

MRI Physics Grade ‘A’ Training Schedule - Kris Armoogum

Aims and objectives of this placement

To prepare the trainee for assessment by IPEM Board of Examiners and to successfully complete the viva voce examination leading to the award of the IPEM Postgraduate Diploma.

Schedule

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| Week 1 | 15-09-03 | Introduction |
| Competencies Covered | | MR 3.4 – MR3.7 |

General

- Personal safety questionnaire.
- Patient confidentiality.
- Tour of MRI unit, and meet the staff.
- Reading list.

Familiarity with MRI Safety

- Magnets (projectile effect, metallic implants, biological and genetic effects, MHD effect).
- Gradients (switching – Faradays law, nerve & cardiac stimulation, auditory noise, pregnancy).
- RF (heating – SAR).
- Cryogenics (burns, asphyxiation, quenches).
- Safety guidelines for all of the above – NRPB, MDA, reports by Shellock and Kanal.
- Local Rules – to include fire protection and emergency services, and an understanding of controlled areas in MRI

EXPERIMENTAL WORK

- A look at the Vagus Nerve Stimulator.

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| Week 2 | 22/09/03 | MRI Hardware |
| Competencies Covered | | MR 1.1, MR 1.7, MR3.6 |

Magnet

- Magnet types (permanent, resistive, superconducting).
- Cost, weight, field stability of magnet types.
- Magnetic shielding (active and passive shielding).
- Shimming the magnet - active and passive shimming.
- Safety implications of the scanner types.
- Commercially available MR systems, field strengths and clinical applications.
- Site planning considerations.

Gradients

- X, Y, Z gradients – Helmholtz pair, Golay set, Maxwell pair.
- Typical magnet coordinate system.
- Definition of gradient amplitude, slew rate, rise time.
- Function of gradients – slice selection, phase encoding, frequency encoding.
- Gradient linearity – pre-emphasis to minimise Eddy currents.

RF System

- The ‘RF chain’.
- Different types of RF coil
Saddle coils.

- Birdcage (Volume) coils.
- Surface coils.
- Linearly polarised coils.
- Circularly (Quadrature) polarised coils.
- Phased array coils.

- RF shielding – Faraday cage, Zipper artefact, Penetration panel.

Computer System

- Operator console.
- Scanner computer.
- Array processor.
- Image storage.

EXPERIMENTAL WORK

- Determine 0.5mT isomagnetic contour of Siemens Impact 1.0T scanner using a Hall Probe.

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| Week 3 | 29/09/03 | MRI Theory |
| Competencies Covered | | MR 1.4 |

The proton NMR experiment to include quantum view

- Effect of magnetic field on a proton.
- Bloch equations.
- Maxwell-Boltzmann distribution.
- Application of an RF pulse (flip angle).
- Free induction decay.
- T1 and T2 relaxation, (some typical values).

The MRI experiment

- RF pulse shapes (ideal, sinc, gaussian), lengths etc., Crosstalk.
- Slice selection (control of location, thickness, profile).
- Phase encoding.
- Frequency encoding.
- Fourier transform and image formation. Nyquist theorem.
- K-space (high/low frequencies, centric ordering, zero filling, half acquisition).

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| Week 4 | 06/10/03 | MRI Sequences |
| Competencies Covered | | MR 1.4, MR 2.2 |

- Gradient Echo (explanation plus sequence diagram).
- Spin Echo (explanation plus sequence diagram).
- Inversion Recovery (STIR and FLAIR).
- T1, T2 and PD weighting.
- Contrast enhancement and effect on T1 and T2.

EXPERIMENTAL WORK

- Use Macintosh based software package to simulate effects of T1 and T2 changes on image contrast.

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| Week 5 | 13/10/03 | Operation of MRI Scanner and QA Procedures |
| Competencies Covered | | MR 1.2, MR 1.3, MR 3.1, MR 3.2, MR 3.3 |

- Factors influencing SNR (TR, TE, TI, FA, FOV, Slice thickness, matrix, BW, NSA, RF coil).

APPENDIX A

MRI TRAINING TIMETABLE

- Types of MRI artefact (movement, motion/flow, ghosting, susceptibility, clipping, zipper, partial volume, Gibbs, wrap around, chemical shift types 1 and 2), Magic angle, Mioré fringes.

- Methods for reduction of artefacts.
- Decision making.

EXPERIMENTAL WORK (WITH SIEMENS IMPACT 1.0T)

- Supervised operation of the MRI Scanner.
- Selection and testing of MRI phantoms and RF coils for QA.
- Use of MRI to obtain images of test objects.
- Image signal uniformity.
- Image SNR.
- Image Resolution.
- Slice profile and width.
- Measurement of T1 and T2.

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| Week 6 | 20/10/03 | Advanced Sequences |
| Competencies Covered | MR 1.5 | |

EXPERIMENTAL WORK (WITH SIEMENS SYMPHONY 1.5T)

Complex Sequences

- Steady state gradient echo sequences – FISP, PSIF, plus typical parameters.
- Spoiled gradient echo sequences – FLASH, plus typical parameters.
- Fast (Turbo) spin echo.
- Multi-echo fast spin echo.
- 3D gradient echo for volumes.
- Echo planar imaging (including BOLD effect).

Incorporated Techniques (Use of advanced sequences)

- Fat suppression techniques.
- Magnetisation transfer imaging.

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| Week 7 | 27/10/03 | Clinical Applications |
| Competencies Covered | MR1.4, MR2.1, MR2.2 | |

EXPERIMENTAL WORK

Case studies of normal and diseased examples of the following:

- (i) Neuro (brain or spine).
- (ii) MR Angiogram (renal/carotid artery).
- (iii) Musculoskeletal (knee).
- (iv) Body (liver).

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| Week 8 | 03/11/03 | Advanced Clinical Applications |
| Competencies Covered | MR 1.6, MR 2.3 | |

- MR Angiography (time of flight, phase contrast, contrast enhanced).
- Flow compensation.
- Diffusion and Perfusion weighted imaging.
- Cardiac gating, respiratory gating, breathold imaging.

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| Week 9 | 10/11/03 | R & D in MRI |
| Competencies Covered | MR 1.6, MR 2.2, MR 2.3, MR 3.1 | |

APPENDIX A

MRI TRAINING TIMETABLE

EXPERIMENTAL WORK

- 'Stand alone' R&D report to assess reproducibility measurements made using MRA and kidney volume analysis for patients with renovascular disease.

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| Week 10 | 17/11/03 | Scottish MRI Seminar |
| Competencies Covered | MR 2.1 – MR 2.3 | |

- Preparation of presentation to be given at Scottish MRI Seminar.
- Scottish MRI Seminar workshop presentation (19/11/2003) – “Artefacts in Clinical MRI”.
- Written report of Scottish MRI Seminar.

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| Week 11 | 24/11/03 | MRI Scanner Commissioning & Acceptance Tests (Theory) |
| Competencies Covered | MR 1.1, MR 1.2, MR 1.3, MR 1.4, MR 3.1 - MR3.7 | |

EXPERIMENTAL WORK

- Purchasing a Scanner – specification for tender, and tender returns.
- Acceptance testing – to include general installation, magnetic field, gradient system, RF system, computer system, MR sequences and software packages, patient handling equipment, general equipment and safety.
- General imaging QA tests

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| Week 12-13 | 01/12/03 | MRI Scanner Commissioning & Acceptance Tests |
| Competencies Covered | MR 1.1, MR 1.2, MR 1.3, MR 1.4, MR 3.1 - MR3.7 | |

- A detailed technical report giving the results of all tests and checks performed, with baseline values and recommended corrective measures if appropriate.