MIPA UGM
Research for Innovations

CURRICULUM 2022

PROGRAM DOCTOR OF PHYSICS

FACULTY OF MATHEMATICS AND NATURAL SCIENCES

GADJAH MADA UNIVERSITY

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GADJAH MADA UNIVERSITY

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DOCTOR OF PHYSICS

CHAPTER 1 FACULTY

1.1 INTRODUCTION

The Faculty of Mathematics and Natural Sciences at Universitas Gadjah Mada (UGM) was officially established on September 19, 1955, through the Decree of the Minister of Education, Teaching, and Culture dated September 15, 1955, with the number 53759/Kab. In this decree, the faculty was still a combined faculty with the Faculty of Engineering, referred to as the Union of Exact Sciences and Engineering Faculties. Starting from September 1, 1956, the Faculty of Exact Sciences and Natural Sciences (abbreviated as FIPA) began to separate from the Faculty of Engineering.

At the time of its establishment as a Union Faculty, FIPA had only one department called the Exact Sciences Department, which had existed since 1950 as a department within the Civil Engineering Department of the Faculty of Engineering. When FIPA began to operate as an independent faculty on September 1, 1956, a new department was opened, initially called the Natural Sciences Department. Then, on September 1, 1960, another department was added, which was the Chemistry Department. On December 28, 1982, the name FIPA was changed to FMIPA (Faculty of Mathematics and Natural Sciences or FMNS), and it had three departments: Physics, Chemistry, and Mathematics.

From its time as a combined faculty until its separation from the Faculty of Engineering, the office and teaching activities were conducted in the old Faculty of Engineering building located at Jetisharjo Street Number 1, Yogyakarta. Basic physics laboratory activities were still held in the Faculty of Medicine complex in Mangkubumen.

Until 1986, the Faculty of Mathematics and Natural Sciences had physical infrastructure with a building area of 13,925 m^2 and a library with 10,529 books and 4,297 book titles. In 1987, with the assistance of World Bank Project IX, the library facilities were expanded to 13,929 books with 5,954 book titles, and the physical building infrastructure was increased by 1,369 m^2, for faculty office rooms and 3,764 m^2 for the chemistry laboratory building, totaling 19,058 m^2.

With the construction of the faculty administration building and the chemistry laboratory building in Sekip Utara by the World Bank Project IX, the FMNS Administrative Office, Department of Physics, and Department of Chemistry started to occupy the new building area in Sekip Utara in February 1989. In February 1994, a fire incident occurred in Sekip Unit III building. Approximately one-third of the building, approximately 1,200 m^2, was severely damaged and could no longer be used. All the Organic Chemistry laboratory spaces, Computational laboratory, and the Postgraduate Mathematics Library, along with all its contents, including laboratory equipment, practical and research materials, books, magazines, journals, and other items, were destroyed in the fire.

At the beginning of the 1995/1996 academic year, a new building for the Department of Physics had been completed, although it was only a part of the original plan. Meanwhile, the construction of new buildings for the Department of Mathematics and the Department of Chemistry had also begun. By early 1996, most of the construction of the new buildings had been completed, and all administrative and academic activities were already located in Sekip Utara.

In early 2003, a three-story building with an area of 1,506.90 m^2 was completed, increasing the total building area to 22,552 m^2. This new building was used for lectures, the Computer Laboratory, and the Student Internet Center.

In order to streamline and optimize the performance of all units within the Faculty of Mathematics and Natural Sciences at UGM to accelerate the realization of the faculty's vision and mission, a new Organizational Structure (SOTK) for the Faculty of Mathematics and Natural Sciences at UGM was established through UGM Rector's Decree Number 809/P/SK/HT/2015. In Article 28 of this decree, the term "Department" was used as the unit under the faculty to replace "Jurusan." Through UGM Rector's Decree Number 580/UN1.P/KPT/HUKOR/2022, a specific SOTK was established for the Faculty of Mathematics and Natural Sciences at UGM, as shown in **Figure 1.1.**

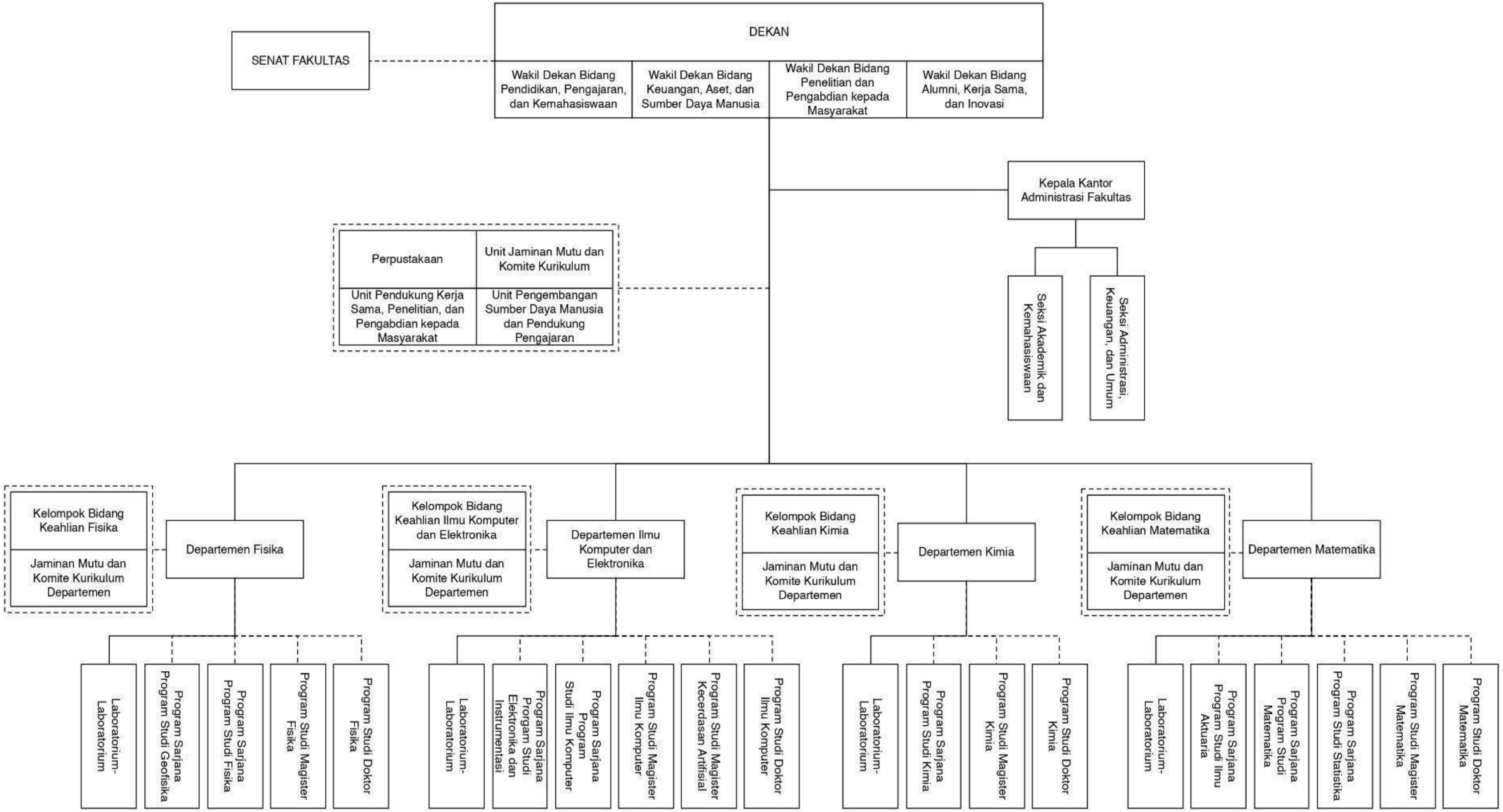

Figure 1. 1 SOTK FMNS UGM

To meet the responsibilities it holds, the Faculty of Mathematics and Natural Sciences at UGM adheres to and follows the Core Values established by the university, as outlined in the Strategic Plan Document of Universitas Gadjah Mada for the period 2018-2022. These core values are as follows:

1. **Pancasila (Indonesian State's Ideology) Values**: These encompass the values of divinity, humanity, unity, democracy, and justice.
2. **Scientific Values**: These include the principles of the universality and objectivity of knowledge, academic freedom and the academic pulpit, recognition of facts and truths for the sake of civilization, and usefulness and happiness.
3. **Cultural Values**: These embrace tolerance, human rights, and diversity.

In general, the research direction of the Doctoral Program conducted at the Faculty of Mathematics and Natural Sciences at UGM is aligned with the research roadmap of the faculty.

1.2 VISION

The vision of the Faculty of Mathematics and Natural Sciences (FMNS) at UGM, as stated in the Strategic Plan and Operational Plan (Renstra and Renop) of FMNS UGM 2018-2022, is to become a nationally excellent and internationally leading faculty by the year 2037. It aims to develop mathematics, physics, chemistry, as well as computer and electronics science for the prosperity of the nation, guided by the cultural values of the nation based on Pancasila.

1.3 MISSION

The mission of the Faculty of Mathematics and Natural Sciences (FMNS) at UGM, as stated in the Strategic Plan and Operational Plan (Renstra and Renop) of FMNS UGM 2018-2022, includes the following objectives:

1. Develop internationally competitive education in the fields of mathematics, physics, chemistry, computer science, and electronics by maximizing research outcomes.
2. Conduct outstanding, innovative, and targeted research in the fields of mathematics, physics, chemistry, computer science, and electronics for the welfare of the nation and humanity at large.
3. Serve the community by utilizing research outcomes in the fields of mathematics, physics, chemistry, computer science, and electronics to address national and global challenges.

4. Continuously develop resources, organization and governance, and supporting facilities in a sustainable manner.

1.4 OBJECTIVE

The objectives to be achieved are the realization of the Faculty of Mathematics and Natural Sciences (FMNS) UGM as part of Universitas Gadjah Mada to become an outstanding faculty in Indonesia with international achievements and reputation through:

1. **Excellence and Innovative Education:** Providing internationally competitive education in the fields of Mathematics, Physics, Chemistry, Computer Science, and Electronics, characterized by cross-disciplinary content, innovation, soft skills, and state-of-the-art information technology. This includes postgraduate programs as the backbone in producing graduates who are healthy, virtuous, confident, competitive, innovative, entrepreneurial, and responsible towards the nation.

2. **Outstanding, Innovative, and Targeted Research:** Conducting research in Mathematics, Physics, Chemistry, Computer Science, and Electronics that is environmentally conscious, nationally and internationally recognized, and capable of providing solutions to national and global challenges. This research should be based on the excellence of human and natural resources and local wisdom, involving stakeholders in accordance with the faculty's research master plan.

3. **Outstanding and Innovative Community Engagement:** Engaging with the community based on expertise in the fields of Mathematics, Physics, Chemistry, Computer Science, and Electronics. This includes contributions to the community through knowledge, appropriate technology, and advocacy in these fields, promoting self-reliance and sustainable well-being. It also involves making the campus a platform for applying science and technology innovations for the community and implementing product development management systems to support the commercialization of research outcomes.

4. **Resource Development, Organizational Governance, and Equitable Collaboration:** Developing resources, organization, governance, and collaboration that are fair, transparent, participatory, and accountable to support the effectiveness and efficiency of resource utilization. This is based on an integrated information technology system to facilitate adaptive learning processes in the era of Industry 4.0.

1.5 TARGETS AND ACHIEVEMENT STRATEGIES

Targets and Achievement Strategies for Objective 1

Objective 1: Excellent and Innovative Education in the fields of Mathematics, Physics, Chemistry, Computer Science, and Electronics, characterized by cross-disciplinary content, innovation, soft skills, and state-of-the-art information technology, with postgraduate programs as the backbone in producing graduates who are healthy, virtuous, confident, competitive, innovative, entrepreneurial, and responsible towards the nation.

Table 1. 1 Targets and Achievement Strategies for Objective 1

Targets	Achievement Strategies
1. Enhancing the quality of the new student admission system based on academic ability, diversity, self-reliance, and inclusivity.	1.1 Strengthening the proportion of new students through affirmative action and financial aid programs (Bidik misi), achievements, and collaborations.
	1.2 Strengthening strategies and promotion systems for the admission of international students.
2. Creating and improving a culture of quality education and learning processes.	2.1 Enhancing the curriculum based on outcome-based education, KKNI (National Qualifications Framework), and SN-DIKTI (Higher Education Data and Information System).
	2.2 Reinforcing e-learning and Massive Open Online Courses (MOOC) for learning.
	2.3 Disseminating knowledge to enhance external learning resources through knowledge channels and knowledge towers.
	2.4 Strengthening institutional mentoring and career counseling for new students and graduates.
	2.5 Enhancing physical and non-physical education and learning infrastructure.
	2.6 Improving student achievements at the national and international levels.
	2.7 Strengthening online-based student services (Student Information System, library services, and others).
	2.8 Enhancing the quality of study programs.
3. Developing interdisciplinary education and learning as well	3.1 Developing interdisciplinary courses (IDC) based on cross-disciplinary synergy,

Targets	Achievement Strategies
as exposure to global competencies.	cross-degree programs, and cross-faculty collaboration.
	3.2 Developing courses to enhance global competency (Global Competency Exposure Courses) to improve student competencies.
4. Making postgraduate education the backbone of Higher Education's Tri Dharma (teaching, research, and community service).	4.1 Improving the quality of student research through participation in faculty research.
	4.2 Increasing the number of scholarships for postgraduate students (domestic and international).
	4.3 Increasing the number of student mobility opportunities for postgraduate students.
5. Internationalization of study programs.	5.1 Developing a visiting professor program.
	5.2 Developing Massive Open Online Courses (MOOC) in collaboration with foreign universities.
	5.3 Expanding double degree programs, dual degree programs, and twinning programs with leading foreign universities.
6. Fostering the spirit of innovation and social entrepreneurship among students.	Developing soft skills, character, and entrepreneurial spirit.
7. Promoting a healthy lifestyle among students.	Providing education on healthy lifestyles to students.

Targets and Achievement Strategies for Objective 2

Objective 2: Research in the fields of Mathematics, Physics, Chemistry, as well as Computer Science and Electronics that is outstanding, innovative, and directed, i.e., research in these fields with an environmental perspective, serving as a national and international reference, and capable of providing solutions to the issues facing the nation and humanity, based on human and natural resource excellence, and local wisdom, involving stakeholders in accordance with the faculty's research master plan.

Table 1. 2 Targets and Achievement Strategies for Objective 2

Targets	Achievement Strategies
1. Developing multidisciplinary research with an environmental perspective and local excellence values	1.1 Developing a culture of multi, inter, and cross-disciplinary research based on the Social Humanities, Agriculture, Health, and/or Science

Targets		Achievement Strategies	
	to provide solutions to societal, national, and state issues.		and Technology clusters through Faculty, School, and Study Center institutions.
		1.2	Advancing comprehensive research (across various aspects) on maritime-archipelagic nations.
2	Advancing innovative research based on cultural wisdom that strongly impacts the advancement of science and technology for the benefit of the nation, state, and humanity.	2.1	Increasing the number of research publications in journals.
		2.2	Expanding intellectual property, including copyrights and geographical indications based on cultural wisdom and natural resources.
		2.3	Enhancing the utilization of research outcomes for strategic policy and industry purposes.
		2.4	Improving the profile of research capacity, activities, and expertise both internally and externally.
		2.5	Increasing the number of foreign research partners.
3	Enhancing research funding capabilities by involving external stakeholders.	3.1	Enhancing the ability and competitive advantage of multi, inter, and cross-disciplinary research to support success in securing funding from national and international sources.
		3.2	Developing and enhancing sustainable strategic partnerships with research funding providers from the government, private sector, and industry.
		3.3	Modernizing and improving the integrated and sustainable capacity of research facilities and laboratories.
4	Improving research institutions and research facility capacity.		Increasing the organization of national and international seminars.

Targets and Achievement Strategies for Objective 3

Objective 3: Excellence and Innovative Community Engagement Based on Expertise in Mathematics, Physics, Chemistry, Computer Science, and Electronics" refers to community engagement activities grounded in scientific knowledge, appropriate technology, and advocacy in these fields. These activities aim to promote community self-reliance and well-being in a sustainable manner by leveraging the campus as a platform for applying science and technology innovations to benefit the community. Additionally, they involve implementing a product development management system to support the commercialization of research outcomes.

Table 1. 3 Targets and Achievement Strategies for Objective 3

Targets	Achievement Strategies
1. Becoming a strategic partner to the government in efforts to enhance productivity and well-being based on community-driven initiatives.	1.1 Increasing FMNS's participation in programs aligned with the DIY (Special Region of Yogyakarta) framework and Jogja Cyber Province.
	1.2 Participating in the development of remote, underdeveloped, and disadvantaged regions (3T areas) through community-based initiatives.
2 Developing the FMNS as a platform for the application of science and technology for the wider community.	Increasing the number of technology applications developed by FMNS for communication, industry, business, and government.
3 Expanding the reach and quality of community service through the development of entrepreneurship and social responsibility.	Providing training and mentoring to the community to create commercially viable products based on appropriate technology and local resources, and facilitating access to funding opportunities for SMEs through sustained improvement in community engagement activities.
4 Building synergy with alumni networks in various regions to strengthen access to community service.	Enhancing synergy between FMNS and alumni in various regions through alumni-managed community engagement activities.
5 Enhancing the role of FMNS as a source of inspiration for community service initiatives.	Expanding the reach and improving the quality of disseminating FMNS's community engagement activities.

Targets and Achievement Strategies for Objective 4

Objective 4: The development of resources, organizational structures, governance, and equitable, transparent, participatory, and accountable collaborations is essential to support the effectiveness and efficiency of resource utilization. This should be based on an integrated information technology system to facilitate adaptive learning processes in the context of Industry 4.0.

Table 1. 4Targets and Achievement Strategies for Objective 4

Targets	Achievement Strategies
Human Resources	

Targets	Achievement Strategies
1. Developing a human resource recruitment system.	1.1 Planning and recruiting faculty based on the development of academic fields.
	1.2 Planning the recruitment of educational staff based on the university's strategic objectives.
2. Developing a career advancement system for employees.	2.1 Developing employee career management.
	2.2 Enhancing the quality and competence of faculty through advanced studies and the management of functional promotions.
	2.3 Enhancing the quality and competence of educational staff.
	2.4 Developing an integrated career information system for faculty promotions and rank advancements.
3. *Implementing a Health-Promoting Faculty program.*	3.1 Improving the health of faculty and educational staff.
	3.2 Enhancing the quality of faculty canteens.
Physical Infrastructure and Environment	
4. Enhancing integration in facility management for optimal service delivery.	4.1 Integrating the management and utilization of building facilities, laboratories, green spaces, sports facilities, and parking areas for improved educational, research, and community service services.
	4.2 Providing common spaces for interaction and connectivity among academic members across departments, faculties, schools, study centers, and other units.
	4.3 Equipping facilities and their surroundings with contemporary security equipment and standard operating procedures for emergency situations.
	4.4 Providing accessible building and facility access for academicians with special needs.
Collaboration and Alumni	
5. Strengthening strategic collaborations to accelerate educational development, research outcomes, scientific and technological innovations, and cultural advancement.	5.1 Improving the quality of sustained strategic collaborations with government, private, and national industrial partners in education, research, and community service.
	5.2 Developing and improving ongoing strategic international partnerships to facilitate joint research, professor exchanges, student exchanges, summer classes, dual-degree programs,

Targets	Achievement Strategies
	international academic exposure, and funding provision.
6. Increasing the synergy and contribution of alumni to strengthen the three pillars of higher education (teaching, research, and community service).	Developing and enhancing strategic collaboration networks between FMNS, alumni, and Kagama (alumni association) to strengthen the role of alumni and Kagama in supporting the three pillars of higher education..
7. Developing programs to facilitate creativity and synergy between research outcomes and downstream activities or incubation.	Supporting start-up businesses initiated by academic members and/or alumni through incubation processes within FMNS.
Governance and Institutional	
8. Strengthening a service-oriented culture and achieving excellent performance through bureaucratic reform.	Enhancing the quality of excellent service systems to promote a positive work attitude, a service-oriented mindset, integrity, and professionalism among staff, as part of the implementation of Good University Governance.
9. Enhancing institutional capacity towards achieving international standards for the faculty.	9.1 Feasibility studies, preparation, and establishment of new postgraduate programs.
	9.2 Feasibility studies, preparation, and establishment of new laboratory or research field groups.

1.6 LEARNING METHODS

A Learning Process Standards

The learning process includes:

1. characteristics of the learning process, consisting of interactive, holistic, integrative, scientific, contextual, thematic, effective, collaborative, and student-centered aspects;
2. planning of the learning process prepared for each course and presented in the Semester Learning Activity Program Plan (RPKPS);
3. implementation of the learning process for each course conducted according to the RPKPS with the characteristics of each course; and
4. Student workload, with one credit equivalent to 170 (one hundred seventy) minutes of learning activities per week per semester, where a semester is the unit of effective learning activities over 16 (sixteen) weeks.

In the learning process, each Doctoral program is given the flexibility to design, develop, establish, organize, and evaluate learning methods that fundamentally have the following characteristics:

a. able to discover or develop new scientific theories, concepts, or ideas, contribute to the development and application of science and/or technology while considering and applying humanistic values in their field of expertise. This is achieved through the production of scientific research based on scientific methodology, logical, critical, systematic, and creative thinking;
b. capable of conducting multidisciplinary, interdisciplinary, or transdisciplinary research, including theoretical and/or experimental studies in the fields of science, technology, arts, and innovation, presented in the form of a dissertation and published papers in reputable international journals;
c. capable of selecting relevant, up-to-date, advanced research topics that benefit humanity through multidisciplinary, interdisciplinary, or transdisciplinary approaches, aimed at developing and providing solutions to problems in the fields of science, technology, arts, or society based on studies of available internal and external resources;
d. able to develop a research roadmap using multidisciplinary, interdisciplinary, or transdisciplinary approaches, based on a study of the main research targets and their constellations within broader objectives;
e. able to formulate scientific, technological, or artistic arguments and solutions based on critical views of facts, concepts, principles, or theories that can be scientifically and ethically justified, and communicate them through mass media or directly to the community;
f. capable of demonstrating academic leadership in the management, development, and nurturing of resources and organizations under their responsibility;
g. capable of managing, including storing, auditing, securing, and retrieving research data and information under their responsibility; and
h. capable of developing and maintaining collegial and mutually beneficial relationships within their own environment or through collaborative networks with research communities outside the institution.

B Semester Credit System

1. 1 (one) credit hour for the learning process in the form of lectures, quizzes, or tutorials consists of:
   a. face-to-face activities for 50 (fifty) minutes per week for 1 semester,
   b. structured assignment activities for 60 (sixty) minutes per week for 1 semester,
   c. independent study activities for 60 (sixty) minutes per week for 1 semester.

2. 1 (one) credit hour for the learning process in the form of seminars or similar activities consists of:
    a. face-to-face activities for 100 (one hundred) minutes per week for 1 semester,
    b. independent study activities for 70 (seventy) minutes per week for 1 semester.
3. 1 (one) credit hour for the learning process in the form of practicums, studio practices, workshop practices, fieldwork, research, community service, and/or similar learning processes, equivalent to 170 (one hundred seventy) minutes per week for 1 semester.

C Candidate Student Requirements

The requirements for doctoral candidates in the Regular Doctoral and Doctor by Research programs are as follows:

1. Have a Cumulative Grade Point Average (CGPA) in the Master's program equal to or greater than 3.25 (three point twenty-five) on a 4.0 scale from a minimally accredited program or department with at least a "B" grade at the time of graduation.
2. Obtain a minimum score of 500 on the PAPs, TKDA PLTI, or TPA Bappenas.
3. Attain a minimum English proficiency score of TOEFL 450 or AcEPT 209 (or its equivalent).
4. Recommendation Letters from 2 (two) individuals who know the applicant:
    a) for applicants who are currently employed, one recommendation should come from the applicant's workplace supervisor, and the other from a professor during their Master's program; or
    b) for applicants who are not employed or do not have a workplace, both recommendations should come from professors during their Master's program.
5. Possess a letter of permission to study or an official study assignment from the applicant's workplace institution if they are currently employed.
6. Include a research pre-proposal.

For applicants from institutions/organizations that have a partnership with UGM, a copy of the Memorandum of Understanding (MoU) or the cooperation agreement with UGM or a letter designating them as scholarship recipients must be attached.

D Study Period

The doctoral program's study period, based on Ministry of Education and Culture Regulation Number 3/2020 and Universitas Gadjah Mada Rector Regulation Number 11/2016, is a maximum of 7 (seven) academic years for the doctoral program, with a minimum student workload of 44 credit hours.

The study phases during the first two years since enrolment as a student are preparation stages for the comprehensive examination. The comprehensive examination must be held no later than the end of the 3rd semester. An evaluation of the study is conducted at the end of the first two years. The first warning letter (SP 1) will be issued at the beginning of the 6th semester, SP 2 at the beginning of the 8th semester, and SP 3 at the beginning of the 10th semester.

E Academic Leave

Residency requirements for regular doctoral program students are one year (two consecutive semesters) following the first registration and a minimum of one year (two consecutive semesters) following the comprehensive examination.

Any doctoral student who is unable to participate in educational activities for one semester must request academic leave with the knowledge of the Promoter/Co-Promoter. Students who do not attend educational activities without academic leave approval will still have their study period counted and will be required to pay tuition fees.

Students may be granted academic leave for a maximum of two semesters, and this leave cannot coincide with the residency period. Each application for academic leave is only approved for a single semester at a time.

1.7 COLLABORATION PROGRAMS

Doctoral programs under the umbrella of Joint Degree, Double Degree, and Dual Degree programs with other universities follow the agreements outlined in the relevant collaboration documents.

1.8 ASSESSMENT METHODS

A Learning Assessment Standards

Assessment reporting involves the qualification of a student's success in completing a course, expressed within the range of:

1. Letter **A** equivalent to a score of 4 (four);

2. Letter **A-** equivalent to a score of 3,75 (three point seven five);
3. Letter **A/B** equivalent to a score of 3,5 (three point five);
4. Letter **B+** equivalent to a score of 3,25 (three point two five);
5. Letter **B** equivalent to a score of 3 (three);
6. Letter **B-** equivalent to a score of 2,75 (two point seven five);
7. Letter **C** equivalent to a score of 2 (two);
8. Letter **D** equivalent to a score of 1 (one); or
9. Letter **E** equivalent to a score of 0 (zero).

B Study Load

The study load for doctoral students consists of 12-16 credit hours of courses and a total of 34 credit hours for the dissertation. Therefore, the study load for doctoral students in the MIPA program is a minimum of 44 credit hours. The study load for each semester is determined at the beginning of the semester through consultation with the Supervisor/Co-Supervisor. The specified study load can be fulfilled by taking required or elective courses.

The breakdown of dissertation credit hours for the Regular Doctoral program, totalling 34 credit hours, includes the following components:

1. Comprehensive Examination: 4 credit hours
2. Publication: 12 credit hours
3. Research Work: 6 credit hours
4. Dissertation Manuscript: 6 credit hours
5. Closed Dissertation Examination: 6 credit hours.

The breakdown of dissertation credit hours for the Doctor by Research program, totalling 40 credit hours, includes the following components:

1. Comprehensive Examination: 4 credit hours
2. Publication: 18 credit hours
3. Research Work: 6 credit hours
4. Dissertation Manuscript: 6 credit hours
5. Closed Dissertation Examination: 6 credit hours.

C Academic Guidance

For doctoral students, a Supervisor/Co-Supervisor is appointed to provide guidance to the students under their supervision, ensuring smooth academic planning for each semester. At the beginning of each semester, students need to consult with their Supervisor/Co-Supervisor to receive academic guidance regarding the completion of the Study Plan Card (Kartu Rencana Studi or KRS). The KRS contains all the courses that the student will take during the semester, in accordance with the applicable regulations.

D Course Repeating and Removal

If a student fails to achieve the minimum required GPA, they can retake a course they have previously taken with the goal of improving their grade and GPA. A student whose GPA does not meet the minimum requirements can improve it by taking additional courses beyond the minimum study load requirements, such as elective courses, or by removing poorly graded elective courses. Course removal is only allowed for elective courses, and the number of credit hours removed should not exceed 10% of the total credit hours of all courses previously taken.

E Evaluation of Study Results

The grade point average (GPA) is calculated using the following formula:

$$GPA = \frac{\Sigma K_i N_i}{\Sigma K_i}$$

where K_i amd N_i are the total credit hours and grade point values for course *i*, respectively.

The evaluation of study results is conducted at various stages of the study period, including at the end of each semester, at the end of the program, and at the end of the maximum study duration based on the total credit hours completed and the GPA achieved.

Doctoral dissertations, which carry a weight of 34 credit hours for the Regular Program and 40 credit hours for the Doctor by Research Program, are evaluated based on components as presented in **Table 1.5.**

Table 1. 5 Components (Weights) of Doctoral Dissertations

No	Component (Weight)	Credit Hours (Regular/ by Research)	Minimum Assessment Criteria	Evaluator
1	Comprehensive Examination	4/4	1.1 Mastery of theory and concepts in the field, demonstrated in problem formulation and literature review. 1.2 Potential for originality and potential contributions to the discipline's proposal. 1.3 Proficiency in research methods. 1.4 Writing quality.	Comprehensive Examination Committee (Program/Department Management, Promoter Team, and Evaluation Team)
2	Research Work	6/6	2.1 Discipline. 2.2 Work proficiency. 2.3 Communication and participation. 2.4 Independence in problem-solving.	Research Promoter Team
3	Dissertation Manuscript	6/6	3.1 Explanation, contextualization, and articulation of research problem and objectives. 3.2 Relevant literature review. 3.3 Formulation, development, and explanation of relevant background theory. 3.4 Methodology. 3.5 Analysis and evaluation of results. 3.6 Dissertation structure and organization.	Dissertation Manuscript Evaluation Team

No	Component (Weight)	Credit Hours (Regular/ by Research)	Minimum Assessment Criteria	Evaluator
4	Publication	12/18	4.1 Journal reputation. 4.2 Conference, dissertation, and publication reputation. 4.3 Manuscript quality, including: a) Originality/freshness of topic and research method. b) Discussion. c) Writing style.	Publication Evaluation Team
5	Closed Dissertation Examination	6/6	5.1 Presentation. 5.2 Reasoning. 5.3 Mastery of the material.	Closed Dissertation Examination Committee

Explanation: The assessment criteria for each component from points 1 to 4 are determined by the Program, while for point 5, it is determined by the Faculty.

At the end of the doctoral program, the stages for students declared to have passed in the Regular Doctoral program are as follows:

1. Have completed a minimum of 44 credit hours.
2. Cumulative GPA ≥ 3,25.
3. Have at least 1 (one) scientific publication in an international journal indexed in the university's designated international database (excluding Google Scholar) and without violating writing ethics.
4. Have a minimum TOEFL score of 500 (AcEPT 269) and TPA/PAPS score of at least 550 (as a graduation requirement). TOEFL/TPA scores (or their equivalents) are valid throughout the doctoral program.
5. Pass the Dissertation Examination.

For students who fail to meet the graduation requirements of the Doctor by Research program within a maximum of 7 (seven) years, they are considered unable to complete their studies and are required to withdraw.

At the end of the doctoral program, the stages for students declared to have passed in the Doctor by Research program are as follows:

1. Have completed a minimum of 44 credit hours.
2. Cumulative GPA ≥ 3,25.
3. Have at least 2 (two) scientific publications in reputable international journals, or 1 (one) scientific publication in a reputable international journal and 2 (two) publications in reputable international proceedings.
4. Have a minimum TOEFL score of 500 (AcEPT 269) and TPA/PAPS score of at least 550 (as a graduation requirement).
5. Pass the Dissertation Examination.

For students who fail to meet the graduation requirements of the Doctoral program within a maximum of 7 (seven) years, they are considered unable to complete their studies and are required to withdraw.

The publication requirements mentioned in point 3 for both the Regular and by Research paths include:

a. The respective doctoral student must be the first author in all publications, indicating UGM as the first affiliation.
b. The publications can be review articles or research-based articles related to the dissertation topic, with the student as the first author.
c. Each publication must include the names of the Promoter team, while for the Doctor by Research program, the Promoter serves as the corresponding author.

F Graduation Honors

Graduation honors for the Regular Doctoral and Doctor by Research programs are as follows:

a. Graduates will be awarded the Cumlaude predicate (graduated with honors) if they have a GPA greater than 3.75 (three point seventy-five) and complete their studies in less than or equal to 8 (eight) semesters, as well as having publications:

   i. at least 2 (two) papers in:
      - International journals (Regular path)
      - Reputable international journals (Doctor by Research path), or

   ii. at least 1 (one) paper in:
      - International journals and 2 (two) papers published in accredited national journals (Regular path)
      - Reputable international journals and 2 (two) papers published in reputable international proceedings (Doctor by Research path), or

iii. at least 1 (one) paper in international journals and 1 (one) paper published in accredited national journals, as well as 1 (one) paper published in reputable international conference/seminar proceedings (Regular path).

b. Graduates will be awarded the Sangat Memuaskan predicate (very satisfactory graduation) if they have a GPA greater than or equal to 3,51 and less than or equal to 3,75 (3,51 ≤ GPA ≤ 3,75) or if they have a GPA greater than 3,75 (three point seventy-five) but do not meet the requirements of point a.

Graduates will be awarded the Memuaskan predicate (satisfactory graduation) if they have a GPA greater than or equal to 3,25 (three point twenty-five) and less than 3,51 (3,25 ≤ GPA < 3,51).

G Regular Doctoral Program Promoter Team

1. The Promoter Team is responsible for:
   a. providing quality consultation in the field of research, including research proposal development, research implementation, and dissertation writing.
   b. ensuring the research's weight and implementation comply with the applicable requirements and deadlines.
   c. ensuring the fulfillment of publication requirements for students.
   d. guiding students to a certain extent according to the applicable rules..
2. The Promoter Team is appointed by the Dean.
3. The Promoter Team consists of two members, including a Promoter and a Co-Promoter. The Promoter must hold a minimum qualification of a Doctorate degree and be an Associate Professor. The Co-Promoter must hold a minimum qualification of a Doctorate degree and be an Assistant Professor (or equivalent). If necessary (due to the required expertise), the number of the Promoter Team members can be increased to three.
4. The Promoter must come from UGM, while the Co-Promoter can be from outside UGM. Further provisions regarding the Promoter Team are determined by the Study Program.

H Doctor by Research Program Promoter Team

1. The Promoter Team is responsible for:
   a) providing quality consultation in the field of research, including research proposal development, research implementation, and dissertation writing;
   b) ensuring that the research's significance and implementation adhere to the applicable requirements and deadlines;
   c) ensuring the fulfillment of publication requirements for students; and
   d) guiding students to a certain extent according to the applicable rules.

2. The Promoter Team is appointed by the Dean.
3. The Promoter Team consists of 1 (one) Promoter and a maximum of 2 (two) Co-Promoters.
4. The Promoter Team must have the following qualifications:
   a. hold at least a Doctorate degree.
   b. have publications in reputable international scientific journals within the last 5 (five) years, starting from the time the doctoral student submits the dissertation writing proposal.
   c. the Promoter must come from UGM with active status and hold a minimum rank of Associate Professor, and must have previously graduated doctoral students.
   d. Co-Promoters can be from outside UGM and must hold a rank of at least Assistant Professor (or equivalent).
   e. for students from institutions that have a cooperation agreement with UGM, one of the Co-Promoters can come from the student's home institution.

I Doctor by Research Program Duration Requirements

The duration requirements for Doctor by Research Program students are as follows:

1. minimum study duration of more than 5 (five) semesters and a maximum of 10 (ten) semesters, which can be extended according to the applicable rules.
2. the study period is calculated from the start of the academic year until the graduation examination.

J Closed Examination

The closed examination for Doctoral program students is as follows:

1. The closed dissertation examination is conducted if the cumulative grade point average is at least 3.25 (three point twenty-five).
2. The closed examination is led by the Dean or their representative.
3. The Closed Examination Committee consists of the Dean or their representative as the chairperson, the Promoter Team, the Dissertation Evaluation Team, and two additional examiners, one of whom comes from outside Universitas Gadjah Mada with expertise relevant to the dissertation topic. The additional examiners must hold at least the rank of Lecturer and have a Doctorate degree.

4. The assessment of the closed dissertation examination results is declared as either pass without revisions, pass with revisions, or fail.
5. The results of the closed dissertation examination are expressed as a numerical score ranging from 3.25 (three point twenty-five) to 4 (four).
6. Students who take the closed examination and are declared as fail can retake the examination once.
7. Conducting the closed examination:
   a. The Dean convenes a closed examination eligibility meeting, attended by the Chair of the relevant Study Program, the Dissertation Evaluation Team, the Promoter Team to determine the dissertation's eligibility, the Closed Examination Committee, and the timing of the Closed Examination.
   b. The complete dissertation manuscript must be received by the Examination Committee no later than 7 (seven) days before the Closed Examination.
   c. If any member of the Dissertation Examination Committee is unable to attend, the closed examination will proceed as scheduled.
   d. The Closed Examination is conducted for 150 minutes, including 30 minutes at the beginning for the candidate to present the key points of the dissertation.
   e. The results of the Closed Examination include:
      1) Pass without revisions.
      2) Pass with revisions, with a maximum revision period of 3 (three) months from the Closed Examination, subject to written approval from the Examination Committee. If not completed, the candidate must retake the Closed Examination.
      3) Fail, with a maximum revision period of 1 (one) year from the Closed Examination. After the revisions are approved by the Promoter Team, the candidate can take a reexamination. If unsuccessful, the candidate is asked to withdraw or is dismissed.
   f. Students who pass the Closed Examination may propose to participate in a Graduation Ceremony or an Open Examination.
   g. An Open Examination is only granted to students with a cumulative grade point average and closed dissertation examination equivalent to a grade higher than 3.50.
   h. The attire for the Examination Committee and the candidate during the Closed Examination is formal civilian attire or at least wearing a tie/long-sleeved batik shirt.

1.9 FACILITIES AND INFRASTRUCTURE

In general, the facilities for conducting the teaching and learning process, reference books, and laboratory equipment are already sufficient. The availability and adequacy of facilities for conducting world-class research publications for Materials Sciences, Computational Sciences, Mathematics, Chemistry, Computer Science, and Physics are excellent. This can be seen from the types of equipment available in each research laboratory (laboratory equipment such as TEM 120 kV, XR Diffractometer, FTIR, and UV-ViS Reflectance, X-ray tomography, etc., as well as hardware and computational programs such as Ferrari computers, Wx Maxima, Miktek, etc.).

The indicator of sufficiency is reflected in the number of international publications that have been successfully conducted and the establishment of research cooperation forums both from institutions within or outside the country. The system needed to maintain and utilize this equipment has already been established, so financially and intellectually, the equipment has high sustainability and can be self-sustaining. In addition, laboratory facilities and service institutions within the UGM environment can be easily accessed for the research needs of all undergraduate, master's, and doctoral students. These laboratories and institutions include the Research and Integrated Service Laboratory (LPPT), the Data and Information Source Center (PSDI), formerly known as the Information and Communication Technology Service Center (PPTIK), INHERENT Project, Postgraduate Library, and others.

For the purpose of exploratory research in various fields of interest to faculty members, the availability and sufficiency of equipment, as outlined above, are already very good. However, it is not denied that for the specific international publication needs in certain fields such as synthesis, analysis, etc., assistance from analytical services, either using equipment from other institutions in Indonesia or abroad, is still required by utilizing advanced equipment as a strength for collaborative research with the principle of mutual symbiosis. In the same way, the leading research equipment available at FMNS UGM can be used by universities throughout the country or other institutions in need. The challenge faced in the process of renewing and adding new equipment lies in the high cost of the equipment. Efforts have been made to obtain funding from DIKTI and grants from abroad.

The availability of classrooms, laboratories, faculty rooms, and research rooms is relatively very good. In 2012, the S2/S3 building with a total building area of 3,750 m^2 was completed with funds from the community, costing around 21 billion rupiahs. The main focus of this building is to facilitate rooms and laboratory equipment for master's and doctoral students, as well as lecture rooms for undergraduate programs. Since August 2012, this building has been used to support the teaching process for undergraduate, master's, and doctoral programs at FMNS UGM. This five-story building is used jointly by the Department of Chemistry (1st floor), Department of Physics (2nd floor), Department of Mathematics (3rd floor), Department of Computer Science and Electronics (4th floor), and shared facilities managed by the faculty (5th floor). In 2002, the Student Internet Center (SIC) building was constructed and has been operational since March 19, 2003. The SIC building is intended as a facility for students of the Faculty of Mathematics and Natural Sciences UGM to work on their course assignments and facilitate internet access as well as IT literacy as intended in the Vision and Mission of FMNS UGM. In addition, the SIC building is also used as a lecture room for doctoral programs, discussion rooms, workspaces for doctoral students, faculty rooms, and the faculty library.

In order to meet national space standards, a Unified Lecture Building (Library, seminar rooms, lecture rooms, and offices) with an area of approximately 6,000 m^2 was built in 2015 with a total budget of around 50 billion rupiahs sourced from the state budget (APBN) and was inaugurated on May 11, 2016. It has been used for teaching in the first semester of 2016/2017. In 2021, the Unified Lecture Building Phase II (auditorium, seminar rooms, lecture rooms, and offices) was built with a total budget of around 63 billion rupiahs. The Unified Lecture Building Phase II was inaugurated on March 16, 2022, and has been used for teaching in the first semester of 2022/2023.

1.10 ACADEMIC QUALITY ASSURANCE

In order to ensure the implementation of education at FMNS UGM to realize the Vision and Mission of FMNS UGM, Goals, and Objectives that meet established quality standards, FMNS conducts the following agenda:

1. Develop a long-term program plan for FMNS UGM that always refers to the Strategic Plan (RENSTRA) of FMNS UGM for the years 2003-2007, 2008-2012, 2013-2017, and subsequently continued as RENSTRA 2017-2022, which has received approval from the Faculty Senate. In its implementation, the points of the RENSTRA are translated into Operational Plans (RENOP) and annual programs in the form of Annual Performance Plans (RKT) and Annual Activity and Budget Plans (RKAT), along with quality standards for implementation.

2. Monitor and evaluate the process of education implementation. The monitoring mechanism is carried out by the Department and study program management through the establishment of the Academic Activity Coordination Team (TK2A) at the department or study program level, as well as the Semester Coordination Team (TKS) within the study program.

To ensure the implementation of the above two points, the Quality Assurance Unit (UJM) has been established at FMNS UGM based on Rector's Decree No. 1619/P/SK/HT/2015. UJM is responsible for the implementation of the Internal Quality Assurance System (SPMI) at the faculty level. SPMI is a systematic activity of higher education quality assurance by the faculty to oversee the provision of higher education by the faculty itself in a sustainable manner. Oversight means "planning," "implementation," "control," and "development/improvement" (PPEPP) of quality standards for higher education as consistently and sustainably determined by the university for stakeholder satisfaction. SPMI is carried out to achieve:

i. compliance with academic policies, academic standards, academic regulations, and academic quality manuals,
ii. assurance that graduates have competencies as determined by each study program,
iii. assurance that each student has a learning experience according to the specifications of the study program, and
iv. relevance of education and research programs to the demands of society and other stakeholders..

In this Internal Quality Assurance System (SPMI), UJM, together with KJM, conducts periodic (annual) internal audits of doctoral study programs to evaluate, correct, and continuously improve. The implementation of SPMI as a form of sustainable quality improvement at the study program level can be presented in the following scheme.

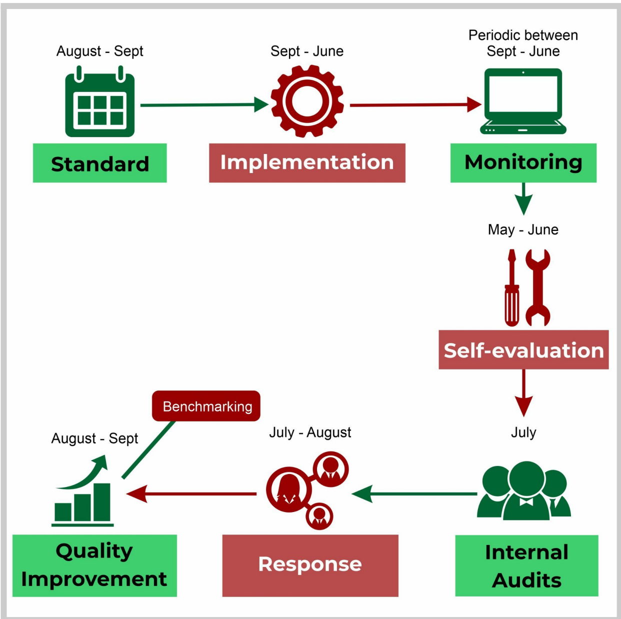

Figure 1.2 Implementation Scheme of Academic Quality Assurance (SPMI)

From the scheme above, it is evident that the faculty-level SPMI cycle can evaluate the implementation of education in accordance with quality standards and promote the continuous improvement of Master's degree programs in FMNS UGM.

1.11 TRANSITIONAL REGULATIONS

1. The 2022 Doctoral Program curriculum is effective starting from the first semester of the 2022/2023 academic year and must be fully followed by students enrolled in 2022 and onwards, and partially by students enrolled before.
2. All courses completed in the old curriculum will be recognized with the corresponding credit hours.

Any matters not covered by these transitional regulations will be accommodated or regulated at the level of the UPPS/individual study programs.

CHAPTER 3 DEPARTMENT OF PHYSICS

3.1 INTRODUCTION

The Department of Physics FMIPA-UGM, previously named Jurusan Fisika FMIPA-UGM was opened in 1955 with only a few teaching staff and several students, then developed rapidly until the formation of the Basic Physics Laboratory, Atomic and Nuclear Physics Laboratory, Solid State Physics Laboratory, Electronics and Instrumentation Laboratory, and Vibration and Wave Laboratory which later developed into a Geophysics Laboratory. In addition to laboratories, the Department of Physics also has workshops as supporting facilities, including Mechanical Workshops, Glass Workshops, Photography Workshops, and Instrumentation Repair and Maintenance Workshops.

Currently, the Department of Physics FMIPA UGM organizes four study programs (Prodi), namely the Physics Undergraduate Program, the Geophysics Undergraduate Program, the Physics Masters Study Program, and the Physics Doctoral Study Program. The Department of Physics has four laboratories, namely the Basic Physics Laboratory, the Atomic and Nuclear Physics Laboratory, the Materials Physics and Electronics Laboratory, and the Geophysics Laboratory. The lecturers at the Department of Physics UGM are grouped into four groups of expertise (KBK): KBK of Theoretical and Computational Physics, KBK of Functional Materials Physics, KBK of Applied Physics, and KBK of Geosciences.

3.2 VISION

The vision of the Department of Physics, Faculty of Mathematics and Natural Sciences UGM is that in 2037 the Department of Physics will become a leading institution on national and international scale that advancing the field of physics and geophysics for the prosperity of the nation imbued with the nation's cultural values based on Pancasila.

3.3 MISSION

The mission of the Department of Physics, Faculty of Mathematics and Natural Sciences UGM is:

1. Enhancing the quality of education in physics and geophysics to meet global standards by incorporating the findings of extensive research.
2. Conducting cutting-edge, creative, and purpose-driven research in the realms of physics and geophysics, primarily for the well-being of the nation and humanity as a whole.
3. Engaging in community service by harnessing extensive research in physics and geophysics to address the challenges faced by the nation and humanity.
4. Establishing enduring resources, organizational structures, governance, and supporting facilities.

3.4 PURPOSE

The goal to be achieved is the realization of the Department of Physics as part of FMIPA UGM to become an excellent department in Indonesia with international achievements and reputation through:

1. An internationally recognized education that spans various fields, emphasizing innovation, soft skills, and backed by cutting-edge information technology. Postgraduate programs form the core, cultivating graduates who are not only physically and morally sound but also self-assured, competitive, pioneering, entrepreneurial, and committed to their nation.
2. Leading, inventive, and purpose-driven research that is ecologically conscious, serves as a global and national benchmark, offering resolutions to local and global challenges. This is achieved by leveraging human and natural resources and indigenous knowledge while engaging with relevant stakeholders.
3. Exceptional and forward-thinking community outreach grounded in expertise, scientific knowledge, and suitable technology within the realms of Physics and Geophysics. This approach promotes self-reliance and lasting community well-being by utilizing the campus as a conduit for introducing scientific and technological breakthroughs to the community. It also involves the implementation of a product development management system to facilitate the dissemination of research findings.
4. The establishment of resources, structures, collaboration, and management that are fair, open, inclusive, and responsible. These are in place to enhance the effectiveness and efficiency of resource allocation, facilitated by an integrated information technology system. This system, in turn, backs the execution of an adaptable education and research process aligned with the principles of Industry 4.0.

3.5 GOALS AND ACHIEVEMENT STRATEGIES

The targets and strategies to achieve the goals of the Department of Physics FMIPA UGM are as follows.

Goals and Achievement Strategies for Goal 1:

An internationally recognized education that spans various fields, emphasizing innovation, soft skills, and backed by cutting-edge information technology. Postgraduate programs form the core, cultivating graduates who are not only physically and morally sound but also self-assured, competitive, pioneering, entrepreneurial, and committed to their nation. Improving the quality of the new student admission system based on academic ability, diversity, independence, and inclusion.

1. Improving the quality of the new student admission system based on academic ability, diversity, independence, and inclusion.
2. Creating and improving the culture of quality education and learning processes.
3. Develop cross-disciplinary education and learning and exposure to global competencies.
4. Making postgraduate education the backbone of the Tridharma of Higher Education.
5. Internationalization of study programs.
6. Improving the spirit of innovation and social entrepreneurship of students.
7. Improving the healthy lifestyle of students.

Goals and Achievement Strategies for Goal 2:

Leading, inventive, and purpose-driven research that is ecologically conscious, serves as a global and national benchmark, offering resolutions to local and global challenges. This is achieved by leveraging human and natural resources and indigenous knowledge while engaging with relevant stakeholders.

1. Develop multidisciplinary research with environmental insight and local values of excellence to provide solutions to the problems of society, nation, and state.
2. Develop innovative research based on cultural wisdom that has a strong impact on the development of science and technology for the benefit of the nation, state, and humanity.
3. Increase research funding capabilities by involving external stakeholders.
4. Improve research institutions and the capacity of research facilities and laboratories.

Goals and Achievement Strategies for Goal 3:

Exceptional and forward-thinking community outreach grounded in expertise, scientific knowledge, and suitable technology within the realms of Physics and Geophysics. This approach promotes self-reliance and lasting community well-being by utilizing the campus as a conduit for introducing scientific and technological breakthroughs to the community. It also involves the implementation of a product development management system to facilitate the dissemination of research findings.

1. Become a strategic partner of the government to increase productivity and welfare based on community driven.
2. Developing the Physics department as a vehicle for the application of science and technology for the wider community.

3. Increasing the reach and quality of community service through the development of entrepreneurship and social care.
4. Building synergy with alumni networks in the regions to strengthen access to community service.
5. Increasing the role of the Physics department as a spring for inspiration for community service.

Goals and Achievement Strategies for Goal 4:

The establishment of resources, structures, collaboration, and management that are fair, open, inclusive, and responsible. These are in place to enhance the effectiveness and efficiency of resource allocation, facilitated by an integrated information technology system. This system, in turn, backs the execution of an adaptable education and research process aligned with the principles of Industry 4.0.

1. Develop an HR admission system.
2. Develop a career system for employees.
3. Health-promoting department.
4. Improve integration in the management and utilization of facilities for service optimization.
5. Increase strategic cooperation to accelerate the development of education, research results, and innovation in science, technology, and culture.
6. Increasing synergism and contribution of alumni in strengthening the Tridharma of higher education.
7. Develop programs to facilitate creativity and synergy of research results that are continued in the process of rotation or incubation.
8. Strengthening a culture of service and superior performance through strengthening bureaucratic reforms.
9. Institutional strengthening to achieve international standard departments.

3.6 FACILITIES AND INFRASTRUCTURE

The Department of Physics has:

1. All lecture rooms and courtrooms are equipped with air conditioning and LCD projectors, and WiFi facilities.
2. All hallways in the Physics Building and the 2nd floor of the S2/S3 Building are equipped with CCTV.
3. Each Lecturer Room, Courtroom, and Student Work Room for Masters and Doctoral programs are equipped with a computer connected to the internet network and WiFi facilities.

4. Laboratory equipment in the Atomic and Nuclear Physics Laboratory includes: Multimeter (AVO METER) Digital / Analog, Digital / Analog Thermometer, Surveymeter, Dosimeter, Binocular Microscope, Sound level meter, LCR Meter, Gauss Meter, Tesla Meter, Oscilloscope, Electrical Photo Effect Equipment unit, Millikan Apparatus, Microwave Gun Diode (Microwave) unit, Michelson Interferometer, TAR (Thermo-Acoustic Refrigerator) unit, Thomson e/m unit, Frank Hertz unit, Electron Spin Resonance (ESR) unit, Atomic Spectroscopy unit; Zeeman Effect unit, Wavelength Meter unit, XRD Apparatus (for practice) unit, GM Counter unit, Alpha Spectroscopy unit, Beta Spectroscopy unit, Gamma Spectroscopy unit, X-ray Spectroscopy unit, Microwave Klystron unit, Raman Spectroscopy unit, Photoluminescence Spectroscopy Unit, UV-VIS Spectrometer, Spin Coater, UTM (Universal Tension Machine), Photoacoustic Laser unit, Digital Radiography (CT Scan) unit, Digital Radiography unit, Tomography unit, Thermoacoustic unit, Spectroscopic Ellipsometry unit, Ray Safe X2 Prestige, Ultrasound Unit And Tomography, Jetson Xavier, Jupyter-hub server, Vacuum Rotary with oil trap, and Acoustic Absorption Coefficient.
5. The list of Material Physics equipment includes Transistor-Kit, Op Amplifier Kit, Logic Gate Kit, Seven Segment Kit, DC Current Circuit Kit, Arduino Kit, Hall effect Kit, Dielectric Kit, Solar Cell Kit, Energy Gap Measurement Kit (bulk), Gap Energy Measurement Kit on LED, Magnetic Susceptibility Test Kit, Computer for computing, Keithley IV Meter, UV Vis Spectrometer, Surface Plasmon Resonance (SPR), Quartz Micro Balance (QCM) Kit, E-Nose Kit, E-Tongue Kit, Electro Spinner, Spin Coater, Centrifuge, Stirrer/Hot Plate, Digital scales, Microwave Oven, Furnace, Microscope, Water Bath, Gaussmeter, pH meter, conductivity meter, Digital Multimeter, Analog Multimeter.
6. The list of main equipment of the Geophysical Laboratory, Department of Physics includes: Gravity Method Survey Tool: Lacoste & Romberg Gravity meter Model G, Magnetic Method Survey Tool: PPM Geotron G5, Fluxgate Magnetometer FGM3D/100, AF Demagnetizer LDA5, Electromagnetic Method Survey Tool: StrataGem EH-4 Magnetotelluric System, T-VLF System IRIS, Electrical Resistivity Method Survey Tool: Resistivity Meter OYO McOHM Mark-2, ARES Resistivity & IP System, Resistivity Meter Naniura NRD-300, Seismic Method Survey Tool: 24 Channels Seismograph DoReMi, Broadband Seismometer Guralp CMG-3T (Merapi Volcano Monitoring), SP Seismometer Lennartz LE-3D/20s, SP Seismometer Lennartz LE-3D/DIN, Seismometer Kinematrics Ranger SS-1, Geological Survey Equipment : Geological Compass and Hammer, SUUNTO Clinometer etc. , Position Survey Tool: GPS Geodetic Altus APS-3, GPS

Mobile Mapper, GPS Geodetic Trimble 4600 SE, Handheld GPS Garmin, Theodolite Manual Topcon, Portable Drone System DJI Mavic Pro, Multipurpose Data Logger, Oscilloscope, Automatic Function Generator, Digital Sound Level Meter, Thermal Sensor, Parallel Computer Device for Geophysical Computing and Modeling, Field Communication Support Device , Field Vehicles.

The Department of Physics occupies:

1. Physics Building with an area of 8,100 m^2 for the Secretariat Room of Departments and Study Programs, Seminar Rooms, Laboratories, Student Workspaces, and Lecturer Rooms.
2. One floor in the S2 / S3 Building with an area of 4,480 m^2 for the Master's Study Program lecture hall, seminar room, and master and doctoral study program student workspace.
3. The 3rd-floor FMIPA Lecture Building will be used by the Physics department for the development of research and innovation in Physics department with an area of 782 m^2.

3.7 QUALITY ASSURANCE

The Department of Physics conducts internal and external quality assurance based on the principles of PDCA (Plan-Do-Check-Action) or PPEPP (Establishment-Implementation – Evaluation – Control – Improvement). The Internal Quality Assurance System (SPMI) follows the quality assurance system at the Faculty level which is carried out annually. SPMI at the Department level is implemented with the formation of a Semester Coordination Team (TKS) whose members consist of the head of the curriculum committee, representatives of study program administrators, KBK coordinators, and students of each batch. TKS meetings are scheduled at least once a semester. The results of the TKS are discussed in a plenary meeting of the department to then be used as an evaluation for improvement.

3.8 FACULTY

The teaching staff of the Department of Physics is as follows:

No.	Name	Functional Positions	Areas of Expertise
1	Agung Bambang Setio Utomo, S.U., Dr., Prof.	Professor	Laser Spectroscopy
2	Sismanto, M.Si., Dr., Prof.	Professor	Exploration Geophysics
3	Harsojo, S.U., M.Sc., Dr., Prof.	Professor	Material Physics
4	Gede Bayu Suparta, Drs., M.S., Ph.D., Prof.	Professor	Imaging Physics

No.	Name	Functional Positions	Areas of Expertise
5	Kuwat Triyana, M.Si., Dr.Eng., Prof.	Professor	Materials and Instrumentation Physics
6	Yusril Yusuf, S.Si., M.Si., M.Eng., Ph.D., Prof.	Professor	Material Physics
7	Pekik Nurwantoro, Drs., M.S., Ph.D.	Associate Professor	Computational Physics
8	Wahyudi, M.S., Dr.	Associate Professor	Volcano Geophysics
9	Moh. Ali Joko Wasono, M.S., Dr.	Associate Professor	Laser Spectroscopy
10	Arief Hermanto, Drs., S.U., M.Sc., Dr.	Associate Professor	Cosmology and Astrophysics
11	Bambang Murdaka Eka Jati, M.S., Dr.	Associate Professor	Medical Physics
12	Muhammad Farchani Rosyid, M.Si., Dr.rer.nat.	Associate Professor	Mathematical Physics
13	Mitrayana, S.Si., M.Sc., Dr.	Associate Professor	Laser Spectroscopy
14	Rinto Anugraha NQZ, S.Si., M.Si., Dr.Eng.	Associate Professor	Sociophysics
15	Edi Suharyadi, S.Si., M. Eng., Dr.Eng.	Associate Professor	Material Physics
16	Fahrudin Nugroho, S.Si., M.Si., Dr.Eng.	Associate Professor	Complex Systems
17	Juliasih Partini, S.Si., M.Si., Dr.	Associate Professor	Metamaterial
18	Moh. Adhib Ulil Absor, S.Si., M.Sc., Ph.D.	Associate Professor	Computational Condensed Matter Physics
19	Sholihun, S.Si., M.Sc., Ph.D.	Associate Professor	Computational Condensed Matter Physics
20	Budi Eka Nurcahya, M.Si., Dr.	Assistant Professor	Exploration Geophysics
21	Wiwit Suryanto, S.Si., M.Si., Dr.rer.nat.	Assistant Professor	Seismology
22	Mochamad Nukman, S.T., M.Sc., Dr.rer.nat.	Assistant Professor	Tectonic-Geothermal
23	Romy Hanang Setya Budhi, S.Si., M.Sc., Ph.D.	Assistant Professor	Cosmology and Astrophysics
24	Chotimah, M.S., Dr.	Assistant Professor	Material Physics
25	Eko Sulistya, M.Si., Dr.	Assistant Professor	Instrumentation Physics
26	Ari Setiawan, M.Si., Dr.Ing.	Assistant Professor	Inversion-Gravity
27	Dwi Satya Palupi, S.Si., M.Si., Dr.	Assistant Professor	Econophysics
28	Mirza Satriawan, S.Si., M.Si., Ph.D.	Assistant Professor	Particle Physics
29	Sudarmaji, S.Si., M.Si., Dr.	Assistant Professor	Computational Geophysics

No.	Name	Functional Positions	Areas of Expertise
30	Eddy Hartantyo, M.Si., Dr.	Assistant Professor	Near-surface Geophysics
31	Iman Santoso, S.Si., M.Sc., Dr.	Assistant Professor	Computational-Spectroscopical Condensed Matter Physics
32	Ari Dwi Nugraheni, S.Si., M.Si., Dr.Sc.	Assistant Professor	Biophysics
33	Ahmad Kusumaatmaja, S.Si., M.Sc., Dr.Eng.	Assistant Professor	Materials and Instrumentation Physics
34	Herlan Darmawan, M.Sc., Dr.rer.nat.	Assistant Professor	Aero geophysics
35	Afif Rakhman, S.Si., M.T., Dr.	Assistant Professor	Geophysical Instrumentation

3.9 DOCTORAL PROGRAM IN PHYSICS

A Introduction

The implementation of the Postgraduate Program in Physics began with the establishment of the master's program which began to open in 1981 with Prof. Dr. Prayoto, M.Sc. as the manager and the first student as many as 3 people. Over time, it was felt necessary to develop by increasing the level of education that could be held, namely at the doctoral level.

Decree of the Higher Education Number **580 / Dikti / Kep /** 1993 dated September 23, 1993, is a decree for the establishment of the Master's Program in Physical Sciences and a Doctoral Program in Mathematics and Natural Sciences Study Program. So the Doctor of Physical Sciences program is part of the doctoral in Mathematical Sciences and Natural Sciences.

Based on the Rector's Decree Number 89 / P / SK / HT / 2006 dated March 9, 2006, the Post-UGM Program is divided into 2 programs, namely Monodisciplinary and Multidisciplinary. The Doctoral Program in Physical Sciences includes a Monodisciplinary Study Program whose curriculum comes from one field of science organized and managed by the relevant Faculty. Starting from the 2006/2007 academic year, all management and administration are carried out by the Faculty of Mathematics and Natural Sciences.

The Physics Doctoral Study Program is held to help the government in developing education and research in the field of Physics. The implementation of the Physics Doctoral Study Program is supported by the existence of 4 laboratories under the management of the Department of Physics, namely the Atomic and Nuclear Physics Laboratory, Material Physics and Instrumentation Laboratory, Geophysics Laboratory, and Basic Physics Laboratory, as well as LPPT, the central Laboratory that is managed by the university. Supported by 35 lecturers, the Physics Doctoral Study Program manages and educates 50 students per year (*student body*).

Since 2021, the S3 Physics Study Program has changed its name to the Physics Doctoral Study Program. For quality assurance, the UGM Physics Doctoral Study Program is annually audited by the UGM Quality Assurance Office through Internal Quality Audit (AMI) and every 5 years is accredited by the National Accreditation Board for Higher Education (BAN-PT). Until 2022, the UGM Physics Doctoral Study Program has received an A accreditation rating.

Since the enactment of the Rector's Decree Number 18 of 2019 concerning the Implementation of Research-based Postgraduate (Master and Doctoral) Programs (Research), the Physics Doctoral Study Program FMIPA UGM has organized a research-based Doctoral program (*by Research*).

B Vision

The vision of the Physics Doctoral Program at the Faculty of Mathematics and Natural Sciences UGM is that in 2037 it will evolve into a globally renowned doctoral program in physics, distinguished for its innovation and excellence across a spectrum of academic endeavors. This program will also generate highly skilled and accomplished physics doctoral graduates who can take pride in their accomplishments, receiving international recognition.

C Mission

The mission of the Physics Doctoral Program at the Faculty of Mathematics and Natural Sciences UGM is

1. Organizing quality Doctoral program education, which can produce graduates with the ability to organize education and research.
2. Organizing a mentoring and mentoring process that can help students in carrying out quality physics activities.
3. Improving Networks with educational institutions and industries on a national and international scale.
4. Improve the ability to publish research results in the field of physics both orally and in writing at the national and international levels.

D Educational Objectives

The objectives of organizing the Physics Doctoral Study Program are:

1. produce a doctor of Physics who is devoted to God Almighty, and has integrity and dedication,
2. updating the latest, most advanced, and leading physics models to solve science and technology problems in the relevant field of physics,
3. increasing the number of cooperation in the Tri Dharma of Higher Education on a national and international scale,
4. Producing tested original scientific work related to the deepening or expansion of physics science through research with an inter-, multi-, or interdisciplinary approach.

E Curriculum Objectives

For the period 2022-2027, the targets to realize the vision, mission, and objectives of the Physics Doctoral Study Program are as follows:

The realization of research-based learning, both fundamental and applied. Research-based learning means that:

a) learning content is always related to the development of research results or gives direction to the development of research in related fields,
b) Students are involved in research carried out by lecturers. Such involvement is expected to be able to provide provisions and train students to be able to solve problems that will be faced in the real world in society and to prepare them to work as academics and researchers.

   Improved international reputation in academia. International reputation is related to recognition by the international world. International reputation in the field of education means international recognition of our graduates or the use of our study programs by the international community as an option for continuing education. International reputation can also be seen from the increase in international reputable publications produced by students and contribute color to the development of existing research.

   Increased international cooperation. The increase in international cooperation networks is closely related to the improvement of international reputation, namely supporting each other. The establishment of international cooperation can be viewed as a recognition of the international reputation of the institution and, conversely, the existence of international cooperation can enhance the international reputation.

F Basic Curriculum Preparation 2022

After going through a process of in-depth evaluation and analysis of various aspects including the implementation of the teaching and learning process based on the 2017 curriculum, the development of physical science with its various branches, the development of expertise in the field of Physics pursued and mastered by lecturers in the Department of Physics who teach in the Physics Doctoral study program, the suitability and harmony of courses at the undergraduate and postgraduate levels, the development of the world of work that will absorb graduates of the Doctoral Physics study program, and the development of the demands of modern life, a new curriculum was compiled for the Doctor of Physics study program which is a refinement of the previous curriculum. Basic Preparation and direction of curriculum change based on:

1. Law Number 12 of 2012 concerning Higher Education.
2. Decree of the Minister of Education and Culture Number 3 of 2020 concerning National Standards for Higher Education.
3. Presidential Regulation Number 8 of 2012 concerning the Indonesian National Qualifications Framework (KKNI).

4. Rector Regulation of Gadjah Mada University Number 14 of 2020 concerning the Basic Framework of the Curriculum of Gadjah Mada University.
5. Rector Regulation of Gadjah Mada University Number 18 of 2019 concerning the Implementation of Research-Based Postgraduate Programs (*by Research*) within Gadjah Mada University.
6. Rector Regulation of Gadjah Mada University Number 11 of 2016 concerning Postgraduate Education.
7. Curriculum document of the Doctoral Program of FMIPA UGM in 2017.
8. Addendum to the curriculum document of the Doctoral Program of FMIPA UGM in 2021.
9. Results of Internal Quality Audit (AMI) during the period 2017 – 2021.
10. The results of the evaluation of the Semester Coordination Team (TKS) for the 2017 – 2021 period.
11. The results of tracking graduates (*tracer study*) and input from *stakeholders* (graduate users, the *Physical Society of* Indonesia (PSI), industry, etc.).

G Graduate Professions/Jobs

Based on the results of tracking graduates who have been carried out by graduates of the UGM Physics Doctoral Study Program (PSMF), they are known to have professions in several fields as follows:

1. Educators in educational institutions
2. Researchers in government, private, and independent agencies,
3. Consultant
4. Bureaucrats, and
5. Entrepreneur.

H Graduate Profile

Based on this profession, it is determined that the profile of PSMF UGM graduates has three main profiles, namely:

1. Educator (Profile 1)
2. Researcher (Profile 2)
3. Consultants, Bureaucrats, and Entrepreneurs (Profile 3).

The detailed description of each graduate profile is described below:

Educator: Have a deep mastery of Physics science, able to teach well, able to conduct research independently and able to present research results well, and ready to continue studies to the Doctoral level.

Researcher: Have an in-depth mastery of Physics science, able to conduct research independently and able to present research results well, and ready to continue studies to the Doctoral level.

Consultants, Bureaucrats, and Entrepreneurs: Have a deep mastery of Physics science, able to apply their scientific understanding to various problems in society related to Physics.

I Graduate Learning Outcomes

Graduate Learning Outcomes (PLO) *programs* are given as follows:

PLO-1: Attitudes and Values

Have a commendable attitude, and ethics as a scientist, which include:

a) be devoted to God Almighty and be able to show a religious attitude;
b) upholding human values in carrying out duties based on religion, morals, and ethics;
c) contribute to improving the quality of life in society, nation, state, and advancement of civilization based on Pancasila;
d) acting as citizens who are proud and love the motherland, have nationalism and a sense of responsibility to the state and nation;
e) respect the diversity of cultures, views, religions, and beliefs, as well as the original opinions or findings of others;
f) work together and have social sensitivity and concern for the community and the environment;
g) obeying the law and discipline in social and state life;
h) internalizing academic values, norms, and ethics;
i) demonstrate an attitude of responsibility for work in their field of expertise independently; and
j) internalizing the spirit of independence, struggle, and entrepreneurship.

PLO-2: Professional Attitude

a) Able to compile scientific, technological, or artistic arguments and solutions based on a critical view of facts, concepts, principles, or theories that can be scientifically and ethically accountable, and communicate through mass media or directly to the public;
b) able to demonstrate academic leadership in the management, development, and coaching of resources and organizations under their responsibility;
c) able to develop and maintain collegial and peer relations within one's environment or through collaborative networks with research communities outside the institution;

d) able to adapt to failures, and difficulties that arise unexpectedly in conducting research or development projects.

PLO-3: Mastery of Physics Science

Mastering the scientific philosophy of physics; Mastering the current, most advanced, and leading issues (*recent/latest*, *advanced, and frontier*) in the application of multidisciplinary theories relevant to the scientific development of physics.

PLO-4: Specific Physics Subfield Expertise

Mastering the scientific development of a specific/certain physics subfield to the level of the latest development (*state of the art*).

PLO-5: Research and Problem-Solving Capabilities

a) Able to find or develop new scientific theories/conceptions/ideas, contribute to the development and practice of science and/or technology that pays attention to and applies humanities values in their fields of expertise, by producing scientific research based on scientific methodology, logical, critical, systematic, and creative thinking;
b) able to choose research that is appropriate, current, most advanced, and provides benefits to mankind through an interdisciplinary, multidisciplinary, or transdisciplinary approach, to develop and/or produce problem-solving in the fields of science, technology, art, or society, based on the results of studies on the availability of internal and external resources;
c) able to develop a research roadmap with an interdisciplinary, multidisciplinary, or transdisciplinary approach, based on a study of the main research objectives and their constellations on broader targets.

PLO-6: Communication Skills and Publication Skills

a) Able to communicate and discuss orally and in writing the results of the studies conducted.
b) Able to compile interdisciplinary, multidisciplinary, or transdisciplinary research, including theoretical studies and/or experiments in the fields of science, technology, art, and innovation as outlined in the form of a dissertation, and papers that have been published in reputable international journals.
c) Able to manage, including storing, auditing, securing, and recovering data and information on research results that are under their responsibility.

J Field / Material of Study

Regarding the formulation of graduate profiles; Learning Outcomes *(Program Learning Outcomes* - PLO) that have been formulated above; as well as paying attention to recommendations and *benchmarks* with several similar study programs in several universities, it is determined that the fields of study of the Physics Doctoral Study Program are as follows:

a) Theoretical and Computational Physics
b) Material Physics
c) Applied Physics
d) Geophysics
e) Research Methods

Map / Matrix / Table of Attachment between MKW and MKP with Field / Material of Study, PLO, and Graduate Profile

The graduate learning outcomes (PLO) that will be realized for each graduate profile can be seen in **Table 3.1.** All graduate profiles have all graduate learning outcomes, but the intensity of a PLO varies between one graduate profile and another. The relationship between PLO in the Physics Doctoral Study Program and cognitive, affective, and psychomotor aspects is presented in **Table 3.2.**

Table 1. 1 Graduate and PLO Profile Map

Learning Outcomes		Profile 1	Profile 2	Profile 3
PLO-1	Attitudes and Values	S	S	S
PLO-2	Professional Attitude	S	S	S
PLO-3	Mastering Physics Science	S	S	M
PLO-4	The ability of Certain Physics Sub-fields	S	S	W
PLO-5	Research and Problem-Solving Skills	S	S	S
PLO-6	Communication Skills and Publication Ability	S	S	S

Description: S: Strong, M: Medium, W: Weak

Table 1. 2 Map of the Linkage of Learning and Cognitive, Affective, and Psychomotor Outcomes

Learning Outcomes		Cognitive (*Knowledge*)	Affective (*Attitude*)	Psychomotor (*Skills*)
PLO-1	Attitudes and Values	✔	✔	
PLO-2	Professional Attitude		✔	✔
PLO-3	Mastery of Physics Science	✔	✔	
PLO-4	The ability of Certain Physics Sub-fields	✔		
PLO-5	Research and Problem-Solving Skills	✔	✔	✔
PLO-6	Communication Skills and Publication Ability	✔	✔	✔

Table 1. 3 Map of the Linkage of Graduate Learning Outcomes (PLO) with Bloom's Taxonomy

	PLO-1	PLO-2	PLO-3	PLO-4	PLO-L5	PLO-6
C1						
C2						
C3	✔	✔	✔	✔	✔	✔
C4			✔	✔	✔	✔
C5			✔	✔	✔	✔
C6			✔	✔	✔	✔

Information:

C1: Knowing C2: Understanding C3: Applying

C4: Analyzing C5: Synthesizing C6: Evaluating

The fields of study that have been compiled and determined by the Physics Doctoral Study Program are then described in more detail in various courses to support the realization of PLO. The grouping of courses into fields of study that have been determined in the Physics Doctoral Study Program along with the PLO map is given in **Table 3.4.**

Table 1. 4 Map of the Relationship between Course Study Materials and Graduate Learning Outcomes (PLO)

Study Materials	Courses		PLO-1	PLO-2	PLO-3	PLO-4	PLO-5	PLO-6
Research Methods	MFF 7001	Research Methodology and Writing Scientific Papers	5	5	3	5	5	5
	MFF 8001	Dissertation	5	5	5	5	5	5
	MFF 8002	Dissertation by Research	5	5	5	5	5	5
Applied Physics	MSF 7430	Acoustics	1	2	4	3	2	2
	MSF 7301	Laser Spectroscopy	1	2	5	3	2	2
	MSF 7302	Spectroscopic Instrumentation	1	2	5	3	2	2
	MSF 7872	Special Topics in 3D Imaging	1	2	5	3	2	2
	MSF 7871	Medical Physics	1	2	5	3	2	2
	MFF 7303	Atomic and Molecular Spectroscopy	1	2	3	5	2	2
	MFF 7873	Physics of Imaging Instrumentation	1	2	3	5	2	2
	MFF 7874	Special Topics in Non-Destructive Test	1	2	3	5	2	2
Theoretical and Computational Physics	MFF 7021	Special Topics in Stochastic Processes for Physicists	1	2	3	5	2	2
	MFF 7111	Special Topics in Particle and Field Physics	1	2	3	5	2	2
	MFF 7971	Special Topics in Astrophysics	1	2	3	5	2	2
	MFF 7042	Special Topics in the Theory of Relativity	1	2	3	5	2	2
	MFF 7023	Special Topics in Functional Analysis for Physics	1	2	3	5	2	2
	MFF 7025	Special Topics in Topology and Differential Geometry for Physicists	1	2	3	5	2	2
	MFF 7027	Special Topics in Stochastic Computational Physics	1	2	5	3	2	2
	MFF 7026	Special Topics in Computational Physics	1	2	5	3	2	2

Material Physics	MFF 7600	Condensed Matter Physics	1	2	5	3	2	2
	MFF 7750	Electromagnetic Material	1	2	5	3	2	2
	MFF 7810	Special Topics in Sensor Systems	1		5	5	5	5
	MFF 7811	Special Topics in Materials Physics	1		5	5	5	5
	MFF 7813	Special Topics in Computational Material Physics	1	2	3	5	2	2
	MFF 7070	Special topics in Instrumentation Physics	1		5	5	5	5
	MFF 7814	Functional Materials	1		5	5	5	5
Geophysics	MFF 7930	Digital Signal Analysis	1	2	3	5	2	2
	MFF 7931	Deformation and Gravity	1	2	5	3	2	2
	MFF 7932	Special Topics in Geodynamics	1	2	3	5	2	2
	MFF 7933	Special Topics in Inversion Method	1	2	3	5	2	2
	MFF 7911	Advanced Quantitative Seismology	1	2	3	5	2	2
	MFF 7912	Special Topics in Seismology	1	2	3	5	2	2
	MFF 7913	Earthquake Hazard Analysis	1	2	3	5	2	2
	MFF 7934	Special Topics in Rock Physics	1	2	3	5	2	2
	MFF 7914	Micro seismic Analysis	1	1	3	5	3	3
	MFF 7915	Computational Seismology	1	2	3	5	2	2
	MFF 7935	Advanced Volcanic Physics	1	2	3	5	2	2
	MFF 7400	Special Topics in Electromagnetics	1	2	3	5	2	2
	MFF 7916	Special Topics in Geothermal	1	2	3	5	2	2
	MFF 7917	Special Topics in Geoelectric Method	1	2	3	5	2	2
	MFF 7918	Special Topics in Geology	1	2	3	5	2	2
	MFF 7901	Special Topics in Geography	1	2	3	5	2	2
	MFF 7919	Special Topics in Geophysical Numerical Methods	1	1	5	4	2	2

K List of Compulsory Courses (MKW) per Semester

Compulsory courses that must be taken by Doctoral students are:

1. MFF 7001, Research Methodology and Writing Scientific Papers: 3 credits
2. MFF 8001, Dissertation (34 credits)
   - Comprehensive Exam: 4 credits
   - Research Performance Seminar I: 3 credits
   - Research Performance Seminar II: 3 credits
   - Regular Scientific Publications: 12 credits
   - Dissertation Manuscript: 6 credits
   - Dissertation Exam: 6 credits
3. MFF 8002, Dissertation *By Research* (40 credits) consisting of:
   - Comprehensive Exam: 4 credits
   - Research Performance Seminar I: 3 credits
   - Research Performance Seminar II: 3 credits
   - Scientific Publications *By Research*: 18 credits
   - Dissertation Manuscript: 6 credits
   - Dissertation Exam: 6 credits

All courses (both compulsory and elective courses) are offered each semester.

L List of Elective Courses (MKP) per Semester

The following are elective courses taken by Doctoral program students whose fields of study are according to their interests and the appropriate KBK:

Table 1. 5 List of Elective Courses

KBK	Code	Credits	Course Name
Applied Physics	MFF 7430	3	Acoustics
	MFF 7301	3	Laser Spectroscopy
	MFF 7302	3	Spectroscopic Instrumentation
	MFF 7872	3	Special Topics in 3D Imaging
	MFF 7871	3	Medical Physics
	MFF 7303	3	Atomic and Molecular Spectroscopy
	MFF 7873	3	Physics of Imaging Instrumentation
	MFF 7874	3	Special Topics in Non-Destructive Test
Theoretical and Computational Physics	MFF 7021	3	Special Topics in Stochastic Processes for Physicists
	MFF 7111	3	Special Topics in Particle and Field Physics
	MFF 7971	3	Special topics in Astrophysics
	MFF 7042	3	Special Topics in the Theory of Relativity
	MFF 7023	3	Specific topics in Functional Analysis for Physics
	MFF 7025	3	Special Topics in Topology and Differential Geometry for Physicists
	MFF 7027	3	Special Topics in Stochastic Computational Physics
	MFF 7026	3	Special Topics in Computational Physics

KBK	Code	Credits	Course Name
Functional Material Physics	MFF 7600	3	Condensed Matter Physics
	MFF 7750	3	Electromagnetic Materials
	MFF 7810	3	Special Topics in Sensor Systems
	MFF 7811	3	Special Topics in Materials Physics
	MFF 7813	3	Special Topics in Material Computational Physics
	MFF 7070	3	Special topics in Instrumentation Physics
	MFF 7814	3	Functional Materials
Geosciences	MFF 7930	3	Digital Signal Analysis
	MFF 7931	3	Deformation and Gravity
	MFF 7932	3	Special Topics in Geodynamics
	MFF 7933	3	Special Topics in Inversion Method
	MFF 7911	3	Advanced Quantitative Seismology
	MFF 7912	3	Special Topics in Seismology
	MFF 7913	3	Earthquake Hazard Analysis
	MFF 7934	3	Special Topics in Rock Physics
	MFF 7914	3	Micro Seismic Analysis
	MFF 7915	3	Computational Seismology
	MFF 7935	3	Advanced Volcano Physics
	MFF 7400	3	Special Topics in Electromagnetics
	MFF 7916	3	Special Topics in Geothermal
	MFF 7917	3	Special Topics in Geoelectric Method
	MFF 7918	3	Special Topics in Geology
	MFF 7901	3	Special Topics in Geography
	MFF 7919	3	Special Topics in Geophysical Numerical Methods

Each course in **Table 3.5** has a Course *Outcome* (CO) found in the syllabus.

M Transitional Regulations

1. The new curriculum is implemented starting in the first semester of the 2022/2023 academic year and must be followed in full by students of the class of 2022 and partly by students of the previous batch.
2. For all courses that have been completed in the old curriculum, the grades of those courses are still recognized with the credits attached to the course.
3. Compulsory courses in the old curriculum can become elective courses if the equivalent courses in the 2022 Curriculum change to non-compulsory courses.
4. The repetition of a course in the old curriculum is carried out by taking its equivalent course in the 2022 Curriculum, then the recognized course is determined by the student himself, with the grades and number of credits attached to it.
5. Matters that have not been covered by this transitional regulation, are accommodated and handled by the Doctoral Study Program in Physics.
6. The provisions in this transitional regulation only apply to students of the class of 2021/2022 and before.

N Course Equivalence

1. Courses in the 2017 Curriculum that have the same code and name as the courses in the 2022 Curriculum are equivalent and are not shown in the Course Equivalence table in **Table 3.6.**
2. The courses from the 2017 and 2022 Curricula contained in the Equality table in **Table 3.6** are equivalent, and the two equivalent courses must not be in the transcript for the judiciary.
3. Students who take two equivalent courses from two different curricula must choose one of the courses that they will remove when filing the judiciary.

Table 1. 6 Course Equivalence

	Curriculum 2017			Curriculum 2022		
No	Code	Course Name	Credits	Code	Course Name	Credits
1	MFF7000	Research Methodology	3	MFF7001	Research Methodology and Writing of Scientific Papers	3
2	-	-		MFF8002	Dissertation By Research	40
3	MFF 7872	Tomography Physics	3	MFF7882	Special Topics in 3D Imaging	3
4	MFF 7874	Undamaged Test	3	MFF7883	Special Topics in Non-Destructive Test	3
5	MFF 7027	Stochastic Computational Physics	3	MFF7037	Special Topics in Stochastic Computational Physics	3
6	MFF 7026	Computational Physics	3	MFF7036	Special Topics in Computational Physics	3
7	MFF 7913	Earthquake Hazard Analysis	3	MFF7923	Earthquake Hazard Analysis	3
8	MFF 7914	Analyzes Mikroseismik	3	MFF7924	Microseismic Analysis	3
9	MFF 7915	Computational Seismology	3	MFF7925	Computational Seismology	3
10	MFF 7916	Geothermal Special Topics	3	MFF7926	Special Topics in Geothermal	3
11	MFF 7936	Finite Element for Geophysics	3	-	-	-
12	-	-	-	MFF 7919	Special Topics in Geophysical Numerical Methods	3

O Learning Methods

The learning method follows the rules of the faculty. Examples of study plans for students of the Doctoral Program in Physics can be seen in Table 3.7 and the path by *Research* can be seen in Table 3.8, while a summary of the study load for each program is presented in **Table 3.9.**

Table 1. 7 Curriculum Map of Regular Track Physics Doctoral Study Program

No	Semester	Study and Research Process	Total Credits	Code	Courses	Credits	Note
1.	I	Lecture	12	MFF7001	Research Methodology and Writing Scientific Papers	3	Perkuliahan - for Options 1, 2, and 3 depending on the student's research topic and taken on the recommendation of the supervisor
					Option 1	3	
					Option 2	3	
					Option 3	3	
2.	II	Preparation of Proposals and Research Activities	7	MFF8001-Dissertation	Comprehensive Exam	4	
					Research Performance Seminar I	3	
3.	III	Research and Publications	3		Research Performance Seminar II	3	
4.	IV	Research and Publications	12		Regular Scientific Publications	12	Attaching Journal Indexation
5.	In	Preparation and Assessment of Dissertations	6		Dissertation Manuscript	6	Assessment of the dissertation manuscript
6.	WE	Dissertation Assessment and Examination	6		Dissertation Exam	6	Closed Exam
	Total credits (minimum)		46			46	

Description:

- Scientific publications in the form of international journals indexed in the international database Scopus or WOS or equivalent.
- In Scientific Publications, the first author is a student, and the *corresponding author* is a supervisor from the UGM physics doctoral study program.

Table 1. 8 Curriculum Map of Doctoral Study Program in Physics Path *by Research*

No	Semester	Study and Research Process	Total Credits	Code	Courses	Credits	Note
1	I	Lecture	6	MFF7001	Research Methodology and Writing Scientific Papers	3	Lectures – for Option 1 depending on the student's research

No	Semester	Study and Research Process	Total Credits	Code	Courses	Credits	Note
					Option 1	3	topic, and are taken on the recommendation of the supervisor
2	II	Preparation of Proposals and Research Activities	7	MFF8002-Dissertation	Comprehensive Exam	4	
					Research Performance Seminar I	3	
3	III	Research and Publications	3		Research Performance Seminar II	3	
4	IV	Research and Publications	18		Scientific Publications *by Research*	18	Attaching Journal Indexation
5	In	Preparation and Assessment of Dissertations	6		Dissertation Manuscript	6	Assessment of the dissertation manuscript
6	WE	Dissertation Assessment and Examination	6		Dissertation Exam	6	Closed Exam
	Total credits (minimum)		46			46	

Description:

- Scientific publications in the form of reputable international journals are indexed in the international database Scopus or WOS or equivalent and have an impact factor.
- In Scientific Publications, the first author is a student, and the *corresponding author* is a supervisor from the UGM physics doctoral study program.

Table 1. 9 Study Load Summary

Regular Doctoral Program (Rector's Decree Number 11 of 2016, article 52)	**Program Doktor *by Research*** (Rector's Decree of Doctoral *Program by Research* Number 18 of 2019)
Lectures: 12 credits Dissertation: 34 credits	Lectures: 6 credits Dissertation: 40 credits
Total Study Load: 46	Total Study Load: 46

P Assessment Methods

Assessment Methods follow faculty rules. Especially for the dissertation, the assessment method follows **Table 3.10.**

Table 1. 10 Details of Dissertation Credits

<table>
<tr><th>No</th><th>Components (weights)</th><th>Minimum assessment criteria</th><th>Assessment</th></tr>
<tr><td rowspan="2">1</td><td>Comprehensive Exam (4 credits)</td><td>1. Mastery of theories and concepts in their field is shown in problem formulation and literature review.
2. Originality and potential contribution to the discipline of science.
3. Mastery of research methods.
4. Quality of writing.</td><td>Comprehensive testing team (study program/department administrators, promoter team, and proposal assessment team).</td></tr>
<tr><td colspan="3">Comprehensive exam assessment form:
<table>
<tr><th>No.</th><th>Rubric</th><th>Value</th></tr>
<tr><td>1</td><td>Mastery of theories and concepts in their field indicated in problem formulation and literature review</td><td>0.00 – 4.00</td></tr>
<tr><td>2</td><td>Originality and potential contribution to the discipline of science</td><td>0.00 – 4.00</td></tr>
<tr><td>3</td><td>Mastery of research methods</td><td>0.00 – 4.00</td></tr>
<tr><td>4</td><td>Writing quality</td><td>0.00 – 4.00</td></tr>
</table></td></tr>
<tr><td rowspan="2">2</td><td>Research Performance (6 credits)</td><td>1. Discipline and hard work
2. Mastery of data processing
3. Communication and cooperation
4. Independence in problem-solving.</td><td>Promoter team (assessment has been given at the time of submitting the Dissertation Eligibility draft)</td></tr>
<tr><td colspan="3">Research Performance consists of 2 courses, namely: Research Performance Seminar I (3 credits) and Research Performance Seminar II (3 credits), and is assessed by the promoter team (Table 3.10).
<table>
<tr><th>No.</th><th>Rubric</th><th>Value</th></tr>
<tr><td>1</td><td>Discipline and hard work</td><td>0.00 – 4.00</td></tr>
<tr><td>2</td><td>Mastery of data processing</td><td>0.00 – 4.00</td></tr>
<tr><td>3</td><td>Communication and cooperation</td><td>0.00 – 4.00</td></tr>
<tr><td>4</td><td>Independence in problem-solving</td><td>0.00 – 4.00</td></tr>
</table></td></tr>
<tr><td rowspan="2">3</td><td>Disertasi manuscript (6 credits)</td><td>1. Explanation, contextualization, and articulation of the problem and objectives of the study.
2. Review of relevant literature.
3. Formulation, development, and explanation of relevant background theories.
4. Methodology, design, and implementation.
5. Testing, results, analysis, and evaluation of results.
6. The structure of writing and organization of the dissertation.</td><td>Dissertation manuscript assessment team. (Outside the Promoters Team) (Maximum 1 month).</td></tr>
<tr><td colspan="3">Dissertation Manuscript Assessment Form:
<table>
<tr><th>No.</th><th>Rubric</th><th>Value</th></tr>
<tr><td>1</td><td>Explanation, contextualization, and articulation of the problem and the objectives of the study</td><td>0.00 – 4.00</td></tr>
<tr><td>2</td><td>Review of relevant literature</td><td>0.00 – 4.00</td></tr>
</table></td></tr>
</table>

No	Components (weights)	Minimum assessment criteria	Assessment

3	Formulation, development, and explanation of relevant background theories	0.00 – 4.00
4	Methodology, design, and implementation	0.00 – 4.00
5	Testing, results, analysis, and evaluation of results	0.00 – 4.00
6	The structure of writing and organization of the dissertation	0.00 – 4.00

No	Components (weights)	Minimum assessment criteria	Assessment
4	**Scientific Publications: Regular (12 credits)/ *by Research* (18 SKS)**	1. Journal reputation, 2. Conference reputation, 3. The quality of the manuscript includes: ● originality/novelty of the topic, ● research methods, ● presentation of data and discussion, ● Grammar.	Dissertation manuscript assessment team and publication.

Scientific Publication Manuscript Assessment Form:

Rubric	Value
Journal reputation: International journal: 3.25 ≤ < score of 3.50 Reputable international journals Q3, Q4, or equivalent: 3.50 ≤ a < value of 3.75 Reputable international journals Q1, Q2 or equivalent: 3.75 ≤ a value of ≤ 4.00	3.25 – 4.00

No	Components (weights)	Minimum assessment criteria	Assessment
5	**Closed dissertation exam (6 credits)**	1. Presentation 2. reasoning and 3. mastery of the material	Closed examination examiner team (Chairman of the session, promoter team and dissertation assessment team, and additional examiners).
	Closed Dissertation Examination Assessment organized by the faculty		

Q Quality Assurance System

The Department of Physics conducts internal and external quality assurance based on the principles of PDCA (Plan-Do-Check-Action) or PPEPP (Establishment-Implementation – Evaluation – Control – Improvement). The Internal Quality Assurance System (SPMI) follows the quality assurance system at the Faculty level which is carried out annually. SPMI at the Department level is implemented with the formation of a Semester Coordination Team (TKS) whose members consist of the head of the curriculum committee, representatives of study program administrators, KBK coordinators, and students of each batch. TKS meeting are scheduled at least once a semester. The results of the TKS are discussed in a plenary meeting of the department to then be used as an evaluation for improvement.

R Admission of Prospective Students

Requirements for Prospective New Students of the Doctoral Program, consisting of:

1. Having a Grade Point Average (GPA) in the Master Program of more than or equal to 3.25 (three points twenty-five) on a scale of 4 (four) of accredited Study Programs of at least B at the time of graduation of the applicant.
2. Having a score of at least 500 (five hundred) on the academic potential test of any of the following types of tests:
    a) UGM Postgraduate Academic Potential Test (PAPs);
    b) Academic Basic Ability Test of Indonesian Test Service Center (TKDA PLTI); or
    c) Academic Potential of the National Development Planning Agency (TPA Bappenas).
3. Having English proficiency test scores with the following scores and types of tests:
    a) *English Proficiency Test (* AcEPT) UGM with a score of at least 209 (two hundred and nine);
    b) *Test of English Proficiency* Indonesian Test Service Center (TOEP PLTI) with a score of at least 40 (forty);
    c) *International English Language Testing System (* IELTS) with a score of at least 5.0 (five points zero);
    d) Test of English as a Foreign Language (TOEFL): 450
    e) *Internet Based Test (* IBT) with a score of at least 45 (forty-five); or
    f) *Institutional Testing Program (* ITP) with a score of at least 450 (four hundred and fifty).
4. Having an advertisement that comes from 2 (two) people who know the applicant:
    a) For applicants who are already working, the recommendation comes from the head of the workplace institution and another person comes from one of the lecturers while studying for the Master's Program; or
    b) For applicants who have not worked or do not have an institution, the recommendation comes from two lecturers when studying a master's program.
5. Having a study permit or study assignment letter from the applicant's workplace agency if the applicant is already working.
6. Having a pre-proposal research document.
7. Applicants for the cooperation path, who come from institutions/agencies/institutions that have cooperation with UGM, must

include a copy of a *memorandum of understanding* document or cooperation agreement with UGM or a letter of determination as a scholarship recipient.

8. When registering, prospective students are advised to have contacted prospective Promoters. The promoter is determined in the selection meeting (discussion of the research design) and the Co-Promotor can be determined later, taking into account the proposed research topic.
9. Interview Test.
   Interview tests for prospective Doctoral students in Physics can be carried out by the Doctor of Physics study program if deemed necessary, with the following conditions:
   a) The interview is carried out when the candidate has met the requirements of the prospective Doctor of Physics student.
   b) The interviewer consists of one deputy administrator of the Department of Physics or Doctoral Study Program in Physics, and two people from representatives of the Field of Expertise Group related to the field of research that prospective students will pursue. Potential mentors should not be interviewers.
   c) The interview test assesses the academic ability and readiness of prospective students to take the Doctor of Physics program.
10. Determination of Admission of Doctoral Students in Physics.
    The determination of the admission of prospective Physics Doctoral students is carried out through a feasibility meeting held by the Doctor of Physics study program or faculty. Admission of candidates is based on the fulfillment of the requirements of prospective Doctoral Students in Physics, the results of interview tests, and the recommendations of prospective supervisors.

S Judiciary Requirements

In addition to graduation requirements, there are administrative requirements from study programs and faculties for Doctoral Physics students, to be able to participate in the judiciary. These administrative requirements are in the form of free lab borrowing requirements, library loan-free, and other administrative requirements set by the study program. The judiciary meeting for Doctor of Physics students is organized by the faculty and is attended by the head of the Department, the head of the Study Program, the Dissertation Promoter Team, and lecturer representatives in the Study Program.

T Graduation Requirements

Students of the Physics Doctoral program can be declared graduated if they have met all the following, namely having had:

1. minimum of 46 (forty-six) credits including a Dissertation, with a minimum cumulative achievement index (GPA) of 3.25 and a minimum grade of B in all courses,
2. meet publication requirements,
3. pass the Dissertation exam,
4. meet the requirements of the length of study,
5. meets the requirements of the judiciary.

U Additional Rules

If there are no rules in the Implementation of the Doctoral Program *by Research*, then the rules follow the rules in the Regular Doctoral Program.

APPENDIX I. Course Syllabus

COMPULSORY COURSES

MFF 7000 Methodology of Research and Writing of Scientific Papers (3 Credits)
Learning Objectives:
After taking this course, students will be able to:
CO 1. Designing research stages.
CO 2. Presenting research results in the form of structured data.
CO 3. Analyze experimental data according to scientific rules.
CO 4. Explain and describe the process of making international / IPR scale papers.
Syllabus:
Introduction to scientific writing (getting to know the basic format of a scientific paper), the function and format of the introduction (introduction), presentation and explanation of scientific data in tables and images, types and styles of writing in discussion sections, introduction to writing the correct library and citations (including an introduction to software in compiling libraries), writing correct conclusions in scientific papers and how to make the right title.
References:
1. Jill Jesson, Lydia Matheson, Fiona M Lacey, 2011, Doing Your Literature Review: Traditional and Systematic Techniques, SAGE.
2. Andrew Booth, Diana Papaioannou, Anthea Sutton, 2012, Systematic Approaches to a Successful Literature Review, SAGE.

Elective Courses from KBK of Applied Physics

MFF 7430 Acoustics (3 Credits)
Learning Objectives:
After taking this course, students will be able to:
CO 1. Distinguish various acoustic processes on various mediums.
CO 2. Developing the use of acoustics in the medical field.
Syllabus:

Basic linear acoustics, Atmospheric acoustic trajectory, Underwater acoustics, Physical acoustics, Photoacoustics, Thermoacoustics, Non-linear acoustics in fluids, Acoustic signal processes, Acoustic and Vibration Structures, Acoustic medicine, Photoacoustic tomography, Modulated ultrasound optical tomography.
References:
1. Thomas D. Rossing, 2007: Handbook of Acoustics, Springer Science+Business Media, LLC New York.
2. Morse, P. M. and Ingard, K.U., 1968, Theoretical Acoustics, Mc Graw-Hill Book Company, New York.

MFF 7301 Spectroscopy Laser (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze the differences, similarities, and effectivity of various laser spectroscopy methods.

CO 2. Designing the most effective and optimal laser spectroscopy system in a particular application.

Syllabus:

Introduction to spectroscopy, emission, and abortion methods. Doppler limited spectroscopy methods: Optogalvanic, photoacoustic, photothermal, laser-induced fluorescence(LIF), Resonance induced, spectroscopy (RIS), resonance-induced mass spectroscopy (RIMS), double resonant method, laser-induced breakdown spectroscopy (LIBS). Doppler-free spectroscopy method, saturation, polarization (POLINEX), intermodulation (IMOGS) method, level crossing spectroscopy. Reasoning/supporting components of laser spectroscopy, its application, and analysis.

References:

1. Svanberg S.,1991, Atomic and Molecular Spectroscopy: Basic concepts and practical applications, Springer-Verlag.
2. Demtroder, W., 1981, Laser Spectroscopy: Basic Concept and Instrumentation, Springer- Verlag.

MFF 7303 Atomic and Molecular Spectroscopy (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze and solve problems of the basic theory of atomic and molecular spectroscopy.

CO 2. Designing experimental systems supporting atomic and molecular spectroscopy.

Syllabus:

Summary of the quantum theory of atoms and molecules, the interaction between radiation and matter, and its selection rules. Atomic and molecular spectra: electronics, vibration, and rotation. Spectroscopic methods: *inner electron* spectroscopy, visible/optical spectroscopy, radio frequency spectroscopy, microwave, and infrared spectroscopy. Supporting equipment/components of atomic and molecular spectroscopy.

References:

1. Svanberg, S., 1991, Atomic and Molecular Spectroscopy, Basic Concepts and Practical Applications, Springer-Verlag.
2. Sindu, P.S.,1985, Molecular Spectroscopy, TataMcGraw-Hill, India.
3. Demtroder, W., 1981, Laser Spectroscopy, Basic Concepts and Instrumentations, Springer- Verlag.
4. Graybeal, J.D., 1988, Molecular Spectroscopy, McGraw-Hill.

MFF 7302 Spectroscopic Instrumentation (3 credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Distinguishes various working functions of the components of spectroscopy instruments.

CO 2. Designing a spectroscopy system for the measurement of certain physical magnitudes.

Syllabus:

Spectrograph and monochromator, Interferometer, Comparison between spectrometer and interferometer, Accurate wavelength measurement, Light detection.

References:

1. Demtroder, W., 1981, Laser Spectroscopy: Basic Cenceptand Instrumentation, Springer- Verlag.
2. SvanbergS., 1991, Atomic and Molecular Spectroscopy: Basic concepts and practical applications, Springer-Verlag.

MFF 7873 Physics of Imaging Instrumentation (3 credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Distinguishes the various working functions of the components of the Imaging Physics instrument.

CO 2. Designing a Physics Imaging system for specific physical measurements.

Syllabus:

This lecture provides a foundation of instrumentation and imaging engineering physics, which includes sensors and transducers, digital imagery, image acquisition, filtering, Fast Fourier Transform, digital image processing, interfacing techniques, and visual programming. For special cases, students are expected to master hardware engineering: Arduino, Raspberry Pi, Android; cloud computing, and parallel processing.

References:

The library adapts to the research topics of Doctoral students.

1. http://spie.org/
2. https://imagej.nih.gov/ij/

MFF 7871 Medical Physics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Designing research that integrates the development of *imaging* and *deep learning* technologies to support diagnosis according to medical research ethics.

Syllabus:

This lecture provides a theoretical foundation for physics and applications of various medical imaging techniques that use ionizing radiation, which includes measurement of ionizing radiation, radiation protection, radiography, CTScan, SPECT, PET, BNCT, DEXA, Mammography, ultrasound, and MRI.

References:

1. Hendee, W.R and Ritenour, E.R., 2002, "Medical Imaging Physics", Wiley-Liss Inc, New York, 4th-ed.
2. http://www.aapm.org
3. https://www.iaea.org
4. The library adapts to the research topics of Doctoral students.

MFF 7874 Special Topics in Non-Destructive Test (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

- CO 1. Explaining the concept and application of UTR, one of the specific topics related to the development of materials science, composites, industry, quality control, and disaster mitigation.
- CO 2. Explain the benefits of UTR in more detail from one of the specific topics related to the development of materials science, composites, industry, quality control, and disaster mitigation.
- CO 3. Understand one of the specialized topics related to concepts, systems, arrangement of tools, how they work, measurement methods, their acquisition, and analysis.
- CO 4. Mastering and understanding one of the UTR techniques that correspond to a related specific topic: visual inspection, liquid penetrant, magnetic particle, eddy current, thermography, ultrasonic, radiography, and tomography.
- CO 5. Understand standard systems, training and certification systems, organizations in the field of UTR, business prospects, and R&D opportunities in any of the related topics in the field of UTR.

Syllabus:

Introduction: Selected NDT Special Topics, History of NDT, concepts of Physics, the context of an application, and scope of the study. NDT Special Topic Application. NDT-Specific Topic Benefits. Exploration of NDT Special Topic Research Support Facilities. Review of the NDT-Specific Topic Standard System. NDT Special Topics Journal Review. Review of NDT Special Topic Patent and Patent Information. Review of R&D Prospects and NDT Special Topic Innovations.

References:

1. Ida, N. and Meyendorf, N., 2019. Handbook of Advanced Nondestructive Evaluation, Springer, Cham. https://doi.org/10.1007/978-3-319-26553-7.
2. Hellier, C.J., 2003. Handbook of Nondestructive Testing. McGraw-Hill, New York.
3. IAEA, 1999. Non-destructive Testing: A Guidebook for Industrial Management and Quality Control Personel. Training Course Series No. 9, IAEA Vienna.

MFF 7872 Special Topics in 3D Imaging (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Describes the concepts and applications of several 3D Imaging specific topics in the process of measuring physics and its presentation, introduction to structure, and analysis when objects are constructed or deconstructed.
CO 2. Describe the benefits of 3D Imaging Special Topics in more detail in the development and construction of an object and understand its construction process with a 3D Printer or 3D image viewer device.
CO 3. Understand the concepts, systems, arrangement of tools, how they work, measurement methods, acquisition, and analysis of the resulting 3D imagery.
CO 4. Understand one or more key techniques in 3D imaging such as stereo photometry, holography, CTScan, 3D morphology, and structure light technique, and compare them with radiography, photography, laminography, and shearography techniques.
CO 5. Understand the R&D potential, application prospects, and innovation of a specific topic of 3D Imaging for industry, quality assurance, and visualization of natural symptoms.

Syllabus:

Introduction: Selected 3D Imaging Special Topics, Related history, required Physics concepts, application context, and the scope of the study. 3D Imaging Special Topic Applications. Benefits of 3D Imaging Special Topics. Exploration of Imaging Special Topic Research Support Facilities 3D. 3D Imaging Special Topic Standard System Review. 3D Imaging Special Topic Journal Review. Review of Patent and Patent Information 3D Imaging Special Topics. Review of R&D Prospects and Innovations of 3D Imaging Special Topics.

References:

1. Zhang S., 2013. Handbook of 3D Machine Vision: Optical Metrology and Imaging, 1st-ed, CRC Press. DOI: https://www.routledgehandbooks.com/doi/10.1201/b13856-4.
2. Distante A and Distante C, 2020. Handbook of Image Processing and Computer Vision, Vol 3: From Pattern to Object. Springer, Cham. DOI: https://doi.org/10.1007/978-3-030-42378-0.

Elective Courses from KBK of Theoretical and Computational Physics

MFF 7023 Specific topics in Functional Analysis for Physics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Understand and master the basic concepts of functional analysis.
CO 2. Understand and master the main theorems of functional analysis.
CO 3. Understand some examples of the application of functional analysis in Physics (adapted to the direction of dissertation research).
CO 4. Able to apply functional analysis in physics problems (adjusted to the direction of dissertation research).

Syllabus:

This lecture is intended for Doctoral students in Physics as a briefing to immediately be able to do research following the title or theme of the dissertation. The content of the lecture can vary from one student to another depending on the theme of the dissertation carried out by each student. One of the special topics that have been given is functional analysis in physics in the form of basic concepts and important facts in functional analysis in more depth and detail as well as special discussions tailored to the theme or title of the research.

References:

1. Linear Operators in Hilbert Space, Joachim Weidmann, Springer-Verlag, Berlin, 1980.
2. Mathematical Topics Between Classical and Quantum Mechanics, N. P. Landsman, Springer-Verlag, Berlin, 1998.
3. Books and Journals that fit the topic. For example, on the topic of Functional analysis in physics.

MFF 7025 Special Topics in Topology and Differential Geometry for Physicists (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Understand and master the basic concepts of topology and differential geometry.

CO 2. Understand and master the main theorems of topology and differential geometry.

CO 3. Understand some examples of the application of differential geometry in Physics (adapted to the direction of dissertation research).

CO 4. Able to apply topological analysis and differential geometry in physics problems (adjusted to the direction of dissertation research).

Syllabus:

This lecture is intended for Doctoral students in Physics as a briefing to immediately be able to do research following the title or theme of the dissertation. The content of the lecture can vary from one student to another depending on the theme of the dissertation carried out by each student. One of the specific topics that have been given is Topology and Differential Geometry in Physics. The content of the lecture can be in the form of basic concepts and important facts in topology and differential geometry in more depth and detail as well as specific discussions tailored to the theme or title of the research.

References:

1. Differential Geometry and Mathematical Physics, Part I: Manifolds, Lie Groups and Hamiltonian Systems, Gerd Rudolph dan Matthias Schmidt, Springer-Verlag, Berlin, 2017.
2. Differential Geometry and Mathematical Physics, Part II: Fibre Bundles, Topology, and Gauge Fields, Gerd Rudolph dan Matthias Schmidt, Springer-Verlag, Berlin, 2017.
3. Books and Journals that are appropriate to the topic, such as on the topic of Topology and Differential Geometry in Physics.

MFF 7021 Special Topics in Stochastic Processes for Physicists (3 Credits)
Learning Objectives:
After taking this course, students will be able to:
CO 1. Understand and master the basic concepts of probability theory and stochastic processes.
CO 2. Understand and master the main theorems and important equations in probability theory and stochastic processes.
CO 3. Understand some examples of the application of probability theory and stochastic processes in Physics (adapted to the direction of dissertation research).
CO 4. Able to apply probability theory and stochastic processes in physics problems (adjusted to the direction of dissertation research.
Syllabus:
This lecture is intended for Doctoral students in Physics as a briefing to immediately be able to do research following the title or theme of the dissertation. The content of the lecture can vary from one student to another depending on the theme of the dissertation carried out by each student. The content of the lecture can be in the form of basic concepts and important facts in the stochastic process in more depth and detail as well as specific discussions tailored to the theme or title of the research.
References:
1. Probability and Stochastics, Erhan Cinlar, Springer-Verlag, Berlin, 2011.
2. Stochastic Analysis on Manifolds, Elton P. Hsu, American Mathematical Society, New York, 2002.
3. Books and Journals that correspond to topics such as the topic of Stochastic processes in physics.

MFF 7111 Special Topics in Particle and Field Physics (3 Credits)
Learning Objectives:
After taking this course, students will be able to:
CO 1. Describes and describes standard models of particle physics.
CO 2. Describe the rules of the Feynman diagram and perform calculations of latitude, and decay rate using various Feynman diagram rules.
CO 3. Compile and analyze models of particle physics using quantum field theory and gauge theory.
CO 4. Describes and uses alternative quantization methods other than operator quantization methods.
Syllabus:
This lecture is intended for Doctoral students in Physics as a briefing to immediately be able to do research following the title or theme of the dissertation. The content of the lecture can vary from one student to another depending on the theme of the dissertation worked on by each student. One of the special topics that have been given in Particle and Field Physics contains materials: Quantization of scalar fields, spinor fields, and vector fields, Tera field theory, PCT symmetry, trajectory integral quantization methods, and non-abelian gauge field quantization. Standard models of particle physics, destruction of

spontaneous symmetry and Higgs mechanisms, neutrino mass formation. Various topics continue in particle physics and quantum field theory.

References:

1. M.E. Peskin dan D.V. Schroeder, An Introduction to Quantum Field Theory, Perseus Book Publishing, Reading Massachusetts 1995.
2. Books and articles from relevant journals such as on the topic of Particle and Field Physics.

MFF 7042 Special Topics in the Theory of Relativity (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Describing the principles of the general Theory of Relativity as a fundamental theory in gravity-related research.

CO 2. Describes specific topics in the Theory of Relativity that is relevant to the research needs of the dissertation theme.

CO 3. Applying the relevant analytical tools needed in researching the theme of his dissertation.

Syllabus:

This lecture is intended for Doctoral students in Physics as a briefing to immediately be able to do research following the title or theme of the dissertation. The content of the lecture can vary from one student to another depending on the theme of the dissertation worked on by each student. One of the specific topics that can be given as an example is the Theory of Relativity. The content of the lecture is in the form of a basic understanding of General Relativity: whether the discussion of non-inertial frames of reference is included in general relativity, various alternatives to the Theory of Gravity as a counterpoint to Einstein's General Relativity, the use of symbolic computing in General Relativity, and so on. The reference book is of course associated with the topic covered. Often it is also in the form of scientific papers in international journals.

References:

1. Symon, K.R., 1971, Mechanics, 3rd edition, Addison-Wesley.
2. Goldstein, H., 1980, Classical Mechanics, 2nd edition, Addison-Wesley.
3. Books and articles from relevant journals such as on the topic of the Theory of Relativity.

MFF 7026 Special Topics in Computational Physics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Formulating physical symptoms from a computational aspect.

CO 2. Analyze the problem logically and carefully.

CO 3. Solve a problem with a structured solution.

Syllabus:

This lecture is intended for Doctoral students in Physics as a briefing to immediately be able to do research following the title or theme of the dissertation. The content of the lecture can vary from one student to another depending on the theme of the dissertation carried out by each student. One of the specific topics that can be given for example contains material: A review of the basics of numerical and discretized computational methods and their differences from stochastic computational methods. A picture of physics and science problems that require numerical or discretized solving as an approach to the analytical form that represents them. The basic principle of the finite difference, finite element, or Fourier transformation method and its application in solving problems of differential equations or integral equations. Various numerical or discretized methods for calculating integral problems, differential equations, eigenvalue problems, matrix solving, minimization, optimization, zero-point finding, function evaluation, interpolation and extrapolation, and other discrete approach problems.

References:

1. W.H. et al, 1987, NUMERICAL RECIPES, The Art of Scientific Computing, dan Vetterling.
2. W.T. et al, Numerical Recipes Examples Book (FORTRAN), Cambridge University Press.
3. Books and articles from relevant journals such as on the topic of Computational Physics.

MFF 7027 Special Topics in Stochastic Computational Physics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Formulating the symptoms of stochastic physics from the computational aspect.

CO 2. Analyze the problem logically and carefully.

CO 3. Solve a problem with a structured solution.

Syllabus:

This lecture is intended for Doctoral students in Physics as a briefing to immediately be able to do research following the title or theme of the dissertation. The content of the lecture can vary from one student to another depending on the theme of the dissertation carried out by each student. One of the specific topics that can be given as an example is stochastic computational physics. The content of the course is in the form of a review of the basics of stochastic computational methods and their differences from numerical or discretized computational methods. A picture of physics and science problems that require stochastic solving. The basic principles of the Monte-Carlo method and its application in solving complex system problems such as the solution of many objects and many variables. A review of various random number generators. Various stochastic methods for calculating integral problems, minimization, optimization, shortest time, shortest distance, determination of thermodynamic magnitudes, and other complex system problems.

References:

1. Press, WH; Teukolsky, SA; Vetterling, WT; Flannery, BP (2007). Numerical Recipes: The Art of Scientific Computing (3rd ed.). New York: Cambridge University Press. ISBN 978-0-521-88068-8.
2. Fabian Spill, Pilar Guerrero, Tomas Alarcon, Philip K. Maini, and Helen Byrne, Hybrid approaches for multiple-species stochastic reaction–diffusion models, J Comput Phys. 2015 Oct 15; 299: 429–445. doi: 10.1016/j.jcp.2015.07.002

3. Books and other articles from relevant journals for the topic of Computational Physics Stokastik.

MFF 7971 Special Topics In Astrophysics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Evaluating fundamental principles in astrophysics.

CO 2. Evaluating advanced topics in astrophysics that are relevant to the research needs of the dissertation theme.

Syllabus:

Following the title, the content of this course is adjusted to the needs of students in their dissertation research. Examples: The Structure and Process of Occurrence of Neutron Stars, the relativistic Boltzmann-Vaslov Equation, the Relationship between Exotic matter and General Relativity in the context of Astrophysics, and so on.

References:

1. Maeder A., 2009, Physics, Formation and Evolution of Rotating Stars, Springer-Verlag, Berlin.
2. Books and articles from relevant journals.

Elective Courses from KBK of Functional Material Physics

MFF 7600 Condensed Matter Physics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Reviewing the concepts of quantum mechanics and quantum statistics in clogged substances.

CO 2. Connecting between thermal and electromagnetic properties from a review of its electronic structure.

Syllabus:

Review of basic concepts in quantum mechanics and quantum statistics, fundamental topics in condensed matter physics: bonding in atoms, molecules, clogged substances; the structure of the compressed substance; electronic structure of the clogged substance; Elementary excitation in compressed substances is associated with the thermal and electromagnetic properties of compressed substances.

References:

1. P M Chaikin, T C Lubensky, 1995, Principles of Condensed Matter Physics, Cambridge University Press, Cambridge, UK.
2. Feng Duan, Jin Guojun 2005, Introduction to Condensed Matter Physics, World Scientific Publishing Co., Singapore.

3. Michael P Marder, 2010, Condensed Matter Physics, second edition, John Wiley & Sons, New Jersey, USA.

MFF 7070 Special topics in Instrumentation Physics (3 Credits)
Learning Objectives:
After taking this course, students will be able to:
CO 1. Choosing the principles of correct measurement and anticipation of sources of uncertainty.
CO 2. Evaluating the concept of analytical instrumentation in characterizing materials.
Syllabus:
Basic concepts of data acquisition systems, sources of noise and denoising, filters, and amplifier instrumentation systems. Application of standard analytical instruments for characterizing materials and devices, based on spectroscopy, chromatography, thermal, etc.
References:
1. Reza Langari dan Alan S. Morris, 2012, Instrumentation Theory and Application, Edisi 12. Academic Press-Elsevier Inc., Waltham USA.
2. Jack Cazes, 2005, Analytical Instrumentation Handbook, 3rd edition, Marcel Dekker, New York, USA.

MFF 7750 Electromagnetic Material (3 Credits)
Learning Objectives:
After taking this course, students will be able to:
CO 1. Analyze the concepts of electromagnetics in a macro and ideal physical system.
CO 2. Discusses the models and basic theories of the field of Electromagnetics of materials.
CO 3. Discusses the basic models and theories of the field of Electromagnetics of materials through research.
Syllabus:
Fundamentals of the theory of electromagnetics, specialized topics in the electromagnetics of materials: elementary excitation (plasmon, polaron, magnon, polariton).
References:
1. Applied electromagnetism, Liang Chi Shen, Jin Au Kong.
2. Scen, L.C., and Kong, J.A. (Translation, Iwa Garniwa), 2001, Electromagnetic Applications, Volumes 1 and 2, Erlangga Publishers, Jakarta.
3. Ramo, S., Whinnery, J.R., dan van Duzer, T., 1994, Fields and Waves in Communication Electronics, John Willey & Son, New York.

MFF 7810 Special Topics in Sensor Systems (3 Credits)
Learning Objectives:
After taking this course, students will be able to:
CO 1. Distinguish static and dynamic characteristics of a sensor system.

CO 2. Choosing the appropriate measurement method to obtain the amount according to the purpose of the study.

CO 3. Analyze the measurement results by various applied methods.

CO 4. Developing sensors based on the concept of sensing mechanisms.

Syllabus:

The physical magnitude of sensing, sensor material, sensing method, static and dynamic characteristics of sensors, and conversion of sensor response variables.

References:

1. Reza Langari dan Alan S. Morris, 2012, Instrumentation Theory and Application, Edisi 12. Academic Press-Elsevier Inc., Waltham USA.
2. John G. Webster dan Halit Eren, 2014 Measurement, Instrumentation, and Sensors Handbook, CRC Press Taylor & Francis Group, New York, USA.

MFF 7811 Special Topics in Materials Physics (3 Credits)

Course Learning Outcomes (CO):

After taking this course, students will be able to:

CO 1. Determining the physical characteristics to be deepened in the study.

CO 2. Designing preparation methods in sampling.

CO 3 Selects the appropriate characterization method.

Syllabus:

Functional polymer characteristics and polymer-based material design for special purposes. In detail, the syllabus is determined after one of the topics that correspond to the research of Doctoral students is selected.

References:

1. M. Doi, Introduction to Polymer Physics, Oxford University Press, Oxford, 1997.
2. Hummel, Rolf E. 1985, Electronic Properties of Materials (An Introduction for Engineers).
3. Craik, D., 1995, Magnetism: Principles and Applications, John Willey &Sons, Chichester, UK.
4. Joseph H Simmons, Kelly S Potter, 2000, Optical Materials, Academic Press, San Diego, USA.
5. Yoshinobu Aoyagi, Kotaro Kajikawa (editors), 2013, Optical Properties of Advanced Materials, Springer-Verlag Berlin, Heidelberg.
6. Heck, C., 1974, Magnetic Material and Their Application, Newnes-Butterworth.
7. Paul C. Painter & Michael M. Coleman, 2009, Essentials of Polymer Science and Engineering, DEStech Pub Inc.

MFF 7813 Special Topics in Computational Material Physics (3 Credits)

Course Learning Outcomes (CO):

After taking this course, students will be able to:

CO 1. Formulate and model the symptoms of physics under study and uncover important information through certain mathematical procedures and computational algorithms.

CO 2. Solve problems in a structured manner (well-defined solutions) in material systems to improve their Problem-Solving Skills.

CO 3. Applying various forms of visualization, graphics, or simulation through computer assistance as well as the use of appropriate software, programming languages, and numerical tools or packages to solve problems in material systems in improving Information & Technology (IT) Skills.

Syllabus:

The use of computational methods in material physics: molecular dynamics, monte carlo, cellular automata, and density functional theory (DFT). Theoretical and computational approaches in the design of functional nanomaterials. Methods of computational physics in the calculation of the structure of the band of solid substances. Methods and implementation of DFT in the periodic physical system.

References:

1. Jerzy Leszczynski (ed.), Computational Materials Science, 2004, Elsevier, Amsterdam, The Netherlands.
2. Dierk Raabe, 1998, Computational Materials Science, Wiley-VCH, New York, USA.
3. Wolfram Hergert, Arthur Ernst, Markus Däne, 2004, Computational Materials Science, From Basic Principles to Material Properties, Springer-Verlag, Berlin.

MFF 7814 Functional Materials (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Evaluating materials based on mechanical, magnetic, and electronic properties as well as types of bio and biomaterial materials.

CO 2. Evaluate materials based on their shape, size, morphology, and structure.

CO 3. Designing process stages ranging from fabrication, modification, characterization, and functionalization of materials for applications in the fields of renewable energy, storage energy, sensors, environment, and medical.

Syllabus:

Synthesis dan Characterization of material functional, Nanoparticles: Properties and applications, designing microscopic to macroscopic properties of functional materials electronic and magnetic, Electrochemical energy storage, Functional ionic liquids electrolytes in lithium-ion batteries, advanced materials for biomedical applications, systems, material functional electrode, material functional mechanics, properties of material criticism. Functional Materials, ForEnergy, Sustainable Development, and Biomedical Sciences.

References:

1. M. Doi, Introduction to Polymer Physics, Oxford University Press, Oxford, 1997.
2. M. Doi and S. F. Edwards, The Theory of Polymer Dynamics, Oxford University Press,
3. Hummel, Rolf E. 1985, Electronic Properties of Materials (An Introduction for Engineers).
4. Craik, D., 1995, Magnetism: Principles and Applications, John Willey &Sons, Chichester, UK.

5. Joseph H Simmons, Kelly S Potter, 2000, Optical Materials, Academic Press, San Diego, USA
6. Yoshinobu Aoyagi, Kotaro Kajikawa (editors), 2013, Optical Properties of Advanced Materials, Springer-Verlag Berlin, Heidelberg
7. Heck, C., 1974, Magnetic Material and Their Application, Newnes-Butterworth
8. Paul C. Painter & Michael M. Coleman, 2009, Essentials of Polymer Science and Engineering, DEStech Pub Inc.

Elective Courses from KBK of Geosciences

MFF 7911 Advanced Quantitative Seismology (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze the equations of elastic and viscoelastic waves.

CO 2. Analyze the interactions of seismic waves.

CO 3. Evaluate methods that depend on the type, kinematics, and dynamics of seismic waves.

Syllabus:

Dynamic Elasticity, Green Function for elastodynamics, seismic source representation, elastic waves from point sources, field waves in a homogeneous medium following transmission and reflection on the boundary plane (elastic isotropy and anisotropy), attenuation, reflection, and refraction in spherical waves, surface waves in vertical heterogeneous medium / layered medium, Earth-free oscillations, body waves in the medium and dependence of wave properties on depth, Kinematics of seismic sources (far field and near field), dynamics of seismic sources (crack propagation and rupture propagation), principles of seismometry.

References:

1. Quantitative Seismology Second Edition by Keiiti Aki (Author), Paul G. Richards ISBN-13: 978-1891389634, ISBN-10: 1891389637
2. Books and articles from relevant journals.

MFF 7912 Special Topics in Seismology (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Designing research stages related to the field of soil vibration and its application.

CO 2. Presenting research results in the form of structured data, graphs, and maps.

CO 3. Analyze earthquake observation data (seismograms) with software based on high-level programming languages (Julia, Python, or MATLAB)

CO 4. Compile a draft seismology paper that is worthy of publication in a reputable international journal

Syllabus:

Knowledge related to seismology and its applications (theory, acquisition methods, data processing, modeling, and interpretation). In detail, the syllabus is determined after one of the topics that correspond to the research of Doctoral students is selected.

References:

1. Ammon, C.J., Velasco, A.A., Lay, T. and Wallace, T.C., 2020. Foundations of Modern Global Seismology, 2nd ed. Elservier, Academic Press.
2. Aki, K. and Richards, P.G., 2002. Quantitative Seismology.
3. Books and articles from relevant journals.

MFF 7913 Earthquake Hazard Analysis (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Design, organize and carry out surveys, QC, and seismicity data processes for the identification of earthquake sources.

CO 2. Analyze the hazards of an earthquake source and the interpretation of risks and develop their analysis.

CO 3. Analyze the software algorithms used and develop them.

CO 4. Communicate professionally (whether written or oral) the results of the earthquake hazard analysis and its implications.

Syllabus:

Earthquakes in space and time, source mechanisms, energy and magnitude, intensity and peak of ground acceleration (pga), peak ground velocity (pgv), peak ground displacement (pgd), deterministic analysis, probabilistic analysis, seismic microzonation, Horizontal to Vertical Spectral Ratio (HVSR), seismic hazard map.

References:

1. Schroeder, J.F., 2014. Hazards and Disasters Series: Earthquake Hazard, Risk, and Disasters. Academic Press, London.
2. Baker, J., Bradley, B. and Stafford, P., 2021. Seismic hazard and risk analysis. Cambridge University Press.
3. Books and articles from relevant journals.

MFF 7914 Micro Seismic Analysis (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze and synthesize the fundamental characteristics of microseismic/microtremor waves

CO 2. Designing, organizing, and carrying out surveys, QC, and microseismic data processes and analysis of the results

CO 3. Analyze the software algorithms used and develop them.

Syllabus:

Fundamental characteristics of microseismic waves/microtremors, surface wave dispersion, spectral representation of microseismic waves, microseismic survey principles (SPAC, ESPAC, etc.), phase velocity and subsurface structure, application of FK, SPAC, ANT.

References:

1. Hiroshi Okada The Microtremor Survey Method(2003) Geophysical Monograph Series SEG http://dx.doi.org/10.1190/1.9781560801740n.
2. Books and articles from relevant journals.

MFF 7915 Computational Seismology (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Applying numerical methods assuming 1D medium.

CO 2. Applying the numerical method assuming a complex medium with the finite difference method, finite element, finite volume method, or Galerkin method.

Syllabus:

Problem-solving in seismology uses numerical methods, wave equations, finite difference method, finite element method, volume element method, and Galerkin method.

References:

1. Igel, H, Computational Seismology: A Practical Introduction 2016 Oxford Publishing 2016, Print ISBN-13: 9780198717409, DOI:10.1093/acprof:oso/9780198717409.001.0001
2. Books and articles from relevant journals.

MFF 7926 Special Topics in Geothermal (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Evaluating the local tectonics of the study area by deriving from regional tectonics.

CO 2. Analyze the relationship of local geological structures with zoning permeability.

CO 3. Analyze the formation of surface types of manifestations.

CO 4. Analyze the quality of geochemical data and the interpretation of geothermal systems.

CO 5. Analyzing the condition of geothermal reservoirs geologically and their geophysical properties.

CO 6. Documenting a *review* based on the literature on the formation of surface types of manifestations.

Syllabus:

Geothermal-related knowledge. In detail, the syllabus is determined after one of the topics that correspond to the research of Doctoral students is selected.

References:

1. Stober, I. and Bucher, K., 2013. Geothermal Energy: From Theoretical Models to Exploration and Development. Springer Berlin Heidelberg.
2. Books and articles from relevant journals.

MFF 7917 Special Topics in Geoelectric Method (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze and synthesize electrical physical properties from lithology/models of dissertation research areas, related to porosity, fluid, temperature, minerals, etc.

CO 2. Designing, organizing, and carrying out surveys, QC, and geoelectrical data processes and analysis of the results.

CO 3. Analyze the software algorithms used and develop them.

Syllabus:

Knowledge related to geoelectricity (theory, acquisition methods, data processing, modeling, and interpretation). In detail, the syllabus is determined after one of the topics that correspond to the research of Doctoral students is selected.

References:

1. Zhdanov, M.S. and Keller, G.V., 2009. The Geoelectrical Methods in Geophysical Exploration. Elsevier, California.
2. Books and articles from relevant journals.

MFF 7930 Digital Signal Analysis (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyzing the concept of advanced mathematical functions in the analysis of discrete-time signals.

CO 2. Analyze and synthesize discrete-time signals in the time realm, frequency realm, and complex frequency realm.

CO 3. Evaluating these specific and advanced mathematical functions in solving data processing problems by utilizing one of the programming languages.

CO 4. Visualize data processing in a standard graph and describe the results of data processing that has been carried out.

Syllabus:

The relationship of input and output of physical systems of frequency and time regions, various transformations of time and frequency regions (Fourier, wavelets, S, etc.), digital filter theory. Z-transformation: system switching function, reverse Z-transformation, system flow chart.

References:

1. Brigham, E.O., 1974, The Fast Fourier Transform, Prentice Hall, Inc.
2. Brustle, W., 1987, Advanced Digital Signal Processing, Lab. Geophysics, FMIPA UGM.
3. Proakis, J.G., and Manolakis, D.G., 1993, Digital Signal Processing: Principles, Algorithms, and Applications, McMillan.
4. Alkin, O., 1994, Digital Signal Processing: A Laboratory Approach using PC-DSP, Prentice Hall.

MFF 7931 Deformation and Gravity (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Process data up to simple Bouguer anomaly and separate local and regional anomalies.

CO 2. Selection of the data that is ready to be modeled.
CO 3. Developed the concept of isostasy in gravity modeling.

Syllabus:

Gravitational anomalies and topographic surface functions of space and time, correlation analysis within the space and time region, interpretation and modeling of various correlation results within the space and time region: case studies of symptoms of subsidence, uplift, or changes in internal structure.

References:

1. National Gayaberat Committee, 1992, Manual for LaCoste & Romberg Gravimeter Operators, Bakosurtanal.
2. Parkinson, W.D., 1983. Introduction to Geomagnetism, Scottish Academic Press.
3. Telford, W. M., L. P. Geldart, R.E. Sheriff, and D.A. Keys, 1981, Applied geophysics: Cambridge, New York, U.S.A.
4. Telford, W.M., 1983., Applied Geophysics. Cambridge University Press.
5. Torge, W., 1989, Gravimetry: de-Gruyter, Berlin; New York Gravimetry.
6. http://astrowww.phys.uvic.ca>celmechs>celm5 gravitational field and potential.
7. Papers on gravity in Journals (a.l. JGR, Geophysics, Geophysical Prospecting), Proceedings (a.l. PIT HAGI).
8. Grant, F.S., dan G.F. West, 1965, Interpretation Theory in Applied Geophysics, McGraw-Hill.

MFF 7932 Special Topics in Geodynamics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze the geophysical properties of the subsurface and can apply mathematics/physics/chemistry to the geological problems of the research area.
CO 2. Develop the concept of the geodynamics of its research area in the context of tectonics, natural resource exploration, disaster, and the environment.

Syllabus:

Knowledge related to geodynamics and its implications for tectonic conditions, exploration of natural resources, disasters, and the environment. In detail, the syllabus is determined after one of the topics that correspond to the research of the doctoral student is selected.

References:

1. Scheidegger, A.E., 1982, Principles of Geodynamics, Springer-Verlag.
2. Kearey, P. and F.J. Vine, 1990, Global Tectonics, Blackwell Sci. Publ.
3. Turcotte, 1982, Geodynamics. Appli. of Continuum Physics to Geological Problems, John Wiley & Sons.

MFF 7933 Special Topics in Inversion Method (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Creating inversion algorithms and programs in the Matlab programming language.
CO 2. Critiquing inversion software.
CO 3. Develop inversion methods for solving dissertation problems.

Syllabus:

Application of the basics of inversion methods in the field of geophysics by creating an inversion program that is following the research theme of the doctoral program both in geophysical methods: seismology, volcanoes, seismic and non-seismic.

References:

1. Albert Tarantola, 2005, Inverse Problem Theory and Methods for Model Parameter Estimation, Siam.
2. Jackson, 1972 Interpretation of inaccurate, insufficient, and inconsistent data Geophys. J. Roy. astr. Soc., 28, 97-109.
3. Menke, 1989, Geophysical data analysis: discrete inverse theory, Academic Press.
4. Mosegaard and Tarantola, 1995, Monte Carlo sampling of solutions to inverse problems, J. Geophys. Res., 100, 12,431–12,447.
5. Parker, 1977, Understanding inverse theory, Ann. Rev. Earth Planet. Sci., 5, 35-64.
6. Randall M. Richardson and George Zandt, 2007, Inverse Problems In Geophysics, 2007, Department of Geosciences, University of Arizona, Tucson, Arizona 85721
7. Richard C. Aster, Brian Borchers, 2012, Parameter Estimation and Inverse Problems, Elsevier.
8. Robert L. Parker, 1994, Geophysical Inverse Theory.
9. Sambridge and Mosegaard, 2002, Monte Carlo methods in geophysical inverse problems, Rev. of Geophys., 40, 3.1-3.29.

MFF 7934 Special Topics in Rock Physics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. developed new knowledge in the field of rock physics.

CO 1. Analyze the physical properties of rocks.

CO 3. Provides arguments regarding the relationship between the physical properties of rocks.

Syllabus:

Introduction to the Process of Rock Occurrence and Petrophysical Parameters of Rocks, Physical properties of rocks, such as Rock Magnetism Properties, Rock Radioactivity, Rock Elasticity, Wave Propagation in Rocks, Elasticity Modeling Theory, Seismic Wave Attenuation, Thermal Properties of Rocks, Electrical Properties of Rocks, and Some relationships between the physical properties of rocks.

References:

1. Schon, JH., 2011, Physical Properties of Rocks, Pergamon Press.
2. Schon, JH., 1998, Physical Properties of Rocks, Pergamon Press.
3. Guegen, Y and Palciauskas, V., 1994, Introduction to the Physics of Rocks, Princeton University Press.
4. Various sources on the Internet and journals related to rock physics.

MFF 7935 Advanced Volcano Physics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze and synthesize the physical properties, internal structure, and dynamics of volcanoes based on geophysical, geological, and other similar data observations.

CO 2. Designing research stages related to the field of volcanoes and their applications.
CO 3. Analyze the software algorithms used and develop them.
CO 4. Communicate research results in a professional and structured manner (whether written or oral).

Syllabus:

The internal structure of the volcano and how geophysical surveys can model it, the internal dynamics of the volcano and how geophysical surveys can model it, monitoring of volcanic activity of volcanoes, pressure relationships, changes in volume and deformation of the volcanic surface, gas bubbles in the multiphase fluid of volcanic magma, deep flow conditions in the magma conduit, how to estimate the density of liquid magma, porosity, and permeability of magma, mechanism of a volcanic eruption.

References:

1. Kirbani Sri Brotopuspito, 2006, Merapi Volcano Inspires Scientific Curiosity, Paper presented at the Volcano International Gathering, Yogyakarta, September 4th-10th 2006.
2. SSAC, 2007, Physical Volcanology Collections, University of South Florida, Tampa.
3. Relevant books and journal articles.

MFF 7400 Special Topics in Electromagnetics (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze and synthesize electrical physical properties from lithology/models of dissertation research areas, related to porosity, fluid, temperature, minerals, etc.
CO 2. Design, organize and carry out surveys, QC, and electromagnetic data processes and analysis of the results.
CO 3. Analyze the software algorithms used and develop them.

Syllabus:

Knowledge related to theory to the application of electromagnetism. In detail, the syllabus is determined after one of the topics that correspond to the research of Doctoral students is selected.

References:

1. Shen, L.C. and Kong, J.A., 1987. *Applied electromagnetism*. PWS Publishing Company.
2. Books and articles from relevant journals.

MFF 7901 Special Topics in Geography (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Visualize spatial information in the form of topography, geomorphology, faults, and slopes of slopes presented in the form of maps properly and correctly.
CO 2. Spatially analyze fracture density to determine fault zones on the surface based on satellite imagery and UAVs.
CO 3. Spatially analyze hydrological information, geomorphological changes, slopes, and landforms from satellite imagery and UAV data.

CO 4. Combine surface information such as topography, faults, and geomorphology with subsurface information from geophysical data through overlay, intersect, clip, merge, and other spatial analysis techniques.

Syllabus:

This lecture provides a theoretical basis for the dynamics of geomorphological processes and their spatial analysis. Several spatial data analyses and visualizations will be provided such as topographic data analysis through Digital Elevation Model data visualization, hydrological analysis, crack density, slope, landforms, and land use and their relation to geological and geophysical information of the research area, as well as a data visualization in the form of maps of research areas. After taking this course, students are expected to be able to analyze spatial data and integrate it with geological and geophysical information independently and visualize it in the form of a comprehensive and informative map.

References:

1. Kenneth J. Gregory & Andrew S. Goudie, 2011, The SAGE Handbook of Geomorphology, SAGE Publications LtD, DOI: https://dx.doi.org/10.4135/9781446201053.
2. J. Ronald Eastman, Michelce Fulk, James Toledano, 1993, The GIS Handbook, Clark University.
3. ESRI, 2021, The ArcGIS Book, website: The ArcGIS Book | The ArcGIS Book.

MFF 7918 Special Topics in Geology (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Investigating geological information to support designing geophysical method measurement designs.

CO 2. Develop applications of geological sciences for the interpretation of geophysical data.

CO 3. Compile and deliver professionally (whether written or oral presentation) the results of thoughts on geology and geophysics for the application of geohazard analysis, natural resource exploration, disaster monitoring, and mitigation.

Syllabus:

This lecture discusses the geological sciences that underlie the interpretation of geophysical data. These geological sciences are summarized in "Physical Geology" for the application of natural resource exploration, natural disasters, and environmental geology. A deeper discussion of the topic of geology will be adjusted to the research interests of the lecture participants.

References:

1. Haakon, F., 2019. Structural Geology. Cambridge University Press.
2. Hall, R. 2010. Indonesia Geology. The Royal Holloway University of London. (along with references in this article).
3. Plummer, C., Carlson, D., Hammersley, L., 2018. Physical Geology. McGraw-Hill Education.

MFF 7919 Special Topics of Geophysical Numerical Methods (3 Credits)

Learning Objectives:

After taking this course, students will be able to:

CO 1. Analyze numerical methods in geophysical computing.

CO 2. Evaluating numerical methods for solving linear algebraic equations.

CO 3. Evaluating numerical methods for solving ordinary and partial differential equations.

CO 4. Designing parallel computing in the field of Geophysics.

Syllabus:

This lecture provides the theoretical foundation for numerical methods for solving partial differential equations and their application in the field of geophysics. Some numerical methods that can be studied include the Euler method, finite difference method, finite volume, finite element, discontinuous-Galerkin finite element, spectral element, and other numerical completion methods tailored to the theme or title of the study.

References:

1. Durran, D. R. (2010). Numerical methods for fluid dynamics: With applications to geophysics (Vol. 32). Springer Science & Business Media.
2. Books and articles from relevant journals.