

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

prof. Stefano Atzeni (6 CFU) and prof. Renato Gatto (3 CFU)

Academic Year 2017 - 2018

Materials:

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

- I. *Lecture Notes on Quantum Mechanics*, updated Sep 25, 2017 (QM2017, 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)

Elements of kinetic theory of gases <ul style="list-style-type: none"> • Microscopic interpretation of temperature and pressure • Equipartition principle • Maxwell velocity distribution function • Boltzmann's factor 	QM2017, Appendix H
Crisis of classical physics	QM2017, Ch. 1
Elements of special relativity <ul style="list-style-type: none"> • Critique of simultaneity • Postulates • Time dilatation and space contraction • Lorentz transformations • Momentum, mass, energy 	QM2017, Ch. 2
Particle behaviour and “old quantum theory” <ul style="list-style-type: none"> • Black body and energy quantization • Photoelectric effect and photon • Compton effect • Bohr's model of the hydrogen atom 	QM2017, Ch. 3
Material waves (De Broglie waves) <ul style="list-style-type: none"> • De Broglie waves • Complementarity • Wave packets • Uncertainty principle 	QM2017, Ch. 4

<p>Elements of quantum mechanics</p> <ul style="list-style-type: none"> • Postulates and Schroedinger equation • One-dimensional problems <ul style="list-style-type: none"> ○ Infinite potential well (quantization) ○ Finite potential well (bound states and free states) ○ Potential step and barrier (tunnelling) • Elementary atomic physics <ul style="list-style-type: none"> ○ Angular momentum, hydrogen atom, energy levels, quantum numbers ○ Concept of spin, exclusion principle, indistinguishability 	<p>QM2017, Ch.5 QM2017, Ch. 6</p> <p>QM2017, Ch. 7</p>
<p>Interaction of charged Particles and gamma radiation with matter</p> <ul style="list-style-type: none"> • Charged Particles <ul style="list-style-type: none"> ○ Coulomb diffusion ○ Ionization energy loss (Bethe-Bloch formula) ○ Stopping power, range and trajectory ○ Energy loss by radiation • Gamma rays <ul style="list-style-type: none"> ○ Photoelectric effect ○ Compton effect ○ Pair creation 	<p>notes on “Interaction of charged particles and X- and gamma-radiation with matter”</p>
<p>Nuclei: fundamental properties</p> <ul style="list-style-type: none"> • 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 	<p>Notes on “Nuclei: fundamental properties”</p>
<p>Radioactivity</p> <ul style="list-style-type: none"> • 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. 	<p>Notes on “Radioactivity”</p>
<p>Nuclear reactions</p> <ul style="list-style-type: none"> • Energy balance; threshold energy for endo-energetic reactions • Cross-sections: differential, microscopic, macroscopic • Spherical wave expansion • Elementary s-wave cross-section theory <ul style="list-style-type: none"> ○ Potential diffusion ○ Breit and Wigner cross-section ○ “1/v” Law 	<p>notes on “Nuclear reactions”</p> <p>QM2017, Ch. 9</p>
<p>Neutron induced reactions</p> <ul style="list-style-type: none"> • Compound-nucleus reactions: mechanism, discussion of the cross-section • Doppler effect • Fission: qualitative description; isotope classification • Fission reaction products; 	<p>notes on “Neutron interaction with matter”</p> <p>notes on “Fission reactions”</p>
<p>Neutron slowing-down (“moderation”)</p> <ul style="list-style-type: none"> • Moderation by elastic diffusion: energy loss, probability distribution, lethargy • Moderator finite-temperature effects • Moderating materials 	<p>notes on “Neutron interaction with matter”</p>
<p>Physical principles of fission reactors</p> <ul style="list-style-type: none"> • Thermal and fast reactors • Four-factor formula • Basic kinetics and role of delayed neutrons • Breeding and conversion coefficient 	<p>notes on “Fission reactions”</p>
<p>Nuclear fusion</p> <ul style="list-style-type: none"> • Fusion reactions • Plasma power balance: ideal ignition temperature; Lawson criterion • Magnetic and inertial confinement 	<p>notes on “Nuclear Fusion”</p>