

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

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Materials:

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

- “Lecture Notes on Quantum Mechanics” (QM in the following)
- “Notes on kinetic theory” (included in the last version of QM)
- “Notes on Black Body Spectrum”
- “Notes on photoelectric effect, Compton Effect, Bohr’s atomic model”

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

- “Interaction of charged particles and X- and gamma-radiation with matter”
- “The atomic nucleus: fundamental properties”
- “Radioactivity”

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

- “Nuclear reactions”
- “Neutron interaction with matter”
- “Nuclear Fission”
- “Nuclear Fusion”

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

- “Modern Physics for Engineers - Exercises”

Text covering most course topics:

K. S. Krane, *Introductory Nuclear Physics*, John Wiley & Sons (1988)

<p>Elements of kinetic theory of gases</p> <ul style="list-style-type: none"> • Microscopic interpretation of temperature and pressure • Equipartition principle • Maxwell velocity distribution function • Boltzmann’s factor 	“Notes on kinetic theory”
<p>Crisis of classical physics</p>	QM, Ch. 1
<p>Elements of special relativity</p> <ul style="list-style-type: none"> • Critique of simultaneity • Postulates • Time dilatation and space contraction • Lorentz transformations • Momentum, mass, energy 	QM, Ch. 2
<p>Particle behaviour and “old quantum theory”</p> <ul style="list-style-type: none"> • Black body and energy quantization • Photoelectric effect and photon • Compton effect • Bohr’s model of the hydrogen atom 	<p>“Notes on Black Body Spectrum”</p> <p>“Notes on photoelectric effect, Compton effect, Bohr’s atomic mode”</p>
<p>Material waves (De Broglie waves)</p> <ul style="list-style-type: none"> • De Broglie waves • Complementarity • Wave packets • Uncertainty principle 	QM, 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>QM, Ch.5 QM, Ch. 6 QM, 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” QM, 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” 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>

