaction products;	notes on "Neutron interaction with matter" notes on "Fission reactions"
Neutron slowing-down ("moderation") • Moderation by elastic diffusion: energy loss, probability distribution, lethargy • Moderator finite-temperature effects • Moderating materials	notes on "Neutron interaction with matter"
Physical principles of fission reactors • Thermal and fast reactors • Four-factor formula • Basic kinetics and role of delayed neutrons • Breeding and conversion coefficient	notes on "Fission reactions"
Nuclear fusion • Fusion reactions • Plasma power balance: ideal ignition temperature; Lawson criterion • Magnetic and inertial confinement	notes on "Nuclear Fusion"