POSTGRADUATE INSTITUTE OF SCIENCE
UNIVERSITY OF PERADENIYA

M.Sc. Programme in Medical Physics
(Course work – SLQF Level 9)

M.Sc. Programme in Medical Physics
(Course work and Research – SLQF Level 10)

1. INTRODUCTION

Medical Physics is an ever-expanding field as a separate discipline. During the past two decades medical physics has undergone a tremendous evolution, progressing from a branch of science on the fringes of physics into an important mainstream discipline that can now be placed on equal footing with other more traditional branches of physics.
Applications of physics in medicine cover a wide range. The four important sub-specialties in medical physics are related to: 1/ Diagnostic imaging with x rays (*diagnostic radiology physics*) 2/ Diagnostic imaging with radio-nuclides (*nuclear medicine physics*) 3/ Treatment of cancer with ionizing radiation (*radiation oncology physics*) 4/ Study of radiation hazards and radiation protection (*health physics*).

Although medical physics is a well-developed discipline in all developed countries it is not well established in developing countries like Sri Lanka. The two obvious areas that Medical Physicists are needed in Sri Lanka are in the fields of Radiotherapy and Nuclear Medicine. In Sri Lanka there are six government cancer treatment centers and one private center to provide all types of radiation therapy procedures. The Maharagama cancer institute, the largest in the country, needs service of about 10 Medical Physicists. The other five government centers in Kandy, Galle, Jaffna, Anuradhapura and Badulla need about two to three Medical Physicists each. In addition, each base hospital in Sri Lanka now has modern diagnostic equipment such as CT scanners and is hoping to have its own nuclear medical facilities. Therefore we need at least one Medical physicist per teaching hospital in Sri Lanka to cover up the need on diagnostic radiology side. As the health service improves, the need for Medical Physicists will further increase.

On the other hand, in Sri Lanka the research activities on topics related to medical physics has not developed due to non-availability of appropriate facilities and resource personnel.

The Postgraduate Institute of Science (PGIS) of the University of Peradeniya with the support of other Faculties of University of Peradeniya, Cancer Institute at Maharagama, Atomic Energy Authority, University of Colombo and Teaching hospitals has formulated a M.Sc. programme in Medical Physics to train physicists, to meet the above demands. PGIS is the pioneer in starting the M.Sc. degree program in Medical Physics in 1996 and is the first institution that provides a postgraduate level program that caters to the need in the whole country. The Board of Study in Physics has regularly updated the M.Sc. programme introducing new courses to suit national needs. This proposal introduces a five-credit independent study module to improve writing/oral communication skills as applied to Medical Physics.

This M.Sc. programme will thus prepare the candidate to take the challenge of meeting not only national needs in diverse areas as stated above, but also to continue toward a higher degree anywhere in the world.

2. OBJECTIVES OF THE PROGRAMME

- To train personnel in Radiotherapy, Diagnostic Radiology and Radiation Protection, so that they will have the basic knowledge to carry out the duties in a hospital as Medical Physicist.
- To provide opportunities for research connected with physics applied to medicine.
- To provide supplementary courses for postgraduate training in some disciplines of medicine such as radiology, anesthesiology etc.

3. PROGRAMME ELIGIBILITY

Applicants for admission to this programme must have successfully completed one of the following courses at a recognized University.

- B.Sc. special degree in physics or B.Sc. special degree in chemistry with physics as the subsidiary or B.Sc. general degree with physics as a subject.
- A degree in engineering science.
- Any other equivalent qualification with strong physics content acceptable to the Board of Study in Physics of the PGIS.

The number of candidates admitted to the programme in a given year will depend on the number of places available in the year. The selection will be based on merit. Candidates should be proficient in English as English will be the medium of instruction.

4. PROGRAMME FEE

Category	**Programme Fee**	
	M.Sc. (Course work)	**M.Sc. by (Course work & Research)**
Local candidates	Rs. 170,000/-	Rs. 250,000/-
Foreign candidates	Rs. 340,000/-	Rs. 500,000/-

Students registered for the M.Sc. degree by course work shall pay the Programme fee in full or in two *(1/2 at the registration and the balance at the end of the first semester)* or three *(1/3rd at the registration, another 1/3rd after 4 months from the date of registration and the balance after 8 months from the date of registration)* installments. An additional payment of Rs. 80,000/- (or Rs. 160,000/- form foreign students) should be made at the end of the first year to continue for the M.Sc. degree by course work & research. Other payments including registration fee, medical fee, library subscription, examination fee and deposits (science and library) should be paid according to the procedure stipulated by the PGIS. (N.B. The Programme fees given above may be revised as per recommendation of the Board of Management of the PGIS.)

5. THE PROGRAMME STRUCTURE AND DURATION

This programme consists of three options for completion.

5.1 Masters Degree with Course Work (SLQF Level 9)

The M.Sc. degree (Course work) can be obtained by completing course work only (without conducting any research project).

Course work, comprising of theory courses, and laboratory and/or fieldwork, shall be conducted over a period of two semesters of 15 weeks each. The total duration of the degree, including examinations, shall be about 12 months. Satisfactory completion of a minimum of 30 credits of course work with a GPA of not less than 3.00 is required for the successful completion of the degree - SLQF Level 9 (Students who do not satisfy the above criteria but obtain a GPA in the range 2.75 to 2.99 for course work of 25 credits are eligible for the Postgraduate Diploma in Medical Physics - SLQF Level 8, and those who obtain a GPA in the range 2.75 to 2.99 for course work of 20 credits are eligible for Postgraduate Certificate - SLQF Level 7).

5.2 Masters Degree (SLQF Level 10)

In addition to Masters Degree with course work (5.1), the Masters Degree (Research) requires a research project. The duration of the entire programme shall be 24 months inclusive of 5.1. Completion of all the requirements of 5.1 with a GPA of not less than 3.00 is a prerequisite for the Masters Degree (Research). The research project for this degree should be conducted on full-time basis, and completed during the second year. The research component is allocated 30 credits, totalling 60 credits for the entire programme. After successful completion of the research project, the student shall be eligible for the award of the M.Sc. Degree in Medical Physics - SLQF Level 10 (Students who do not complete the research project within the stipulated time period shall be awarded the M.Sc. Degree in course work in Medical Physics - SLQF Level 9).

5.3 Extension of the programme for M.Phil. (SLQF Level 11) or Ph.D. (SLQF Level 12)

After conducting research for a period of six months in the M.Sc. degree (research) programme, students who have demonstrated exceptional progress may apply for upgrading the degree status to M.Phil. The student should continue the research project and any additional research work/assignments recommended by the PGIS for a total of two years (60 credits of research) to qualify for the award of the M.Phil. degree (SLQF Level 11).

During the second year of research, students who have demonstrated exceptional and continuous progress may apply for upgrading the degree status from M.Phil. to Ph.D. The student should continue the research project and any additional research work/assignments recommended by the PGIS for another year on full-time basis (additional 30 credits) to qualify for the award of the Ph.D. degree (SLQF Level 12).

Programme Summary

Course Code	Course	Lecture hrs	Practical hrs	No. of Credits
PH 531	Human Biology and Cell Biology	30	--	2
PH 532	Physics of Diagnostic and Therapeutic Radiology	30	--	2
PH 533	Nuclear Medicine I	15	--	1
PH 534	Radiobiology	15	--	1
PH 535	Statistics	15	--	1
PH 536	Computing*	15	--	1
PH 537	Introduction to Digital Electronic and Microprocessors	15	--	1
PH 538	Applications of Physics in Medicine	15	--	1
PH 540	Clinical Instrumentation	15	--	1
PH 541	Laboratory Course	---	30	1
PH 546	Radiation Protection	30	--	2
PH 547	Radiotherapy Physics	30	--	2
PH 548	Medical Imaging Physics	30	--	2
PH 549	Radiotherapy and Medical Imaging Laboratory		60	2
PH 550	Nuclear Medicine II	15	30	2
PH 551	Medical Electronics and Instrumentation*	15	--	1
PH 552	Computer systems and method*	15	--	1
PH 553	Biomechanics, Biomaterials and Rehabilitation Engineering*	15	--	1
PH 554	Computer Architectures and Artificial Intelligence*	15	--	1
PH 555	Ultrasound in Medicine*	15	--	1
PH 556	Non-ionising E.M. Radiations in Medicine*	15	--	1
PH 557	Clinical Tutorials and Demonstrations	--	30	1
PH 558	Advanced techniques and special procedures in Radiotherapy*	15	--	1
PH 599	Independent Study II**[1]	500 notional hrs.		5
PH 699	Research Project**[2]	3000 notional hrs. (one year duration)		30

**Optional courses. Students are required to obtain 3 credits from optional courses.*
***[1] Compulsory for M.Sc. (Course work)*
***[2] Compulsory for M.Sc. (Research)*

6. PROGRAMME CONTENTS OF PH 599 AND PH 699

Course code	PH 599
Course title	Independent Study
Credits	05
Compulsory/optional	Compulsory
Prerequisites	None
Time allocation	500 notional hrs.
Aims	Aims: The overall aim is to familiarize the student with concepts and methods involved in scientific research.

	Specific aims: 1. To explain the scientific process in the conduct of research. 2. To develop skills to write a review paper and a scientific research proposal. 3. To develop skills to make a presentation. 4. To master the application of statistical methods on quantitative scientific data.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to, 1. Use the scientific method to design and conduct a research study, 2. Conduct an independent review of literature on a selected topic in the area of Medical Physics, 3. Write a formal scientific report conforming to the guidelines provided, 4. Transfer the knowledge gained through (2) and (3) above in the form of a presentation, 5. Complete a research proposal conforming to the guidelines provided, 6. Perform statistical analysis of quantitative data.
Content	*Review paper*: Review of literature; Development of the review paper in concise and professional manner and logical presentation of results that have been reported, writing the abstract, compilation of the list of references. *Proposal writing*: Interpretation and critical evaluation of results of published research; Formulation of a research problem: Concise literature review, justification, time frame, identification of resources, budgeting, etc. *Project*: Collection and statistical analysis of data on a topic associated with the review paper. *Seminar*: Presentation of literature and data collected on a given topic; Preparation of an abstract, preparation of slides.

Assessment criteria: Continuous Assessment

Component	% marks
Review paper	20
Proposal writing	10
Project	40
Seminar	30

Recommended Texts:

1. Backwell, J., Martin, J. (2011) A Scientific Approach to Scientific Writing, Springer.
2. Postgraduate Institute of Science (2016) Guidelines for Writing M.Sc. Project Report/M.Phil. Thesis/Ph.D. Thesis
3. Priyantha, N (2015) Measurements and Errors in Chemical Analysis, Science Education Unit, University of Peradeniya.
4.

Course code	PH 699
Course title	Research Project
Credits	30
Compulsory/optional	Compulsory
Prerequisites	
Time allocation	3000 notional hrs. (one year duration)
Aims	Aims: The overall aim is to prepare the student to conduct a research independently. **Specific aims:**

	1. To train students to apply scientific method in scientific research. 2. To train students to generate researchable hypotheses. 3. To train students to plan, design and conduct scientific research. 4. To gather reliable scientific data, analyse, and interpret. 5. To develop skills in scientific writing.
Intended learning outcomes	At the end of the successful completion of the course, students will be able to, 1. Apply the scientific method. 2. Design a research project. 3. Complete a research project. 4. Describe ethical issues in scientific research 5. Explain the patenting process in research . 6. Make presentations at national/international conferences. 7. Produce a thesis conforming to the requirements of the PGIS. 8. Write manuscripts for publication in refereed journals.
Content	The students will conduct sufficient amount of laboratory/field work on a chosen research topic under the guidance provided by an assigned supervisor/s, make a presentation of research findings at a national/international conference, and produce a thesis.

Assessment criteria

Continuous assessment	End-semester examination
30%	Oral examination (20%) Thesis (40%) Conference presentation (10%)

Recommended Texts:

1. Backwell, J., Martin, J. (2011) A Scientific Approach to Scientific Writing, Springer.
2. Postgraduate Institute of Science (2016) Guidelines for Writing M.Sc. Project Report/M.Phil. Thesis/Ph.D. Thesis
3. Priyantha, N (2015) Measurements and Errors in Chemical Analysis, Science Education Unit, University of Peradeniya.

CONTENTS OF OTHER COURSES

PH 531 Human Biology and Cell Biology (2 credits)

Basic Physiology

Role, function and interactions of the major organs and body systems. Physiological regulatory processes. Introduction to organ systems, Gastrointestinal system, Respiratory system, Heart, Circulation, Urinary system, Reproductive system, Blood and body fluid, Nervous system, Joints and bones. Sensory Organs: Eye, Ear, Vestibular sensations taste and smell.

Diseases in man

A brief overview of the various types of clinical conditions the medical physicist might encounter in practicing hospital physics.

Cell Biochemistry

The basic body cell, cell organelles; Fundamental biochemical building blocks; DNA structure, synthesis and replication; protein synthesis; energy metabolism.

PH 532 Physics of Diagnostic and Therapeutic Radiology (2 credits)

Atomic physics

Atomic and nuclear structure, radioactivity, production of radioactive materials; Interactions of photons and other ionizing radiations with matter.

Basic interaction processes

Coherence scattering, incoherence scattering (Compton), photo electric, pair production, Photonuclear reaction and their clinical importance, Range of secondary electrons, Bragg curve,. HVL/TVL, Attenuation and absorption coefficients, stopping powers, LET.
X-ray radiology
X-ray production, design of X-ray tubes. X-ray generators, heat rating, Beam collimation. Interaction of X-photons with patients, radiographic contrast. Film construction, role of intensifying screens. Film processing, Film contrast, scatter reduction. Characteristics curve.
Radiation dosimetry
Kerma, absorbed dose, charged particle equilibrium (CPE). Bagg-Gray Cavity Theory ,practical ion chambers.
Radiation Detectors
Gas ionisation, Scintillation, Semiconductor, film, Thermoluminescence (TLD) detectors.
Chemical and calorimetric methods of measuring radiation and their clinical applications.
A general introduction to radiotherapy physics
Radiation as a treatment for cancer, historical review including X-ray and gamma ray teletherapy equipment, treatment planning and brachytherapy.
Physics of teletherapy
Definition of PDD, TAR, BSF, TPR, TMR, SAR their properties and application. Iso-dose curves, beam modifier -Wedge filter, Clarkson segmental integration, Calculation of simple treatment techniques for clinical applications.

PH 533 Nuclear Medicine I (1 credit)
Nuclear Physics, Planar and tomographic imaging, Data processing, Mode of action of radiopharmaceuticals and the interpretation of clinical studies, In vitro studies, Positron emission tomography.
The gamma camera, Specification of camera performance.

PH 534 Radiobiology (1 credit)
Basic radiobiology
Free radical formation; damage to biological molecules; effects at cellular and whole body levels.
Radiobiology and human oncology
Cell survival curve - RBE therapeutic ratio, cell cycle and radio sensitivity; Sensitivity of different types of tissues; Tissue tolerance dose LD 50/5, LD 5/5, paediatric dosimetry; Fractionation NSD concept; Prescribing, recording, and reporting photon beam therapy ICRU report 50; Design and conduct of clinical trial - study objective, patient eligibility end points, treatment allocation, size and duration of study, data management, ethics, Surface marking of organs.

PH 535 Statistics (1 credit)
Definitions, Descriptive statistics, Binomial, Poisson and Gaussian distributions, Central limit theorem, Inferential statistics, population mean, standard error and deviation, difference between statistics, Curve fitting, regression analysis.

PH 536 Computing (1 credit)
Technology evolution, Structure of algorithms, Representation and models of arithmetic manipulation, Operating system and language review, Principles of project and system design, Future trends, Tutorials on use of packages, Overview of biomedical applications of computing, including Artificial Intelligence and parallel processing approaches, Introductory signal and image processing, Data reduction, Principles of software design, Software development techniques and good programming practices, Introduction to C with worked examples and opportunities for supervised programming.

PH 537 Introduction to Digital Electronic and Microprocessors (1 credit)
Digital Electronics
Boolean logic, Digital circuit elements, Truth tables and state tables, Common logic circuits.
Microprocessors

Microprocessor hardware, Interfacing devices.

PH 538 Applications of Physics in Medicine (1 credit)

UV, Lasers and Fiber Optics, uses in Medicine

EM radiation in medicine, The role of lasers and Fiber optics in medicine, UV radiation in medicine. Hazards of lasers and UV radiation, Audiological physics, Physics applied to ophthalmology.

Nuclear Magnetic Resonance in Medicine

Energy levels; effects of magnetic fields; the spin system; precession; field gradients; spatial information; relaxation phenomena; basic pulse sequences, inversion recovery and spin echo; basic hardware.

Ultrasonics in Medicine

Generation, properties of acoustic waves; reflection, transmission at interfaces; intensity and other parameters; imaging; artifacts; measurements of acoustic power and intensity: hyperthermia and tissue destruction by ultrasound: bio-effects.

PH 540 Clinical Instrumentation (1 credit)

Bio-electric potentials; causes and nature; suitability of different electrodes for their measurement: the electrocardiogram. Transducers to measure physiological parameters such as pressure, temperature. Amplifiers for measurement of physiological signals, the reduction of electrical interference. ECG and EEG equipment;. Blood pressure measurements; Pacemakers; Defibrillation; Surgical diathermy; Infusion pumps. Safety of equipment, Management of equipment

PH 541 Laboratory Course (1 credit)

Each student MUST complete TEN of the following experiments. Each experiment is 3hr.

1. Scintillation techniques for radionuclide counting
2. Pulse height spectroscopy, Analysis of spectrum from radioactive sources with the use of a single-channel spectrum analyser
3. Measurement of HVL for diagnostic X-ray beams
4. Electrocardiograph performance
5. Performance of a gamma camera
6. Stray -Radiation detection and dose measurement
7. Clinical thermoluminescent dosimetry
8. Personnel dosimetry
9. Counting statistics
10. Digital electronics hardware
11. Ultrasound scanner
12. Optical analogue for X-ray CT and Emission Tomography
13. The failure mechanism of ligaments
14. Central axis depth dose and dose profiles measurement for Co-60 Teletherapy beam
15. Measurement of TAR and PDD for C0-60 teletherapy beam
16. Construction and calibration of a GM-Monitor
17. Study of voltage current characteristics of an ion-chamber
18. Calibration of gamma-ray spectrometer and identification unknown sources
19. Calibration of TLD with TLD –reader and dose evaluation

PH 546 Radiation Protection (2 credits)

Radiation protection

Unit and quantities used in radiation protection including Calculation of Effective dose, Radiation Protection principles including current dose limits, and ICRP regulations, Calculations of shielding form X and gamma ray, neutrons and beta particles with practical exercise. Calculations of does from ingestion and diagnostic investigations, External and Internal Radiation hazards and methods of control; Design of radioactive laboratories and their safety. Epidemiological data and maximum permissible dose. . Personnel dosimetry. Practical use of health physics instruments. Emergency procedures and risks, role of police, fire brigade, decontamination procedures, waste disposal. Calculation of shielding for Medical linear Accelerators

Practice of Radiological safety
Sri Lankan regulations on Radiation Protection; with emphasis on Radiation Protection Adviser, regulation of working practices, local rules, controlled and supervised areas.
Safety in use of x-rays in Diagnostic Radiology and proper use of imaging systems. Preparation of a QA programme and its practical implementation
Practice of Radiation Protection
Optimisation of occupational exposure in radiotherapy and radiology practices. Safety features in controlled areas ,protective gears and application of time /distance /shielding related to radiotherapy and Nuclear medicine with typical examples. Selection of proper monitoring devices for RP. Preparation of contingency plans for radiotherapy and Nuclear medicine.

PH 547 Radiotherapy Physics (2 credits)
Dosimetry and calibration of photon and electron beams with cavity ion chambers
Determination of absorbed dose in free space and in water for photons and electron beams, IAEA code of practice: TRS 277and 398 protocols.
Radiation Detectors
Diode, films, TLD, chemical and calorimetric methods of measuring radiation and their clinical applications.
Radiotherapy Treatment Planning-EBT
Tumour localization and cross sectional information. Acquisition of patients' specific data from simulators, CT scanners and from other procedures. General principles in treatment planning. Dose specifications planning techniques - fixed, moving, irregular fields. Use of wedge filters, tissue compensation filters, bolus, patient immobilization devices.2-D planning. 3D-conformal radiation therapy (3D-CRT). Treatment verification methods and treatment optimisation methods. Quality control of treatment planning systems.
Radiotherapy Equipment
SXRT, DXRT machines, Isotope machines, LINACS, particle generators, Equipment specifications, tests and Quality Control..
Brachytherapy
Introduction - Radium and its radio active series. Other brachytherapy sources and their properties. Construction and care of brachytherapy source. Source strength specifications. Dose specifications. ICRU practice. Dosimetric systems . Brachytherapy techniques - Intra cavitory, interstitial, moulds, and intra lumenal.
Modern HDR-Brachytherapy
Source reconstruction and dose calculations manual and computer methods. Dose optimization. Quality assurance of brachytherapy systems. RBE+ comparison of HDR, MDR, PDR, LDR systems.
Unsealed Source Therapy
Choice of radio nuclides - physical and biological considerations, dosimetry. MERD theory and practice. Preparations for therapy, dispensing monitering and discharge of patients.

PH 548 Medical Imaging Physics (2 credits)
Radiography Physics, Basic imaging concepts and their relationships, imaging system capabilities
Physics of plain radiography, mammography, fluoroscopy, dental x-ray and Image processing; emphasizing relevant design features, main physical features and functions, optimisation of image quality/noise/patient dose, controlling scatter radiation and their limitations. (typical exposure levels and dose levels associated with each imaging modality); Types of x-ray films and intensifying screens used;Importance of routine Quality Control (QC) for equipments and procedures; Contrast, noise, signal-to-noise ratio, detective quantum efficiency, resolution, point-spread function, modulation-transfer function. Rose model.
Magnetic Resonance Imaging (MRI)

Brief introduction of relaxation processes, excitation, magnetic field gradients. k-space interpretation of selective excitation and data acquisition; Medical applications of magnetic resonance imaging; Behaviour of magnetisation after excitation; Image contrast and measurement of MR related phenomena: s/n, c/n, proton density - gradient echo MRI (FLASH), T2* - gradient echo MRI, T2 - spin echo MRI, T1 - progressive saturation, saturation recovery, inversion recovery - selective suppression of T1 components (STIR, FLAIR), diffusion coefficient - diffusion weighted pulse gradient spin echo-navigator echo, phase contrast flow sensitive pulse gradient spin echo, magnetisation contrast - off resonance saturation of bound (high linewidth) species, gadolinium contrast enhancement via T1 - flow sensitive via bolus tracking, spin tagging assessment of slow flow. Examples of contrast changes with changes of instrumental parameters

Applications of Digital Imaging

Physics of photostimulable plates. Physics of direct conversion detectors, Basic principles of Digital Subtraction Angiography (DSA) and Digital Fluroscopy.

Image reconstruction techniques

Fourier, ART, convolution and filtered back projection, algebraic reconstruction. CT equipment designs, and current trends.

Problems in use: partial volume effects, beam hardening, artifact generation.

Applications and evaluation diagnosis and radiotherapy. methods of performance evaluation QA procedure of CT scanner.

PH 549 Radiotherapy and Medical Imaging Laboratory (2 credits)

1. Measurement of HVL of KV radiation beams;
2. Absorbed dose determination in free space and to water for KV and MV radiations;
3. Calibration of brachytherapy source;
4. Quality Assurance tests for teletherapy machine .
5. Quality Assurance tests for HDR brachytherapy systems
6. Quality Assurance of computer treatment planning systems (TPS)
7. Quality Assurance tests for Simulator and CT;
8. Treatment planning and dose calculations, fixed fields, moving fields, irregular fields, wedge fields, conformation therapy; optimisation treatment verification , and delivery.
9. Source reconstruction and dose calculation for brachytherapy (manual and computer methods); LDR + HDR
10. Calibration of radiation survey meters
11. Preparation of sealed sources for treatment;
12. Preparation and dispensing unsealed sources;
13. Mould room procedures;
14. Treatment verification, clinical applications.

Medical Imaging (Radiology)

15. kVp, effective keV and half-value layer of x-ray beams.
16. QA of film processing
17. Measurement of x-ray tube focal spot size. Pinhole, Siemens Star and "line-pair" techniques for measurement of focal spot size.
18. Measurements of various film parameters (H & D curves, speed and film gamma). 19. Phototimer systems.
20. Exposure timer and mAs reciprocity.
21. Measurement of fluoroscopic resolution. Low and high contrast resolution tools.
22. Beam restriction and beam alignment.
23. Evaluation of image performance of a CT scanner.

CT test phantoms: low and high contrast resolution, slice width, CT linearity, impulse response. Effects of various reconstruction filters on image quality.

24. Basic QA of an ultrasound scanner. Evaluation of: penetration, accuracy with respect to depth; image uniformity; resolution (axial, lateral and near-field).
25. Uses of QA phantoms in MRI. Evaluation of system performance and image quality using standardized phantoms in a routine quality control program.

Radiotherapy
Clinical Treatment planning session will be done with the supervision of an Oncologist. Dose calculation, dose optimisation, treatment verification etc. will be supervised by a physicist. This would involve in each case.
A. Discussion
Tumour volumes – GTV, CTV, ITV, PTV, TV, IV, OR, PRV; Outline and delineation of GTV; Simulation and verification of PTV; Field arrangement and techniques of treatment; Dose identification for critical organs; Computer planning and verification of plans, weightage of doses - rechecking of critical organ doses; Checking of treatment set up with Oncologist and checking of the 1st. treatment.
B. Candidates Should Personally Plan Tumours of the Following Sites.
CNS tumour - Spinal cord, pituitary, brain stem glioma; Head and neck - PNS, tonsil/base of tongue. Supra glotic larynx, larynx. Maxillary antrum; Thorax - Lung, esophagus; Abdoman - Pancreas, bladder; Cervix - external beam + brachytherapy; Soft tissue sarcoma of limbs, brachytherapy + external beam.
Medical Imaging (Radiology)
Diagnostic Radiology – Participating with relevant staff professionals in the performance of clinical x-ray, mammography, fluoroscopy and angiography machines. Performing dosimetry tests and quality assurance.
CT, MRI, and DSA – Performing acceptance and quality assurance tests on CT, DSA, and MR scanners and machines. Performing dosimetry measurements to insure radiation safety.
Medical Ultrasound - Performing acceptance and quality assurance tests for clinical diagnostic ultrasound scanners. Operating clinical ultrasound equipment independently.

PH 550 Nuclear Medicine II (2 credits)
Covers the whole field of Nuclear Medicine, Starts with the physics of instrumentation from radiation detectors to gamma cameras, beta and gamma sample counters, etc. Considers the use of this equipment in clinical practice and the measurement of performance for quality control. The interpretation of nuclear medicine images and their role in clinical practice is considered together with the application of data processing techniques.
Image analysis
Use of computers in nuclear medicine, acquisition of data, data processing, algorithms for analysis.
Single Photon Emission Tomography (SPECT)
Reconstruction algorithms, detectors, sensitivity, scatter, attenuation and count rate problems, statistical limitations, instrumentation, calibration and quality control, artifacts. *Positron Emission Tomography (PET)*
Detection process, reconstruction algorithms, Ring/multi-ring systems, occurrence of random counts, attenuation correction.

PH 551 Medical Electronics and Instrumentation (1 credit)
Topics will include: Active filters, amplifiers for physiological signals, transducers, instrumentation amplifiers, signal processing and recording, automated signal analysis, renal dialysis equipment, electrical stimulation, anaesthetic gas analyzers, pulse oximetry, management of equipment.

PH 552 Computer systems and method (1 credit)
This unit is intended to give an insight into the concepts and techniques of applying computer systems and includes the following topics: Data and file structure, sorting and searching: numerical methods including random numbers and optimisation. Information theory and data compression; computer communications and networking. Real-time control systems. Image registration, multimodal image matching, 3D surface and volume rendering.

PH 553 Biomechanics, Biomaterials and Rehabilitation Engineering (1 credit)
Biomechanics of the musculo-skeletal system, locomotion and gait analysis. Biomechanical instrumentation. Orthopaedic biomechanics. Rehabilitation engineering. Structure and function of

biological materials, properties of bioengineering materials. Implant materials and biocompatiibility. Audiology, communication aids. Respiratory and cardiovascular mechanics.

PH 554 Computer Architectures and Artificial Intelligence (1 credit)
Modern serial and parallel computer architectures and their use in imaging and real time applications. Technology and programming of parallel systems. Artificial intelligence; introductory concepts and applications, including and outline of networks, expert systems and Prolog.

PH 555 Ultrasound in Medicine (1 credit)
Propagation of Ultrasound (US) and interaction with human tissues
Specific acoustic impedance, pressure and intensity reflection and transmission at plane interfaces, transmission through layers, attenuation, scattering and absorption, frequency dependence of absorption coefficients, tissue absorption and image resolution, beam plotting and power measurements.
Use of pulse- echo method in diagnostic US
Design and construction of single element transducers, Piezoelectric effect, Transducer construction, Transducer circuit models Characteristics of single element type.
Demodulation, time gain compensation (TGC), dynamic range, registration, pre-processing, post-processing , Mechanical scanners, multi-element linear array scanners, multi-element phased array scanners, signal processing, pulse repetition frequencies, frame rates multi-element arrays, beam steering; beam focusing, dynamic focusing
Basic Imaging Techniques
A-scan, B-scan, TM mode; Imaging of moving structures and flow measurement with US: (Doppler Techniques) Principles of continuous wave blood velocity measurements, transducers, signal processing, bi-directional detection, pulsed Doppler, duplex scanners, colour coded Doppler images.
Artifacts in Ultrasound Images: Reverberation artifact, Refraction and beam deflection, Side lobes and grating lobes , Speed of sound artifacts ,Attenuation artifacts ,Gray scale texture and lesion detectability.
Therapuetic Ultrasound
Ultrasound in Hyperthermia, High Intensity Focused Ultrasound.
Clinical applications
Examples of applications, dosimetry , use of phantoms , safety.

PH 556 Non-ionising E.M. Radiations in Medicine (1 credit)
Therapeutic and diagnostic applications of electromagnetic radiations in medicine. Laser surgery and therapy, diathermy using RF and microwave radiations, PUVA and other ultraviolet treatments and thermographic imaging of temperature distribution. Non -ionising radiation interactions with tissue, techniques employed in medicine, biological effects dosimetric considerations and safety requirements will be covered.

PH 557 Clinical Tutorials and Demonstrations (1 credit)
(Assessment of this course will be based on routing clinical interaction and viva)
Whenever possible during Phases II and III, arrangements will be made for students to receive illustrated tutorial from clinical staff or to visit clinics or operating theatres and intensive care units. The object of these tutorials and demonstrations is to enable students to appreciate the viewpoint of clinicians whose specialties involve physics, imaging computing or engineering. As dates, time and places for such events are governed by Consultant's commitments and the availability of clinical material, students will be notified when arrangements are made. The consultants in the following specialties would co-operate in providing this tuition although all may not be available each year: Anaesthesia; Diagnostic and theraputic radiology; Cardiology; Endoscopy; Pulmonary Function; Audiometry; Renal Dialysis; ICU.

PH 558 Advanced techniques and special procedures in Radiotherapy (1 credit)
Radiotherapy with heavy particle beams: pions, neutrons, heavy charged particles.
Isodose distributions and percentage depth dose. Advantages and disadvantages of particle beams.

Electron therapy; Total and half-body irradiation with photon beams (TBI); Total skin electron irradiation (TSEI); 3D-Conformal Radiation Therapy (3D-CRT); Stereotactic radiosurgery and therapy (SRS),(SRT); Intensity Modulated Radiation Therapy IMRT; Image Guided Radiation Therapy (IGRT); HDR Brachytherapy/Prostate Implant / Intra-vascular Brachytherapy.

7. PROGRAMME EVALUATION

Evaluation of Course work

Based on the scheme given below, the overall performance of a student in a given course shall be evaluated by the respective instructor(s) and a grade shall be assigned.

Evaluation Scheme

- For all courses a minimum of 80% attendance is expected.
- The evaluation of each course (except independent study and research project) shall be based on within course and end of course examinations, and assignments. The weightage of marks given below can generally be used as a guideline in the computation of the final grade, except for Independent Study and Research Project.

End of course examination	50 - 60%
Continuous assessments (mid-semester examination, assignments, etc.)	40 - 50%

- Courses with laboratory and/or fieldwork shall be evaluated, where applicable, on a continuous assessment basis.
- The minimum grade a student should achieve to pass a course is C.
- Students will be informed of the evaluation scheme by the instructor at the beginning of a given course.

Grade Points and Grade Point Average (GPA)

The Grade Point Average (GPA) will be computed using the grades earned for core courses and optional courses, taken for credit. Preliminary courses, industrial training, research project and seminar will be evaluated on a pass/fail basis.

On completion of the end of course examination, the instructor(s) is/are required to hand over the grades of a given course to the programme coordinator who will assign the Grade Points using the following table:

Grade	Grade Point
A+	4.0
A	4.0
A^-	3.7
B^+	3.3
B	3.0
B^-	2.7
C^+	2.3
C	2.0
F	0.0

The Grade Point Average (GPA) will be computed using the formula:

$$GPA = \frac{\Sigma c_i g_i}{\Sigma c_i},$$

where c_i = number of credit units for the i^{th} course, and
g_i = grade point for the i^{th} course

Make-up Examinations

‘Make-up’ examinations may be given only to students who fail to sit a particular examination due to medical or other valid reasons acceptable to the PGIS.

Repeat Courses

If a student fails a course or wishes to improve his/her previous grade in a course, he/she shall repeat the course and course examinations at the next available opportunity. However, he/she may be exempted from repeating the course, and repeat only the course examinations if recommended by the teacher-in-charge or M.Sc. Programme Coordinator. The student may repeat the same course or a substituted (new) optional course in place of the original course. A student is allowed to repeat five credits of coursework free-of-charge. The maximum number of credits a candidate is allowed to repeat is fifteen. The maximum grade, a candidate could obtain at a repeat attempt is a B and he/she is allowed to repeat a given course only on two subsequent occasions.

Evaluation of Research Project

Research project will be evaluated on the basis of a written report (M.Sc. project report) and oral presentation (see Section 6.0 of the PGIS Handbook for the format of the project report).

8. PANEL OF TEACHERS

Prof. M.A.K.L. Dissanayake, National Institute of Fundamental Studies, Kandy.
B.Sc. (Perad.), Ph.D. ((Indiana)

Prof. B.S.B. Karunaratne, Department of Physics, University of Peradeniya.
B.Sc. (Perad.), Ph.D. (Warwick)

Prof. B. Hewawitharana, Department of Radiology, University of Peradeniya.
M.B.B.S., M.D.

Prof. K Sivakanesan, Department of Biochemistry, University of Peradeniya.
B.V.Sc., Ph.D.(Hull)

Dr. S. Rosairo, Department of Radiology, University of Peradeniya.
M.B.B.S., M..D.

Dr. R.Ranaweera, Faculty of Engineering, University of Peradeniya.
B.Sc. Eng, M.S.B.m.E.(Purdue), Ph.D. (Purdue)

Dr. K.M.G.G. Jayasuriya, Department of Botany, University of Peradeniya.
B.Sc.(Perad), Ph.D. (Kentucky)

Dr. L.R.A.K. Bandara, Department of Physics, University of Peradeniya.
B.Sc. (Perad.), Ph.D. (Perad.)

Dr. C.P. Jayalath, Department of Physics, University of Peradeniya.
B.Sc. (Perad.), Ph.D. (Hampton)

Dr. B.S. Dassanayake, Department of Physics, University of Peradeniya.
B.Sc. (Perad.), Ph.D. (Western Mich.)

Dr. M.L. Jayatilake, Faculty of Allied Health Science, University of Peradeniya.
B.Sc.(Perad), Ph.D. (Cincinnati)

Dr. S.Kulatunga, Department of Nuclear Science, University of Colombo.
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B.V.Sc(Pera)., Ph.D.

Dr. A.J. Pinidiyaarachchi, Faculty of Science, University of Peradeniya.
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Dr. R.D. Yapa, Faculty of Science, University of Peradeniya.
B.Sc. (J'pura), M.Sc., Deng
Mr. A. Ranjith, Atomic Energy Authority, Orugodawatte, Wellampitiya
B.Sc., M.Sc.
Mr. T.H.S. Shantha, Atomic Energy Authority, Orugodawatte, Wellampitiya
B.Sc., M.Sc.
Mr. C. Kasige, Atomic Energy Authority, Orugodawatte, Wellampitiya
B.Sc., M.Sc.
Mr. Dilip Kumara, Teaching Hospital, Karapitiya, Galle.
B.Sc., M.Sc.
Mr. M.G.J. Gunerathne, Ceylinco Healthcare Services, Colombo
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9. PROGRAMME COORDINATORS

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