SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babes-Bolyai University
1.2 Faculty	Physics
1.3 Department	Department of solid state physics and advanced technologies
1.4 Field of study	Physics
1.5 Study cycle	Master of Science
1.6 Study programme / Qualification	MSc./Solid State Physics

2. Information regarding the discipline

2.1 Name of the discipline	Transport Phenomena in Solid						
2.2 Course coordinator	Iosif G. Deac, Associate. Prof.Dr.						
2.3 Seminar coordinator	Iosif G. Deac, Associate. Prof.Dr.						
2.4. Year of study	**MSc. 2**	2.5 Semester	**III**	2.6. Type of evaluation	**E**	2.7 Type of discipline	**S**

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	3	Of which: 3.2 course	2	3.3 seminar/laboratory	1/1
3.4 Total hours in the curriculum	42	Of which: 3.5 course	28	3.6 seminar/laboratory	28
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					45
Additional documentation (in libraries, on electronic platforms, field documentation)					30
Preparation for seminars/labs, homework, papers, portfolios and essays					45
Tutorship					3
Evaluations					4
Other activities:					

3.7 Total individual study hours	126
3.8 Total hours per semester	182
3.9 Number of ECTS credits	7

4. Prerequisites (if necessary)

4.1. curriculum	• Solid State and semiconductor Physics
4.2. competencies	• Identification and proper use of the main laws and principles of physics in a given context.

5. Conditions (if necessary)

5.1. for the course	• lectures hall with video projector (beamer) and blackboard
5.2. for the seminar /lab activities	• Seminar hall with blackboard

6. Specific competencies acquired

Professional competencies	• The advanced use of the theoretical and experimental concept of the solid state physics. • The development of some algorithms to solve problems . • Data processing and data acquisition by using the advanced computational systems. • Critical/constructive analysis of the results by using advanced models/theories.
Transversal competencies	• Identification of the advanced continuous formation opportunities and effective exploitation of learning techniques for the own development. • Identification of the roles and responsibilities in a team, and the application of effective work and relationship techniques in a team.

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	The course extends the ideas developed in the (Advanced) Solid State Physics course on the basis of the main models and new experimental data. It will develop the basic knowledge underlining the relationship between the crystal structure and the physical properties of solids. This course will provide microscopic pictures of energy transport and energy conversion processes from nanoscale to macroscale.
7.2 Specific objective of the discipline	• the students will be they to be able to do some advanced and technological research in the field of solid state devices. • the students will be able to characterize the solids from electrical, magnetic and thermal properties points of view. • the students will also be able to find the correlations between the experimental data and the phenomenon under study.

8. Content

8.1 Course	Teaching methods	Remarks
1. **Introduction**. General. Fick's Law. Particle diffusion. Thermal conductivity. Viscosity. Generalized. Forces. Boltzmann Equation. Relaxation time approximation. Classical distribution. Fermi – Dirac distribution. Electrical resistivity.		4 hours
2. **Electronic transport in conductors.** Electron-phonon scattering. Impurity scattering. Ziman theory for the electrical resistivity. Band structure effect on the electron transport equation.		2 hours

3. **Electron-imperfection scattering.** Electrical resistivity due to electron-phonon interaction. Bloch-Gruneisen law. Residual resistivity of metals. Impurity effect in a metal.		2 hours
4. **Conduction electron scattering and the resistance of the magnetic elements.** Magnetic scattering. Electron transport in ferromagnetic materials. Electron-magnon scattering. Magnetic impurities in metals. Anderson model. Kondo effect.		2 hours
5. **Thermal conductivity.** Thermal conductivity in metals. Wiedemann-Franz law and Lorenz number. Electron Scattering Mechanisms Defect Scattering. Phonon Scattering. Boundary Scattering (Film Thickness, Grain Boundary).Phonon-phonon scattering. Normal processes. Umklapp processes. Experimental determination of the thermal conductivity.		2 hours
6. Thermoelectric effects. Peltier Effect. Phonon drag effect.Thermoelectric power in metals and semiconductors. Thermoelectric thermometers. Thermoelectric applications.		2 hours
7. Electrical conductivity in magnetic fields. Magnetoresistance and Hall effect. Ordinary magnetoresistance.Kohler' Rule.		2 hours
8. **Hall effect in magnetic metals.** Anomalous Hall effect (AHE). Magnetoresistance in magnetic metals. Anisotropic Magnetoresistance. Spin dependent electrical transport in ferromagnetic metals.		2 hours
9. **Giant magnetoresistance (GMR).** Mott Modell. Two currents model. GMR in granular materials. GMR sensors. Spintronics.		3 hours
10. **Colossal Magnetoresistance (CMR).** Mixed valence MANGANITES. Double echange interaction. Charge ordering. Orbital ordering.		2 hours
11. **Tunel magnetoresistance(TMR).** Introduction to tunnel effect.TMR-the basic of magnetic tunnel junctions. Julliere's model. GMR vs. TMR. TMR in granular material		3 hours
12. Strongly correlated electron systems. What is it? Fermi liquid theory. Heitler-London approximation. Hubbard model. Electronic structure of 3d transition metal oxides. Mott insulator. Multiferoics.		2 hours

Bibliography

1. C. Kittel, Introduction to Solid State Physics (7ed., Wiley, 1996)
2. N. W. Ashcroft, N. D. Mermin, *Solid State Physics*, Saunders, 1976.
3. C. Kittel, Thermal Physics (W.H. Freeman and Company New York, 1998).
4. Ch. Enss, S. Hunklinger, Low-Temperature Physics, Springer-Verlag Berlin Heidelberg 2005.
5. U. Mizutani, Introduction to the Electron Theory of Metals, Cambridge University Press 2001.

6. M. Coldea, Magnetorezistenta, efecte si aplicatii , Presa Universitara Clujana, 2009.
7. J.M deTeresa, New magnetic materials and their functions, 2007, Cluj-Napoca, Romania. Summer School
8. L. Ranno, Spin dependent tunnel transport and spin polarization, 2003, Brasov. Romania. Summer School
9. http://esm.neel.cnrs.fr

Optional bibliography:

1. E. Dagotto, Complexity in Strongly Correlated Electronic Systems, Science 309, 257 (2005).
2. Ziman, Electrons and Phonons, Oxford Classic Texts in the Physical Sciences
3. Simulation in solid state physics: http://pages.physics.cornell.edu/sss/simulationlist.html

8.2 Seminar/Laboratory Will consist in preparing and presentation of homework **projects**. You will be required to make presentations in the class Each student will choose a **project** consisting from a **report** (6-12 pages) and a **Power Point presentation** (30 minutes-10 for discussions) . **details about the homework projects will be discussed in the first class** **Projects proposal** (tentative, subject to changes in agreement with students preferences)	Teaching methods	Remarks
1. Electronic transport in low-dimensional systems	Problematisation, demonstration	The main topics and bibliography will be discussed with the students (1 hour each of them)
2. Colossal magnetoresistance		
3. Magnetic tunnel junctions		
4. Electronic transport in graphene		
5. Carbon nanotubes		
6. Multiferroic materials		
7. Topological Insulators		
8. Introduction to Oxide Thermoelectrics		
9. Quantum Dots		
10. Spin valves		
11. Spin Transfer Torque		
12. Introduction to heavy-fermions systems		
Bibliography: To be discussed with the students for each chosen project Books, articles and papers from magazines and journals will be made available.		

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

- The content of the course is congruent to the similar matter studied in representative European and

national universities. In order to better adapt to the work market requirements, the content of the course was related with the main trends from this field in the regional scientific research, industry and business environment.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	-correctness and completeness of the knowledge. - logical coherence - the ability to use the scientific language	3 hours written exam	45%
	-criteria related to the dutifulness, the interest for individus study.	Active presence in courses	5%
10.5 Seminar/lab activities	the ability to work with the gained knowledge.	Project Power Point presentation	25%
	The corectness and the originality of the homework.	Project report	15%
	Involvment degree	Active presence in seminars	10%
10.6 Minimum performance standards			
➢ basic elements of theory are requested. A candidate shall be declared to have passed the examination in a subject of study only if he/she secures not less than 50% of the total marks.			

Date	Signature of course coordinator	Signature of seminar coordinator
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Date of approval	Signature of the head of department
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